

Three essays on supply and demand in the Swiss health care system

February 2, 2016

PhD Thesis submitted to the Faculty of Economics and Business
Institute of Economic Research
University of Neuchâtel

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Defended in Neuchâtel, 28 October, 2015

IMPRIMATUR POUR LA THÈSE

Three essays on supply and demand in the Swiss health care system

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Neuchâtel, le 23 novembre 2015

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Executive summary

The Swiss health care system is facing various challenges including high health care costs, wasteful and medically harmful over-treatment, regional variation in access to care and a lack of transparency. Because physicians and patients are granted considerable autonomy in medical decision making a thorough understanding of their motives and behaviors is a prerequisite for successful policy. This doctoral thesis investigates physicians' preferences for financial profit, the role of patients' levels of information, the effects of prospective payment systems on the provision of care and the effects of public health promotion programs on the demand for preventive care. The first empirical study shows that physicians react to changes in marginal revenue per unit of care which confirms the hypothesis that they have preferences for financial profit. This result implies that physicians provide more care when they are paid retrospectively and that prospective payment systems can be effective measures against over-provision of care. The second study investigates the effects of consumer information on the outcome of the physician - patient interaction in outpatient care to identify physician induced demand. The analysis does not show any significant effect of consumer information on the number of outpatient physician visits and thus does not confirm the hypothesis that physicians induce more demand in their less-informed patients. The third study shows that organized screening programs providing health information and free access to mammography have only a modest effect on the demand for mammography when utilization is already high. The empirical results of this thesis suggest that the provision of consumer information or organized screening programs are potentially ineffective policy instruments and that prospective payment systems can be used more widely to control the provision and the costs of medical care in Switzerland.

Keywords: Switzerland, health care, physician agency, supplier induced demand, prospective payment, marginal price effect, hospital, psychiatry, length of stay, health literacy, outpatient service utilization, mammography, screening, hospital registry, Swiss health survey, hurdle model, difference-in-difference

Acknowledgements

Although it has always been my ambition to write a doctoral thesis I am well aware of the fortune to have been given all the opportunities to achieve this goal. With these few lines I want to thank all the people who made this doctoral thesis possible.

First and foremost, I want to thank my thesis supervisor Professor Claude Jeanrenaud for being such a great mentor to me. When I was accepted by Prof. Jeanrenaud as an external doctoral student it felt as if a heavy door had been pushed open. But also on the intricate and steep paths behind that door, he always boosted my morale and showed me the right direction when I was stuck. I am extremely grateful for his scientific support, his optimism and his generosity. I also want to thank the members of the thesis committee, Jean-Marie Grether, Stefan Felder and Joachim Marti, for taking the time to read the manuscript and for their valuable feedback.

I further want to thank my supervisors at the Winterthur Institute of Health Economics, Simon Wieser and Urs Brügger, for giving me the time to write this thesis and for their material and moral support. While my own assessment of the probability of success only improved gradually they always believed in the success of this venture. The combination of the work on my PhD and the applied research carried out at the institute allowed me to grow not only as a researcher but also as a professional. The International Doctoral Courses in Health Economics and Policy at the Swiss School of Public Health (SSPH+) allowed me to improve my methodological skills and meet great people. I want to thank all the administrative and academic staff as well as the Swiss National Fund for making these courses possible.

A strenuous journey in an unknown territory is much more pleasant when it is made together with companions. Lukas Kauer has accompanied me during the entire time of this thesis and, during many intense discussions, gave me valuable advice. In 2013, Lukas introduced me to Per Johansson who invited me to visit the Institute for Evaluation of Labour Market and Education Policy (IFAU) in Uppsala. In this inspiring and productive environment and with the support of Per, I was able to carry out the main study of this thesis.

Finally, I want to thank my parents for their love, their unconditional support and for making everything in my life possible. I want to express my love for Susanne and my gratitude for her sacrifices to this PhD.

All the above mentioned people are very important to me and I want to thank all of them

very deeply.

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"Then, isn't it the case that the doctor, insofar as he is a doctor, considers or commands not the doctor's advantage, but that of the sick man? For the doctor in the precise sense was agreed to be a ruler of bodies and not a money-maker. Wasn't it so agreed?"

Plato BC 427-BC 347: "The republic". Book I, p. 22

Part I

Introduction

1 Preface

The greek demigod Asclepius, the son of Apollo and a mortal woman, was famous for his extraordinary medical skills, which were so strong that he could even bring back the dead from the underworld. Hades, the ruler of the underworld, was so furious about this encroachment on his authority that he visited Zeus to complain about Asclepius' crimes against the natural order of the world. Zeus, who feared the excessive growth of the human population, killed Asclepius with a thunderbolt, but he turned him into a god in recognition of the good deeds he did during his life.

The story of Asclepius is not only a piece of ancient mythology but also resembles the relationships among physicians, health economists and policy makers in modern health care systems. Asclepius has become the patron saint of the medical profession, and many physicians accuse health economists of acting like Hades and undermining their actions out of ulterior motives. However, the tale highlights how the noble deeds of those who heal people can have unintended consequences for society as a whole. Policy makers thus often have to regulate the activities of physicians, although they are keen to avoid the impression that they underestimate the virtues of the medical profession.

It is amazing that the fundamental problem of single-minded focus on medical outcomes had already been acknowledged in ancient Greek mythology. Asclepius' medical work had unintended consequences for the world because the resources to satisfy the basic needs of the human population were limited. The same is true in modern health care systems in which health care expenditures have reached the limits of affordability, and the use of resources to care for some patients inevitably implies the denial of these resources to others. It is thus an important function of health economics to reflect on the conditions under which individual behaviors can lead to efficient allocations and fair distributions of resources within a health care system.

The market for medical care differs from markets for other goods in several respects. Asymmetric information, uncertainty, limited competition, externalities and strong roles of non-market institutions create situations in which market mechanisms can lead to inefficient outcomes. Because physicians play a dominant role in medical decision making, their motives largely

influence the results of market interactions. On the one hand, the focus on medical outcomes in medical decision making can lead to inefficiently high provision of care; on the other hand, financial motives can lead to medically harmful over- or under-treatment of patients. Policy makers thus have to promote careful use of available resources while keeping an eye on the potential side-effects of institutions and regulations in the market for medical care. This delicate task requires a thorough understanding of the motives and behaviors of physicians and patients and of the interaction between the two.

This doctoral thesis investigates the interactions between physicians and their patients in the medical decision-making process. Important topics include physicians' preferences for patient benefit and financial profit, the role of patients' levels of information in their interactions with physicians, the effects of prospective payment systems on the provision of care and the effects of public health promotion programs on the demand for preventive care.

In the first part, I discuss different models of physician and patient behavior and compare them with the empirical literature. Each of the theoretical models is visualized through an influence diagram representing the medical decision-making process (figure 1.1). In an influence diagram, rectangular nodes designate decisions, elliptical nodes contain information and rounded rectangles show outcomes. Medical decision making can be seen as a two-fold process in which the patient makes a decision to seek care, and the treatment decisions are made in an interaction between the physician and the patient (Hay and Leahy, 1982; Deb and Trivedi, 2002; Mullahy, 1998). The patient's decision to seek care depends on information about his health state H , while the treatment decision is based on information about the patient's health state H , the medical benefits of medical interventions $B(q)$ and the costs of care $c(q)$. The patient's influence on the treatment decision is determined by the patient's level of information about health and medical care and the physician's power to set quantities and prices. The results of the physician-patient interaction are the use of medical care q at a price p and the utilities that physicians and patients derive from this trade.

In parts II to IV, I present three essays addressing the determinants and outcomes of the physician-patient interaction (figure 1.1). The first study evaluates whether marginal revenue per inpatient day in inpatient psychiatric hospitals affects physicians' decisions about length of stay. This study provides novel insights into the potentially conflicting objectives of physicians and has important policy implications. The significant effect of marginal revenue on length of stay indicates that psychiatrists have not only their patients' best interests but also the

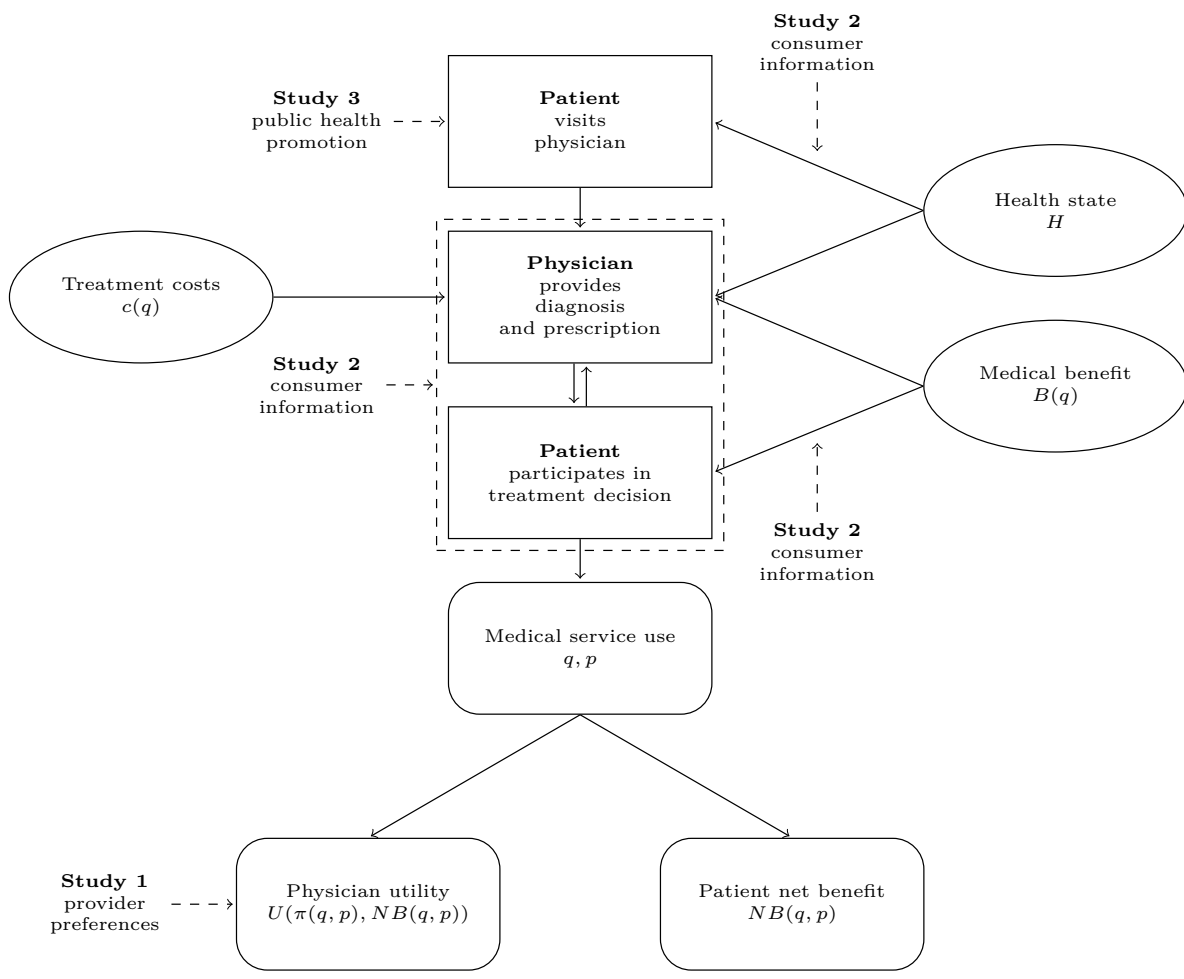


Figure 1.1: Influence diagram of a physician-patient interaction

financial profits of their hospital in mind when they make decisions about length of stay. At a time when Switzerland is implementing a prospective payment system for inpatient psychiatry, this study shows that prospective payment systems can reduce the average length of stay in inpatient psychiatry. The second study investigates the effects of consumer information on the number of outpatient physician visits by Swiss residents. The two-part regression model allows me to disentangle the effects of consumer information on the patient's propensity to seek care and the effects on decision making during the physician-patient interaction. The regression analysis does not show significant effects of consumer information on the patient's decision to seek care or on the number of outpatient physician visits among those who have visited a physician. This result contradicts the hypothesis that physicians induce more demand in their less-informed patients. The third study evaluates the effects of organized screening programs in Swiss cantons on the demand for mammography. It shows that organized screening programs providing health information and free access to mammography have only a modest effect on the demand for mammography when utilization is already high. This finding can guide political decisions regarding organized screening programs in Switzerland, which have been the subject of recent criticism.

2 What makes the market for medical care special?

The market for medical care departs from a number of principles under which market mechanisms maximize welfare. In his classic article, Arrow (1963) noted that asymmetric information, uncertainty, limited competition, externalities and strong roles of non-market institutions limit the efficiency of market mechanisms in the health care sector. Although many everyday goods share some of these characteristics, only few combine as many of them as medical care.

2.1 Asymmetric information

The most important characteristic of health care markets is that information is distributed asymmetrically between consumers and providers of medical care. Consumers are generally not well informed about health or health care, and they depend on the expertise of physicians, who act as their agents. Although people are often aware of their symptoms, it is virtually impossible for them to make a diagnosis or choose the most effective treatment. Even if patients participate in the decision-making process, many medical interventions can only be performed by clinical experts. Inefficiencies arise when physicians pursue several objectives and act in their own interests at the expense of patients and payers.

2.2 Uncertainty

Inefficiency due to information asymmetry is not the consequence of the unequal distribution of the information per se but of the non-marketability of this information due to uncertainty (Arrow, 1963). Uncertainty in the market for medical care arises from the acute and probabilistic nature of health events and from the heterogeneity of patients' preferences and responses to treatment.

Health events are probabilistic because the need for medical care is irregular and cannot be planned. Most acute health events are rare and occur randomly. In cases of acute health shocks, the information possessed by physicians is non-tradable because such events require immediate treatment and leave the patient no time to collect information. The probabilistic nature of health and medical care also reduces the value of acquiring medical information ex ante because mere statistical information does not tell the patient anything about his own chance of getting sick or benefiting from a treatment. Especially when a health event is rare, the patient has few opportunities to learn his location on the probability distribution and which treatment suits him

best. Both *ex ante* and *ex post* uncertainty reduce the value of medical information because, even after a treatment episode, the patient can never be sure about the extent to which the therapy was actually responsible for the results or whether the physician made a sufficient effort (Darby and Karni, 1973; Emons, 1997; Sloan, 2001; Demange and Geoffard, 2006).

2.3 Limited competition

The market for medical services is far from perfectly competitive because medical care is a highly differentiated good, providers face strong barriers to entry and exit, and the market is highly regulated.

Medical care is a differentiated good because patients have different needs; physicians differ in various characteristics, such as location, specialty, skills and personality; and the quality of medical care depends on the personal relationships between patients and their physicians (Léger and Strumpf, 2014). A physician with an established relationship is more familiar with the patient's physical condition, preferences and treatment response and has a better chance of making a correct diagnosis and choosing the best treatment. The comparison of physicians involves considerable costs. On the one hand, the patient needs to find a new physician, travel there and build trust, on the other hand, the physician needs to learn the medical history and preferences of the patient. Because of these search and switching costs, many patients prefer to stay with a physician they do not like rather than visit a new one they do not know (Pauly and Satterthwaite, 1981). The provision of objective information, e.g. through ratings on the internet, does not necessarily reduce the search costs because medical care is often tailored for each individual case and patients are uncertain whether a physician who is good for others will also be good for them.

Barriers to entry and exit in the market for medical care can stem from regulatory restrictions, high investments and positive returns to scale. Regulatory restrictions include requirements for admission to medical school as well as licensing and practice regulations. The investments required to enter the market include financial capital and knowledge acquired in medical school and as learning-by-doing (Dafny, 2003a; Gaynor et al., 2005). Positive returns to scale can be the consequence of a positive relationship between volume and quality (Preyra and Pink, 2006) or a negative relationship between volume and costs (Physician Payment Review Commission, 1992; Escarce and Pauly, 1998).

Regulations that directly limit competition among providers include licensing restrictions,

price regulations and regulations of the modalities of reimbursement by third-party payers. The effects of these non-market institutions are discussed in section 2.5 below. Licensing restrictions are often established with the aim of guaranteeing high-quality care and avoiding an oversupply of physicians associated with excessive health care expenditures. However, licensing also protects physicians from competition by other providers, especially by non-physicians, which can lead to monopolistic physician behavior (section 3.3).

2.4 Externalities

Many medical activities affect people who are not involved in the transactions. The prevention or cure of communicable diseases, for instance, not only benefits the patients themselves but also prevents others from becoming infected. Similarly, the conscious use of antibiotics prevents the development of resistant microorganisms. Another externality originates from rivalry in consumption in countries with fixed health care budget wherein the use of medical care by an individual necessarily reduces the capacity available for others. This competition for limited resources can be observed especially well in services with waiting lists, as each patient on the list extends the waiting time of those who are added later. A less apparent externality is the disutility that people experience because others suffer or die because they have limited access to care (Donaldson and Gerard, 1993; Lindsay, 1969; Pauly, 1978). This externality is probably the main reason why most developed countries introduced institutions to guarantee universal health coverage for their populations. The establishment of a social health insurance system, however, creates another externality because the costs of medical services are partly borne by all other insurees, which might lead to the over-use of medical care by patients (Pauly, 1968). Overall, we can conclude that medical services cause manifold externalities and are thus not consumed efficiently in unregulated markets.

2.5 Non-market institutions

The non-marketability of the physicians' superior information and the externalities associated with the consumption of medical care have motivated the establishment of various non-market institutions to bridge the optimality gap. According to Arrow (1963), the observed behavior of physicians and patients in modern health care systems is less the consequence of market imperfections, such as asymmetric information, limited competition and externalities, than of the incentives established by non-market institutions mitigating these market imperfections. Profes-

sional organizations, payer organizations and government bodies regulate the health insurance system, issue licensing restrictions, establish professional codes and control prices.

The social health insurance system is certainly the most important non-market institution in modern health care systems. Social health insurance systems not only pool risk but also place physicians in the role of double agents of patients and payers (Blomqvist, 1991). First, physicians make treatment decisions for their ill-informed patients who wish to receive the care with the highest net medical benefit. Because patients tend to over-use medical services when they are insulated from the costs, payers expect physicians to consider the costs of care. To comply with payers' objectives, however, physicians also need to act as agents against demand-side moral hazard.

Licensing restrictions and ethical codes are intended to ensure that only physicians with sufficient quality standards operate in the medical market. Unfortunately, regulating the supply of physicians can also lead to higher prices and lower quality, as the incumbents are protected from competition. The prices of medical services are thus often controlled by payer organizations and government agencies to mitigate the providers' market power. To guarantee the provision of medical care to the population, however, administratively set prices must not be smaller than the marginal costs, which can lead to excessive average profits and limited incentives to reduce costs. Even under administratively set prices, providers can exercise market power through quantity setting; thus, most payer organizations or social health insurance systems regulate the quantities of care by limiting the coverage of services or by implementing prospective payment systems. In effect, physicians who operate in a highly regulated market can only alter their unobservable effort, which can impair the quality of care.

2.6 Discussion

Many would argue that medical care is special because health is a matter of life and death and is thus priceless. From this view, many people conclude that resources to restore health should not be limited, that it is unethical to deny medical care to anybody who is sick and that market mechanisms are not appropriate to guide the allocation of resources. Many of the modern institutions and attitudes that guide health policy and medical decision making originate from this line of thinking. This reasoning, however, is subject to several fundamental errors. The fact that the risk of dying is an important aspect of individual decisions is not unique to health and medical care. The job market, leisure activities and consumer decisions often

involve a valuation of mortality risks, and markets seem to be decently efficient in these areas. In addition, the limitation of available resources is hardly anywhere as obvious as in health because a lifetime is finite, and the affordability of health care has become an issue in many Western health care systems. Health is not priceless, but its production entails considerable opportunity costs.

The differences between medical care and dangerous jobs, risky sports activities and cars with seatbelts is that the consumers of medical care are much less informed than the providers, the need for care is probabilistic, and it is provided in imperfectly competitive markets, causes externalities and is highly regulated. Other goods often share some of the characteristics of medical care, but they rarely completely coincide. In the face of these particularities, the efficiency of market mechanisms can be called into question. As Arrow (1963) wrote, "it is the general social consensus, clearly, that the laissez-faire solution for medicine is intolerable." This phrase has often been interpreted as a statement against market-based solutions in the health care sector. However, he stated clearly that the question of the efficient design of the health care system was beyond the scope of his article. Since Arrow's (1963) classic article, health economics has been concerned with the efficient design of non-market institutions in health care. Because asymmetric information and limited competition place physicians in a superior role vis-à-vis their patients, a strong focus was on the supply side.

3 Theories of physician behavior

Because physicians exert a strong influence on the utilization of medical care, an informed discussion of social welfare in the health care sector should be based on a well-grounded theoretical framework in which physician behavior can be analyzed. Useful theories of physician behavior should describe the physicians' motives as well as the manner in which they exercise market power. In this section, I discuss the four most important theories of physician behavior: the neoclassical model of perfectly competitive markets, the target-income hypothesis, the model of monopolistic competition under full and symmetric information and the model of imperfect agency under asymmetric information. In section 5, I compare the models' predictions with the empirical evidence on the effects of exogenous changes in reimbursement policies, competition and consumer information (table 1.1). Reimbursement policies include health insurance plans¹ that insulate patients from the costs of care, administratively set prices and prospective payment systems. Competition is conceptualized by physician-to-population ratios and measures of hospital market concentration. Consumer information includes general knowledge about health and health care as well as quality information about health care providers.

¹Most health insurance plans include some type of patient cost-sharing mechanism. Patients can contribute to the direct medical costs through deductibles, copayments and coinsurance rates. A deductible is a fixed amount of direct medical costs per period that the patient has to pay himself before health insurance starts paying for medical care. Copayments are fixed fees per service or treatment episode, which the patient has to pay regardless of the actual costs of the service. Coinsurance rates determine the fixed percentage of all direct medical costs that the patient has to pay.

Table 1.1: Comparison of model results

	neoclassical model	target-income hypothesis	monopolistic competition	imperfect agency
outcomes				
equilibrium price	p^*	n.a.	$p > p^*$	n.a.
equilibrium quantity	q^*	n.a.	$q > q^*, q \leq q^{pat}$	$q > q^{pat} > q^*$
price discrimination	no	(yes)	yes	n.a.
correlation between changes in market conditions and outcomes				
establishment of health insurance $\rightarrow q$	+	0	+	+
establishment of health insurance $\rightarrow p$	+	0	+	n.a.
prospective payment reform $\rightarrow q$	0	0	-	(-)
fee increase $\rightarrow q$	+	-	-	ambiguous
more intensive competition $\rightarrow q$	+	+	$q \rightarrow q^{pat}$	+
more intensive competition $\rightarrow p$	-	n.a.	-	n.a.
better consumer information $\rightarrow q$	n.a.	n.a.	$q \rightarrow q^{pat}$	n.a.
better consumer information $\rightarrow p$	n.a.	n.a.	-	n.a.

Legend: * social optimum, pat patient's private optimum, n.a. not applicable, + positive correlation/increase in the outcome, - negative correlation/decrease in the outcome, 0 zero correlation/no change in the outcome.

3.1 The neoclassical model of perfectly competitive markets

In the neoclassical model of the health care market, profit-maximizing physicians encounter perfectly informed patients who maximize their private utility. If health and health care are subject to diminishing marginal utility, the physician's profit maximization is constrained by a downward sloping demand curve (Santerre and Neun, 2009). The assumption that patients are perfectly informed about their health and the medical benefits of care implies that physicians only reveal their costs and leave all treatment decisions to the patients (figure 1.2). If an infinite number of physicians compete for patients, prices equal marginal costs, physicians make no excess profits, and social welfare is maximized.

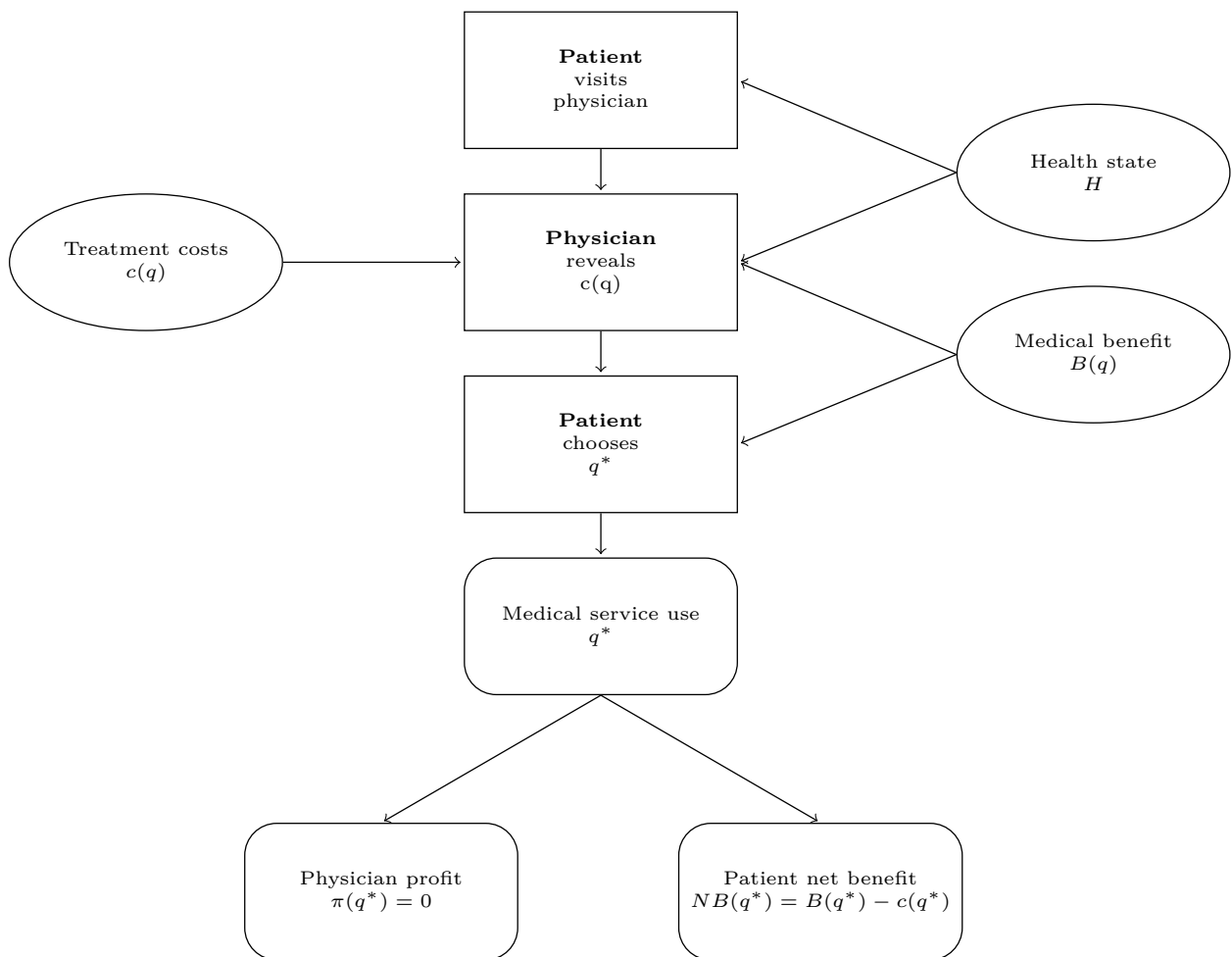


Figure 1.2: Influence diagram of a physician-patient interaction under perfect competition with full and symmetric information

3.1.1 The effects of reimbursement policies

The introduction of full health insurance coverage insulates patients from the costs of care, and demand becomes perfectly inelastic. With a perfectly inelastic demand curve, the relationship between quantities and prices is determined by the supply curve, and the introduction of health insurance thus increases both quantities and prices. From a societal perspective, health insurance causes a welfare loss because the marginal costs of medical care in the market equilibrium exceed the marginal medical benefits to the patient.

In a competitive market with perfectly informed agents, prices are market clearing mechanisms, and the regulation of prices causes a welfare loss. If patients pay for medical care themselves, price regulations away from the equilibrium price lead to a reduction in the traded quantity of care, which is determined by the shorter market side. The correlation between fees and quantities can thus be positive or negative depending on whether the fee is below or above the equilibrium price. In the presence of a third-party payer, the quantities are determined by the supply curve, and the neoclassical model predicts a positive relationship between fees and quantities as long as the quantity is lower than the patient's medical optimum.²

A cost-neutral change from a fee-for-service to a prospective payment system³ reduces the marginal revenue per unit of care but leaves total revenue per encounter unaffected. From a physician's perspective, the profit maximum lies at the minimum quantity of care required to earn the prospective payment. If physicians compete for patients, however, they have to provide as many services as the prospective payment allows to satisfy their patients. Under the assumption that physicians in a perfectly competitive market make zero profits under either reimbursement system, a change from fee-for-service to prospective payment does not affect the quantity of care.

3.1.2 The effects of competition

In the neoclassical model, an increase in physician density decreases the quantity per physician and, thus, the marginal costs of production. A reduction in the marginal costs of care can be

²The neoclassical model treats payers as passive parties who have no influence on the utilization of medical care. In reality, payer organizations do exert control over costs and often limit the reimbursable quantities of care when prices are administratively set.

³A tariff system is prospective if the payment is made for an episode of care regardless of the actual quantities of services provided during this episode. In inpatient care, the term prospective payment is generally used for per case payment systems that do not adjust the revenues per inpatient case for the actual number of days a patient spends in the hospital. A per diem rate can also be referred to as prospective because the revenue per inpatient day is not adjusted for the number of services provided per day. In outpatient care, prospective payment systems are typically annual lump sum payments per patient (capitation) to a managed care organization.

represented by a downward shift of the supply curve increasing the aggregate utilization of care through a price effect. The neoclassical model thus predicts a negative correlation between the physician-to-population ratio in a market and prices and a positive correlation between the ratio and quantity of care.

3.1.3 The effects of consumer information

In the neoclassical model, consumers are perfectly informed about their health stock and the marginal benefit of health care. This implies that patients always know how medical care affects their utility and only need to shop for the best offer (figure 1.2). In such a patient-physician interaction, the physician's position is simply "this is the price of my services, how many do you want?" (McGuire, 2000). Additional information affects the decisions made under perfect and symmetric information only by reducing random errors.

3.1.4 Discussion

The neoclassical model is one of the simplest applications of standard economic theory to the market for medical care. It assumes profit-maximizing physicians, rational and perfectly informed patients and perfect competition among physicians. The model makes four fundamental predictions that stand as warnings about the potential inefficiencies arising from government interventions. First, health insurance increases demand and, thus, quantities and prices beyond the efficient level. Second, the correlation between administratively set fees and quantities is positive when patients have health insurance. Third, competition decreases the quantity of care per provider, reduces prices and increases aggregate utilization of care. Fourth, prospective payment systems do not affect the provision of care.

A common critique of the neoclassical model is that the underlying assumptions are unrealistic as physicians do care about their patients' welfare, patients possess less information and expertise than their physicians and competition among physicians is not perfect. Indeed, the model has been confronted with a large body of conflicting real-world experience. Many providers of medical care, particularly hospitals, operate on a not-for-profit basis, and the available evidence seems to confirm that physicians care about their patients' welfare (McGuire, 2011; Ellis and McGuire, 1986; Newhouse, 1970b; Frank and Lave, 1989; Dranove and White, 1994; Norton et al., 2002). Before the advent of administratively set fees, the market prices of medical services were often higher in areas with higher physician density (Fuchs, 1978; Feldstein,

1970; Newhouse, 1970a; Fuchs and Kramer, 1973; Evans, 1974), and administratively set fees in the presence of health insurance seemed to be negatively correlated with the number of services per encounter (Rice, 1983) and per physician (section 5.3). In contrast to the model prediction, prospective payment systems appear to be effective in reducing the provision of care (section 5.2), and the observation that physicians do price discriminate when prices are free can also be regarded as counter-evidence of a perfectly competitive market (Kessel, 1958). Empirical findings of significant effects of supply-side factors on the treatment decision show that physicians exercise market power in a way that is inaccessible to firms in perfectly competitive markets (Gaynor and Gertler, 1995; Wong, 1996).

Although most health economists agree that simple neoclassical models of perfectly competitive health care markets do not accurately describe provider behavior, there is no consensus on a universal model of physician behavior (McGuire, 2000). In the following, I discuss three alternative models: target-income seeking, monopolistic competition and imperfect agency under asymmetric information.

3.2 The target-income hypothesis

The idea that physicians try to earn a target annual income was an attempt to explain higher prices with higher physician density or the rising supply of services after a decrease in administered fees in the presence of health insurance. A physician's annual income depends on the number of encounters e , the quantity of care provided per encounter q , the price per unit of care p and the marginal costs of care c . The marginal costs c can also be seen as an indicator of the physician's effort to produce good quality.

$$\bar{T} = eq(p - c) \tag{1}$$

If physicians try to achieve a fixed income \bar{T} , they can compensate for negative income shocks by increasing the number of encounters e , raising prices p , increasing the number of services per encounter q or reducing the marginal costs c . At a given level of e and c , the target-income hypothesis implies a negative relationship between the price and the quantity of care per encounter (figure 1.3).

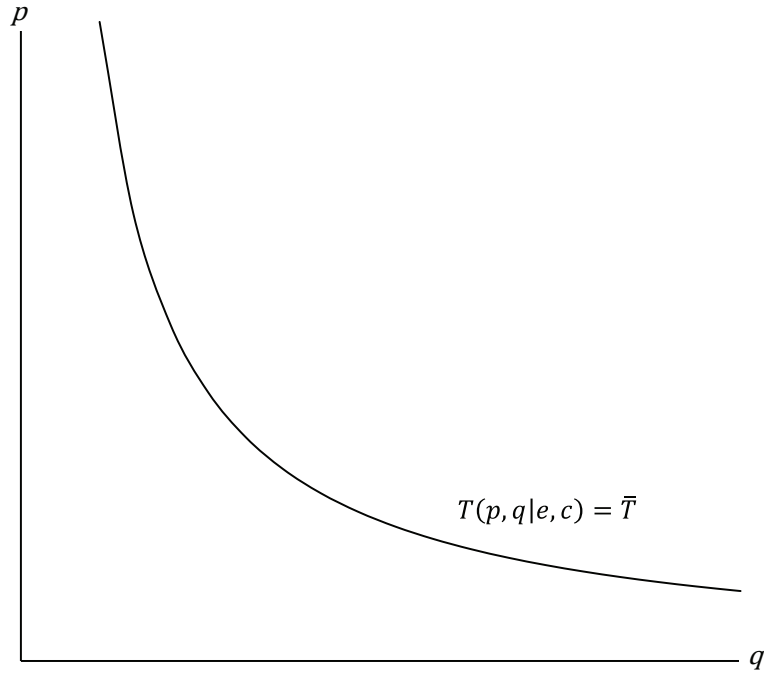


Figure 1.3: Price-quantity bundles chosen by target-income seeking physicians

3.2.1 The effects of reimbursement policies

Because the target-income hypothesis neglects the role of the patient in the medical decision-making process it does not predict how health insurance and demand-side cost sharing affect the market equilibrium. A reduction in administratively set fees, however, can lead to an increase in the number of encounters e or services q , or it can lead to impaired quality of care because the physician reduces marginal costs c . Holding the number of encounters constant, the elasticities of q with respect to the profit margin $p - c$ and of c with respect to the fee p are both -1 (McGuire, 2000). The target-income hypothesis thus suggests that price controls are ineffective measures to control health care expenditures and that policy makers should instead control the number of physicians.

With a prospective payment system, the physician's revenue R is independent of the prescribed quantity of care. If a prospective payment reform leaves total revenue per encounter unchanged, it should not alter the provision of care by target-income seekers. A change in the prospective payment rate R , however, is positively correlated with the annual number of services per physician or the marginal costs of care. An increase in the payment rate can thus increase the quantity or the quality of care. A prospective payment system is therefore suitable for controlling the provision of care by target-income seekers and the associated health care

expenditures.

$$\bar{T} = e(R - cq) \tag{2}$$

3.2.2 The effects of competition

An increase in the provider density in the market of a medical practice decreases the number of encounters per provider and thus causes a negative income shock to which target-income seekers can react by increasing the prices p and the number of services per encounter q or by decreasing the marginal costs of care c .

3.2.3 The effects of consumer information

The target-income hypothesis is based on the assumption that physicians are not restricted by demand and can recommend any bundle of quantity, quality and price to the patient. Therefore, the patient's level of information does not necessarily affect the treatment decisions made during a consultation. The only manner in which patients can influence the provision of care by target-income seekers is to switch physicians. This type of consumer behavior is considered in the model of monopolistic competition presented in section 3.3.

3.2.4 Discussion

The target-income hypothesis assumes that physicians try to earn a certain target income and compensate income losses from exogenous changes in market conditions by altering the quantity, quality or prices of medical care. If physicians behave like target-income seekers, fees and quantities are negatively correlated, and competition increases the provision of care or decreases the quality of care. In a fee-for-service payment system, fee controls are ineffective cost control measures, while prospective payments can be used to control the quantities and costs of care.

Before the introduction of administratively set fees, the target-income hypothesis was used to explain higher prices with higher physician density by assuming that physicians compensate for income losses due to increased competition by increasing their prices. The hypothesis that physicians reduce prices when they face less competition was seen as noble self-restraint in exploiting monopoly power – as long as a certain target income could be earned (McGuire, 2000). With administratively set prices, however, the target-income hypothesis implies quantity and quality setting by physicians, which suggests inducement. Physicians who care for their

patients' welfare or who follow high ethical standards could limit their responses in favor of their patients as a form of altruism (Evans, 1974).

The target-income hypothesis has three major limitations. First, it is difficult to explain why a rational agent would not want to earn extra money under otherwise equal conditions. Although the incomes of other physicians can serve as a reference, it is not plausible that a physician who earns more than others would like to earn less. Second, the target-income hypothesis does not describe the physician-patient interaction and does not specify how physicians exert market power. Theories of provider behavior should consider the source of the physician's superiority and describe how physicians and patients interact. Third, the target-income hypothesis produces ambiguous predictions about physicians' reactions to changes in market conditions when they provide more than one service or when they can alter several parameters simultaneously (McGuire, 2000).

3.3 Monopolistic competition under complete information

Given the unrealistic predictions of the model of perfect competition and the limitations of the target-income hypothesis, models of physicians as profit-maximizing agents under monopolistic competition emerged to explain the anomalies observed in the market for health care. The assumptions of profit maximizing physicians and perfect and symmetric information allow the analysis of market interactions between supply and demand using standard economic models. Because preconditions for perfect competition are not fulfilled, physicians are assumed to act as local monopolies.

Physicians can exert monopoly power because they provide differentiated goods that are tailored to each patient and because switching physicians takes time or costs money. When switching physicians is associated with either lower medical benefits or higher monetary costs, patients are willing to pay a price premium or forgo medical benefits to stay with their current physician. As a consequence of this monopoly power, physicians can price discriminate across patients and extract consumer surplus. If physicians know each patient's willingness to pay, they can make "take-it-or-leave-it" offers, including a price that is above the patient's marginal willingness to pay at the prescribed quantity of care.

The physician-patient interaction under monopolistic competition can be visualized using an influence diagram (figure 1.4). The solid arrows between the elliptical information nodes for the patients health state H and the medical benefit of medical care $B(q)$ show that both parties are

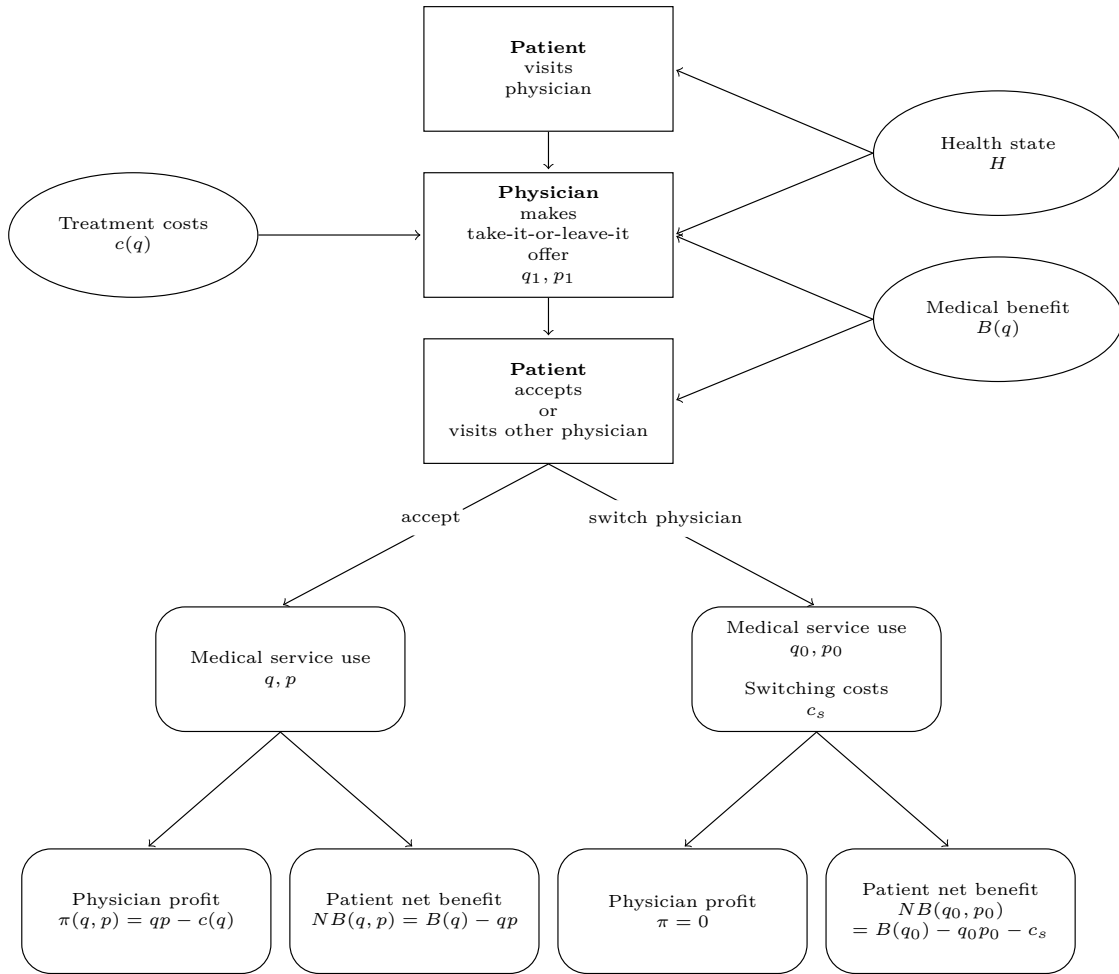


Figure 1.4: Influence diagram of a patient-physician interaction under monopolistic competition with full and symmetric information

perfectly informed. The patient visits the physician, who then makes a "take-it-or-leave-it" offer that deviates from the patient's private optimum. Although the patient knows that this offer is not in his/her best interests, the patient has to either accept it or see another physician, which is associated with switching costs c_s .

Most textbooks do not formalize the strategic interaction between physicians under monopolistic competition, merely graphically showing how patient mobility across physicians shifts the demand curve that each physician is facing (e.g., Phelps (2014, 186-189), Folland et al. (2004, 65-66), Henderson (2011, 244), Santerre and Neun (2009, 226)). McGuire (2000) extended the standard model of monopolistic competition and formalized the interaction between physicians. Let the physician's profit π be the difference between revenue pq and total costs cq from the provision of medical care and the patient's net benefit NB be the difference between medical benefit $B(q)$ ($B'(0) > 0$, $B''(q) < 0$) and the direct medical costs to the patient pq . A rational patient will compare the net benefit NB from a "take-it-or-leave-it" offer with the net benefit

from the next-best offer NB^0 and visit the physician with the best offer. $NB(q)$ can also comprise direct non-medical costs, such as travel expenses and lost production, and in the case of the next-best provider, the switching costs c_s . Because switching physicians is costly, a patient is willing to forgo medical benefits or pay a price premium to see a familiar physician (Pauly and Satterthwaite, 1981).

The physician chooses a profit maximizing (p, q) bundle under the constraint that the net benefit to the patient NB must be larger than the net benefit of the next-best offer NB^0 .

$$\max_{p,q} \pi(p, q) = (p - c)q \text{ s.t. } B(q) - pq \geq NB^0 \quad (3)$$

The first order conditions of this maximization problem are:

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial p} &= q - \lambda q = 0 \\ \frac{\partial \mathcal{L}}{\partial q} &= p - c + \lambda(B'(q) - p) = 0 \\ \frac{\partial \mathcal{L}}{\partial \lambda} &= B(q) - pq - NB^0 = 0. \end{aligned} \quad (4)$$

The first condition in equation (4) implies that the shadow price λ of increasing the patient's net benefit (consumer surplus) equals 1, which means that an increase in the net benefit goes directly into the physician's profits. Using a value of $\lambda = 1$, the second first order condition simplifies to $B'(q) = c$, which implies that the physician prescribes the efficient quantity q^* , where the patient's marginal medical benefit equals marginal costs (figure 1.5). The third first order condition suggests that the physician charges a price $p = \frac{B(q) - NB^0}{q}$ corresponding to the average excess benefit per unit of care compared to the net benefit of the next-best provider. Because each physician extracts the entire excess net benefit compared to the next-best physician, the patient experiences the same net benefit with all physicians. In figure 1.5, the net benefit is represented by the light shaded triangle minus the dark shaded triangle representing the consumer surplus lost because of the price premium.

If physicians can choose not only the price but also the quality and, thus, the marginal costs of care, the "take-it-or-leave-it" offer depends on the price and quality elasticities of demand. When patients are relatively price insensitive and quality sensitive, physicians offer excessively

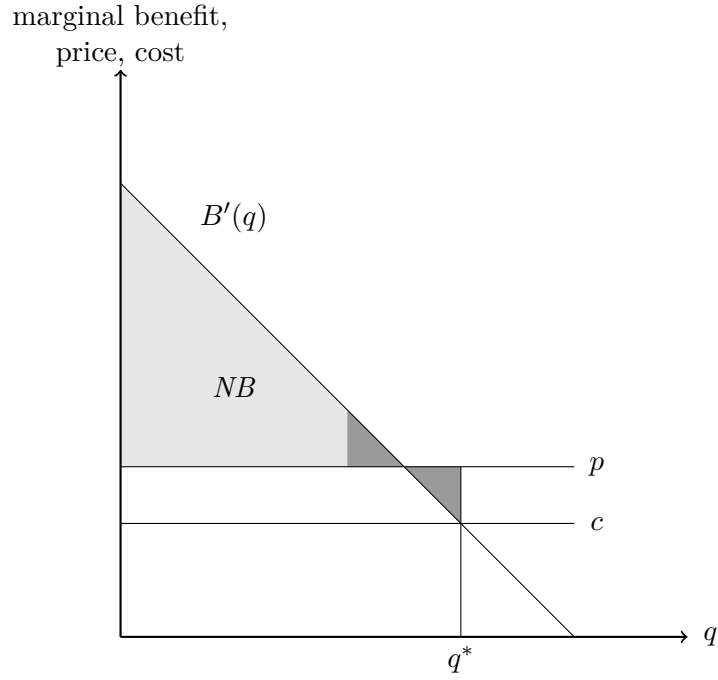


Figure 1.5: "Take-it-or-leave-it" offer by a monopolistic physician

high quality; however, when patients are price sensitive but not quality sensitive, physicians provide excessively low quality (Dranove and Satterthwaite, 1992, 2000).

3.3.1 The effects of reimbursement policies

In the presence of a third-party payer, the patient bears only a proportion $\gamma \in [0, 1)$ (the coinsurance rate) of the direct medical costs. At the same time, the third-party payer will exercise control over prices, and physicians set quantities but not prices. The maximization problem of a monopolistic physician in the presence of a third-party payer takes the following form (McGuire, 2000).

$$\max_q \pi(q) = \bar{p}q - cq \text{ s.t. } B(q) - \gamma\bar{p}q \geq \alpha NB^0 \quad (5)$$

The first order conditions of this maximization problem are:

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial q} &= \bar{p} - c + \lambda(B'(q) - \gamma\bar{p}) = 0 \\ \frac{\partial \mathcal{L}}{\partial \lambda} &= B(q) - \gamma\bar{p}q - NB^0 = 0. \end{aligned} \quad (6)$$

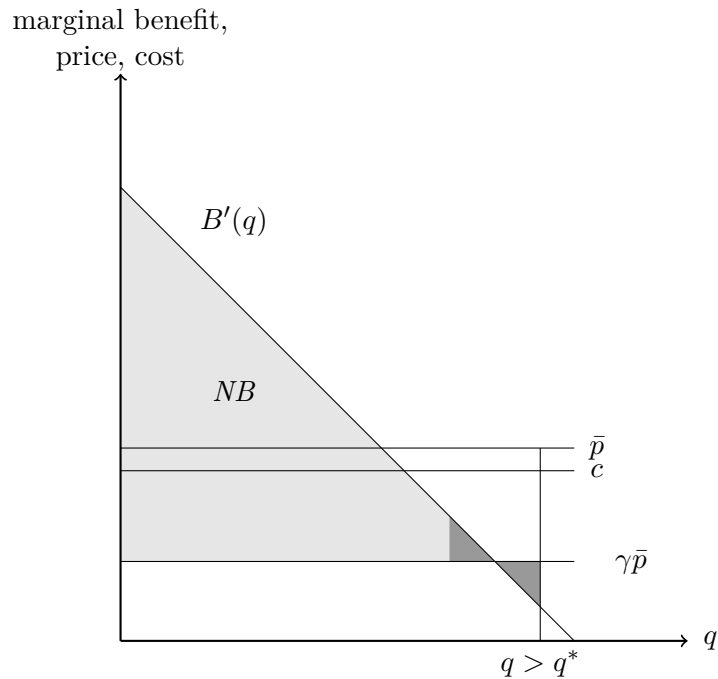


Figure 1.6: "Take-it-or-leave-it" offer by a monopolistic physician in the presence of a third-party payer and administratively set prices

The first condition in equation (6) shows that the marginal medical benefit at the prescribed quantity $B'(q) = \frac{c-(1-\lambda\gamma)p}{\lambda}$, and thus, the quantity of care depends on the coinsurance rate. The positive correlation between the coinsurance rate γ and the marginal medical benefit implies a negative correlation between the coinsurance rate and the prescribed quantity. This solution shows that the physician will prescribe more care to patients with health insurance than to patients who bear the full costs of care. If the price the patient has to pay $\gamma\bar{p}$ is smaller than marginal costs, the quantity included in the "take-it-or-leave-it" offer made to a patient with health insurance will be larger than the efficient quantity of care q^* but may be larger or smaller than the patient's private optimum (figure 1.6). The second condition in equation (6) shows how a physician is expected to react to exogenous changes in fees by the third-party payer. The prescribed quantity $q = \frac{B(q)-NB^0}{\gamma p}$ is negatively correlated with prices as long as NB^0 is independent of these prices. This solution implies that the physician will compensate for income losses from price cuts by increasing the supply of services. Ma and McGuire (2002) show that the negative relationship between the administered prices and the supply of services can also hold when all suppliers are affected by the price change. The model of monopolistic competition can therefore explain an increase in the supply of services after a decrease in prices, as observed by Rice (1983).

The introduction of a prospective payment system reduces the prescription of services to-

wards the efficient quantity of care because marginal profit per unit of care becomes negative. Each unit of care increases costs but not revenues; however, a profit-maximizing physician will still provide a positive amount of care to prevent the patient from choosing another physician. More importantly, a prospective payment system can establish incentives to make a non-contractable effort for higher quality to attract patients (Dranove and Satterthwaite, 1992, 2000).

3.3.2 The effects of competition

In a model of monopolistic competition, a change in physician density affects the physicians's treatment decisions through the net benefit the patient receives from the next-best provider NB^0 . A higher physician density could go along with shorter travel distances and lower search costs, which reduces the direct non-medical costs of visiting another physician (Rochaix, 1989). When patients can plausibly threaten to seek care elsewhere, competition is expected to limit the providers' ability to make "take it or leave it" offers and to establish appropriate incentives to satisfy the needs of patients (Allard et al., 2009; Léger and Strumpf, 2014). In general, this implies that prices decrease and that the quantity approaches the efficient quantity of care. Nevertheless, Pauly and Satterthwaite (1981) argue that a higher number of physicians makes it more difficult to choose an alternative provider and that physicians can thus charge higher prices when more competitors are in the market.

3.3.3 The effects of consumer information

Because physicians want to prevent their patients from seeing another physician, they might offer more beneficial packages to their better-informed consumers if these can switch physicians more easily. Better-informed patients might have lower switching costs because they know more alternative physicians, can assess the benefit of different offers more accurately or have fewer difficulties in establishing a relationship with a new physician (Pauly and Satterthwaite, 1981). Dranove and Satterthwaite (1992) note that the patients' ability to observe prices or quality alone can also reduce patient welfare under monopolistic competition. The reason for such a perverse effect may be that physicians excessively reduce quality when patients mainly compare prices and excessively increase prices when patients mainly observe quality. As a consequence, consumer information only improves welfare if precision in the assessments of prices and quality both improve.

3.3.4 Discussion

Models of monopolistic competition assume that physicians can act as local monopolies because they provide differentiated goods and because switching physicians is costly for patients. If physicians know their patients' willingness to pay, they can extract consumer surplus by making "take-it-or-leave-it" offers, including a price above the marginal willingness to pay. Patients are left with the decision to accept the offer or to search for a new physician.

Under monopolistic competition, health insurance increases the quantity of care, fees are negatively correlated with quantities, and prospective payment systems decrease the provision of care. Competition makes switching physicians less costly for patients and thus forces physicians to comply with their patients' needs. As a consequence, the model of monopolistic competition predicts lower prices and quantities that are closer to the patients' private optimum in areas with higher physician density. If physicians are restricted by their patients' threats to seek care elsewhere, they treat better-informed patients better because they can switch physicians more easily.

Much empirical evidence is consistent with monopolistic competition. Both the negative correlation between fees and quantities (Rice, 1983) and the observation of price discrimination (Kessel, 1958; Masson and Wu, 1974) are in line with the predictions of the model. The notion that physicians exert market power seems even more plausible considering the evidence of negative volume-cost relationships, which can reinforce natural monopolies (Physician Payment Review Commission, 1992; Escarce and Pauly, 1998). Because monopolistic physicians operate on the elastic portion of the demand curve, the model can also be used to explain findings of a negative relationship between revenues and factor input prices (Wong, 1996).

Although the model of monopolistic competition is based on less restrictive assumptions than the model of perfect competition and is in line with a large body of empirical evidence, it also has shortcomings. The physician-patient relationship is reduced to a strategic interaction concerning a "take-it-or-leave-it" offer, and the patients' role in the medical decision-making process is neglected. Further, it is unlikely that physicians know each patient's willingness to pay, which is a prerequisite for their ability to extract consumer surplus. The evidence of higher prices or higher quantities per physician in areas with higher physician density conflicts with the idea that competition leads to lower prices and less over-treatment (Fuchs, 1978; Dranove and White, 1994). In addition, the assumption that patients are perfectly informed about health and medical care and that they can observe the physician's effort has been questioned ever since

Arrow's 1963 seminal article. The unequal distribution of non-marketable information between patients and physicians will thus be addressed in the next section.

3.4 Physician agency under asymmetric information

Agency theory describes the interaction between two parties: the principal and the agent. The principal lacks the skills and the knowledge to perform a certain task and authorizes an agent to act on his/her behalf. Inefficiencies arise when the two parties have different interests, and the agent possesses more information than the principal (Ross, 1973). This information advantage can take two forms: *hidden knowledge* and *hidden action* (Arrow, 1984). *Hidden knowledge* refers to a situation in which the agent has information that the principal does not. The agent can use this information to make decisions on behalf of the principal, but the principal cannot verify whether the information has been used in his/her best interests. The *hidden action* problem occurs when the agent's costly effort to produce high quality is unobserved by the principal. In this case, the agent is expected to exert less effort than the principal would like.

The physician-patient interaction is an obvious case of an agency relationship. Patients do not know which treatments they need, nor do they have the authority and skills to conduct them. With the physician as the key decision maker, treatment decisions largely depend upon the physician's motives. Many studies provide evidence that medical treatment decisions are guided not only by the medical objectives but also by the financial motives of providers (McGuire, 2011; Ellis and McGuire, 1986; Newhouse, 1970b; Frank and Lave, 1989; Dranove and White, 1994). However, the view of the physician as a pure profit maximizer has often been questioned on the grounds that it neglects other aspects influencing the physician-patient interaction and contrasts sharply with the moral ethics of the medical profession (Mooney and Ryan, 1993; Chalkley and Malcomson, 1998; Kessel, 1958; Arrow, 1963; Feldstein, 1970). The terms "perfect agency" and "imperfect agency" have thus been introduced to describe the degree to which the patient's benefit matters to the physician. A simple strategy to model departure from the profit maximization approach is to include the patient's benefit into the physician's objective function (Ellis and McGuire, 1986, 1990; Choné and Ma, 2011).

The physician-patient interaction under asymmetric information can be displayed in an influence diagram (figure 1.7). The dashed arrow between the health information ellipse and the patient's decision to seek care indicates that the patient only has limited information about his/her health state. This information may include the symptoms for which the patient sees

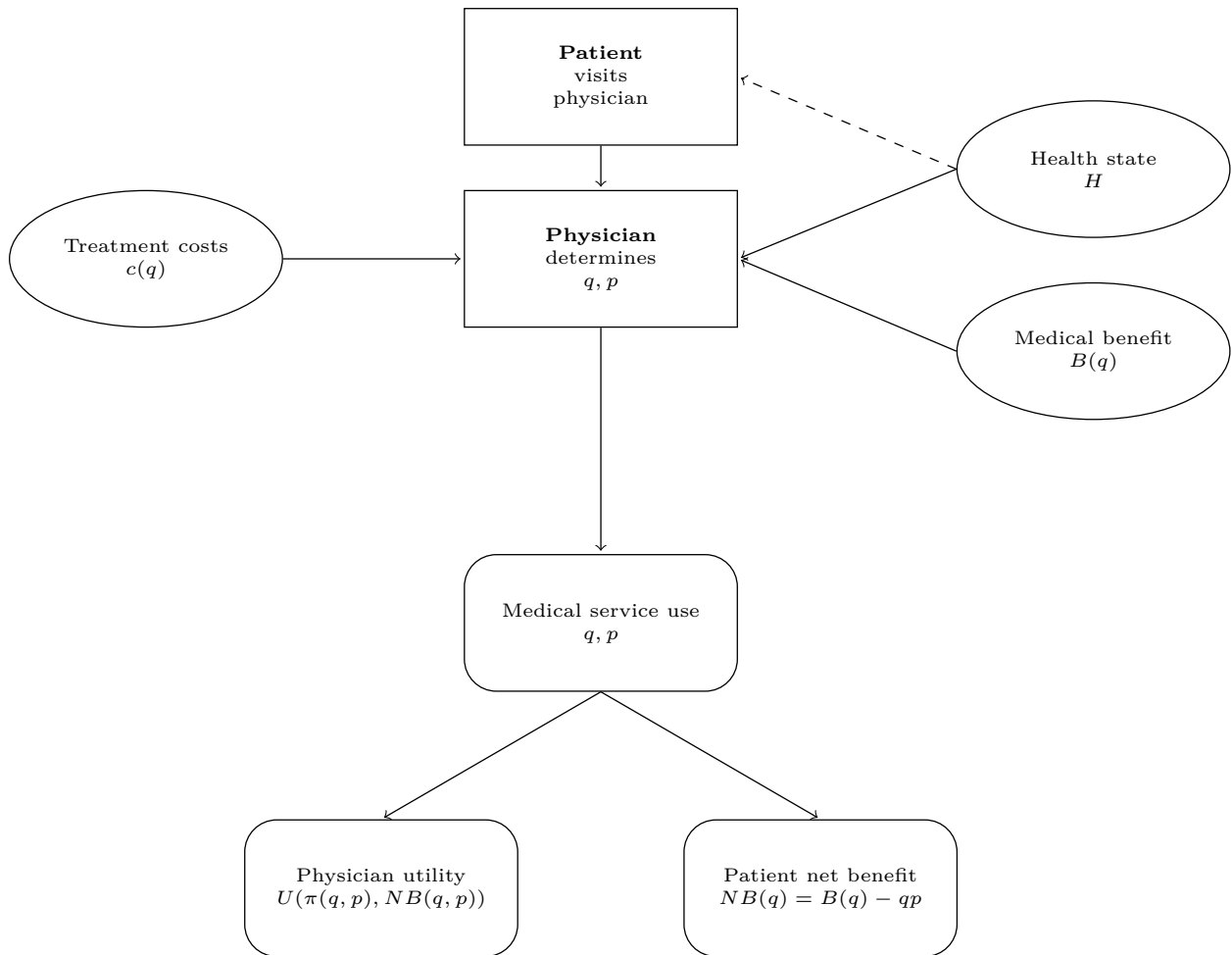


Figure 1.7: Influence diagram of a patient-physician interaction with asymmetric information and uncertainty

the physician but not the underlying health problem. The physician, however, is supposed to have full information about the patient's health state H and the benefits of medical care $B(q)$. Because the patient is poorly informed, medical care is determined by the physician with no patient involvement. The result of the prescribed medical treatment is the patient's net benefit $NB(q)$ and the physician's utility from both the financial profits $\pi(q, p)$ and the patient's net benefit from the treatment $NB(q)$.

A formal model of the provision of medical care by imperfect agents under asymmetric information can be derived from the model developed by Ellis and McGuire (1990). Let $\pi(q)$ be the physician's profits (revenue minus costs) and $NB(q)$ be the net medical benefits (medical benefits minus health care expenditures) to the patient. Physicians, who are imperfect agents of their patients, have preferences over their patients' net medical benefits and their own financial profits. The physician maximizes utility $U(q)$ by setting the quantity of care q under the constraint of non-negative profits. The marginal utilities of financial profits $\frac{\partial V}{\partial \pi}$ and net medical

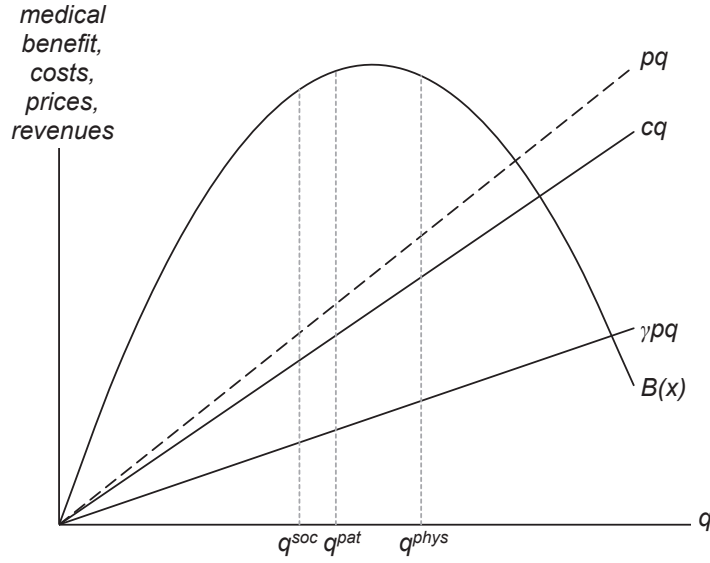


Figure 1.8: Imperfect agency under asymmetric information in a fee-for-service payment system

benefits $\frac{\partial V}{\partial NB}$ are assumed to be strictly positive but diminishing in q ($\frac{\partial^2}{\partial \pi^2} < 0$; $\frac{\partial^2}{\partial NB^2} < 0$).

$$\max U(q) = V(\pi(q), NB(q)) \text{ s.t. } \pi(q) \geq 0 \quad (7)$$

The financial profit per encounter $\pi(q)$ is the difference between the physician's revenue pq and cost cq .

$$\pi(q) = (p - c)q \quad (8)$$

The net medical benefit to the patient $NB(q)$ is defined as the difference between the medical benefits $B(q)$ and direct medical costs pq to the patient. Medical benefits are assumed to be increasing in the quantity of care ($B'(q) > 0$), but at a diminishing rate ($B''(q) < 0$). The second derivative is negative because of the diminishing marginal utility of health and the diminishing marginal returns to medical care. If over-treatment can also be medically harmful, the medical benefit $B(q)$ exhibits an inverse u-shape with a maximum defined as the medical optimum (figure 1.8). The simplest representation of such a relationship between medical benefits and medical care is a quadratic function with slope parameters a and b . In the presence of a third-party payer, the contribution of the treatment costs to the patient's net benefit $NB(q)$ depends on the coinsurance rate γ .

$$NB(q) = aq - bq^2 - \gamma pq \quad (9)$$

The socially efficient amount of care q^* is reached when the marginal medical benefits $a - 2bq$ equal the marginal costs of care c (figure 1.8).

$$q^* = \frac{a - c}{2b} \quad (10)$$

Patients would like to be treated until their net benefit is maximized, and physicians who are perfect agents of their patients ($U(q) = V(NB(q))$) will comply with this objective. If patients bear the full costs of care, their private objective function reflects a social welfare function. If the price that patients pay γp is smaller than the marginal costs of care c , the patients would like to consume more care than is socially efficient ($q^{pat} > q^*$) because they are insulated from some portion of the costs (figure 1.8).

$$q^{pat} = \frac{a - (1 - \gamma)p}{2b} > q^* \text{ if } \gamma p < c \quad (11)$$

Because physicians only operate in the market if total profits are non-negative, administratively set fees must be larger than the marginal costs to guarantee the provision of care to the population. With fees above marginal costs and strictly positive marginal utility from financial profits and medical benefits, the physician's optimality condition requires a negative marginal net patient benefit (equation (12)). A negative marginal net benefit implies that the physician provides more care than the patient would like. The incentive to over-treat patients can be illustrated by a situation wherein the physician treats the patient up to the patient's private optimum and then decides whether to increase the quantity by a marginal unit. If the patient's private optimum marginal net benefit is zero while marginal profits are still positive, the physician has an incentive to increase the quantity. According to this model, an imperfect agent provides the quantity q^{phys} , which is larger than the social optimum and the patient's private

optimum (figure 1.8).

$$\begin{aligned}
\frac{\partial U}{\partial q} &= \frac{\partial V}{\partial \pi} \frac{\partial \pi}{\partial q} + \frac{\partial V}{\partial NB} \frac{\partial NB}{\partial q} \stackrel{!}{=} 0 \\
&= \underbrace{\frac{\partial V}{\partial \pi}}_{>0} \underbrace{(p - c)}_{\geq 0} + \underbrace{\frac{\partial V}{\partial NB}}_{>0} \underbrace{(a - 2bq - \gamma p)}_{\leq 0} \stackrel{!}{=} 0
\end{aligned} \tag{12}$$

3.4.1 The effects of reimbursement policies

Health insurance increases the provision of care by an imperfect agent because the patient with health insurance wants to consume more, and a physician who acts in the patient's best interests would comply with this demand. In the absence of a third-party payer, agency models make ambiguous predictions about the provided quantity-price bundles because a completely uninformed consumer would accept any treatment and believe that the price is appropriate. Agency models are thus more suitable for describing quantity-setting behavior when fees are administratively set. However, the model's predictions about the effects of price control policies are ambiguous because a fee change affects the patient's net benefit and the physician's financial profit in the opposite direction and because it affects the physician through an income effect and a substitution effect (equation (13)). In the literature, the income and substitution effects are mostly discussed from the perspective of pure profit maximization ($U(q) = V(\pi(q))$) or a zero coinsurance rate ($\gamma = 0$). For a pure profit maximizer, or for fully insured patients, an increase in a fee causes a positive income shock, reducing the marginal utility of profit (income effect: $\frac{\partial^2 V}{\partial \pi \partial p} < 0$), but also makes earning profits from this service more productive (substitution effect: $\frac{\partial^2 \pi}{\partial q \partial p} > 0$). From the perspective of a perfect agent with self-paying patients, however, an increase in a fee causes a negative shock to the patient's net benefit, increasing marginal physician utility from net benefits (income effect: $\frac{\partial^2 V}{\partial NB \partial p} > 0$) but also reducing the patient's marginal net benefits from using medical care (substitution effect: $\frac{\partial^2 NB}{\partial q \partial p} < 0$). The reaction of an imperfect agent to changes in fees depends on the strength of the physician's preferences for financial profits and patients' net benefits, the coinsurance rate, and the strength of the income and substitution effects. Without further assumptions about the functional form of the physician's utility function, the imperfect agency model only provides ambiguous predictions

about the net effect of a fee change.

$$\begin{aligned}
\frac{\partial^2 U}{\partial q \partial p} &= \frac{\partial^2 V}{\partial \pi \partial p} \frac{\partial \pi}{\partial q} + \frac{\partial V}{\partial \pi} \frac{\partial^2 \pi}{\partial q \partial p} + \frac{\partial^2 V}{\partial NB \partial p} \frac{\partial NB}{\partial q} + \frac{\partial V}{\partial NB} \frac{\partial^2 NB}{\partial q \partial p} \\
&= \underbrace{\frac{\partial^2 V}{\partial \pi \partial p}}_{<0} \underbrace{(p-c)}_{\geq 0} + \underbrace{\frac{\partial V}{\partial \pi}}_{>0} + \underbrace{\frac{\partial^2 V}{\partial NB \partial p}}_{>0} \underbrace{(a-2bq-\gamma p)}_{\begin{smallmatrix} ? \\ \leq 0 \end{smallmatrix}} + \underbrace{\frac{\partial V}{\partial NB}}_{\leq 0} \underbrace{(-\gamma)}_{\begin{smallmatrix} ? \\ \leq 0 \end{smallmatrix}} \leq 0
\end{aligned} \tag{13}$$

A change from a fee-for-service to a prospective payment system with a per episode payment R disconnects physician revenues and patient expenditures from the provided quantity of care per episode.

$$\pi = R - cq \tag{14}$$

$$NB = aq - 2bq^2 - \gamma R \tag{15}$$

A prospective payment reform may affect the provider by decreasing the marginal revenue per unit of care (a marginal price effect) or by altering the total revenue per episode or, equivalently, the average revenue per unit of care (an average price effect). Imperfect agents react to changes in marginal revenue because they have preferences for financial profits, and they react to average revenue because they have preferences for medical benefits and use the available resources to maximize quality of care (Ellis and McGuire, 1986, 1990; McGuire, 2011). A payment reform leaving total revenue per episode of care unchanged should only produce a marginal price effect.

However, even model predictions about the effects of a cost-neutral, prospective payment reform that only changes marginal prices are ambiguous because it affects patients and physicians in opposite ways. After the introduction of a prospective payment system, the physician's marginal financial profit becomes negative, but the self-paying patient's marginal net benefit increases. The effect of prospective payment reform on the quantity of care thus depends on the strength of the physician's preferences for patients' net benefits. A physician with strong preferences for financial profits will reduce the quantity of care compared to a fee-for-service payment system. A physician with strong preferences for patient benefits will increase the quantity of care because the patients want to consume more when an extra unit of care does not increase costs.

$$\begin{aligned}
\frac{\partial U_{PPS}}{\partial q} &= \frac{\partial V}{\partial \pi} \frac{\partial \pi}{\partial q} + \frac{\partial V}{\partial NB} \frac{\partial NB}{\partial q} \\
&= \frac{\partial V}{\partial \pi}(-c) + \frac{\partial V}{\partial NB}(a - 2bq) \stackrel{?}{\leq} \frac{\partial U_{FFS}}{\partial q}
\end{aligned}
\tag{16}$$

3.4.2 The effects of competition

An agency model predicts that an increase in physician density leads to an increase in the provision of care per episode. From a provider perspective, an increase in physician density causes a negative income shock and increases the marginal utility of profit (i.e., a unit increase in profit increases utility by more when the total profit is low and the marginal utility of profit is high) while leaving the marginal products of profit and medical benefit (i.e., the increase in profit and medical benefit per unit of care) unaffected. A utility-maximizing physician will thus increase the quantity of care per episode of care in response to a loss in market share.

$$\frac{\partial^2 U}{\partial q \partial \pi} = \frac{\partial^2 V}{\partial \pi^2} (p - c) < 0
\tag{17}$$

3.4.3 The effects of consumer information

Pure agency models imply that patients make only the decision to seek care, leaving all treatment decisions to the physician. The patient's level of information thus does not affect medical decisions, only the decision to seek care.⁴ One way through which consumer information can improve welfare in a pure agency model is through the reduction of random errors by physicians who can assess their better-informed patients' net benefits more accurately because these patients can communicate their health state and preferences more effectively.

3.4.4 Discussion

The model of physicians as imperfect agents of their patients with preferences for both financial profits and their patients' net benefits assumes that all medical decisions are made solely by physicians, that is, without patient involvement. The model departs from the rather unrealistic

⁴Because the decision to seek care is an expression of demand, the effect of consumer information on health care demand will be discussed in section 4.

assumption of physicians as pure profit maximizers and accounts for asymmetric information between physicians and their patients.

The model predicts that patients are over-treated under fee-for-service reimbursement and that both health insurance and competition increase the provision of care. Agency models can thus explain the observed positive correlation between physician density and average per capita utilization in a market (Fuchs, 1978). The predicted effects of fee changes are ambiguous because fee changes affect physicians and patients in opposite ways and can have both income and substitution effects.

An important hypothesis that originates from agency models is that prospective payment reforms can affect physicians with preferences for financial profits by altering the marginal revenue per unit of care and physicians with preferences for their patients' net benefits by altering the average revenue per unit of care. An empirical test of the strength of the marginal and average price effects can yield novel insights into motives that guide medical decision making. To the best of my knowledge, only one study has examined the marginal and average price effects, which found that average revenue but not marginal revenue per inpatient day affected the length of stay in inpatient psychiatric care (Norton et al., 2002). This result suggests that the observed physicians did not have preferences for the financial profits of their hospital and acted as perfect agents of their patients. The absence of empirical evidence of a marginal price effect has important policy implications, as it means that prospective payment reforms do not necessarily provide incentives to reduce the provision of care.

Agency models do not consider the patient to play an active role in the medical decision-making process. The assumption that patients do not influence on medical decisions is not only unrealistic but also conflicts with evidence of significant effects of non-medical patient characteristics on medical service use (Schneider and Ulrich, 2008). Agency, target income and monopolistic competition models share the limitation that the physician-patient interaction during medical decision making is not reflected. Under monopolistic competition, patients are at least left with the decision to switch physicians, while agency models assume that the patients merely accept what their physicians prescribe. The inclusion of a model of joint medical decision making could make agency models much more realistic and substantially improve the understanding of the dynamics of the market for medical care.

3.5 Physician-induced demand

It is undisputed that physicians exert a strong influence on the utilization of medical care. Economic theory suggests at least three mechanisms through which physicians can control the quantities of care used by their patients. First, physicians operating in monopolistic markets can set the quantities of care because they provide differentiated goods, and switching physicians is costly for patients. Second, physicians can act as their patients' agents and make treatment decisions for them. Third, physicians can alter their patients' preferences, shifting the demand curve. All three of these mechanisms can produce "physician-induced demand" situations.

According to common definitions, quantity setting, agency relationships and demand shifting alone do not necessarily constitute physician-induced demand. The first important aspect of demand inducement is that physicians act against their "interpretation of the best interest of the patient" (McGuire, 2000) or prescribe services that "the patient would [not] have chosen if he had the same information and knowledge [as] the physician" (Pauly, 1980). If patients are ill-informed or behave irrationally, physicians can move them towards their private optimum, which would constitute not physician-induced demand but useful agency. The second important characteristic of physician-induced demand is that physicians actually influence their patients' demand and not merely ration them. Under demand inducement, patients are influenced away from their private optimum but receive what they want, while under rationing, demand remains unchanged but is not satisfied.

A realistic model of demand inducement must incorporate some costs of inducement in the physicians' utility function to consider that physicians do not induce demand infinitely. These costs could include monetary costs analogous to advertising costs under monopolistic competition (Stano, 1987), negative health effects of too much work or psychological costs because physicians care for their patients' benefits or consider it unethical to induce demand (McGuire and Pauly, 1991). Models of imperfect agency with physicians who care for their patients' welfare inherently imply a trade-off between physician profits and potential harm done to patients.

Empirically, physician-induced demand is usually identified by changes in the physicians' prescription behavior associated with changes in the returns to inducement (McGuire, 2000). Most studies investigating physician-induced demand exploit exogenous changes in fees, physician-to-population ratios or consumer information. Each of these three identification strategies has its advantages and drawbacks. Studies using fee changes have the advantage that changes in administratively set prices can be plausibly considered exogenous, affect the returns to demand

inducement directly and are unlikely to affect demand for care when patients are insulated from costs. However, changes-in-fees studies also have two major limitations. First, fee changes can affect provider behavior through income and substitution effects, which work in opposite directions. A possible solution to this problem is to analyze the effects of changes in the fees for some services on the quantities of other services for which the income and substitution effects should work in the same direction. The second limitation of changes-in-fees studies is that the fee changes must have a large effect on physician incomes. A small income loss can be compensated by a minimal change in the provision of all services and can be masked by an opposite substitution effect or a standard supply response due to altered marginal costs of production.

The main advantage of studies investigating variation in physician-to-population ratios is that changes in the number of competitors have an income effect but no substitution effect from a change in relative prices, which should facilitate empirical identification. This property, however, can also be regarded as a drawback of this strategy because changes in the physician-to-population ratios alter the marginal utility of income but neither the marginal revenues nor the marginal costs of inducement. Studies investigating variations in physician-to-population ratios thus only identify the joint effect of an income effect and demand inducement. The effect of a change in provider density could be zero either because physicians do not compensate for income losses or because they do not induce demand. The identification of the effect of competition on demand inducement imposes relatively high demands on the empirical design of a study. First, changes in provider density can also affect the demand for medical care through access to care, a so-called availability effect. Second, the number of providers in an area can be endogenous if physicians move to areas with high demand. Third, area-level shocks can affect the quantities provided by different physicians in the opposite way. A possible reason for the heterogeneous effects is that physicians who can set quantities and prices simultaneously can compensate for changes in quantities by changing prices. When different physicians would prescribe different quantities of care to a given patient, the price elasticity of demand, which determines the marginal rate of substitution between quantity and price, can vary across physicians. Competition could further exhibit heterogeneous effects on the provision of care because it increases the pressure on physicians to comply with their patients' needs, but some patients receive more care and some receive less care than the private optimum.

A very promising empirical strategy to identify physician-induced demand is to examine the effects of the patients' level of information on the provision of care. In the model of monopolistic

competition, consumer information can have a positive or negative effect on the provision of care depending on whether a poorly informed patient is over- or under-treated compared to the private optimum. Although agency models do not reflect consumer information, they are not contradictory to the hypothesis that better-informed patients have a larger say in the medical decision-making process and are less prone to demand inducement. In this case, an agency model would predict a negative effect of consumer information on the provision of care because patients are assumed to be over-treated and better informed patients can mitigate the over-provision of care more effectively. In addition, studies examining consumer information mostly rely on patient-level data, which allows for control of the patients' individual characteristics.

3.5.1 Discussion

The hypothesis that physicians induce demand is often used to explain observations of inefficient resource use and medically harmful under- and over-treatment. However, a stricter definition of physician-induced demand requires that physicians influence their patients to alter the utilization of care against the patients' best interests. Under limited competition or in an agency relationship, physicians can set quantities without influencing their patients. Physicians who act as agents of their patients can provide more care than is socially efficient if their patients wish to consume more. Such an agency relationship does not constitute demand inducement even if physicians have selfish motives for their actions. Rationing is not considered demand inducement because patients who are rationed by their physicians can switch physicians, and patients who are influenced may not notice that their treatment decisions are not optimal.

Although demand inducement is often regarded as unethical in the face of the privileged nature of the physician-patient relationship, it does not necessarily imply a welfare loss when physicians represent the interests of third-party payers and act against demand-side moral hazard. A possible incentive for physicians to induce demand in a socially efficient way is the introduction of prospective payment systems.

Empirically, physician-induced demand can be identified by changes in the provision of care after changes in the returns to inducement. Possible exogenous factors that can affect the returns to inducement are changes in fees, in provider density and in the patient's level of information. All empirical approaches suffer from certain limitations, making a definite proof of the existence of physician-induced demand difficult. The two most promising approaches are probably to investigate cross-fee elasticities for which the income and substitution effects

work in the same direction and to examine the role of consumer information in the medical decision-making process.

Because it is difficult to distinguish demand inducement from the effects of asymmetric information or quantity setting, the data requirements for studies testing for demand inducement are high. Studies using aggregate data for different geographic regions are potentially biased by physician mobility across regions, effect heterogeneity within regions and demand-side availability effects. Studies analyzing physician-level data can control for the determinants of the number of physicians in a market and for the effect heterogeneity across physicians but can still be affected by an availability effect. Studies using patient-level data can be considered more robust than analyses of aggregated data because patient-level data allow for controlling for the determinants of demand and for heterogeneity in the characteristics of the providers' patient populations.

4 The Grossman model of health care demand

According to economic theory, patients can influence the utilization of care both by their decisions to seek care and during the medical decision-making process (Hay and Leahy, 1982; Deb and Trivedi, 2002; Mullahy, 1998). An analysis of the determinants of health care utilization should thus be based not only on theoretical models of physician behavior but also on a model of health care demand. Because the demand for medical care depends on patients' willingness to pay for an improvement in health, the demand for medical care arises directly from the demand for health. Contrary to the popular belief that health is priceless and that the demand for health is infinite, the production of health entails opportunity costs, and people face trade-offs between health and other goods.

In general, most people highly value good health, particularly when they are sick. Good health increases quality of life and enables people to pursue joyful activities and earn good incomes. A special property of health is that it is not only produced by the use of medical services alone but also by living a healthy lifestyle. People are therefore not only consumers but also producers of their own health. In this view, health can be regarded as a form of a capital stock in which people can invest. Because the health stock depreciates, people must continuously engage in healthy activities to maintain their health. Individuals not only have to maintain an optimal health stock in the present but must actually optimize their health over a lifetime horizon. This dynamic optimization problem has been described in the classic article by Grossman (1972) who developed a model of the demand for health and the consequent demand for health care. In the following, I follow Breyer et al. (2004) and discuss the simplified version of the Grossman model proposed by Wagstaff (1986).

Let us consider the dynamic maximization problem of an individual with preferences for healthy hours h and consumption C who lives for an expected number of T years and discounts future utility at a rate ρ .

$$U = \int_{t=0}^T e^{-\rho t} V(h_t(H_t), C_t) dt \quad (18)$$

$$\frac{\partial V}{\partial h} > 0 \quad \frac{\partial U}{\partial C} > 0 \quad \frac{\partial h}{\partial H} > 0 \quad (19)$$

$$\frac{\partial^2 U}{\partial h^2} < 0 \quad \frac{\partial^2 U}{\partial C^2} < 0$$

The number of healthy hours h_t an individual experiences during year t is a function of the

health capital stock H_t . The individual is born with an initial health stock H_0 , and the health capital stock depreciates at an annual rate δ_t . The depreciation rate δ_t increases over time ($\frac{\partial \delta}{\partial t} > 0$), which means that health deteriorates faster at older ages. If the individual does not exert some effort, health capital decreases over time. The change in the health stock from one period to another is determined by the individual's investment I_t and the natural depreciation of the health stock $\delta_t H_t$. Every year, the individual can increase the health stock by using medical services M_t or by spending time P_t on prevention measures. These investment are assumed to be more efficient with higher individual educational status E . Both medical service use M_t and time spent on preventive measures P_t contribute to future health at a positive but diminishing rate.

$$H_{t+1} - H_t = I(M_t, P_t, E) - \delta_t H_t \quad (20)$$

$$\begin{aligned} \frac{\partial I}{\partial M} > 0 \quad \frac{\partial I}{\partial P} > 0 \quad \frac{\partial^2 I}{\partial M \partial E} > 0 \\ \frac{\partial^2 I}{\partial M^2} < 0 \quad \frac{\partial^2 I}{\partial P^2} < 0 \quad \frac{\partial^2 I}{\partial P \partial E} > 0 \end{aligned} \quad (21)$$

The prices of medical service use and consumption are p_M and p_C , respectively. Medical services and consumption are financed through labor income Y , financial capital stock A and real interest on financial capital rA . Because an individual can only work during healthy hours, labor income depends positively on the number of healthy hours that are not spent on preventive activities ($h_t - P_t$). The better educated an individual, the higher the wage rate and, thus, the return to time spent at work. The change in financial capital from one period to another is the difference between labor and capital income and the expenditures for medical services and consumption.

$$A_{t+1} - A_t = rA_t + Y(h_t - P_t, E) - p_m M_t - p_c P_t \quad (22)$$

$$\frac{\partial Y}{\partial h} = -\frac{\partial Y}{\partial P} > 0 \quad (23)$$

The choice of the optimal health stock is a dynamic optimization problem that can be solved assuming that the individual is born with a positive health and financial capital stock ($H_0 > 0$, $A_0 > 0$), that the financial capital stock at the end of life is non-negative ($A_T \geq 0$) and that the

individual dies when the health stock falls below a critical value H' . The optimality condition in equation (24) requires that the marginal return to investments in health equal the marginal costs. A formal derivation of condition (24) can be found in Breyer et al. (2004, 113-115). The variable q_t denominates the effective unit price of an investment in health, which is determined by the price of medical care p_M and the opportunity costs of time spent on prevention P_t . $\lambda_0 e^{-rt}$ denotes the marginal utility of wealth at birth ($t = 0$).

$$\left[\frac{\partial U}{\partial h_t} \frac{e^{-\rho t}}{\lambda_0 e^{-rt}} + \frac{\partial Y_t}{\partial h_t} \right] \frac{\partial h_t}{\partial H_t} = \left[r + \delta_t - \frac{q_{t+1} - q_t}{q_t} \right] q_t \quad (24)$$

The first term in the square brackets on the left hand side expresses the direct marginal utility of healthy hours as a consumption good. The second term shows the marginal utility an individual experiences from better health as an investment good increasing labor market productivity. The effects of exogenous variables on the demand for health and for medical care can be obtained by treating health either as a pure consumption good ignoring the labor market effects or by treating it as a pure investment good but not as a direct source of utility.

Pure investment model

Assuming that health only affects an individual's utility through its effect on the labor market, we can derive the pure investment model of the demand for health H_t and health care M_t from equations (24) and (20) (Breyer et al., 2004, 115-118).

$$\ln H_t = \alpha_1 + \beta_M \varepsilon \ln w_t - \beta_M \varepsilon \ln p_M - \beta_\delta \varepsilon t + \beta_E \varepsilon E \quad (25)$$

The variable ε denotes the elasticity of the marginal return of health in the labor market with respect to the health capital stock. The optimal health stock H_t is positively associated with the wage rate w_t because an increase in the wage rate increases the marginal return of healthy hours in the labor market by more than it increases the marginal costs of time spent on medical care and prevention. This condition only holds if each hour spent on using medical care or preventive activities increases the number of healthy hours by more than one. The optimal health capital stock is negatively correlated with age and the prices of medical care p_M . Better educated people are expected to be healthier because they are more efficient in producing health

by using medical care or undertaking preventive activities.

$$\ln M_t = \alpha_2 + [\beta_M(\varepsilon - 1) + 1] \ln w_t - [\beta_M(\varepsilon - 1) + 1] \ln p_M + \beta_\delta(1 - \varepsilon)t - \beta_E(1 - \varepsilon)E \quad (26)$$

The demand for medical care M_t in the pure investment model is obtained by combining equation (20) with the optimality condition (24) and substituting $\ln H$ with equation (25) (Breyer et al., 2004, 118). The demand for medical care is positively associated with the wage rate because an increase in the wage rate increases the total costs of preventive activities (time) by a higher percentage than the total costs of medical service use (time + fees). An increase in the wage rate thus leads to a substitution of prevention by medical service use. Similarly, a price increase causes a substitution of medical care by preventive activities. At higher age t the demand for health care increases because health depreciates faster and more effort is needed to maintain a certain health stock. Despite the higher demand for health by better educated people the Grossman models assumes that education decreases the demand for medical care because better educated patients use medical care more effectively and thus need less to maintain their health stock.

Pure consumption model

The demand for health in the pure consumption model is obtained by combining the consumption part of the optimality condition (24) with equation (22).

$$\ln H_t = \alpha_3 - (1 - \beta_M)\kappa \ln w_t - \beta_M\kappa \ln p_M - \beta_\delta\kappa t + \beta_E\kappa E - \kappa \ln \lambda_0 \quad (27)$$

The variable $\kappa \in [0, 1]$ denotes the elasticity of the marginal utility of health with respect to the health stock H . From a consumption perspective, the optimal health stock is negatively correlated with the wage rate w_t because the wage rate only enters the marginal costs of health production. The rationale behind the effects of the price of medical care p_M , age t and education E is the same as in the pure investment model. The price of medical care p_M affects the optimal health stock negatively because it increases the average costs of health production. The health stock decreases with age t because health depreciates faster with age. Education E makes people more productive in health and thus increases the optimal health stock. In a pure

consumption model, the marginal utility of financial capital at birth λ_0 affects the demand for health negatively because of a substitution effect between wealth and health.

The demand for medical care in the pure consumption model is obtained by substituting $\ln H$ in equation (27) by equation (20) (Breyer et al., 2004, 118-119). The demand for medical care in the pure consumption model increases with the wage rate w_t , decreases with the price of medical care p_M , increases with age t and decreases with education E . The effect of education is based on the assumption that education makes the use of medical care more effective and thus reduces the amount of care needed to achieve the optimal health stock. Individuals with a higher marginal utility of wealth λ_0 are predicted to use less medical care.

$$\ln M_t = \alpha_4 + \ln H_t + (1 - \beta_M)(1 - \kappa) \ln w_t - (1 - (1 - \kappa)\beta_M) \ln p_M + \beta_\delta(1 - \kappa)t - \beta_E(1 - \kappa)E - \kappa \ln \lambda_0 \quad (28)$$

4.1 The effect of consumer information

The effect of consumer information on the demand for health care is best described by the effect of education in the pure consumption model because health information is not expected to affect labor market productivity – only the effectiveness of medical service use. Following this argument, better-informed patients use less medical care because they use it more effectively. Better-informed patients can use medical care more effectively because they choose the right provider in the first place, can communicate their problems and preferences more accurately and adhere better to treatment regimes.

4.2 Discussion

Since its first publication, the Grossman model has been key to explaining health-related behaviors because it makes testable predictions about the determinants of the demand for health and the consequent demand for prevention and medical care. The model considers the opportunity costs of health and accounts for the long time horizon over which consumption decisions can affect health. The core assumption of the model is that health is a capital good that depreciates and needs to be maintained. This assumption leads to the hypothesis that healthier people use more care because a higher capital stock depreciates faster. The Grossman model further predicts that the demand for medical care is negatively correlated with prices and education

and positively correlated with age. The effect of the wage rate on the demand for medical care can be positive or negative depending on whether health is seen as a consumption good or an investment good. People who have strong preferences for financial wealth are predicted to use less medical care.

Despite its popularity, the Grossman model only makes unambiguous predictions under rather strict assumptions and has often been confronted with conflicting evidence. In his vibrant critique, Zweifel (2012) discusses three critical assumptions underlying the model. First, individuals are assumed to have an infinite planning horizon, which is unrealistic. Second, many scholars use the excessively restrictive Cobb-Douglas function with a fixed elasticity of substitution between medical care and preventive activities to guarantee unambiguous predictions. Third, the model implies that individuals can always restore their health regardless of their medical condition.

The Grossman model's predictions are only partly supported by the empirical evidence. While the negative effect of prices and the positive effect of age have been documented consistently, the evidence for education does not support the model. In many instances, better educated people have been found to consume more care and not less as the model suggests (Wagstaff, 1986). However, the main discrepancy between real life experiences and the predictions of the Grossman model lies in the relationship between health and demand for medical care. While the model predicts that healthier people use more care, we usually observe that people mainly use medical services when they are sick (Laporte, 2014).

The hypothesis of a positive association between health and the use of medical care questions the validity of the Grossman model, as this prediction arises from the core assumption of health as a capital good that depreciates at a constant rate. This is unfortunate because this inconsistency can be easily resolved. A model with a depreciation rate that diminishes with health would imply a negative relationship between health and health care demand while maintaining the central idea of the model.

5 Empirical literature

In this section, I review the empirical literature on the effects of changes in fees, prospective payment reforms, competition and consumer information on prices and quantities in the market for health care. The empirical results are compared with the predictions of the theoretical models presented in section 3. The emphasis is on prices and quantities because these outcomes are best described by the theoretical models reviewed above. Other outcomes, such as costs, quality or equity, are addressed only marginally. As this review covers a wide range of topics, I confine myself to those studies that had a major influence in their field or are directly related to the three articles presented in this doctoral thesis.

The literature search provided a large number of studies covering the U.S. health care system, which differs from the Swiss system in several respects. The U.S. has one of the most market-based health care systems in the world, while the Swiss health care sector is best described as a system of regulated competition. Because a substantial proportion of U.S. residents do not have health insurance, which is mandatory in Switzerland, I focus on studies including people with health insurance or Medicare and Medicaid beneficiaries. Studies including U.S. patients with health insurance can produce important policy implications for social health insurance systems because some large U.S. payer organizations, such as Medicare or Medicaid, regulate the provision of care strongly. Although U.S. studies investigating prices as outcomes do not apply to the Swiss health care system wherein most prices are administratively set, they can still provide valuable insights into the validity of different theoretical models and conclusions about physician behavior. The fact that U.S. health plans can include very different benefits while mandatory health insurance plans in Switzerland include the same benefits may seem as a drawback at first glance, but the variation on coverage can also be used to analyze the effects of health insurance on the utilization of care.

5.1 Changes in fees

In the 1960s, the U.S. Congress, under the leadership of president Johnson, created the Medicare and Medicaid payer organizations that provide health insurance for elderly and low-income residents. In the following years, Medicare and Medicaid paid for certain services used by their beneficiaries and set the prices of these services administratively. This type of price control policy opened the way for new studies examining the effects of fee changes on medical service

use. Studies investigating changes in fees can test the demand-inducement hypothesis and provide policy makers with evidence on the effectiveness of fee controls for controlling health care expenditures. Fee control studies are particularly suitable for investigating the physician's influence on the use of medical care because changes in administratively set fees can be considered exogenous and should not affect the demand side when patient contributions are low. A negative correlation between fees and quantities can occur if physicians behave like target-income seekers or local monopolies, if the income effect on an imperfect agent with strong preferences for financial profit dominates the substitution effect or if the substitution effect on a physician with strong preferences for the self-paying patient's net benefit dominates the income effect. A positive correlation between fees and quantities can occur if the substitution effect on a physician with strong preferences for financial profit dominates the income effect or if the income effect on a physician with strong preferences for the self-paying patient's net benefit dominates the substitution effect.

Negative fee-quantity correlation

A negative correlation between fees and quantities suggests that physicians compensate income losses from price cuts by increasing quantity and, thus, that fee controls are weak policy instruments for controlling health care expenditures. One of the first studies investigating changes in fees was an evaluation of a price control policy by Medicare limiting the annual growth of physician payment rates between 1971 and 1974 to 2.5% (Holahan and Scanlon, 1979). Despite the price control policy, annual Medicare payments per physician increased by 10–13% as a consequence of a pronounced increase in the provision of services. After the suspension of the price control policy, the quantity of services did not increase, but physicians raised their prices by 23%. Later studies investigating a similar policy intervention during the Medicare fee freeze in 1984–1986 showed that Medicare fee controls not only increased the number but also the complexity of services, leading to higher expenditures per beneficiary (Mitchell et al., 1989; Wedig et al., 1989). The same experience as in the U.S. occurred in Canada where the prices of medical services were capped between 1971 and 1985. Barer et al. (1988) found that the utilization of services per physician increased excessively in Quebec, where fees grew less than inflation, but increased less than average in British Columbia, where fees grew more than inflation. Total expenditures for physician services as a percent of GDP, however, fell in Quebec and rose in British Columbia, indicating that price cuts can be effective cost control measures

when the volume response is smaller than the price reductions. Rice and Labelle (1989) analyzed Canadian fee controls between 1975 and 1985 and also found a positive volume response, which led to higher expenditures for physician services even in provinces experiencing real fee reductions. The authors interpreted their results as evidence for demand inducement and against fee controls as cost containment instruments. These early studies, however, all suffered from the methodological problems of aggregate regional data. Cross-regional analyses require an extensive set of covariates to control for regional differences in health care utilization. Aggregate panel data reduces the need to control for time-invariant regional characteristics but still cannot prove that the volume responses happened at the physician level.

Later studies addressed the problems associated with regional data by using provider- or patient-level data. Yip (1998) evaluated the effect of Medicare fee cuts under the Omnibus Budget Reconciliation Act of 1987 on the volume of coronary artery bypass grafting (CABG) interventions performed by thoracic surgeons in the states of New York and Washington. Using a panel of physicians covering the years 1987 and 1989, they found that the fee cuts led to an increased number of CABG procedures per physician. This effect was particularly strong for more intensive CABG procedures and was also observable for non-Medicare patients where no price change occurred. This effect on non-Medicare patients suggests that physicians compensated income losses by increasing the number of interventions. Nguyen and Derrick (1997) used the nationwide Medicare Annual Provider Files from the years 1989 and 1990 to assess physicians' responses to fee reductions in the course of the Omnibus Budget Reconciliation Act of 1989. They found that for every fee reduction of one dollar, physicians compensate for approximately 40 cents of their income loss by increasing volume. This estimate suggests that fee controls can be used to control health care expenditures despite income compensation by physicians. However, the effect varied across specialties and depended on the size of the fee reductions. A recent study by Jacobson et al. (2013) investigated the impact of a change of Medicare fees in 2005 that led to a decrease in the profit margins for overpaid chemotherapy treatments. The analysis of individual Medicare claims of beneficiaries diagnosed with lung cancer between 2003 and 2005 showed that both the probability of receiving chemotherapy and the number of chemotherapy cycles increased significantly. Physicians also substituted drugs with the largest decrease in profit margin with more expensive drugs favored by the reform. Although this response offset some of the expected cost savings, it also improved the survival prospects of cancer patients. A limitation of the study was that it relied on a before-after comparison, as the fee changes were

established for the entire U.S. simultaneously. The results could therefore be biased by other simultaneous shocks in the market for chemotherapy.

A second strategy to identify the causal effects of fee changes is to exploit the consolidation of geographic regions within which the same physician fees apply. Rice (1983) analyzed a change from area-specific Medicaid tariffs to uniform rates in the state of Colorado in 1977. He found that physicians in areas experiencing a relative price decrease increased the provision of services per physician and per Medicaid beneficiary, charged more value units per encounter and ordered more laboratory tests. The results were regarded as evidence of demand inducement by physicians and motivated a large body of theoretical and empirical literature investigating physicians' motives for the provision of care. Christensen (1992) reanalyzed the Colorado data used by Rice (1983) to obtain an estimate of the cost impact of the fee changes. They used a two-stage approach to correct for the endogenous changes in the proportion of claims that physicians assigned to Medicare instead of other payers. The correlation between Medicare rates and the quantities per physician was also significantly negative but closer to zero than the estimates reported by Rice (1983). The results implied that the volume response would compensate for approximately half of the cost impact of the fee changes, which is comparable to the effect size estimated by Nguyen and Derrick (1997). At first glance, this result indicates that price cuts can lead to cost savings, but a subgroup analysis showed that an equalization of tariff rates across regions is not likely to be cost saving because the losers increase their volume by more than the gainers reduce theirs.

Positive fee-quantity correlation

Although earlier studies tend to find a negative fee-quantity correlation, there is also a substantial body of evidence showing a positive correlation. A positive fee-quantity relationship can be regarded as evidence of a substitution effect among physicians with strong preferences for financial profits and suggests that fee controls are an effective measure to control the provision of care and reduce health care expenditures.

An early descriptive analysis of Medicare claims from 1986 to 1989 showed that the positive time trend in the utilization of overpriced procedures slowed after the implementation of the 1987 Omnibus Budget Reconciliation Act (Escarce, 1993). However, the descriptive nature of the study limits the conclusions that can be drawn from these results. In a more recent study, Decker (2007) showed that more generous Medicaid fees lead to an increase in the Medicaid

participation of physicians, improving access to care for underprivileged patient groups (Decker, 2007). She also found that physicians are more likely to accept Medicaid patients and spend more time with them when Medicaid fees increased. A reduction in Medicaid fees thus entails the danger of under-treatment of Medicaid patients in private outpatient practices and a shift towards emergency hospital visits and outpatient hospital care. Gruber et al. (1999) studied the effect of fee differentials between Medicaid and privately insured patients on cesarean delivery rates. Their analysis of a random sample of Medicaid hospital discharges in eleven states between 1988 and 1992 showed that an increase in the fee differential of USD 100 led to a increase in the probability of a cesarean delivery of 0.7 percentage points. However, the results presented by Gruber et al. (1999) should be interpreted with caution, as their econometric model neglected the general time trend in cesarean delivery rates. Grant (2009) tried to correct this omission by introducing state-specific time trends in cesarean delivery rates and found that Gruber et al. (1999) overestimated the effect of Medicaid fees by a factor of four. They also showed that the original results were sensitive to sample selection and variable definitions. A recent study by Clemens and Gottlieb (2014) exploited the consolidation of Medicare payment regions in 1997 in a similar fashion as the classic study by Rice (1983). The analysis of aggregate data per payment area showed that, on average, a 2% increase in payment rates led to a 3% increase in the provision of relative value units in a payment area. This effect was largest among elective procedures and procedures using new technologies. The authors interpreted their results as evidence that fee controls can be used effectively to control health care expenditures, to guarantee access to care and to promote cost-effective health technologies. Despite the elaborate econometric specification of the study and the plausible exogeneity of the price shocks, the study shares the limitation of earlier studies using aggregate data in that it is unclear whether the estimated changes really happened at the physician level.

A promising approach to test whether a substitution effect is at work is to estimate the cross-price elasticities across different services or payers while holding income constant (McGuire and Pauly, 1991). A study by Mitchell et al. (2002) tested the effect of the fee reductions for cataract extraction surgery on the provision of non-cataract services over the course of the Medicare Fee Schedule between 1992 and 1994. The study controlled for physicians' incomes and showed that, holding income constant, a 10% decrease in the fee for cataract extraction surgery led to a 5% increase in the provision of non-cataract services. Together with the relatively small coefficient of the physicians' incomes, this result suggests that substitution effects were more relevant than

income effects and that the included ophthalmologists behaved more like profit maximizers than like target-income seekers. A strength of this study is the use of physician-level panel data, which solves the problem of unobservable time-invariant physician characteristics and allows for controlling for a general time trend.

Inconclusive fee-quantity correlation

Considering that the substitution and income effects of a fee change work in opposite directions, it is unsurprising that there are also studies finding no significant correlation. Hurley and Labelle (1995) estimated the effect of changes in administratively set fees on the aggregate utilization of 28 procedures in Ontario over the 1975–1987 period. They used three measures of fees: the absolute dollar value, a relative fee comparing the fee of a procedure to a weighted average fee for the specialty providing the procedure, and a real fee deflated by the Toronto Consumer Price Index. The absolute and real fees were only weakly correlated with the utilization of the 28 services. Relative fees, however, were positively correlated with the utilization of three procedures (cataract, tonsillectomy and hysterectomy), negatively correlated with the utilization of another seven procedures and uncorrelated with the remaining 18 procedures. However, the interpretation of these results is difficult, as it is unclear to what extent the relative fee measure was adjusted for changes in the physicians' incomes. Tai-Seale et al. (1998) evaluated the effects of the Omnibus Budget Reconciliation Acts of 1989 and 1990 to test the predictions of the McGuire and Pauly (1991) model of physicians' response to fee changes in the presence of multiple payers. The analysis of hospital-level data showed that for most services there was no significant effect of Medicare or non-Medicare fees on the utilization of care. Among the eight own- and cross-price elasticities that were significant, seven were negative, indicating compensating volume responses by physicians. However, the authors concluded that their evidence did not unambiguously confirm the predictions of their theoretical model and that physicians reacted to the fee changes in complex ways. Keeler and Fok (1996) evaluated a payment reform by the California Blue Cross, which equalized the tariff rates of cesarean and vaginal deliveries. On the basis of discharge data, they found a small and non-significant decrease in cesarean delivery rates after the payment reform. The authors conclude that reducing fees can help to reduce health care expenditures in this treatment area. Although they adjusted for the case-mix in the observed hospitals, the before-after identification strategy is vulnerable to other unobservable factors affecting cesarean delivery rates. Grytten et al. (2008) analyzed insurance claims filed by

Norwegian fee-for-service physicians to estimate the effects of income changes associated with changes in administratively set fees. The estimation provided no evidence that changes in incomes due to fee changes affected the number of consultations or the number of laboratory tests per physician. This result even persisted among physicians who experienced the largest income shocks.

5.1.1 Discussion

Changes in fees can affect the provision of care by changing the marginal utility of income (income effect) and the marginal return to the provision of care (substitution effect). For a service that is affected by a fee change, the income and substitution effects move in opposite directions, and theoretical models of provider behavior can predict positive or negative correlations between fees and the provision of care. The correlation between fees for some services and the provision of other services is expected to be positive when physicians have preferences for financial profits because the income and substitution effects on the unaffected services move in the same direction.

The empirical literature provides evidence of both positive and negative correlations between fees and quantities. Both positive and negative correlations can be regarded as evidence of demand inducement by physicians because fee changes can be considered exogenous, directly affect the marginal return to inducement and only affect the supply side when patients have health insurance.

Evidence of a negative correlation between fees and quantities suggests that physicians compensate income losses and has important policy implications: Fee controls are weak policy measures for controlling health care expenditures and can even lead to higher health care expenditures depending on the price elasticity of the utilization of medical care. If the elasticity is smaller than one, as suggested by most studies, policy makers can control health care expenditures by altering fees, but they need to take the volume response into account to achieve the intended effects.

Interestingly, most studies investigating Medicaid beneficiaries find a positive fee-quantity correlation. A possible explanation for these findings could be that only few patients are Medicaid insured and thus the effect on the physician's marginal utility of income may be small compared to the change in the marginal return to the provision of care.

The results in the empirical literature need to be interpreted with caution because many studies suffer from methodological limitations. Studies relying on cross-sectional designs or

on before-after comparisons tend to overestimate physicians' responses to fee control policies because they fail to control for simultaneous exogenous shocks and general time trends. Studies using aggregate regional utilization data have the limitation that it is difficult to show that the observed aggregate effects are the consequence of altered provider behaviors. The most robust approach is to use provider- or patient-level panel data and exploit policy changes that do not affect all individuals at the same time as natural experiments.

5.2 Prospective payment reforms

The notion that physicians tend to waste resources and harm their patients when their revenues depend on the provision of care has motivated the implementation of prospective payment systems in many treatment areas. Prospective payment systems disconnect the payment for an episode of care from the quantity of care provided within that episode and thus create a trade-off between medical benefits and financial profits. Models of monopolistic competition and imperfect agency under asymmetric information predict that a change from retrospective to prospective payment reduces the utilization of care per episode because each unit of care increases costs but not revenues. However, prospective payment reforms can increase the number of cases because the reduction in the quantity of care per case frees up capacity to treat more cases. Freed capacity can increase the number of cases because demand was rationed before the payment reform or because physicians induce more demand to use the freed capacity. In the following, I present a brief summary of the evidence on the effects of prospective payment reforms in inpatient and outpatient care.

5.2.1 Inpatient care

A large body of evidence on inpatient care stems from the U.S. where DRG-based prospective payment systems were implemented much earlier than in Europe. The U.S. experience consistently points towards a negative effect of prospective payment on length of stay. Examples of such studies are the evaluations of the 1976 Maryland prospective payment system (Rupp et al., 1985), the 1983 federal Medicare prospective payment reform (DesHarnais et al., 1987; Fitzgerald et al., 1988; Taube et al., 1988; Freiman et al., 1989; Frank and Lave, 1989; Ellis and McGuire, 1996), the 1989 Massachusetts prospective payment system (Cutler, 1990), the capping of the number of reimbursable days in rehabilitation hospitals by Medicare between 1986 and 1993 (Chan et al., 1997) and the 2002 inpatient rehabilitation facility prospective

payment system (Sood et al., 2011). Often-cited studies showing a negative effect on length of stay outside the U.S. stem from Israel (Shmueli et al., 2002), England (Farrar et al., 2009, 2007), Austria (Theurl and Winner, 2007) and Japan (Besstremyannaya and Shapiro, 2012). As expected, a change from per diem to per case reimbursement often increased the number of admissions (Farrar et al., 2007, 2009; Sood et al., 2011; Shmueli et al., 2002; Shigeoka and Fushimi, 2014) and led to shifts from inpatient hospital care to nursing homes (Fitzgerald et al., 1988; Qian et al., 2011) and day clinics (Farrar et al., 2007, 2009).

5.2.2 Outpatient care

Studies covering the outpatient sector are less numerous but mirror the result for inpatient care. Yan et al. (2009) provided a review of studies comparing capitation and salaries to fee-for-service systems in outpatient care. Physicians working for a salary or under a capitation system provide fewer services to their patients (Dumont et al., 2008; Hennig-Schmidt et al., 2011; Ferrall et al., 1998) and see their patients less often (Krasnik et al., 1990; Devlin and Sarma, 2008; Dijk et al., 2013; Coleman et al., 1999) than fee-for-service physicians. Notable exceptions are the studies by Hickson et al. (1987), Davidson et al. (1992) and Madden et al. (2005), which did not find a difference in the number of consultations between fee-for-service and capitation or salaried compensation. Dumont et al. (2008) found that physicians who opted for a mixed reimbursement scheme combining a fee-for-service and a per diem component spent even more time per service, which the authors interpret as evidence of a quantity-quality substitution under prospective payment in outpatient care.

5.2.3 Discussion

The empirical evidence confirms the hypothesis that prospective payment systems decrease the utilization of care, especially in the inpatient sector. This result suggests that prospective payment systems are effective measures against socially wasteful and medically harmful over-treatment. However, prospective payment can also increase costs when physicians increase the length of stay or improve the quality of care to attract profitable patients (Dranove and White, 1994). Hospitals can also increase their revenues by upcoding the severity of their cases in DRG-based prospective payment systems. Carter et al. (1991) reported that the disagreement of reviewers with hospital coding increased from basically zero to 33% after the introduction of a Medicare DRG system. Shigeoka and Fushimi (2014) found that birth weight was manipulated

more often after the implementation of the Japanese partial prospective payment system.

Fears of detrimental effects of prospective payment systems on the quality of care have been raised repeatedly. However, the empirical results on the effects of prospective payment on the quality of care are mixed. Shmueli et al. (2002) and Qian et al. (2011) reported elevated in-hospital mortality after prospective payment reforms, while Fitzgerald et al. (1988), DesHarnais et al. (1987), Gaumer et al. (1989) and Rogers et al. (1990) did not find any detrimental effect on mortality.

An important question that arises from the empirical results presented above is whether inpatient prospective payment reforms affect length of stay through changes in marginal or average revenue per inpatient day. Findings of a positive correlation between the size of the per case payment and the average length of stay confirm the presence of an average price effect and suggest that physicians have preferences for their patients' medical benefits (Dafny, 2003b; Gilman, 2000; Cutler, 1990; Friesner and Rosenman, 2002). Norton et al. (2002) examined the differences in marginal and average prices per inpatient day across hospitals and estimated that no marginal price effect but only an average price effect was at work. This result implies that physicians act as perfect agents of their patients and do not take hospital profits into account when they make medical treatment decisions. The absence of a marginal price effect suggests that prospective payment systems should not be used in inpatient care because they do not necessarily provide incentives to reduce length of stay and deviate more from the actual costs per case than revenues from a per diem system. Because the study by Norton et al. (2002) questions the benefit of prospective payment systems, more research about the presence and strength of marginal and average price effects needs to be conducted.

5.3 Provider competition

Empirical analyses of physicians' responses to changes in the competitiveness of their market have often served as tests of the demand-inducement hypothesis because more intense competition causes a negative income shock but leaves relative prices unchanged. In the neoclassical model, an increase in the number of providers in a market decreases prices and increases quantity of care. In a model of monopolistic competition, higher provider density makes it easier for patients to switch providers, and physicians need to comply better with their patients' needs. While this should lead to a decrease in prices, the predicted effects on the quantity of care are ambiguous because the "take-it-or-leave-it" offer can include more or less care than the patient's

private optimum. Agency models predict that physicians provide more care to their patients when they experience a negative income shock from more intensive competition.

5.3.1 Physician-to-population ratios

In the physician market, the level of competition is typically measured by the physician-to-population ratio in a market area.

Prices

Most studies investigating the effects of changes in physician density on prices stem from the U.S. from the period before Medicare and Medicaid and administratively set prices. At that time, physicians could react to negative income shocks not only by expanding the provision of care but also by increasing prices. One of the earliest studies by Steinwald and Sloan (1974) reported a positive correlation between physician density and fees for internists and obstetricians. In his classic article, Fuchs (1978) used an instrumental variable approach to control for physicians' mobility across regions and also found a positive effect of surgeon density on fees. Cromwell and Mitchell (1986) confirmed the results by Fuchs (1978) using a household survey covering the 1969–1976 period. While Fuchs (1978) saw his results as evidence of demand inducement, Pauly and Satterthwaite (1981) suggested that a positive relationship between the number of physicians and prices could also be a sign of increasing switching costs, as finding a better provider becomes more complicated and physicians can charge higher prices without losing patients to the next-best provider.

Not all studies investigating prices, however, support the hypothesis that an increase in provider density leads to higher prices. Despite the positive correlation observed among internists and obstetricians, Steinwald and Sloan (1974) estimated a negative effect of provider density on the prices of services provided by general practitioners. Wilensky and Rossiter (1983) estimated a positive but non-significant effect of physician-to-population ratios on fees, and a Norwegian study by Grytten and Sørensen (2000) even reported a small negative effect of the total number of dentist labor years on dental fees in a market area. This result was unlikely to be affected by the very low mobility of dentists across markets.

Quantities

A large body of literature investigates the association between the physician-to-population ratio and quantities. The majority of these studies reports a positive correlation, which many

authors interpret as indirect evidence of demand inducement by physicians.

Early studies

Empirical studies using physician-to-population ratios as an explanatory variable face the challenge that the supply of physicians is endogenous when physicians move to areas with higher demand. The most common approach to account for an endogenous supply is a two-stage instrumental variable approach. Fuchs (1978) estimated such a two-stage least squares model and found that a 10 percent increase in the surgeon-to-population ratio in a geographical area increased the per capita surgery rate by 3 percent. However, this result needs to be interpreted with caution, as the sample only included 22 geographical areas, and the results could be affected by an availability effect. Wilensky and Rossiter (1983) tried to attribute the observed correlation directly to physician behavior by analyzing physician-initiated consultations recorded in a physician survey. They found that physician density was positively related to the probability of a physician-initiated office visit and to the number and costs of these visits. No significant effects were found for the likelihood of surgery or total physician-initiated expenditures, including laboratory tests. The authors interpreted their results as evidence of physician-induced demand for outpatient visits but not for surgery. Cromwell and Mitchell (1986) refined the analysis by Fuchs (1978) and used the 1969–1976 Health Interview Survey, which allowed the analysis of 360 geographical areas instead of only 22. Although they also found positive elasticities of surgery rates with respect to the surgeon-to-population ratio, the values were only one-third of those found by Fuchs (1978). Carlsen and Grytten (1998) estimated the association between the physician-to-population ratios in Norwegian municipalities and the number of outpatient visits per physician. The estimated elasticity of the number of outpatient visits per physician with respect to the physician-to-population ratio was positive and close to one. Although an elasticity of one implies that the physicians' incomes were unaffected by variation in the provider density, the authors did not interpret this result as evidence of income compensation because in their theoretical model, an elasticity of one is in line with an availability effect. An availability effect, however, would require that the increase in the number of consultations per physician stem from an increase in the number of patients and not from the number of consultations per patient. This hypothesis was tested by Sørensen and Grytten (1999), who found that the number of consultations but not the number or costs of services per consultation was positively correlated with provider density. The authors interpreted this result as evidence against demand inducement. To disentangle the income and availability effects Grytten et al. (2001) examined the

interaction between the physicians' non-practice income and local physician density. Because non-practice income may also be reversely determined by the physicians provision of services, it was instrumented by the physician's age, number of children and a variable indicating whether the physician's spouse worked in a medical profession. In municipalities with high physician densities, non-practice income affected neither the number of consultations per physician nor the practice revenue. In municipalities with low physician density, however, non-practice income was negatively associated with the provision of services but not with the practice revenue. The results mean that income can affect the provision of care and suggest that physicians can induce more demand in municipalities with a lower physician density. One reason for this interaction could be that patients in areas with fewer physicians face higher search and switching costs or because the physicians find it less unethical to induce demand when the patients are not already being over-treated.

Critique of the two-stage approach

Many of the above-mentioned studies used a two-stage least squares instrumental variable approach to correct for the endogeneity of physician density. Dranove and White (1994) tested the validity of this method by estimating the relationship between the predicted obstetrician-to-population ratio and childbirths, an outcome that can hardly be influenced by physicians. They estimated a significant, positive correlation and concluded that earlier studies using the instrumental variable approach did not provide evidence of demand inducement; they recommended continuing to use the instrumental variable approach but using other instrumental variables to identify the first-stage regression.

Alternative identification strategies

After this fundamental critique of the instrumental variables approach, several studies adopted new identification strategies. Gruber and Owings (1996) used within-state variation in fertility rates over time as measures of exogenous income shocks to obstetricians. The result that a birth was more likely to be delivered by cesarean section in states experiencing larger declines in fertility rates suggests that obstetricians compensated income losses by inducing demand for more generously reimbursed cesarean sections. Although the effects were relatively small, this study provides rather robust evidence for income compensation because it identified exogenous income shocks, used longer observation periods than earlier studies and controlled for the characteristics of patients, hospitals and states. Another interesting approach to circumvent the problems

associated with the instrumental variable approach was adopted by Iversen and Lurås (2000) and Iversen (2004), who compared the number of patients per physician with the physician's preferred number of patients. The endogeneity of the actual number of patients was addressed by a two-step approach and propensity score matching. Physicians who thought they did not have enough patients provided more and longer visits, ordered more lab tests and earned higher incomes from fees per patient than their non-rationed colleagues. A French study by Delattre and Dormont (2003) used a fixed effects panel data model to identify the causal effects of the provider density on the provision of care. The analysis of a French panel of 4,500 physicians over the 1973–1993 period showed that physicians who experience an increase in the physician-to-population ratio in their market partly compensate for their income loss by increasing the number of consultations per patient and by providing more services per encounter. The authors regarded these results as strong evidence of physician-induced demand in the French outpatient sector. Chalkley and Tilley (2005) also employed a fixed effects model to estimate the effect of the dentist-to-population ratio on dentists' fee income per consultation. Using data from the English Management Information and Dental Accounting System (MIDAS) over a period of 10 years, they found that an increase in the number of physicians in a market positively affected the number of services per dental consultation. Based on the idea that competition increases physicians' incentives to comply with their patients' needs, the authors concluded that dentists under-provided care in less competitive markets. Andersen and Serritzlew (2007) examined the effect of physicians' patient list size on the annual number of services per patient in the Danish county of Aarhus and found that physicians with fewer patients provided more services per patient and year. This volume response was stronger for cognitive therapy than for ordinary consultations, which the authors explained by the stronger professional norms associated with ordinary consultations. Unfortunately, the authors do not control for the physicians' income and thus cannot distinguish rationing from income compensation. Rationing could happen when the physician faces more demand than he/she can satisfy and a reduction in the number of patients merely allows adequate treatment. In addition, the possible endogeneity of the physicians' patient list size is not addressed at all, and the number of services per patient could also be the consequence of an availability effect.

Inconclusive supply - quantity correlation

While evidence from the U.S., France, England and Denmark supports the notion that the provider density positively affects the provision of care, a Norwegian group of researchers

regularly reported evidence against income compensation by physicians. Grytten and Sørensen (2000) found that the number of man-labor years of private dentists per 10,000 inhabitants in a geographic area was negatively correlated with the number of consultations per dentist. A 1% increase in the dentist capacity led to a decrease in the number of consultations by 0.15%. Grytten and Sørensen (2001) compared the effects of provider density between salaried and fee-for-service physicians. The comparison of the two types of physicians eliminates the effects of unobserved regional shocks affecting all physicians equally. In addition, the authors not only used population and income per municipality as instruments for the provider density but also controlled for physicians' self selection into the two types of remuneration in a first-stage regression. Neither salaried nor fee-for-service physicians ordered more laboratory tests, extended the duration of consultations or earned higher revenues in municipalities with more physicians per capita. Another study by Grytten and Sørensen (2007) exploited the introduction of the the Norwegian registered patient list system stipulating that all citizens had to choose a general practitioner as their primary physician. The outcome of interest was the number of consultations per physician, which should be unit elastic with respect to the patient list if no rationing or income compensation was at work. Using a two-stage approach to account for endogeneity of the list size, the authors found neither rationing by physicians with large patient lists nor income compensation by physicians with short patient lists. One possible explanation for this result is that physicians with small patient lists treated more patients who were not on their list than physicians with large patient lists (Grytten and Sørensen, 2008). These results provide rather robust evidence against the demand-inducement hypothesis in the Norwegian outpatient sector.

One of the few studies finding no income compensation in an English-speaking country was conducted by Davis et al. (2000), who analyzed data on 9,746 general practice encounters in the New Zealand region of Waikato. The physician-to-population ratios in different market areas could not explain any differences in the rates of prescriptions, laboratory tests and follow up visits across physicians. Unfortunately, the endogeneity of physician density was not addressed empirically.

5.3.2 Hospital competition

The effects of competition on the prices and quantities of medical care provided in the hospital market are particularly important because inpatient care accounts for a large proportion of health

care expenditures in industrialized countries. In the hospital market, the level of competitiveness is typically captured by measures of market concentration indicating how equally the market shares are distributed across firms. Unequal market shares imply unequal market power and limited competition.

The literature on the consequences of limited competition in the hospital market focuses on the effects on prices and costs. Prices are important because they are negotiated bilaterally between payer organizations and hospitals, and the hospitals' market power also determines their negotiation power. Costs are important because they can be seen as indicators of the efficiency gains from competition.

Prices

Many studies confirm the standard economic paradigm that a higher number of competitors leads to lower hospital prices. Two early examples are the studies by Staten et al. (1988) and Melnick et al. (1992) investigating the prices negotiated by the private Blue Cross insurance group. Both studies found that Blue Cross received larger discounts in areas with more hospitals. However, Melnick et al. (1992) showed that the definition of the market area and the measurement of market concentration affected their results. The generalizability of the results was also limited because this buyer organization had considerable market power and used health maintenance organizations to control costs. Gruber (1992) constructed a hospital panel dataset and measured the market concentration using a patient origin Herfindahl index defining the market area by the place of residence of the patients treated in each hospital. He found that, over the 1984–1988 period, prices decreased more in less concentrated markets. Dranove et al. (1993) confirmed the results by Gruber (1992) using a larger panel dataset. However, the studies by Gruber (1992) and Dranove et al. (1993) might underestimate the effects of competition on prices because they did not control for the market penetration of health maintenance organizations (Dranove and White, 1994).

Another problem of the studies investigating the price effects of hospital competition is that they considered the prices of a wide array of services for which hospitals compete not only with other hospitals but also with private practice physicians. Brooks et al. (1997) circumvent this problem by focusing on appendectomy, which is always provided in inpatient care and is a well-defined procedure with little clinical variation. Combining individual Medicare claims data with hospital-level data, the authors conduct a nationwide analysis and control for a number

of hospital characteristics, such as the number of patients in health maintenance organizations and the hospitals' case-mix. The regression analysis showed that over the 1988–1992 period, competition in the market for appendectomies decreased the prices for this procedure significantly. Although a procedure-specific competitiveness measure was a novelty in the literature, it was only calculated on the county level, which may not reflect markets properly. Krishnan (2001) investigated the price effect of hospital mergers and acquisitions in the states of Ohio and California in the 1990s. The advantage of this approach is that it should not be affected by omitted demand-side factors. Because hospitals can merge with facilities from other market areas, the author controlled for the hospital-specific Herfindahl index and the change in the merging hospitals' local market shares. The regression analysis showed that hospital mergers and acquisitions increased the prices per DRG charged for non-governmental patients (i.e., commercial insurance and self-pay) and that these prices were lower in less concentrated markets. Melnick and Keeler (2007) identified the effect of hospitals' bargaining power by their membership in a multi-hospital network. Belonging to a hospital network increased the prices charged by a hospital, particularly if the network was large. It did not depend, however, on the location of the other members of the network, which points to the importance of bargaining power vis-à-vis large cross-regional buyer organizations.

Two important studies examined time trends in the association between market concentration and prices. Keeler et al. (1999) created a panel dataset of California hospitals over the 1989–1994 period and found that the correlation between market concentration and prices was positive and became stronger over time. Operating in a concentrated market also increased prices for not-for-profit hospitals, which led the authors to the conclusion that even mergers of not-for-profit hospitals can have undesired welfare effects. Dranove et al. (2008) addressed the possible endogeneity of market concentration following an instrumental variable approach and controlling for hospital fixed effects using patient-level discharge data from California. According to their results, the positive effect of hospital competition on prices became stronger between 1990 and 2001 and weakened in the subsequent years. This trend went along with the diffusion of managed care in the early 1990s and a relaxation of the constraints on consumer choice due to new legislation in the mid-1990s.

Despite the multitude of studies showing a negative price effect of hospital competition, many scholars question the validity of the tested theoretical models in the hospital industry. Connor et al. (1998) argued that even under limited competition, hospitals need to pass on

cost savings to payers when they compete on prices. Indeed, their analysis of a nationwide hospital panel dataset over the 1986–1994 period showed that hospital mergers led to lower market prices independent of market concentration, which conflicts with the findings of Keeler et al. (1999). Dranove and White (1994) cite three studies not finding an association between hospital competition and prices (Davis, 1971; Noether, 1988; Chirikos, 1989), and a recent study using patient-level data showed that not only hospital market concentration but also insurance market concentration can affect prices (Moriya et al., 2010).

Costs

The results of the effects of hospital competition on costs are mixed. Earlier studies by Robinson and Luft (1985) and Noether (1988) find results consistent with the medical arms race hypothesis, suggesting that hospitals in competitive markets tend to use more resources to provide high quality care (Dranove and White, 1994; Dranove and Satterthwaite, 1992). Later studies showed that this phenomenon disappeared in the 1990s and that hospital competition instead had a negative impact on hospital costs (Kessler and Geppert, 2005; Kessler and McClellan, 2000; Meltzer et al., 2002; Zwanziger and Melnick, 1988). A possible explanation for the negative relationship between competition and costs is that payers imposed stricter cost and price control measures in more competitive markets. A second hypothesis is that the diagnosis-related patient classification systems were accurate enough to reduce the incentives of hospitals to compete for patients with below average costs. This notion is supported by the finding that less severe cases received less care and more severe cases received more care in more competitive markets Kessler and Geppert (2005).

5.3.3 Discussion

Economic theories of physician behavior suggest different effects of elevated competition on the provision of care. In a competitive market, competition can reduce the marginal costs of production and thus decrease market prices and increase the utilization of care. However, if competition is limited, intensified competition can decrease physicians' incomes to which they can react by increasing the provision of care.

Most studies investigating the physician market examined the correlation between physician-to-population ratios and prices or quantities. Studies examining prices suggest a positive correlation between the number of physicians and prices. However, these studies stem from the time

before the emergence of large payer organizations and administratively set fees and are thus only of limited relevance for modern health care systems. The empirical results on the effects of competition on quantities suggest that an increase in the number of physicians in a market increases quantities per physician and per patient.

A positive effect of provider density on the provision of care has often been interpreted as evidence of physician-induced demand. The identification of physician-induced demand by changes in physician density has the advantage that the income effect is not obscured by the substitution effect of altered fees. None of the discussed studies, however, gives definitive proof that physicians alter the quantities of care by influencing their patients or that these adjustments are contrary to their patients' best interests. An increase in the number of physicians in a market can also increase the quantity of care per physician because patients have better access to care (availability effect), and it can increase the quantity per patient because physicians with fewer patients have more time to treat patients adequately than their colleagues who have too many patients (rationing) (Pauly, 1980). An availability effect can only be ruled out if a higher physician density makes it even more difficult for patients to switch providers, as suggested by Pauly and Satterthwaite (1981). Regardless of the mechanism of action, a positive volume response to increased competition suggests that increasing the number of physicians is an ineffective or even counterproductive policy instrument for controlling costs or preventing over-provision of care.

Empirical analyses of hospital markets use measures of market concentration to capture the competitiveness of a market and predominantly investigate prices and costs. The evidence on prices consistently points towards a negative effect of hospital competition on prices. This finding stands in opposition to the results obtained in the physician market. An important difference between the physician and the hospital market is that physicians determine their prices in an interaction with their less-informed patients, while hospitals negotiate prices with large payer organizations. The result that hospital competition leads to lower prices means that anti-trust policies can be effective measures to increase welfare in the hospital sector. The evidence on the effects of competition on hospital costs are mixed and do not allow conclusions about the effects of anti-trust policies on productive efficiency.

Limitations of the studies investigating hospital competition are that they are unable to capture the long-term gains from mergers, ignore the effects of increased market power on factor input prices or suffer from methodological shortcomings. The problem of market power

concerns both hospitals and large buyer organizations because the latter can not only exploit their market power to negotiate lower hospital prices but also to increase prices towards customers. Many of the studies supporting a negative price effect of hospital competition suffer from methodological shortcomings. Price measures were sometimes imprecise, studies investigating a broad set of services might be affected by unobserved heterogeneity when the market areas differ across services, and the hospital-level Herfindahl index might not measure the true intensity of competition when a service is also performed in private practices.

Most of the cited studies investigating hospital competition neglected the quality implications of competition. If the volume of a hospital affects the quality of care, the observation of higher prices in more concentrated markets could also reflect higher quality. While Mukamel et al. (2001) and Kessler and Geppert (2005) reported higher quality in more competitive markets, Gowrisankaran and Town (2003) demonstrated that the effect of competition on quality also depends on the patients for which hospitals compete. While competition for health maintenance organizations reduced risk-adjusted mortality, competition for Medicare enrollees increased it.

5.4 Consumer information

Consumer information can affect health care utilization by a demand- or supply-side effect. The demand-side effect can be described by the Grossman model, which predicts a negative association between health information and health care utilization because better-informed people are more efficient in taking care of themselves and can use medical care more efficiently (Grossman, 2000). On the supply side, the theoretical models of provider behavior suggest that better-informed patients are in a stronger position in their interactions with providers. In the model of monopolistic competition, physicians comply more with their better-informed patients' needs because they are more likely to see another physician. Models of imperfect agency do not rule out the possibility that physicians can better fulfill the needs of patients who are able to communicate their problems and preferences and who understand the instructions provided by the physician.

An empirical approach to disentangle the demand-side and supply-side effects of consumer information is to examine the decision to seek care and the number of follow-up services used separately (Deb and Trivedi, 2002; Mullahy, 1998). While the decision to seek care is mainly made by patients, the decision about the course of treatment is largely influenced by physicians. The effect of consumer information on treatment decisions has often served as a test of the

demand-inducement hypothesis because better-informed patients are expected to be less prone to demand inducement. This identification strategy has the advantage that it is not affected by an availability effect and does not depend on income or substitution effects of income shocks to the physician.

Although many studies used educational status as a proxy for health information, I focus on studies using direct measures of health information. The limitation of education as a measure of health information is that it not only enables people to make good decisions in the market for health care but also increases the marginal return of good health in the labor market. A direct measure of health information, however, should affect medical service use only through its effect in the market for health care.

5.4.1 Physician visits

In a now classic article, Kenkel (1990) estimated the effect of a direct measure of health information on the probability of seeing a physician and on the number of follow-up visits separately. The information variable was constructed from the answers to health knowledge questions included in a household survey by the Center for Health Administration Studies and the National Opinion Research Center (CHAS-NORC) of the University of Chicago. Reverse causality from a positive effect of physician visits on health information was addressed using an instrumental variable approach. The model did not show a significant effect of health information on the decision to see a physician or on the number of follow-up visits. Kenkel (1990) interpreted these results as evidence against the hypothesis that physicians induce less demand in better-informed patients.

An alternative strategy to test whether physicians prescribe more care to their less-informed patients was adopted by Bunker and Brown (1974), who examined the surgery rates of U.S. physicians and their spouses, probably the best-informed consumers. Age- and sex-adjusted surgery rates of physicians and their spouses were approximately 25 to 30 percent higher than in the rest of the country. This result conflicts with the hypothesis that physicians and their families are less prone to demand inducement. However, Hay and Leahy (1982) noted that physicians and their families might use more surgery because they face lower prices and have better access to high-quality care. In their own study, they controlled for sociodemographic characteristics, access to care factors and self-assessed health in an analysis of outpatient office visits using the National Survey of Access to Medical Care 1975–1976. Despite these improvements of the

empirical specification, they also found that medical professionals and their families were more likely to see a physician than were other respondents. Domenighetti et al. (1993) replicated the study by Bunker and Brown (1974) in Switzerland, where patients bear a smaller proportion of the costs of surgery than in the U.S. Their physician survey showed that physicians exhibited significantly lower age- and sex-adjusted surgery rates for 6 of 7 procedures. The authors concluded that the fee-for-service tariff system active at the time of the study promoted the over-provision of surgery to the population and that physicians were less likely to use more care than medically indicated. One explanation for the difference between the two U.S. studies and the work by Domenighetti et al. (1993) is that U.S. physicians can also charge higher prices to increase their incomes, while Swiss physicians who operate under a fee-for-service tariff system can only increase quantities. Poorly informed individuals are thus expected to pay excessively high prices in the U.S. and use excessive care in Switzerland.

Wagner et al. (2001) tested whether better-informed patients have fewer physician visits because they have lower demand for health information provided by health professionals. They evaluated a community intervention in Boise (Idaho) including the provision of a self-care handbook sent to each household, a toll-free telephone advice nurse and computer-based information terminals in public libraries and businesses. Their analysis showed that the intervention reduced the number of phone calls to physicians significantly compared to two control communities. However, this beneficial effect of health information on the demand for outpatient care does not seem to hold when the information is collected on the internet. An analysis of two waves of the U.S. Annenberg National Health Communication Survey (ANHCS) showed that patients who use the internet to search for health information are more likely to see a physician (Lee, 2008). The effect was particularly strong for physician visits with the objective to obtain further information. This finding was confirmed by Suziedelyte (2012), who estimated the association between information seeking on the internet and the annual number of visits to a health professional using the U.S. Health Information National Trends Survey (HINTS). The potential reverse effect of visits to health professional on the propensity to seek health information on the internet was controlled for using an instrumental variable approach. The effect of seeking health information on the internet on the number of visits was significantly positive and was larger the more often a patient searched the internet for health information.

A limitation of the studies by Wagner et al. (2001), Lee (2008) and Suziedelyte (2012) is that they do not distinguish the propensity to seek care from the decisions made during the

physician-patient interaction. Dwyer and Liu (2013) estimated a two-part model to disentangle the effect of seeking health information from the decision to seek care and the number of consultations. Respondents of the Community Tracking Study (CTS) 2000–2001 Household Surveys who searched for health information on the internet, from friends, on television, in books or magazines and from other sources were more likely to have seen a physician and had more physician visits but were less likely to have been admitted to an emergency room. These results are in opposition to the hypothesis that better-informed patients are less prone to demand inducement but suggest that health information enables patients to navigate in the health care system effectively. To shed some light on the effects of information-seeking behavior on the physician-patient interaction, Fang and Rizzo (2011) examined the physician's perception of the effects of patient information. Using a large physician survey, they assessed the relationship between the proportion of a physician's patients who talked about medical conditions and therapies they have heard about from other sources and the physician's self-assessed incentives to expand or reduce the provision of care. The authors addressed possible endogeneity of the percentage of better-informed patients using an instrumental variable approach. The ordered probit regression showed that physicians with more well-informed patients perceived that they had weaker incentives to provide care.

5.4.2 Preventive care

While the results on outpatient physician visits are inconclusive, studies in the area of preventive care showed consistently that better-informed people are more likely to use preventive health services. An early study by Kenkel (1994) analyzed two household surveys from 1976 and 1982 and showed a positive association between education and the annual probability of a pap test or breast exam. It is unclear, however, whether this effect was the consequence of higher returns to good health or of more efficient use of medical care. The results by Kenkel (1994) have been confirmed by a Taiwanese study using a direct measure of health information in a two-stage least squares estimation (Hsieh and Lin, 1997). Respondents who answered more questions about the symptoms associated with diabetes and high blood pressure correctly had a higher probability of having their blood pressure measured and their urine and blood sugar checked. Several studies using clinical assessments of health literacy confirmed that patients with higher health literacy scores exhibit higher immunization rates (Bennett et al., 2009; Scott et al., 2002; Sudore et al., 2006; Howard et al., 2005). One reason for the positive association

between consumer information and the use of preventive services might be that better-informed patients know the benefits of the insurance system better. This hypothesis has been confirmed by Parente et al. (2005), who found that elderly patients who knew about the newly established insurance coverage of mammography examinations and influenza vaccinations under Medicare and Medicaid in 1992 were more likely to use these preventive services.

The above-cited studies mostly covered preventive interventions that are cost-effective and tend to be under-used by the general population. If health information really enables people to make good choices, however, it should not just increase the propensity to use preventive care in general but also decrease the utilization of ineffective or even harmful preventive services. A Swiss team conducted a randomized survey experiment evaluating the effects of quality information about mammography screening, a preventive measure deemed to be of doubtful effectiveness (Domenighetti et al., 2000). The authors sent two different questionnaires to a representative sample of 1,000 Swiss non-institutionalized residents, one providing only basic information about the conduct of mammography and the other including extended information about the accuracy of the procedure. While 60% of the women receiving basic information declared themselves willing to undergo a screening mammography only 13.5% of those receiving the extended information were willing to accept the test. This result suggests that health information can improve the utilization of preventive care because it enables patients to distinguish between effective and ineffective measures.

5.4.3 Quality report cards

Consumers need health information not only to choose the right services in the appropriate quantity but also to choose the best providers. If quality information affects consumer decisions, the provision of such quality information can improve the welfare effects of competition in the market for medical care. A large body of literature addresses the effects of quality information in the form of quality report cards, which have become increasingly common in the U.S. The advantage of quality report cards for empirical research is that they create natural experiments, which can be exploited for the identification of causal effects. In this section, I focus on the effects of quality information on consumers' choices of health care providers.⁵

The main body of literature on quality report cards focuses on the choice of hospitals. In one

⁵For empirical studies investigating the effects of quality report cards on health plan choice, see Cherner and Scanlon (1998), Scanlon et al. (2002), Wedig and Tai-Seale (2002), Dafny and Dranove (2008) and Jin and Sorensen (2006).

of the first studies in this research area, Mennemeyer et al. (1997) examined the publication of death rates in five hospitals by the Health Care Financing Administration (HCFA) between 1982 and 1992. They found only a small effect of the data releases on the annual number of discharges, while press reports of single events reduced the number of discharges by 9%. Cutler et al. (2004) examined the annual publication of hospital-specific risk-adjusted mortality rates in the state of New York since the late 1980s as a series of mini experiments. They estimated that hospitals that received a high mortality flag experienced a decline in the number of admissions for bypass surgery in the subsequent year and a reduction in the mortality rate. The authors conclude that the publication of quality information can guide patients in their choice of provider and improve the quality of care. Quality report cards have also been shown to affect the market share of fertility clinics. Bundorf et al. (2009) estimated that clinics with higher birth rates in previous years experienced increases in their market shares after the publication of success rates in 1997. Holding the success rate constant, clinics with younger patients who have higher chances of success experienced a decrease in their market share. The results suggest not only that quality information affects consumer decisions in this therapeutic area but also that patients are able to adjust the quality information for the case-mix of the treated patient populations. However, assisted reproductive therapy differs from other therapeutic areas because it leaves the patients time to collect information and is only used by younger patients who either can afford to pay for it by themselves or have special insurance for it.

One problem of the studies by Mennemeyer et al. (1997), Cutler et al. (2004) and Bundorf et al. (2009) is that quality report cards convey information that is also available to the consumers through other sources. The inability to control for information obtained from other sources can lead to an overestimation of the effects of quality report cards. Mukamel et al. (2004) used the predicted mortality rates of surgeons based on publicly available information as a measure of the quality information that would have been available to patients in the absence of report cards. To identify the effect of new information delivered by report cards they estimated the effect of the difference between the predicted and published mortality rate on the probability that a patient chose a specific surgeon. The results suggested that after the publication of the report cards patients were more likely to choose a physician whose published mortality rates were lower than what patients could infer from observable characteristics. In addition, the report cards reduced the importance of surgeon experience and prices for the patients' choices. A problem of the econometric model by Mukamel et al. (2004) is that it assumes that the patients' prior

beliefs about quality remain constant. Dranove and Sfekas (2008) enhanced the specification proposed by Mukamel et al. (2004) and incorporated regular updating of CABG patients' beliefs about hospital quality over time. The analysis confirmed that quality report cards can affect the patients' choice of provider but only when quality scores really are news to the patients. Howard and Kaplan (2006) evaluated the U.S. national program for reporting quality outcomes in transplantation medicine and used a patient-level panel dataset to estimate the effect of the new information provided by quality report cards by controlling for hospital and time fixed effects. They only found a significant effect among younger and better-educated patients but not in the general patient population.

Information about hospital quality is not only published by public organizations but also in media hospital rankings. Pope (2009) analyzed the effect of the U.S. News and World Report (USNWR) hospital rankings – first published in 1990. The rank of a hospital in the previous year positively affected the number of non-emergency Medicare patients discharged from the hospital and the probability that a patient chose the hospital. The authors estimate that approximately 6% of all non-emergency Medicare patients changed their decisions because of the rankings. The effect might be larger than in other studies because Pope (2009) focus on non-emergency cases and because the rankings were published in an easy-to-understand manner in the mass media.

Quality information also seems to affect the patients' choices of providers in the long-term care sector. An analysis of a patient-level panel dataset showed that Medicare and Medicaid beneficiaries were more likely to choose nursing homes with high post-acute care quality scores after the publication of this information in 2002 (Werner et al., 2012). However, the effect was rather small and only the sub-domain of pain scores had a significant effect on nursing home choice.

In a much noticed study, Kolstad (2013) tested a theoretical model in which physicians not only respond to quality information because high quality pays off in the market but also because they have an intrinsic motivation to do a good job. The quality improvements due to intrinsic motivation was measured by the effect of the unpublished absolute number of fatalities on the number of fatalities in the subsequent year. Quality improvements due to profit incentives were measured by the effect of the difference between the unpublished absolute number of fatalities and the published risk-adjusted mortality rates on the physicians' risk-adjusted mortality rates in the subsequent year. The demand-side effect of good quality was measured by the effect of the published risk-adjusted mortality rates on the patients' propensity to choose a surgeon. The

results of the analysis of discharge data supported the theoretical predictions. Patients were less likely to choose a surgeon with a high risk-adjusted mortality rate after the publication of the report cards, and surgeons who learned from report cards that they performed worse than their colleagues later reduced their mortality rates. Most importantly, physicians also showed an intrinsic motivation to reduce their absolute mortality rate, and the intrinsic response was approximately four times as large as the response to profit incentives.

5.4.4 Discussion

While the Grossman model of health care demand suggests that health information affects the demand for medical care negatively, the theoretical predictions about the effects of health information on the supply of medical care are ambiguous because it is unclear whether physicians tend to over- or under-treat poorly informed patients.

Both the theoretical and empirical results on the effects of health information are mixed. While better-informed patients appear to make better choices about the use of preventive care, the correlation between health information and physician visits seems to depend on the type and source of health information. Being generally well-informed does not affect the use of outpatient services in a uniform way, while the public provision of health information in a controlled way seems to reduce the need to see a physician. However, people who seek health information on the internet exhibit higher demand for physician visits. A possible explanation for this difference is that people use information from the internet more often when they have particular symptoms and become confused by all the possible causes of these symptoms. A limitation of the studies investigating information seeking on the internet is that they do not control for personality traits that are associated with both elevated medical service use and the propensity to seek health information on the internet.

The provision of quality information has consistently been shown to affect patients' choices of providers, especially when they have time to make an informed decision. Quality report cards can thus provide incentives for physicians to provide good quality care and have the potential to increase the welfare effects of competition among hospitals and surgeons. However, the welfare effects of quality information also depend on the accuracy of the information. If the quality outcomes are not properly adjusted for the severity of the treated cases, hospitals might have incentives to refuse more severe cases, which can lead to limited access to care for sicker patients. Cutler et al. (2004) cite several studies showing detrimental effects of quality report cards on

the quality of care and on the access to care of high-risk patients.

In general, the available evidence does not support the prediction of the Grossman model that better-informed patients use less care because they use medical services more efficiently. Rather, it appears that better-informed patients use the same amount of care but navigate in the health care system more effectively and choose services more wisely.

Some studies use the effects of health information on service use as a test of the demand-inducement hypothesis assuming that better-informed patients are less prone to be influenced by their physicians. The available evidence, however, does not support this hypothesis. A possible explanation for the absence of a negative effect is that the effects of consumer information on the physician-patient interaction are obscured by a positive demand-side effect.

6 The Swiss health care system

The Swiss health care system is best described as a model of regulated competition (Enthoven, 1988). The regulation of the health care system is established on three levels of government. The federal government is responsible for the national health insurance system; the registration and reimbursement of drugs and medical devices; the oversight of medical training, health promotion, and prevention; and the maintenance of health statistics. The cantons are responsible for regulating and overseeing medical practices and hospitals, organizing and financing medical education, regulating the prices of medical services and operating public hospitals. The municipalities mainly organize and finance the provision of nursing homes and home care. The federal government can mandate cantons to implement federal laws, and the cantons can delegate certain responsibilities to municipalities.

6.1 Health insurance

Universal coverage is granted through a mandate that every Swiss citizen has to purchase a basic health insurance plan from one of 67 private health insurance companies (Swiss Federal Office of Public Health, 2015a). Customers can choose the provider of mandatory health insurance freely, and the health insurance companies have to accept any application for such a health plan. The mandatory health plan covers all services listed in a minimum benefits basket. These services include outpatient care by private practice physicians and hospitals, inpatient hospital care, drugs and certain preventive interventions. Although the Swiss Health Insurance Act stipulates that only effective, appropriate and efficient medical services should be reimbursed by mandatory health insurance, only a few interventions undergo a health technology assessment by a government agency. Health insurance companies thus have to commission independent medical examiners to assess whether the criteria of effectiveness, appropriateness and efficiency are fulfilled in an individual case and can ask the Swiss Federal Office of Public Health to evaluate a doubtful intervention.

Health insurance companies can charge different insurance premia across predefined geographic regions but not across individuals within these regions. To reduce incentives to attract patients with low expected health care expenditures (cream skinning), a risk-adjustment scheme re-distributes revenues between insurance companies according to their mix of insureds, as measured by age, sex and a hospital stay lasting 3 days or more in the previous year. Health

insurance companies are not allowed to make profits from the provision of mandatory health plans but can provide supplementary private insurance plans that cover services that are not included in the minimum benefits basket.

The Swiss Health Insurance Act specifies several cost-containment measures. The basic mandatory health plan includes a deductible of CHF 300 and a 10% coinsurance rate until a maximum annual copayment of CHF 700 is reached (Swiss Federal Office of Public Health, 2015b). Insurance companies are allowed to offer health plans with higher deductibles between CHF 500 and 2500 and to provide managed care health plans that place the insureds under the obligation to consult preferred providers or a gate-keeper. In 2012, 56% of all Swiss residents were insured in a managed care health plan (Enderli et al., 2015). The preferred providers operating within managed care health plans are often paid on a capitation basis or receive bonus payments for below average costs.

6.2 Financing

The mandatory out of pocket contributions by patients and the federalist structure are also reflected in the financing of the health care system (table 1.2). Of the total health care expenditures in 2012, 25% were paid directly by private households through out-of-pocket expenses and cost-sharing agreements with health insurers, 47% were financed by social insurance, 7% by supplementary private insurance and 20% by governmental institutions. Of the total health care expenditures in 2012, 17% were funded by the cantons, which cover a minimum of 55% of the costs of inpatient care.

6.3 Outpatient care

The outpatient sector is regulated at both the canton and federal levels. The cantons oversee the provision of outpatient care by private practice physicians and hospitals, while the TARMED outpatient tariff system is negotiated at the federal level among the Swiss Medical Association representing the physicians, the Swiss association of hospitals (H+), the organization of health insurance companies (santésuisse) and the Swiss Medical Tariff Commission representing accident insurers. TARMED is a fee-for-service tariff system that assigns tariff points to each service. The values of the tariff points, however, vary across cantons as a result of negotiations between the provider organizations and the canton health administrations. Laboratory tests and expendable materials are reimbursed according to national price lists.

Table 1.2: Funding of the Swiss health care system 2012

Source	in million CHF	in % of total costs
governmental institutions	67,982	20
federal government	149	0
cantons	11,664	17
municipalities	1,982	3
social insurance	31,615	47
mandatory health insurance	24,347	36
accident insurance	2,045	3
disability insurance	2,546	4
old-age and survivors' insurance	2,276	3
old-age and nursing support	401	1
private insurance	4,863	7
health insurance companies	1,319	2
other insurance companies	3,544	5
private households	17,045	25
out of pocket expenses	13,298	20
cost sharing	3,747	5
other private funding	662	1

Source: Swiss Federal Statistical Office (2012).

6.4 Inpatient care

The Swiss cantons have extensive authority over the supply of inpatient hospital care. The cantonal health administrations grant approvals to operate hospitals in their jurisdictions and compile lists of hospitals from which patients with mandatory health insurance can choose freely. In addition, most cantons own and operate public hospitals.

Since 2012, inpatient acute care is reimbursed by a DRG-based prospective payment system. The cost weights assigned to inpatient cases are defined at the national level, while the base rates of hospitals are negotiated between insurers and hospitals. The health administrations of the Swiss cantons can regulate the negotiated base rates and even set them if they do not approve negotiated prices.

Although the Swiss Health Insurance Act stipulates that inpatient care is reimbursed prospectively, inpatient rehabilitation and inpatient psychiatric care are still reimbursed by per diem rates. In 2010, the Swiss association of hospitals H+ and the not-for-profit organization Swiss-DRG commissioned the Zurich University of Applied Sciences to develop new prospective payment systems for inpatient rehabilitation and psychiatric care, including a patient classification system and prospective payments.

The procedures and therapies performed in inpatient care are not regulated actively in Switzerland. A physician can conduct any intervention as long as the patient gives his/her consent and the physician has liability insurance. If physicians or hospitals have been proven

to systematically harm patients, the canton health administrations can revoke their practice licenses. If a stakeholder officially questions the appropriateness or efficiency of a procedure, the Swiss Federal Office of Public Health makes a reimbursement decision based on a recommendation by the Federal Commission for General Services and Fundamental Questions, which is made up of members nominated by the Swiss Federal Council.

6.5 Pharmaceuticals

Pharmaceuticals are regulated at the federal level. New substances need to be approved by the Swiss medicines agency (Swissmedic) to be placed on the market. The decisions about reimbursement and maximum prices of drugs are made by the Federal Office of Public Health based on the recommendations of the Swiss Medicines Commission. The Swiss Medicines Commission is made up of medical experts and representatives of various stakeholders nominated by the Swiss Federal Council. Although a substance must be proven effective, appropriate for the licensed therapeutic indications and efficient, the reimbursement decisions are not based on systematic health technology assessments or cost-effectiveness analyses.

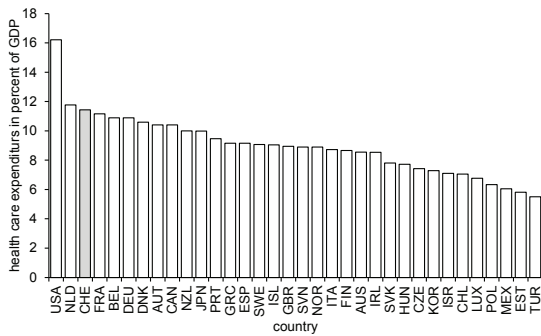
6.6 Challenges

Although the Swiss health care system is known for its excellent quality (OECD/WHO, 2011) and has often been used as a positive example of universal coverage without the drawbacks of national health services (Krugman, 2009), it also has its shortcomings. The most important challenges for the future include high health care expenditures, dangers of over-treatment, regional variation in access to care and a lack of transparency.

6.6.1 Affordability

Swiss health care expenditures as a percent of GDP are among the highest in the OECD and have increased between 2000 and 2012 (figure 1.9). Because the largest part of health care expenditures are financed collectively and reflect a political process, it is unclear whether the steady increase reflects the preferences of the population. In the current institutional environment, however, none of the involved parties have strong incentives to take effective cost containment measures. Patients are partly insulated from the costs of care, and approximately 30% of Swiss households receive premium subsidies (Swiss Federal Office of Public Health, 2014a). Insurance companies operate on a not-for-profit basis and are obliged to contract with all providers of

(a) OECD, 2012 (or last available year)



(b) Switzerland, 2000–2012

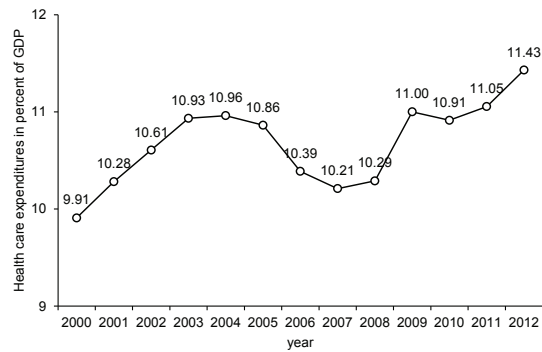


Figure 1.9: Health care expenditures as a percent of GDP (source: OECD (2014), own presentation)

care within the standard health insurance plan with a minimum deductible. The competition among health insurers is also a weak incentive to control costs because Swiss residents are rather reluctant to change their health insurance company (Trottmann et al., 2012). At the federal level, not only the payers but also the providers of care play important roles in the design of tariff systems and are well represented in committees making decisions about the reimbursement of medical interventions, devices and drugs.⁶ The cantons often play a dual role as regulators and providers of care, which limits their incentives to impose rigid constraints on providers.

6.6.2 Over-treatment

Switzerland enjoys a greater density of health professionals, diagnostic devices and hospitals than most other OECD countries (OECD/WHO, 2011). There are some indications that the high supply leads to wasteful and potentially harmful over-treatment. Often-cited examples include knee and hip arthroplasties and cesarean section delivery. Knee and hip arthroplasties are performed more often than in other countries (figure 1.10), and more than 30% of all births in Switzerland are delivered by cesarean section, which is approximately twice many as recommended by the World Health Organization (Gibbons et al., 2010; Hanselmann and von Greyerz, 2014).

Both the fee-for-service tariff system in outpatient care and the per diem reimbursement in inpatient rehabilitation and psychiatric care involve the danger that physicians provide more care than is socially efficient. Neither patients nor health insurance companies, however, have strong incentives to counteract the waste of resources by physicians. Patients are often poorly

⁶These committees include the Swiss Medicines Commission, the Federal Commission for General Services and Fundamental Questions, the Federal Commission for Analyses, Appliances and Devices and the Federal Commission for Questions of Vaccinations.

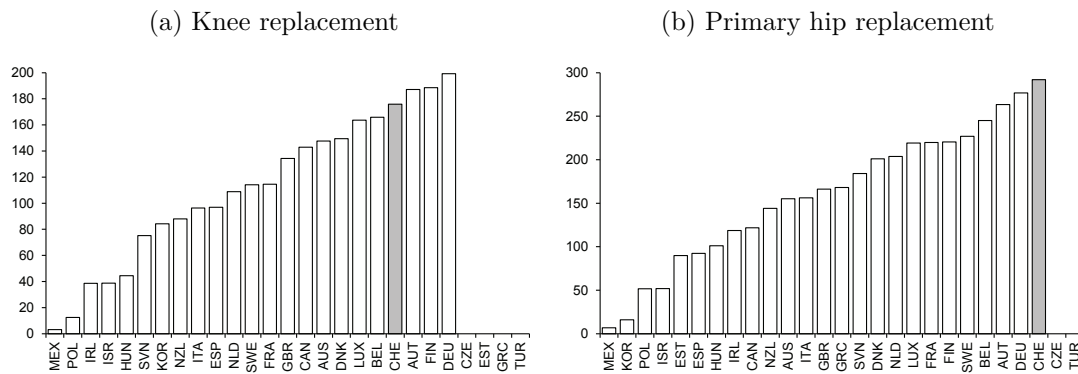


Figure 1.10: Rates of knee and hip replacement procedures per 100,000 inhabitants in OECD countries, 2008 (source: OECD (2014), own presentation)

informed and are partly insulated from the costs of care, while insurance companies operate on a not-for-profit basis and are obliged to contract with all licensed providers of care.

The minimum benefits basket in mandatory health insurance is rather comprehensive and does not impose rigid constraints on medical service use. The decisions about the reimbursement of drugs and surgical procedures are not based on systematic cost-effectiveness analyses, and rationing is the exception rather than the rule. Rare examples of coverage limitations that have received much attention include the federal court verdict against the reimbursement of alglucosidase alfa (Myozyme[®]) for morbus pompe (Swiss Federal Supreme Court, 2010) and the limitation of reimbursement for the hepatitis C drug sofosbuvir (Sovaldi[®]) to patients with advanced-stage disease (Swiss Federal Office of Public Health, 2014c).

Possible measures against an inefficient allocation of resources are prospective payment systems, promotion of managed care health plans, relaxation of the obligation of health insurance companies to contract with all physicians, higher deductibles and coinsurance rates, and stricter regulation of the health services covered by mandatory health insurance based on systematic health technology assessments.

6.6.3 Regional variation in health care utilization

Due to the federalist structure of the health care system, the utilization of medical care and health care expenditures vary substantially across cantons with no indication of different needs (Schleiniger, 2014). This is particularly disturbing when the utilization of care correlates with the supply of physicians and hospitals (Reich et al., 2012; Crivelli et al., 2006). Filippini et al. (2006) observed significant differences in per capita antibiotic sales across Swiss cantons and found that antibiotic use is significantly correlated with the density of medical practices. Cerboni

and Domenighetti (2010) found considerable inter-cantonal variation in the rates of hip and knee arthroplasty, hospitalizations for coxarthrosis and treatments for herniated discs. A report by the Swiss health observatory also showed pronounced regional variation in the use of coronary artery bypass surgery, percutaneous transluminal coronary angioplasty, coronary angiography, knee and hip arthroplasty and hospitalizations for hip fractures and cesarean sections (Pellegrini et al., 2014). Ess et al. (2010) found significant differences in breast cancer care between Swiss cantons. Both the rates of early detection of malignomas and the treatment strategies varied substantially. The high disparity in mastectomy was the most disturbing finding, as this intervention has severe consequences for the treated women. A study by Camenzind (2012) found significant canton disparities in the consumed quantities of six general service categories (visits to general practitioners and specialists, inpatient hospital care, outpatient medication and nursing homes).

6.6.4 Lack of information and transparency

Although the Swiss health care system provides patients with a high degree of autonomy, patients are not provided with public information about the quality of care of different providers. While a limited set of quality-of-care indicators for hospitals was published for the first time in 2014 (Swiss Federal Office of Public Health, 2014b), information on the quality of care delivered outside hospitals is only available through individual or local initiatives.

Data for research is also limited and highly fragmented. While all episodes in inpatient acute care, inpatient rehabilitation and inpatient psychiatry are recorded in a national hospital registry, no such data is available for outpatient care. Disease or patient registries are less prevalent than in other European countries and many of them are privately funded and are not subject to binding quality or data publication standards (OECD/WHO, 2011). Health insurance companies are not allowed to store diagnostic data with the insurance claims data, which makes it impossible to identify the causes of outpatient care.

The reimbursement decisions at the federal level are not based on a well-defined methodology for health technology assessments, and the decision-making process lacks transparency. The Swiss Federal Office of Public Health publishes neither the minutes of meetings of reimbursement committees nor the scientific reports that are used as a basis for their decisions. This is particularly problematic as the providers of medical care are well represented in the reimbursement committees and are involved in the design and definition of national tariffs.

Possible solutions to the lack of information can be the provision of provider quality informa-

tion by a public institution, the adoption of a solid methodology for the assessment of new and existing health technologies, the publication of all documents used for reimbursement decisions and the publication of all protocols of the meetings of reimbursement committees.

7 Summary

7.1 Theoretical models

The physicians' dominant role in medical decision making and the manner in which they exert market power have long been important research topics in health economics. While most economists agree about the sources of market failure in the market for medical care, economic theory struggles to explain how physicians influence the use of medical care and how patients and physicians interact during medical decision making. The model of perfectly competitive health care markets in which profit-maximizing physicians interact with perfectly informed patients has been confronted with conflicting evidence. Observations of price discrimination, positive effects of competition on prices and quantities per physician, a negative correlation between fees and quantities, and significant effects of non-monetary factors on the provision of care have questioned the validity of the neoclassical model in health care. An early attempt to explain these departures from the model of perfectly competitive markets was to assume that physicians do not behave like profit maximizers but try to earn a target income. Although the target-income hypothesis can explain the unexpected effects of competition and fee changes on the provision of care, it is based on the rather unrealistic assumption that physicians would not accept higher earnings under otherwise equal conditions. In addition, it does not specify how physicians and patients interact and how physicians influence the use of medical care. To consider the strategic interaction between physicians and their patients while maintaining the assumption of rational agents, the model of monopolistic competition was applied to health care markets. Models of monopolistic competition assume that physicians influence prices and quantities of medical care because switching physicians is costly for patients. Patients who face search and switching costs are more likely to stay with a physician even when they know that they do not receive the best possible care or pay excessively high prices. Under certain assumptions, the model of monopolistic competition can explain price discrimination, positive effects of competition on quantities and prices, and negative effects of fee changes on the provision of care. However, the assumptions that physicians only care about financial profit and that patients are perfectly informed have often been criticized, as they do not reflect the moral ethics of the medical profession or the limited knowledge of patients. Agency models depart from the assumption of perfectly informed patients and explain the physicians' superior role in the asymmetric distribution of information between physicians and their patients. Asymmetric information is acknowledged as one of the

dominant features of the medical care market. Agency models can explain market failure in health care and adverse effects of competition and price control policies on the provision of care. In addition, the inclusion of patient net benefit in the physicians' decision-making process departs from the rather narrow profit maximization paradigm.

None of the four theoretical models of physician behavior specifies how physicians and patients interact during the medical decision-making process. The neoclassical model of perfectly competitive markets assumes that patients are perfectly informed and only shop for the best prices. The target-income hypothesis is a mere description of the physicians' preferences and does not model medical decision making explicitly. Agency models assume that all medical decisions are made by physicians with no patient involvement. Only the model of monopolistic competition gives the patient an active role and considers the effects of the patients' level of information. However, even the model of monopolistic competition does not represent the interaction between physicians and patients during the medical decision-making process. In addition, the more realistic assumptions underlying the models of monopolistic competition and imperfect agency come at the price that they often make ambiguous predictions about the effects of changes in the market conditions and are difficult to test empirically.

7.2 Empirical evidence

Empirical studies have consistently shown that physicians compensate for income shocks by providing more care and respond to changes in the return to the provision of care. Although this evidence does not prove the existence of physician-induced demand in the narrow sense, it shows that physicians can provide too much care when they have monetary incentives to do so. The knowledge of physicians' response to changes in the market conditions can guide policy interventions that aim to improve the efficiency and equity of health care systems. Price control policies have often been shown to increase the supply of services, which has to be taken into account in the design of these policies. An increase in physician density seems to increase the prices and utilization of outpatient care in an area. This finding suggests that increasing the number of physicians in a market is not an effective cost control policy. Hospital competition, however, has been shown to decrease the price of hospital care. Institutional conditions that stimulate competition among hospitals, such as anti-trust policies, the relaxation of licensing restrictions and free choice of hospitals for patients, have the potential to improve efficiency in the hospital market. The empirical evidence on the effects of prospective payment systems consis-

tently confirms the hypothesis of a negative effect on the provision of care. In cases where price controls and competition reach their limits prospective payment systems seem to be the tool of choice to prevent an over-provision of care. Studies investigating the patients' level of health information provide inconclusive results about the effects on the use of outpatient physician services but show that better-informed patients are more likely to use effective preventive services. Information campaigns can thus motivate the uptake of effective preventive interventions and could also prevent the over-use of ineffective interventions. The provision of quality information has also been shown to affect patients' choices of high-quality providers, which demonstrates that quality information can increase competition in the hospital sector and improve the quality of inpatient care.

7.3 Implications for the Swiss health care system

Although a large part of the empirical literature stems from the U.S., the results are of high relevance for Switzerland. Negotiations on the TARMED fee-for-service outpatient tariff system are ongoing and policy makers should consider physicians' income compensating behavior in the regulation of the tariff rates. For instance, a reduction in the reimbursement of relatively costly diagnostic procedures using magnetic resonance imaging or computer tomography can increase health care expenditures if physicians compensate the price cuts and use these procedures or other services more often after the tariff reform. The question of the effects of provider density has been an important topic since the establishment of mandatory health insurance in 1996. Medical education is the only field of study to which access is restricted in Switzerland. The Federal Office of Public Health has allowed the Swiss cantons to limit the licenses of specialists with a private practice, implicitly acknowledging a positive association between provider density and the utilization of specialist care. At the same time, Switzerland faces a shortage of general practitioners and hospital physicians. This discrepancy, together with the modest effects of licensing restrictions, call for more effective measures against increasing health care expenditures and inefficient allocations of resources.

In inpatient care, a DRG-based prospective payment system for acute inpatient care was established for the entire country in 2012. In other therapeutic areas, such as inpatient psychiatry and inpatient rehabilitation care, new prospective payment systems are currently being developed. The empirical literature clearly indicates that prospective payment systems can establish strong incentives for a reduction in the provision of care. Prospective payment systems also have

a high potential to avoid the over-provision of outpatient care under the current fee-for-service TARMED outpatient tariff system. Annual payments per patient treated in a managed care organization or fixed salaries per physician can also be considered prospective payment systems that effectively prevent to over-provision of care.

Together with prospective payment systems, the provision of public information about the effectiveness of medical interventions and the quality of different providers may improve the efficiency of the Swiss health care system substantially. In this area, Switzerland has a lot of catching up to do. Medical interventions are not evaluated systematically using a standard HTA methodology and the provision of quality information provided by the Swiss Federal Office of Public Health is limited to inpatient care and includes only few rudimentary quality indicators such as age- and sex-adjusted mortality rates. In addition, the hospital quality indicators are not communicated in a way that is easy to understand, and hospital ratings published in the media are rather the exception, not the rule.

7.4 Open research questions

Despite the multitude of studies investigating physician markets, there are still questions that have not been answered conclusively. Although the evidence on the negative effects of prospective payment systems on the provision of medical care is rather robust, it is unclear whether prospective payment reforms affect the provision of care by altering the marginal or average revenue per unit of care. This question is vital to the efficient design of tariff systems because prospective payment systems create a trade-off between incentives to reduce the quantity of care and the accuracy of the tariff rates. Prospective payment reforms reduce the accuracy of tariff payments because they are not adjusted for the observed utilization of care and thus deviate more from the actual costs per case than cost based tariff payments. A low accuracy of tariff rates involves the danger of an under- and over-provision of care to patients with above or below average costs per case. If prospective payment systems do not affect medical decisions through the decrease in marginal revenue, as suggested by Norton et al. (2002), they do not necessarily create incentives to reduce the quantities of care but can lead to over- and under-provision.

The evidence about the effects of patients' health information on the utilization of outpatient physician services is inconclusive. This uncertainty calls for further research because significant effects of consumer information would have important implications for economic theory and policy. If the patients' level of information does affect the utilization of care, this means that

patients can influence the utilization of medical care. A significant effect of health information on the utilization of care not only suggests that an unequal distribution of health information across patients can lead to an unequal utilization of care but also that the provision of health information can counteract the over- and under-use of medical care.

7.5 Objectives of this thesis

This doctoral thesis aims to shed light on the manner in which prospective payment systems affect the provision of care, on the effects of consumer information on the physician-patient interaction, and on the effects of public health interventions using information measures to motivate people to use preventive care. The first study evaluates the introduction of a mixed payment system in one psychiatric hospital in the Swiss canton of Zurich as a natural experiment. Because the mixed payment system includes tariff rates that vary over the length of stay, a duration approach is used to examine the effects of changes in marginal and average revenue per inpatient day. The second study investigates the effects of health literacy as a measure of health information on the utilization of outpatient physician services using a hurdle model approach. The hurdle model allows the analysis of the decision to seek care and the number of follow up visits separately and can provide evidence on the effects of health information on the outcomes of the physician-patient interaction under asymmetric information. The third study evaluates the effects of organized screening programs in 9 Swiss cantons on the demand for mammography. The empirical approach exploits the gradual implementation of these programs to estimate their causal effects on screening initiation by 50- to 69-year-old women.

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Part II

Marginal revenue and length of stay in inpatient psychiatry

Abstract

This study examines the changes in marginal revenue during psychiatric inpatient stays in a large Swiss psychiatric hospital after the introduction of a mixed reimbursement system with tariff rates that vary over length of stay. A discrete time duration model with a difference-in-difference specification and time-varying coefficients is estimated to assess variations in policy effects over length of stay. Among patients whose costs are fully reimbursed by the mixed scheme, the model demonstrates a significant effect of marginal revenue on length of stay. No significant policy effects are found among patients for whom only health insurance rates are delivered as mixed tariffs, and government contributions are made retrospectively. The results indicate that marginal revenue can affect length of stay in inpatient psychiatry facilities but that the reduction in marginal revenue must be sufficiently large.

JEL-Classification: I18, C41

Keywords: Prospective payment, marginal price effect, hospital, psychiatry, length of stay

1 Introduction

The use of prospective payment systems for inpatient psychiatry is increasing internationally. Prospective payment systems reimburse care by predetermined rates regardless of actual costs. In inpatient care prospective payment systems typically include a patient classification system and per-case payments to establish incentives for the efficient provision of care. Patient classification systems aim to form homogeneous cost groups with tariff rates close to actual costs to reduce incentives for the under- or over-provision of services to patients with above or below average costs. Per-case payments are intended to reduce length of stay by decreasing marginal revenue per inpatient day. A disadvantage of per-case payments is that they deviate more from the actual cost per episode than revenues from a per diem system, which are adjusted for observed length of stay. The introduction of a per-case reimbursement system thus creates a trade-off between the accuracy of tariff rates and incentives to reduce the average length of stay. The accuracy of tariff rates is a critical issue in inpatient psychiatry, in which length of stay varies substantially within cost groups (Ashcraft et al., 1989; Siegel et al., 1986; Warnke et al., 2011; Hunter and McFarlane, 1994; Taube et al., 1984; Drozd et al., 2006).

Many studies have investigated the effect of per-case payment on length of stay in inpatient psychiatry (for a review see Chalkley and Malcomson (2000)). The early results stem from evaluations of the U.S. Medicaid and Medicare payment reforms. Frank and Lave (1989) explored variations in the manner in which state Medicaid programs reimbursed psychiatric care between

1981 and 1984. They found that the average length of a stay in inpatient psychiatry was lower under per-case prospective payment systems than with cost-based reimbursement. Freiman et al. (1989) documented a reduction in the length of stay for psychiatric patients treated in acute care hospitals after the 1984 Medicare prospective payment reform. The effect, which was greatest during the first months of the new system, began before it even came into effect, indicating anticipatory behavior by hospitals. An evaluation of the 1989 New Hampshire Medicaid payment reform by Ellis and McGuire (1996) showed significant reductions in the average length of stay of psychiatric patients but increased length of stay for short episodes. The authors interpreted this result as evidence of quality competition among hospitals for profitable patients, as postulated by Dranove and White (1994). A second explanation for the increase in length of stay for short episodes was provided by Norton et al. (2002), who analyzed the responsiveness of length of stay to changes in marginal and average revenue per inpatient day in the cross-section. Their results suggest that providers of inpatient psychiatric care did not respond to changes in marginal revenue but only to changes in average revenue per inpatient day, which was higher for short episodes. The absence of a marginal price effect has important policy implications: it means that a switch from per diem to per-case reimbursement reduces the accuracy of the tariff rates and leads to over- and under-treatment but does not necessarily establish incentives to reduce average length of stay.

This study examines the decrease in marginal revenue after the switch from a per diem system to a mixed reimbursement system in a large psychiatric hospital in the Swiss canton of Zurich. The evaluated mixed system consists of a high per diem rate during the first 5 days of a stay, a per-case payment on day 6 and a low per diem rate thereafter. The objective of this study is to test whether the payment reform affected length of stay by altering the marginal or average revenue per inpatient day.

2 Background

Between 2008 and 2011, the cost of inpatient psychiatric care in the Swiss canton of Zurich was borne approximately equally by private health insurance companies and the government. When residents of other cantons were treated in a Zurich hospital, the canton of residence also made government contributions. Reimbursement agreements between the cantons and hospitals defined the services that each hospital was obliged to provide to all patients with mandatory

health insurance in return for public funding.¹ At the time of this study, no patient classification system had been implemented.

The delivery mode for the government contributions depended on the patient's canton of residence. The canton of Zurich made retrospective annual payments to hospitals, whereas other cantons paid their shares in the form of tariff rates. The tariff rates from other cantons were intended to cover the expected cost per inpatient day net of health insurance rates. Before the policy reform, health insurance companies paid their shares in the form of per diem rates, which differed among hospitals, as a result of negotiations between hospitals and health insurance companies.

In 2009, the health administration of the canton of Zurich introduced a mixed reimbursement system in the state-run Psychiatric University Hospital of Zurich (hereafter, "intervention hospital"), whereas all other hospitals in the canton of Zurich (hereafter, "comparison hospitals") remained in the traditional per diem system.² In the new mixed system, tariff payments by health insurance companies consisted of a high per diem rate for the first 5 days of a stay, a per-case payment on day 6 and a low per diem rate for subsequent days (table 2.1).³ The canton of Zurich still made retrospective global payments based on deficits of the past year. Other cantons, however, delivered their payments for the stays of their residents in Zurich hospitals after the payment reform in the form of a mixed tariff, with a per-case payment on day 6 and a low per diem rate thereafter. The decrease in marginal revenue per inpatient day on day 6 is, therefore, much higher for the residents of other cantons than for the residents of the canton of Zurich.

3 Hypotheses

According to Cutler (1995), a switch from cost-based to prospective payment can affect length of stay by altering the marginal and average revenue per inpatient day. The decrease in marginal revenue alone creates an incentive for the provider to reduce length of stay because each inpatient day increases cost but not revenue. Such a *marginal price effect* only occurs if physicians have

¹Between 2008 and 2011, the following cantons had reimbursement agreements with the canton of Zurich that allowed their residents to be treated in Zurich hospitals: Appenzell-Innerhoden, Appenzell-Auserrhoden, Glarus, Graubünden, St. Gallen, Schaffhausen, Thurgau and Zug. Patients from other cantons or from abroad had to pay the government share themselves.

²According to staff of the health administration of the canton of Zurich the intervention hospital was selected because it was a state run hospital and because it treated a typical patient population. The comparison group also included state run hospitals.

³As an example, a stay of 20 days in the intervention hospital was reimbursed by health insurance with $20 \times 309 = 6,180$ in 2008, and $3,062 + 5 \times 356 + 15 \times 217 = 8,097$ in 2009.

Table 2.1: Reimbursement rates [CHF] for stays in the Psychiatric University Hospital Zurich by canton of residence

year	2008		2009			2010			2011		
	per diem		per diem	per-case	per-case	per diem	per-case	per diem	per-case		
days	1-60	60+	1-5	6+	6	1-5	6+	6	1-5	6+	6
Health Insurance											
Zurich & non-Zurich residents	309	217	356	217	3,062	374	228	3,218	374	228	3,218
Government contributions											
Zurich residents	annual payment		annual payment			annual payment			annual payment		
Non-Zurich residents	494	321	541	329	4,658	585	370	5,059	585	370	5,059

preferences for hospital profit (Ellis and McGuire, 1986, 1990; McGuire, 2011). A second mechanism through which per-case payment can affect length of stay is average revenue per inpatient day or, equivalently, total revenue per episode. An *average price effect* occurs when physicians have preferences for medical benefit of their patients and use the available resources to maximize the quality of care under the constraint of non-negative profits. Physicians, who are imperfect agents of their patients, react to changes in marginal revenue because these changes affect the utility maximizing length of stay, and they react to changes in average revenue because these changes determine the maximum length of stay associated with non-negative hospital profit. In this model, a change in average revenue affects an imperfect agent's choice only if the profitability constraint is binding, i.e. if the maximum affordable length of stay is shorter than the agent's utility-maximizing choice.

The research question of this study is whether the switch from per diem to mixed reimbursement affected length of stay in the intervention hospital by altering the marginal or average revenue per inpatient day. The payment reform left the revenue during the first 5 days essentially unchanged. On day 6, the per-case payment increased the average revenue per inpatient day while the reduction in per diem rates decreased the marginal revenue. Total revenue per episode increased on day 6 and but was lower than in the old per diem system after 36 or 40 days, depending on the canton of residence.⁴ In a homogeneous patient population, with a constant marginal cost per inpatient day, a per diem tariff must yield non-negative profits for an infinite number of days to allow the provision of a positive amount of care without losses. This assumption suggests that the profitability constraint was not binding before the reform and its loosening did not affect length of stay. Therefore, I do not expect the increase in average

⁴An episode of a non-Zurich resident of 36 days was reimbursed by health insurance and the government with $36 \times 803 = 28,908$ in 2008, and with $7,720 + 5 \times 897 + 31 \times 546 = 29,131$ in 2009. The revenue from health insurance for a stay of a Zurich resident of 40 days was $40 \times 309 = 12,360$ in 2008, and $3,062 + 5 \times 356 + 35 \times 217 = 12,437$ in 2009.

revenue between days 6 and 36 (or 40) to affect length of stay in this interval but only later, when the profitability constraint was tighter than it was previously. Based on the information provided above, I hypothesize that the introduction of the mixed Zurich system produced the following effects:

- *Marginal price effect*, the decrease in marginal revenue on day 6 increases the probability of discharge.
- *Average price effect*, the decrease in average revenue after day 36 (non-Zurich residents) or day 40 (Zurich residents) increases the probability of discharge.
- *Heterogeneity in response*, the effects of the payment reform are larger among non-Zurich residents, for whom both the health insurance rates and government contributions were subject to the reform.

4 Empirical strategy

This study exploits the introduction of the mixed Zurich system in only one hospital; all other hospitals remained in the traditional per diem system. The unaffected hospitals serve as a comparison group to control for a counterfactual situation in a difference-in-difference framework. Because the marginal and average price effects of the payment reform are expected to manifest at different time points during inpatient stays, a duration model with time-varying coefficients is estimated. A change in the shape of the hazard curve over specified intervals is regarded as evidence of a marginal or average price effect.

Because the length of stay (los) of psychiatric patients is recorded in discrete intervals of days, a discrete time duration model is estimated. The discrete time hazard rate $h(t)$ is defined as the conditional probability that an event would occur during time period t , given that it had not yet occurred (Singer and Willett, 1993).

$$h(t) = P(los = t | los \geq t) \tag{1}$$

The hazard rate $h(t)$ can be estimated as the probability of discharge $P(discharge_t = 1)$ at time t by a discrete choice model in a dataset containing one observation per inpatient day. The dependent binary variable ($discharge_t$) indicates whether a patient is discharged on day t . A link function specifies the dependence of the hazard on predictors and time. Commonly used

link functions for discrete time duration models are probit, logit and complementary log-log. This study uses the complementary log-log specification, as shown in equation (2), which is the discrete time counterpart of continuous time proportional hazards models (Beck et al., 1998). Complementary log-log models are a popular choice for grouped continuous time variables because the coefficients are the same as the coefficients from the corresponding continuous time proportional hazards model (Kalbfleisch and Prentice, 2002, 47), and the coefficients are invariant to the length of the discrete time intervals (Allison, 1982). Complementary log-log models invoke the proportional hazards assumption, whereas logit models depend on the proportional odds assumption, which is less well integrated into the survival time theory. Although logit and complementary log-log functions yield similar results when hazards are low, a logit link is also tested in sensitivity analyses.

To test the formulated hypotheses, each inpatient episode is characterized by predictors of the hazard rate during time period t . Let D_i be a binary variable indicating whether an episode was recorded at the intervention hospital, and let T_i be an indicator of admission during the post-intervention period (after January 1, 2009). The interaction term D_iT_i captures the exposure to the payment reform. Although the per-case payment and the decrease in marginal revenue on day 6 become effective only if a patient remains hospitalized beyond this time, the treatment assignment can be considered to be exogenous after a patient is admitted to the hospital.

Because this study focuses on the effect of the mixed Zurich system on the shape of the hazard function, the treatment effect is allowed to vary over length of stay using an interaction term between the D_iT_i term and interval dummies I_{6+} , I_{36+} , I_{40+} and I_{60+} ; in accordance with the proposed hypotheses, the interval dummies indicate whether an inpatient day is observed later than day 6, day 36, day 40 or day 60, respectively. With such a backward difference coding, the treatment effect in an interval is compared with the effect in the prior interval. This model describes the effect of the payment reform on within-spell variation in the hazard rate, not only a proportional shift.

Indicator variables for hospitals in the comparison group H_i and indicators of the quarter of admission Q_i counted from January 1, 2008, are used to control for hospital and quarterly fixed effects. The time dependence of the probability of discharge is controlled for by piecewise constant baseline hazards B_t . The piecewise baseline hazards are estimated in daily intervals for the first two weeks, in two-day intervals during days 15 to 27, in weekly intervals between

days 36 and 63, in monthly intervals from day 64 to day 183 and in quarters thereafter.

$$\begin{aligned}
 P(\text{discharge}_t = 1) &= 1 - e^{-e^{g(\cdot)}} \\
 g(\cdot) &= \alpha_t B_t + \beta H_i + \gamma Q_i + \delta D_i + \varepsilon T_i + \eta_t I_t + \theta_t I_t D_i + \kappa_t I_t T_i + \lambda D_i T_i + \mu_t I_t D_i T_i
 \end{aligned}
 \tag{2}$$

In this non-linear difference-in-difference model the marginal price effect of the payment reform is not identified by the coefficient μ_t but by its incremental effect $h_i^1(t) - h_i^0(t)$ at a given day (Ai and Norton, 2003). Because the incremental effect is only positive if μ_t is positive one can still interpret the sign of the coefficient μ_t (Puhani, 2012).

$$\begin{aligned}
 h_i^1(t) &= 1 - e^{-e^{\alpha_t + \delta + \varepsilon + \eta_t + \theta_t + \kappa_t + \lambda + \mu_t}} \\
 h_i^0(t) &= 1 - e^{-e^{\alpha_t + \delta + \varepsilon + \eta_t + \theta_t + \kappa_t + \lambda}}
 \end{aligned}
 \tag{3}$$

The change in the shape of the hazard curve after the policy reform can also be shown graphically by comparing the predicted hazard function $h_i^1(t)$ of post-intervention spells in the intervention hospital ($D_i = 1, T_i = 1$) with the counterfactual function of those spells without the treatment effects λ and μ_t .

This identification strategy depends on the assumption that the shape of the hazard curves in the intervention and comparison groups would have changed similarly in the absence of the intervention. This assumption cannot be tested with only one pre-intervention year. The empirical approach of this study, however, is robust against deviating trends in overall length of stay as long as the shape of the hazard curve remains the same. It seems plausible that the hazard curves followed the same general trends because the analyzed hospitals all operate in the same geographically small jurisdiction and adhere to the same regulations.

Another critical assumption of the difference-in-difference strategy is the absence of anticipatory responses to the policy reform. The health administration of the canton of Zurich announced the policy reform only four months before it came into effect, making anticipatory effects unlikely. Spillover effects between hospitals, however, are possible if the intervention altered patient selection behavior in the intervention hospital. To control for the effects of compositional changes over time, I estimate a model with patient-specific covariates in the sensitivity analysis.

5 Data

The primary data source analyzed in this study is the PSYREC registry, a database of all inpatient episodes in 13 psychiatric hospitals in the canton of Zurich between 2008 and 2012. The PSYREC registry contains information about patient characteristics, diagnoses, therapies, cost data and clinical assessments of functioning and symptom severity.

The variable of interest in this study is the length of psychiatric inpatient stays in days. Non-reimbursable therapeutic leaves during a stay are not counted as days spent in the hospital. The patient identification numbers in the PSYREC registry allow the identification of readmissions to the same hospital but not to other hospitals. Inpatient episodes in different hospitals, therefore, cannot be attributed to specific patients.

Together with the mixed Zurich system, the health administration of the canton of Zurich introduced a new definition for treatment episodes in the intervention hospital. Beginning on January 1, 2009, readmissions within 30 days after the last discharge from the intervention hospital were reimbursed as a treatment continuation after a non-reimbursable therapeutic leave. To allow a comparison between the intervention hospital and the comparison hospitals and to obtain a consistent picture over time, I apply this definition to all the episodes in the dataset and connect readmissions to the same hospital within 30 days to the previous episode. This strategy leads to a reduction in the number of spells and an increase in the average length of stay compared with other publications using the PSYREC registry data.

For this study, only data from patients 18 to 65 years of age at admission were available. The sample includes only completed spells of 365 days or less with an admission date between February 1, 2008, and December 31, 2011. I do not consider the period between January 1 and January 31, 2008, in this analysis to ensure that after recoding readmissions within 30 days as continuations of previous stays, all studied episodes begin during the observation period. The year 2012 is excluded because hospital financing was reformed in the entire country that year.

6 Results

6.1 Descriptive statistics

Between 2008 and 2011, there were 10,644 inpatient episodes that fulfill the inclusion criteria described in section 5 in the intervention hospital and 24,794 inpatient episodes in the comparison hospitals (table 2.2). The intervention hospital is a large provider of psychiatric inpatient care

in the canton of Zurich and provides care to approximately 30% of all psychiatric patients. The vast majority of the patients treated in the included hospitals lived in the canton of Zurich. In 2008, residents of the canton of Zurich constituted 95.30% of the patients in the intervention hospital and 89.50% in the comparison hospitals.

The average length of stay was shorter in the intervention hospital than in the comparison hospitals during the entire observation period, although it followed a similar trend (figure 2.1). Both groups exhibited an increase from 2008 to 2009, followed by a steady decline until 2011. Compared with the year 2008, the average post-intervention length of stay was 0.83 days shorter in the intervention hospital and 0.90 days shorter in the comparison hospitals (table 2.2).

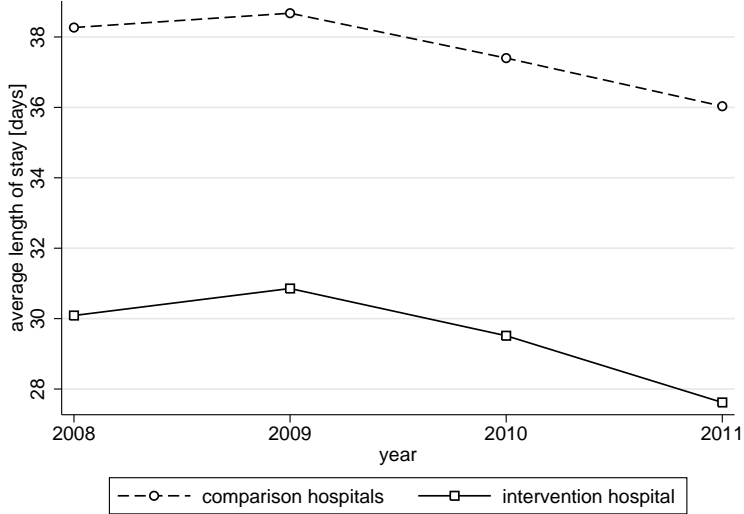


Figure 2.1: Average length of stay per year in the intervention hospital and comparison hospitals

The observed density of length of stay exhibited a different pattern in the intervention hospital than in the comparison hospitals (figure 2.2). A much greater proportion of patients were discharged from the intervention hospital during the first 5 days of hospitalization. The peak on day 5 shown in figure 2.2 can be explained by the standard "crisis intervention" package, which lasts for exactly five days, provided in the intervention hospital. The higher proportion of episodes lasting two, three or four days could be a consequence of early discharges from crisis intervention.

In 2008, the patient populations of the intervention and comparison hospitals exhibited different characteristics. The intervention hospital accommodated more patients of foreign nationalities, fewer patients with supplementary private insurance plans and fewer patients undergoing compulsory hospitalization. The proportions of cases of psychotic disorders (ICD-10 F2) and

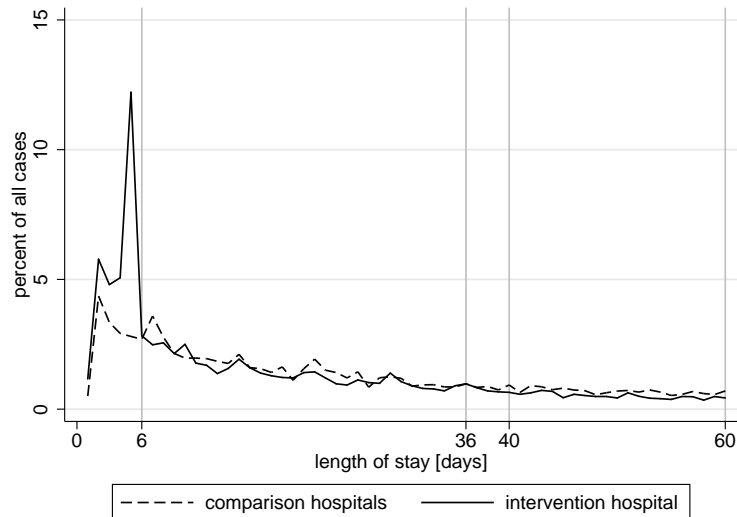


Figure 2.2: Observed density of length of stay in the intervention hospital and the comparison hospitals

disorders in childhood and adolescence (ICD-10 F9) were higher, and the proportion of cases of affective disorders (ICD-10 F3) was lower than in the comparison hospitals. The intervention hospital has a long tradition in the treatment of schizophrenia and still specializes in this field.

The descriptive statistics presented in table 2.2 also reveal some changes in the patient population of the intervention hospital between the pre- and post-intervention periods. The proportion of patients with mandatory schooling decreased from 22.25% to 11.07%, and the proportion of patients with an apprenticeship declined from 26.21% to 20.53%. These reductions in the number of patients with low educational status accompany an increase in the number of records with unknown educational status from 26.90% to 44.34%. The proportion of patients with a paid job decreased from 40.79% to 29.44% in the intervention hospital but increased slightly from 36.49% to 37.99% in the comparison hospitals. After the payment reform the combined proportion of patients with a main diagnosis of a psychotic (ICD-10 code F2) or affective disorder (ICD-10 code F3) increased from 42.93% to 50.61%, while the proportion of patients with a disorder occurring in childhood and adolescence (ICD-10 F9) decreased from 7.97% to 0.81%. The intervention hospital appears to have become even more specialized in the treatment of schizophrenia than before the payment reform. The frequency of patients undergoing compulsory hospitalization increased markedly from 1.39% to 5.93% in the intervention hospital but decreased from 6.45% to 4.04% in the comparison hospitals. The illness severity at admission, which was measured using the clinical global impression scale (CGI), shifted toward lower severity in the intervention hospital.

Table 2.2: Mean values of explanatory variables before and after the payment reform in intervention and comparison hospitals

		pre-intervention		post-intervention	
		(2008)		(2009-2011)	
		comparison hospitals	intervention hospital	comparison hospitals	intervention hospital
length of stay	[days]	38.27	30.09	37.37	29.26
Zurich resident	[%]	89.50	95.30	89.51	94.88
age	[years]	40.64	39.31	40.80	40.00
female	[%]	49.71	49.54	49.95	49.14
married	[%]	29.86	23.07	28.67	23.63
foreign	[%]	19.39	31.48	18.41	31.10
education = no education	[%]	4.90	4.53	3.79	5.70
education = mandatory schooling	[%]	17.94	22.25	16.44	11.07
education = apprenticeship	[%]	36.80	26.21	38.30	20.53
education = A-level degree	[%]	3.17	6.14	3.57	4.59
education = higher professional education	[%]	7.34	8.40	8.21	6.90
education = university degree	[%]	5.52	5.57	6.43	6.86
education = unknown	[%]	24.34	26.90	23.25	44.34
working (full- or part-time)	[%]	36.49	40.79	37.99	29.44
supplementary hospital insurance	[%]	11.56	4.18	12.60	4.17
compulsory hospitalization	[%]	6.45	1.39	4.04	5.93
main diagnosis F0	[%]	1.45	1.31	1.43	1.81
main diagnosis F1	[%]	33.17	20.72	30.73	19.41
main diagnosis F2	[%]	16.54	24.34	15.58	27.30
main diagnosis F3	[%]	26.44	18.59	28.37	23.31
main diagnosis F4	[%]	12.61	15.45	14.74	16.29
main diagnosis F5	[%]	0.95	0.65	0.76	0.29
main diagnosis F6	[%]	6.37	10.62	6.84	10.05
main diagnosis F7	[%]	0.64	0.30	0.52	0.52
main diagnosis F8	[%]	0.10	0.04	0.06	0.20
main diagnosis F9	[%]	1.73	7.97	0.97	0.81
CGI ^{a)} = 1 (normal, not at all ill)	[%]	0.17	0.09	0.01	0.05
CGI = 2 (borderline mentally ill)	[%]	1.30	1.35	0.68	2.00
CGI = 3 (mildly ill)	[%]	5.36	3.40	2.92	5.68
CGI = 4 (moderately ill)	[%]	21.23	19.16	20.75	30.56
CGI = 5 (markedly ill)	[%]	42.27	47.58	47.38	41.64
CGI = 6 (severely ill)	[%]	16.14	19.85	17.78	14.60
CGI = 7 (extremely ill)	[%]	0.76	1.83	1.33	1.09
CGI = not assessable	[%]	3.67	6.75	4.83	4.37
CGI = not rated	[%]	9.10	0.00	4.32	0.00
location after discharge = home	[%]	72.16	57.16	73.19	66.77
location after discharge = sheltered home	[%]	10.55	12.28	10.38	12.74
location after discharge = psychiatric hospital	[%]	5.92	3.70	4.48	3.98
location after discharge = rehabilitation hospital	[%]	1.09	0.35	1.61	0.92
location after discharge = acute care hospital	[%]	0.67	1.39	0.97	1.09
location after discharge = penal institution	[%]	0.87	0.74	0.93	0.83
location after discharge = homeless	[%]	1.56	1.92	1.60	1.82
location after discharge = other	[%]	7.18	22.46	6.85	11.86
<i>N</i>		5,780	2,297	19,014	8,347

a) Clinical Global Impression scale at admission

Some of the observed changes in patient characteristics may be the consequence of revised coding practices. The lower severity ratings, the higher proportion of jobless patients and the altered distribution of main diagnoses, however, may indicate altered patient selection after the switch from per diem to mixed reimbursement. A model with covariates from table 2.2 is, therefore, estimated to examine the effects of compositional changes in the patient population.

6.2 Regression results

A regression analysis is used to test whether the payment reform changed the shape of the hazard curve over the length of stay in the intervention hospital. The coefficient of the interaction term $treat * post$ gives a difference-in-difference estimate of the policy effect on the probability of discharge during the first 5 days of inpatient episodes. This coefficient alone cannot be interpreted in a non-linear model because the marginal effect of the payment reform in this interval depends on the expected outcome of each patient and is not constant across the treated group (Ai and Norton, 2003; Puhani, 2012). The coefficient of the multiple interaction $treat * post * I_{6+}$ indicates the increase in the treatment effect after day 6 compared with the first 5 days. This coefficient demonstrates how the payment reform changed the shape of the hazard curve on day 6. The positive coefficient of 0.6322 ($p < 0.005$) in the group of non-Zurich residents is interpreted as evidence of a marginal price effect of the payment reform on length of stay. In the group of Zurich residents, however, this coefficient is close to zero and shows no marginal price effect. The coefficients of the interaction terms $treat * post * I_{40+}$ (Zurich residents) and $treat * post * I_{36+}$ (non-Zurich residents) indicate whether the probability of discharge increased after day 40 or day 36 compared with the earlier days of inpatient episodes, which could be interpreted as an average price effect. The analysis does not reveal a significant change in the treatment effect in this time interval, thus providing no evidence of an average price effect. The decrease in the probability of discharge after day 60 does not necessarily represent an effect of the mixed tariff system because the per diem rates in the comparison hospitals and the pre-intervention rates in the intervention hospital also decreased after day 60 (table 2.1).

A prediction of the hazard functions of the post-intervention episodes in the intervention hospital and the counterfactual functions of the same episodes, without the treatment effect, allow a graphical representation of the regression results (figure 2.3). For this exercise, I simulate the treatment effect for the second quarter of 2009, which had the smallest quarterly fixed effect. The hazard curves of Zurich residents are predicted to be essentially unaffected by the policy

Table 2.3: Regression results

	full sample		Zurich residents		non-Zurich residents	
	Coef.	<i>p</i> -value	Coef.	<i>p</i> -value	Coef.	<i>p</i> -value
complementary loglog link function, without covariates						
treat*post	-0.0188	0.7486	-0.0009	0.9877	-0.2890	0.1694
treat*post*I ₆₊	0.0572	0.4279	0.0230	0.7558	0.6322**	0.0281
treat*post*I ₃₆₊	0.1278	0.4496			0.1952	0.6791
treat*post*I ₄₀₊	-0.2422	0.1901	-0.1099	0.2613		
treat*post*I ₆₀₊	0.0484	0.6612	0.0883	0.4379	-1.1748**	0.0393
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	no		no		no	
log-likelihood	-157,656		-143,160		-14,192	
spells	35,438		32,302		3,136	
inpatient days	1,209,650		1,076,817		132,833	
complementary loglog link function, with covariates						
treat*post	-0.1240**	0.0351	-0.1088*	0.0760	-0.3714*	0.0809
treat*post*I ₆₊	0.0787	0.2754	0.0411	0.5788	0.6546**	0.0235
treat*post*I ₃₆₊	0.1123	0.5066			0.4210	0.3733
treat*post*I ₄₀₊	-0.2413	0.1918	-0.1280	0.1906		
treat*post*I ₆₀₊	0.0486	0.6600	0.1001	0.3795	-1.4640**	0.0109
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	yes		yes		yes	
log-likelihood	-155,587		-141,190		-14,011	
spells	35,438		32,302		3,136	
inpatient days	1,209,650		1,076,817		132,833	
logit link function, without covariates						
treat*post	-0.0196	0.7455	-0.0010	0.9877	-0.2982	0.1769
treat*post*I ₆₊	0.0587	0.4283	0.0234	0.7579	0.6471**	0.0301
treat*post*I ₃₆₊	0.1295	0.4496			0.1972	0.6801
treat*post*I ₄₀₊	-0.2456	0.1897	-0.1115	0.2608		
treat*post*I ₆₀₊	0.0485	0.6644	0.0889	0.4404	-1.1955**	0.0387
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	no		no		no	
log-likelihood	-157,661		-143,165		-14,191	
spells	35,438		32,302		3,136	
inpatient days	1,209,650		1,076,817		132,833	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

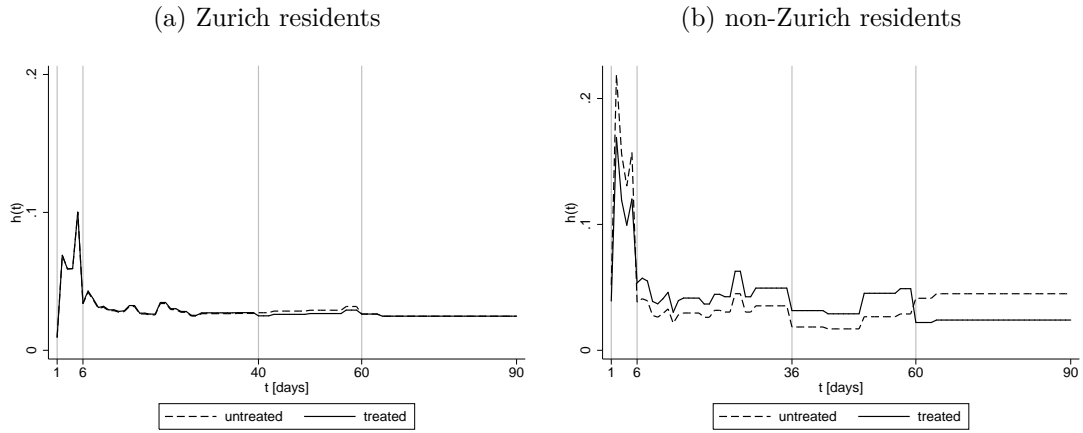


Figure 2.3: Predicted hazard functions of post-intervention spells in the intervention hospital vs. counterfactual hazard functions

reform. The hazard curves of non-Zurich residents, however, exhibit a pronounced change in shape.

6.3 Robustness tests

The robustness tests that are performed include a specification with covariates, a comparison between the complementary log-log function and the logit link function and two subgroup analyses. The short pre-intervention period does not allow a test of the vital common trend assumption. A finer temporal resolution would provide too few observations per period, particularly in the group of non-Zurich residents.

6.3.1 Model with covariates

A model with covariates is estimated to determine whether the results are influenced by compositional changes in the patient populations or by dynamic selection over length of stay. When the patient characteristics listed in table 2.2 are controlled for, the standard errors in the non-Zurich sample become smaller, and the sizes of the coefficients increase slightly (table 2.3). The coefficient of the interaction term $treat * post * I_{6+}$, however, does not change considerably, indicating that the base case results are not biased by patient selection or by "spurious" duration dependence because of unobserved heterogeneity (Lancaster, 1992, 64). Unfortunately, the effect of unobserved heterogeneity cannot be tested using a complementary log-log model with gamma frailty because the likelihood function cannot be maximized in specification (2).

6.3.2 Alternative link function

The complementary log-log link function seems particularly appropriate for the problem at hand because the dependent variable is a grouped continuous time variable (Kalbfleisch and Prentice, 2002). An alternative specification with a logit link function is estimated to examine whether the results are sensitive to the choice of the link function. As shown in table 2.3, this is not the case; the results are similar in both estimations.

6.3.3 Subgroup analyses

The results of this study are in contrast to the findings of Norton et al. (2002), who did not find a marginal price effect among patients with schizophrenia and affective disorder. A subgroup analysis by main diagnosis at discharge could reveal whether this selection of patients could explain some of the differences between my results and those of Norton et al. (2002). Indeed, the estimation among non-Zurich residents with psychotic and affective disorders (ICD-10 codes F2 and F3) produces smaller coefficients for the shift after day 6, indicating that the marginal price effect is weaker in this patient group (table 2.4).

Table 2.4: Complementary log-log estimates by diagnostic group

	full sample		Zurich residents		non-Zurich residents	
	coef.	<i>p</i> -value	coef.	<i>p</i> -value	coef.	<i>p</i> -value
schizophrenia and affective disorder (F2, F3)						
treat*post	-0.0078	0.9408	-0.0132	0.9047	-0.1309	0.7161
treat*post*I ₆₊	0.1464	0.2396	0.1483	0.2483	0.3392	0.4502
treat*post*I ₃₆₊	0.2762	0.2268			-0.0248	0.9660
treat*post*I ₄₀₊	-0.4172*	0.0903	-0.1504	0.2611		
treat*post*I ₆₀₊	-0.0234	0.8706	0.0190	0.8977	-0.9066	0.2219
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	no		no		no	
log-likelihood	-73,894		-66,951		-6,776	
spells	16,052		14,543		1,509	
inpatient days	625,824		565,785		60,039	
other diagnoses (F0, F1, F4-F9)						
treat*post	0.0297	0.6740	0.0521	0.4776	-0.1896	0.4728
treat*post*I ₆₊	-0.0186	0.8358	-0.0733	0.4237	0.6401	0.1082
treat*post*I ₃₆₊	-0.1648	0.5164			0.6536	0.4331
treat*post*I ₄₀₊	-0.0405	0.8854	-0.1951	0.1819		
treat*post*I ₆₀₊	0.1523	0.3840	0.1958	0.2777	-1.4350	0.1332
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	no		no		no	
log-likelihood	-82,819		-75,304		-7,335	
spells	19,386		17,759		1,627	
inpatient days	583,826		511,032		72,794	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A second subgroup analysis by the severity of illness, measured using the global clinical impression (CGI) at admission as a proxy for cost per day, is performed.⁵ Patients with scores between 1 and 4 are classified as moderate cases, and those with scores above 5 are considered to be severe cases. According to the model estimates in table 2.5 and the graphs in figure 2.4, the marginal price effect among non-Zurich residents is stronger in moderately ill patients. This result indicates that the payment reform does not disproportionately affect patients with greater needs.

Table 2.5: Complementary log-log estimates by severity of illness

	full sample		Zurich residents		non-Zurich residents	
	coef.	<i>p</i> -value	coef.	<i>p</i> -value	coef.	<i>p</i> -value
severe cases (CGI ^a = 5, 6, 7)						
treat*post	-0.1560*	0.0561	-0.1410*	0.0968	-0.3927	0.1901
treat*post*I ₆₊	0.1047	0.2801	0.0749	0.4512	0.5114	0.1810
treat*post*I ₃₆₊	0.1558	0.4188			0.1735	0.7441
treat*post*I ₄₀₊	-0.1942	0.3571	-0.0389	0.7365		
treat*post*I ₆₀₊	0.0474	0.7103	0.0893	0.4969	-0.3328	0.6149
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	no		no		no	
log-likelihood	-102,616		-93,502		-8,933	
spells	22,438		20,491		1,947	
inpatient days	840,137		757,010		83,127	
moderate cases (CGI = 1, 2, 3, 4)						
treat*post	-0.0628	0.4971	-0.0560	0.5605	-0.0837	0.8066
treat*post*I ₆₊	0.0121	0.9212	-0.0398	0.7518	1.0470**	0.0444
treat*post*I ₃₆₊	0.3202	0.4734			0.6559	0.5773
treat*post*I ₄₀₊	-0.2375	0.6277	0.0683	0.7719		
treat*post*I ₆₀₊	-0.1998	0.5138	-0.0095	0.9760	-5.5227***	0.0003
hospital fixed effects	yes		yes		yes	
quarterly fixed effects	yes		yes		yes	
covariates	no		no		no	
log-likelihood	-40,100		-37,351		-2,652	
spells	10,002		9,331		671	
inpatient days	231,075		213,433		17,642	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

a) Clinical Global Impression scale at admission

7 Discussion

At a time when many countries are implementing prospective payment systems for inpatient psychiatry, this study produced some interesting policy-related findings. The results indicate that the marginal revenue per inpatient day can affect length of stay and that a switch from per diem to per-case or mixed reimbursement can reduce length of stay even if the average revenue

⁵The CGI rating is an overall assessment of symptom severity by the treating physician; its scores range from 1 ("normal, not at all ill") to 7 ("extremely ill").

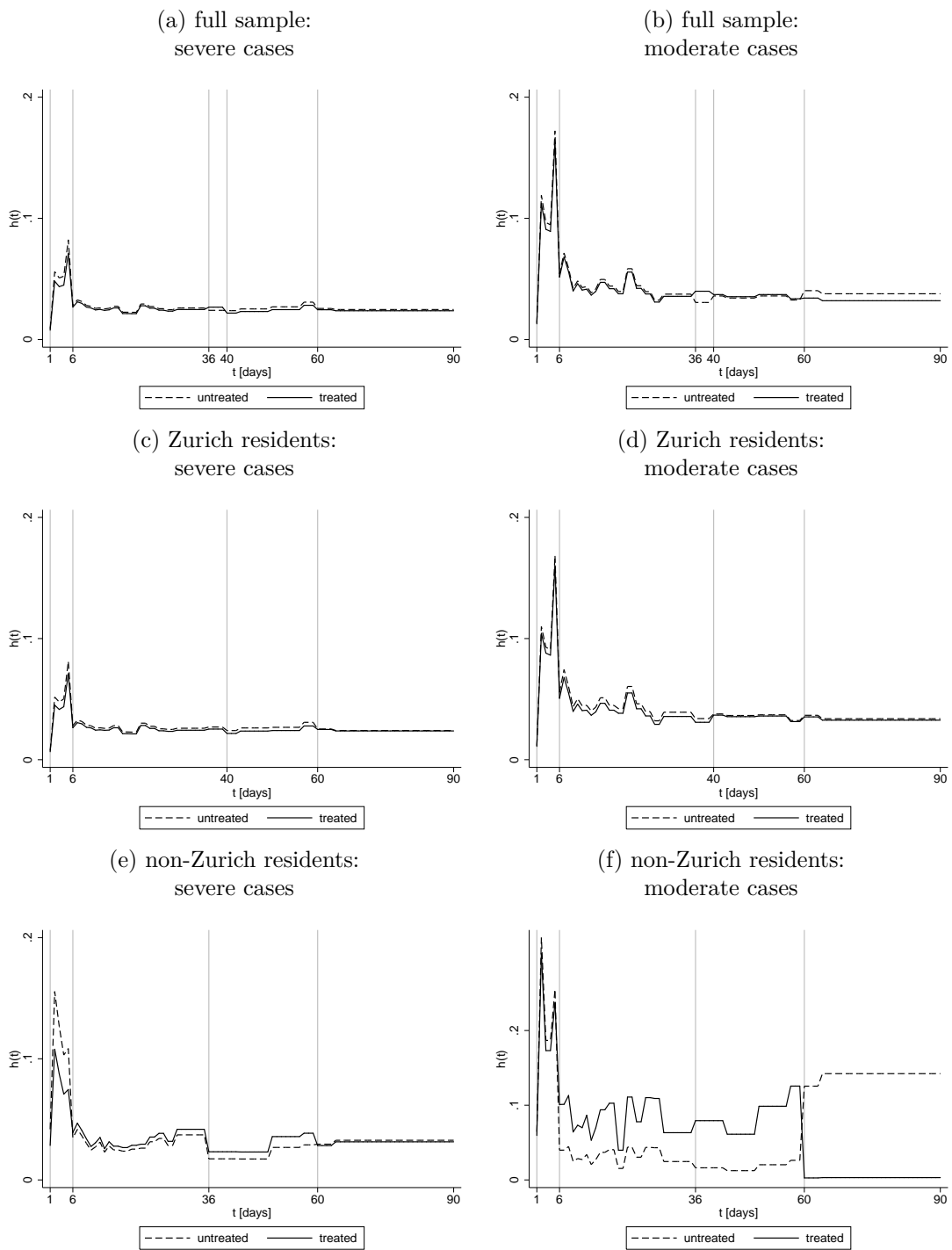


Figure 2.4: Predicted hazard functions of post-intervention spells in the intervention hospital vs. counterfactual hazard functions by severity of illness

remains similar.

A significant change in the shape of the hazard curve is found only for the subgroup of non-Zurich residents, for whom the payments by both the health insurance companies and the government were delivered as mixed tariff rates. No effect is found in the subgroup of Zurich residents for whom only health insurance rates were subject to the payment reform, and government contributions were delivered as retrospective annual payments based on accumulated losses. The difference between the Zurich and non-Zurich residents suggests that the decrease in marginal revenue must be sufficiently large to establish incentives to reduce length of stay. A small change in marginal revenue may not be a strong incentive, for example, when the management and optimization of patients' length of stay is costly. Another possible explanation for the heterogeneity in response is that simultaneous retrospective government financing could function as a disincentive for improving operational efficiency. The retrospective government financing mechanism may also be responsible for the lack of evidence of an average price effect because this mechanism allows hospitals to make negative profits if they have medical motives for treating patients longer than the tariffs allow.

The subgroup analysis produces larger estimates of the marginal price effect among moderately ill non-Zurich residents and smaller estimates among the severely ill. A stronger marginal price effect among the less severe cases suggests that the motive to make a financial profit is stronger in the treatment of moderately ill patients, whereas the motive to create medical benefit is relatively stronger in the treatment of severely ill patients. This interpretation could allay concerns that a switch to a prospective payment system particularly harms patients with greater needs.

This study also reveals differences between diagnostic subgroups. The estimated effect of the decrease in marginal revenue is smaller among the patients with psychotic (ICD-10 F2) and affective (ICD-10 F3) disorders. If this observation is generally valid, it might explain the difference between the results of this study and those of Norton et al. (2002), who did not find evidence of a marginal price effect.

The heterogeneity of the effects underlines the need for an accurate patient classification in prospective payment systems. Considering that per-case payments come at the price of a higher deviation of tariff rates from actual costs, the per-case component of a mixed tariff could be higher in more homogeneous cost groups, in which the per-case payments are closer to actual costs, and in moderately ill patients, in which incentives for a reduction in length of stay are

more effective.

The empirical model uses variations in marginal and average revenue over length of stay to test for the presence of marginal and average price effects. In the special case of the mixed Zurich system, which has a per-case payment on day 6 and a lower per diem rate thereafter, the marginal price effect is measured by testing for changes in the shape of the hazard curve over specified intervals. Note that this analysis has some limitations. The first and major limitation is that, with only one pre-intervention year, I cannot examine the pre-intervention trends to support the vital common trend assumption. Second, I do not analyze the effects of the payment reform on readmission rates or on the total number of inpatient days. However, the simultaneous policy regulation stipulating that readmissions to the intervention hospital within 30 days should be reimbursed as a continuation of the previous stay may have partially offset the incentives to increase the number of cases. Future research should shed more light on the effects of the payment reform on readmissions and the total number of inpatient days. Third, I cannot estimate the exact elasticities of length of stay with respect to marginal revenue in the cross-section because the comparison hospitals cannot be identified for legal reasons and no tariff rates can be attached to the inpatient episodes. A comparison between the presented duration approach and the elasticities estimated in the cross-section might produce some interesting methodological insights.

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Part III

Health literacy and outpatient physician visits

Abstract

Inadequate health literacy is an important contributor to health inequalities in modern health care systems. Previous studies have shown that people with inadequate health literacy use less preventive care and are more likely to be admitted to a hospital. The association between health literacy and the utilization of outpatient primary care, however, is not well covered in the literature. The objective of this study was to investigate the relationship between health literacy and the annual number of outpatient physician visits by respondents to the Swiss Health Survey using a hurdle model approach. The hurdle model made it possible to disentangle the effects of health literacy on the patients' decision to seek care and the decision concerning the number of follow-up visits made jointly by physicians and their patients. The regression analysis did not show any significant effects of health literacy on the probability to have visited a physician or the number of follow-up visits. Better-educated people, however, had fewer follow-up visits with general practitioners but were more likely to have visited a specialist. The results did not support the hypotheses that patients with inadequate health literacy need more medical care to maintain their health stock or are more likely to be influenced by their physician.

JEL-Classification: I11, I18, C21

Keywords: Health literacy, outpatient service utilization, hurdle model, Swiss health survey

1 Introduction

Inadequate health literacy is a major challenge for modern health care systems because it is associated with poor health outcomes and high health care expenditures (Berkman et al., 2004; DeWalt et al., 2004; Nielsen-Bohlman et al., 2004; Eichler et al., 2009; Spycher, 2006; Vernon et al., 2007; Berkman et al., 2004). One possible explanation for this association is different levels of health care utilization by people with inadequate health literacy. It has been shown that people with inadequate health literacy use diagnostic procedures less frequently, have lower immunization rates, are more likely to be admitted to emergency departments, and have more inpatient hospital stays. Outpatient physician visits, however, are not well covered in the literature, and most studies analyzing the effects of health literacy on service utilization are limited to specific patient groups. The objective of this study was to investigate the relationship between health literacy and outpatient physician visits in the Swiss general population using a hurdle model approach. Hurdle models make it possible to describe medical decision making as a two-fold process and to disentangle the effects of health literacy on the patients' decision to seek care and the treatment decisions made in a physician-patient interaction.

The remainder of this study is organized as follows. After a review of the existing literature

in section 2, hypotheses are formulated in section 3. The statistical methods and the dataset are described in sections 4 and 5. Section 6 includes a description of the model specification and of the results obtained from the final regression model. The empirical and practical implications of the results and possible areas for future research are discussed in section 7.

2 Literature

Health literacy can be defined as "the capacity to obtain, interpret and understand basic health information and services and the competence to use such information and services to enhance health" (United States Department of Health and Human Services, 2000). Inadequate health literacy is not just a problem of developing countries or of the very poor but is also quite prevalent in industrialized countries. A review of 85 U.S. studies found an average prevalence of inadequate health literacy of 26% (Paasche-Orlow et al., 2005a). Recent results indicate that inadequate health literacy is also a common problem in Switzerland. Twenty-five percent of the participants in a health literacy survey reported difficulties in understanding health-related information in the media (Institute of Social and Preventive Medicine, 2006). Of the participants in an UNIVOX survey, 16% believed that AIDS could be cured, and only one-third of the respondents could deduce the correct dosage schedule of aspirin from a patient information leaflet (Neck-Häberli et al., 2008).

In the following, we discuss selected studies on the relationship between health literacy and the utilization of inpatient and outpatient hospital care, emergency department visits, preventive interventions and outpatient physician visits based on a systematic review by Berkman et al. (2011) and a hand search on EconLit, PubMed and Google Scholar. Because the focus of this study was on health literacy, studies using general measures of health information or education as explanatory variables were excluded from this review.

2.1 Hospitalizations and emergency department visits

The available evidence suggests that people with inadequate health literacy use more hospital care and have more emergency department visits than people with adequate health literacy.

Howard et al. (2005) showed that Medicaid enrollees with inadequate health literacy scores in the Short Test of Functional Health Literacy in Adults (STOFHLA) were more likely to use emergency room care and had higher emergency room and inpatient care costs than those with

marginal or adequate health literacy. Cho et al. (2008) investigated the pathways connecting health literacy, health behavior, health status and health service utilization among 489 elderly Medicare patients and found that health literacy was negatively associated with hospital admissions and emergency department visits and that this relationship was not strongly mediated by health-related behavior or preventive care. Many studies have focused on chronic diseases; among patients with such diseases, differences in the propensity to use care are more likely to become observable absolute differences in the utilization of care. Paasche-Orlow et al. (2005b), for instance, investigated the correlation between STOFHLA scores and the use of hospital care in adult asthma patients and found a significantly negative correlation. Infant asthma patients included in a retrospective cohort study by DeWalt et al. (2007) had more hospital and emergency department visits if their parents' reading ability was below a ninth grade level. A study of 192 heart failure patients found that patients with low STOFHLA scores and those with a low ability to accurately read and interpret prescription labels had more heart-failure-related emergency department visits and more hospitalizations for other reasons (Murray et al., 2009). The importance of reading abilities has been confirmed by Hope et al. (2004), who found that participants in a cardiac drug trial with difficulties in reading standard prescriptions visited emergency departments more often.

2.2 Preventive interventions

Several studies have shown that individuals with inadequate health literacy use less preventive care, which can have detrimental health effects and increase future service use (Kenkel, 1994; Tian et al., 2010). A study of elderly U.S. residents showed that the likelihood of receiving an influenza vaccination or undergoing mammography was lower among respondents with poor test results in the health literacy domain of the National Assessment of Adult Literacy (Bennett et al., 2009). The authors assumed that health literacy is a mediator between sociodemographic variables and the use of preventive health services. Other studies, however, have confirmed the lower immunization rates of people with inadequate health literacy independent of individual characteristics (Scott et al., 2002; Sudore et al., 2006; Howard et al., 2005). A statistical analysis of the entire 2003 National Assessment of Adult Literacy survey dataset including more than 18,000 adults confirmed the positive association between health literacy and the use of preventive interventions such as Papanicolaou smear tests, dental checkups, vision checkups, influenza vaccinations, prostate cancer screening, mammography, osteoporosis screening and colon cancer

screening (White et al., 2008). The significance and strength of the effects, however, differed considerably by age and sex. A study of 99 participants recruited in a community health clinic in Nashville, Tennessee found that patients with inadequate health literacy scores in the Rapid Estimate of Adult Literacy in Medicine assessment were less likely to adhere to their colorectal cancer test schedule and indicated more barriers to fecal occult blood testing or colonoscopy than those with adequate health literacy.¹ Although the authors considered the results clinically relevant, they were not statistically significant. Migrant groups are of particular interest in the health literacy literature because these patients often face language barriers and know little about health and the health care system. Studies of Latinas from Philadelphia and New York showed that women with low STOFHLA scores were less likely to have ever undergone mammography or a Papanicolaou test (Guerra et al., 2005; Garbers, 2004).

2.3 Outpatient physician visits

The original literature search performed for this study in 2011 yielded only one study investigating the effects of health literacy on outpatient physician visits. Baker et al. (2004) analyzed administrative data on 3,260 U.S. Medicare managed care enrollees to assess the correlation between the participants' STOFHLA scores and the number of physician visits in the previous 12 months and did not find any significant association. This study, however, is not representative of Switzerland, as it only covered certain types of physicians and only included participants who were enrolled in a managed care health plan. After the first publication of our own study in 2012, another analysis of the dataset analyzed in our study was published. Schmid (2014) examined the relationship between health information and outpatient physician visits using a constructed measure of health information in a hurdle model regression. The analysis showed that health information did not affect the probability of having visited a physician but was negatively correlated with the number of physician visits among those who had visited a physician. The author interpreted this result as evidence of supplier-induced demand in the Swiss outpatient sector, under the assumption that better-informed patients are less prone to demand inducement.

¹The respondents could choose from the following potential barriers to colorectal cancer tests: not understanding what to do, embarrassing, time consuming, fear of finding something wrong, fear of pain, having to follow a special diet and take a laxative, cost concerns, not having problems or symptoms, possibility of bleeding or colon tearing, transportation problems.

3 Hypotheses

The objective of this study was to investigate the association between health literacy and the annual number of outpatient physician visits. Economic theory suggests several mechanisms through which health literacy can affect the annual number of outpatient physician visits. In the following, we discuss the implications of the Grossman model, the model of monopolistic competition and agency models under asymmetric information.

The Grossman model

The Grossman (1972) model regards individuals as consumers and producers of their own health as a capital good. Good health produces benefits because it increases labor market productivity and quality of life and allows people to engage in joyful activities. Individuals can invest in their health capital stock by using medical care and by spending time on healthy activities. Because people have to maintain an optimal health capital stock over their entire lifetime, the demand for health and the resulting demand for medical care are the result of a dynamic optimization of the individual's utility over a lifetime horizon. In the Grossman model, the effects of health literacy on the demand for medical care can be derived from the effects of education. First, education increases the return on good health in the labor market and thus the demand for medical care (Grossman, 1972, 8). Second, education increases the efficiency of medical care and thus decreases the quantity of care needed to maintain an optimal health stock (Grossman, 1972, 25). Health literacy should affect the demand for medical care only through its effect on the efficiency of medical care, as it is not expected to play a role in the labor market. Health literacy could make medical care more efficient because it facilitates communication with physicians, increases treatment adherence and enables patients to choose the right provider in the first place without wasting resources.

Monopolistic competition

Models of monopolistic competition are based on the assumption that physicians provide differentiated goods and thus act as local monopolists. A physician who acts as a local monopolist is not restricted by the patient's marginal willingness to pay but can make a "take-it-or-leave-it" offer that includes a price above the patient's marginal willingness to pay and a quantity beyond the patient's private optimum (McGuire, 2000). When the patient can plausibly threaten to seek care elsewhere, the physician has to lower the price or the quantity included in the "take-

it-or-leave-it" offer. If health literacy facilitates patients' efforts to search for a new physician and establish a new physician-patient relationship, health literacy can reduce the over-provision of care by the physician.

Imperfect agency under asymmetric information

Agency models describe the interaction between an ill-informed principal and a well-informed agent. The agent acts on behalf of the principal, who can not verify whether the agent used his/her knowledge in the principal's best interest or made a sufficient effort. Physician-patient interaction is a notorious example of a principal-agent relationship. In a fee-for-service reimbursement system that guarantees positive marginal returns per unit of care, the physician has incentives to provide more care than the patient would use if the patient had the same information as the physician. The better a patient can verify whether the physician's treatment decision is in his/her best interest, the more the physician has to comply with the patient's needs and the less the physician can over-prescribe care to the patient. If health literacy enables patients to assess the medical benefit of medical care, it should prevent the over-provision of care by better-informed physicians.

The theoretical models of health care demand, monopolistic competition and imperfect agency under asymmetric information lead to the following hypotheses.

***Hypothesis 1:** People with higher health literacy have lower demand for medical care.*

***Hypothesis 2:** People with higher health literacy are less prone to over-provision of care by their physicians.*

4 Methods

The empirical approach of this study builds on the study by Kenkel (1990), who used a two-part model to analyze the relationship between a direct measure of health information and the annual number of outpatient physician visits reported by 5,336 survey respondents. The direct measure of health information was constructed by the number of correct answers to questions on the symptoms associated with diabetes, heart disease, cancer and tuberculosis. The model included a probit model for the estimation of the probability of having visited a physician and a linear regression model for the estimation of the number of physician visits among patients who had visited a physician. The endogeneity of the health information variable was accounted for by the use of a first-stage instrumental variable estimation.

The two-part approach makes it possible to disentangle the effects of health information on the patients' decision to seek care and the decision concerning the number of follow-up visits made during a physician-patient interaction. The probability of a positive number of visits can be interpreted as a function of the demand for medical care, while the probability of a follow-up visit is also influenced by the physician.

The present study extends the work by Kenkel (1990) in two ways. First, we account for the discrete nature of the number of physician visits by using a count data model to estimate the number of physician visits. Second, we support the theory-driven choice of empirical model by comparing the model fit of five possible count data models using likelihood-based tests and a graphical analysis.

4.1 Count data models

Discrete count outcomes differ from normally distributed outcomes in that they must be non-negative, often follow a skewed distribution, exhibit large variability and can include many zeroes. In the presence of these characteristics, econometric models assuming normally distributed outcomes can produce inconsistent and inefficient results.

Possible models for the analysis of count data are the Poisson model (PRM), the negative binomial model with a quadratic variance term (NBRM), the zero-inflated Poisson model (ZIP), the zero-inflated negative binomial model (ZINB) and the logit-zero-truncated negative binomial hurdle model (LOG-ZTNB).² The PRM assumes that the conditional distribution of the outcome variable follows a Poisson density function, which accounts for the non-negative range and skewness of the data. A limitation of the PRM is that it assumes that the conditional variance equals the conditional mean, an assumption that is often not satisfied. In cases in which the variance is larger (overdispersion) or smaller (underdispersion) than the mean, the NBRM model is more appropriate for the data because it extends the Poisson probability density function with a quadratic variance term accounting for unobserved heterogeneity. However, both the PRM and the NBRM model are based on continuous probability density functions, which might underpredict the probability of zero outcomes when the data include many zero observations. To account for excess zeroes, the ZIP and ZINB models use a finite mixture of a binary and a count data probability density function. In ZIP and ZINB models, zero outcomes are generated by both the binary and the count data generation process, while the positive outcomes are

²The econometric models are described in detail in the appendix.

realizations of the count data generation process. Hurdle models, however, assume that zero and positive outcomes are the consequence of two separate data generation processes and that zero outcomes are only the product of a binary process. In the LOG-ZTNB model, the probability of a zero outcome is estimated by a logit regression model and the average number of counts among positive outcomes by a zero-truncated negative binomial model. While the LOG-ZTNB model is well suited to the theoretical concept of medical decision making as a two-fold process, the empirical model fit depends on the mean-variance relationship and the proportion of zero outcomes in the data.

4.2 Specification tests

The goodness of fit of the five candidate models was compared based on the log-likelihood, the Akaike information criterion (AIC), the Bayesian information criterion (BIC), the Vuong test, a test for overdispersion and a graphical analysis of the difference between the predicted and observed probability of each number of physician visits. The AIC is defined as twice the difference between the log-likelihood and the number of free parameters k in the model. The BIC is defined as the difference between twice the log-likelihood and the number of parameters k multiplied by the logarithm of the number of observations in the data n . By introducing a penalty term, the AIC and BIC require that an additional parameter increases the log-likelihood to an extent that is sufficient to justify the increased complexity of the model.

$$AIC = -2ll + 2k \tag{1}$$

$$BIC = -2ll + k \ln(n)$$

The Vuong test is based on the BIC and tests the null hypothesis that two models have the same model fit. In the present study, the Vuong test was used to evaluate whether addressing zeroes by using zero-inflated models improves the model fit significantly relative to the plain PRM and NBRM. The validity of the Poisson assumption that the conditional mean equals the conditional variance was tested by a likelihood ratio test of the hypothesis that the dispersion parameter α in the NBRM equals zero.

After the selection of the best count data model, the AIC and BIC were also used to select the control variables and specify the higher-order and interaction terms in a stepwise backward

selection process. This stepwise elimination of unnecessary variables and a conscious selection of higher-order and interaction terms was important for this study because the likelihood function could not be maximized for overly complex specifications.

5 Data

The primary data source of this study was the Swiss Health Survey 2007, a representative survey of Swiss residents aged 15 years and older who lived in private households. After an initial telephone interview, the respondents received a written questionnaire with questions that require the consultation of documents or that are too personal to be answered over the phone. The 2007 wave includes 18,760 participants, 14,432 of whom returned the written questionnaire. The Swiss Health Survey 2007 includes four questions regarding health literacy and a comprehensive set of questions covering individual health care utilization, health status, health-related behavior, health insurance and socioeconomic characteristics. The sampling weights included in the Swiss Health Survey could not be used in this analysis because the likelihood function of the hurdle model could not be maximized with sampling weights.

5.1 Dependent variables

The regression analysis was performed for the total number of outpatient physician visits, the number of visits to general practitioners and the number of visits to specialists during the previous 12 months. Female respondents were also asked about their visits to gynecologists. The consultations with gynecologists were excluded from the number of physician visits because many women undergo regular preventive examinations and receive invitations from their gynecologist, which affects the probability of having seen a physician and the number of physician visits in a way that is incompatible with the concept of the hurdle model.

Physician visits were distributed unequally in all categories (figure 3.1). A substantial proportion of respondents had not visited a physician during the previous 12 months, and a small number of respondents reported a high number of physician visits. Nearly 20% of respondents had never visited a physician, more than 30% had never visited a general practitioner and more than 60% had never visited a specialist. The average number of visits was 4.07 for any type of physician, 2.31 for general practitioners and 1.47 for specialists (table 3.1).

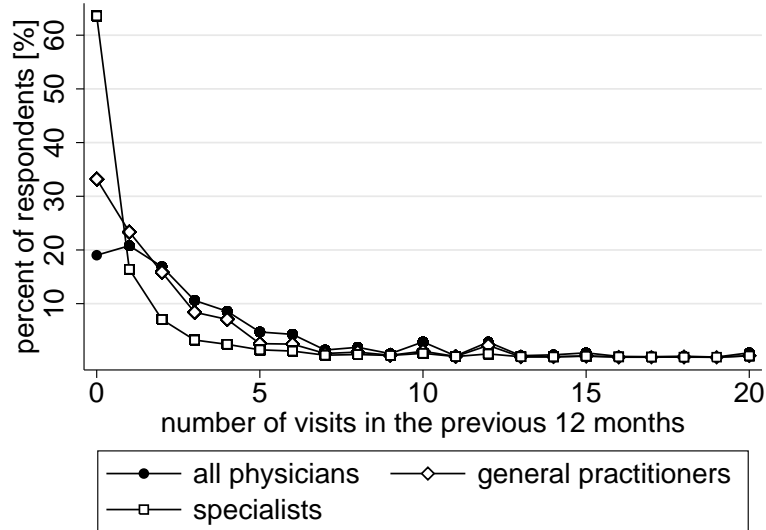


Figure 3.1: Frequency distribution of outpatient physician visits

5.2 Health literacy

The Swiss Health Survey 2007 included questions assessing the respondents' self-assessed state of knowledge in four domains of health literacy rated on a five-level scale. These domains were "personal health behavior (e.g., nutrition, physical activity)", "general consumer behavior (e.g., buying healthy food or over-the-counter drugs)", "consumer and patient behavior in the health care and insurance system (e.g., communication with a physician, choice of health plan)", and "voting behavior in health-related issues".³ Based on personal communication with Prof. Thomas Abel, one of the creators of the health literacy questions in the Swiss Health Survey, we only analyzed the self-assessed state of knowledge in consumer behavior in the health and insurance system because this variable is most likely to capture a general concept of health literacy.

Of the respondents, 53% in the study sample felt confident or very confident in their knowledge of consumer and patient behavior in the health and insurance system, 27% chose the central category, and 20% assessed their state of knowledge at the lowest two levels, indicating inadequate health literacy (figure 3.2). The prevalence of inadequate health literacy according to this definition is similar to the prevalence rates reported in other studies.

³The original wording of the health literacy questions in German, French and Italian is presented in the appendix.

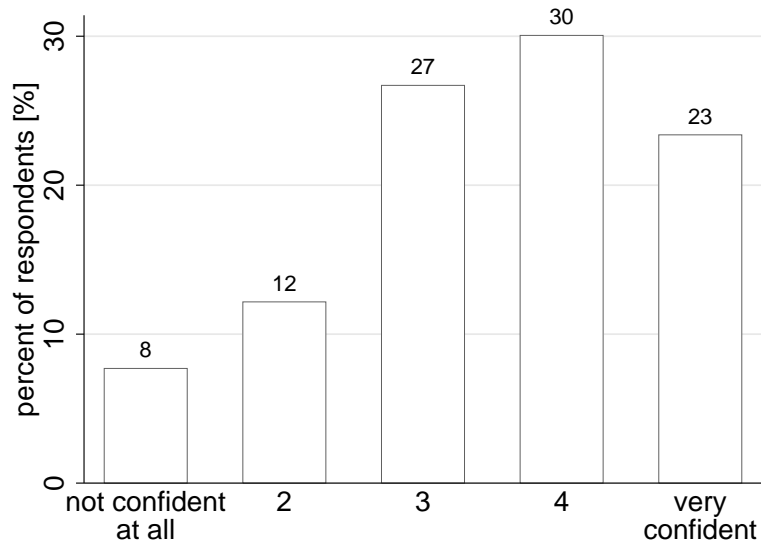


Figure 3.2: Frequency distribution of health literacy

5.3 Covariates

The covariates for the regression analysis were selected from a set of candidate variables in a stepwise backward selection procedure. The candidate variables (table 3.1) were chosen based on theoretical considerations and empirical evidence on their association with health literacy and outpatient physician visits.

Education: Education can affect the demand for medical care in two ways. First, education allows people to use medical care more efficiently, which reduces the demand for medical care. Second, education increases the return on good health in the labor market, which in turn increases the demand for medical care. Because the effect of education in the market for medical care should be captured by health literacy, the simultaneous use of health literacy and education allows us to identify the effect of education on the demand for medical care through the return on good health in the labor market. Of the respondents, 8.9% reported mandatory schooling as their highest degree, 57.9% a professional education, 3.5% an A-level degree (Matura / Baccalauréat), 9.0% a higher professional education and 20.7% a university degree (Universität / Fachhochschule).

Lifestyle: People whose "thoughts on maintaining health affect [their] lifestyle" may feel more competent in health-related topics and use medical care differently. A large majority of respondents (89.4%) reported a health-oriented lifestyle.

Age: Older people not only use more health care but also are more likely to have inadequate health literacy (Kirsch et al., 1993). The average age in our sample was 50 years.

Table 3.1: Sample means and variable description

variable	mean	description	format
docvis	4.072	number of visits to any physician	\mathbb{N}_0
gpvis	2.314	number of visits to general practitioners	\mathbb{N}_0
specvis	1.469	number of visits to specialists	\mathbb{N}_0
hl1	0.077	health literacy = 1	0,1
hl2	0.122	health literacy = 2	0,1
hl3	0.267	health literacy = 3	0,1
hl4	0.301	health literacy = 4	0,1
hl5	0.234	health literacy = 5	0,1
educ1	0.089	mandatory schooling	0,1
educ2	0.579	professional education	0,1
educ3	0.035	A-level degree	0,1
educ4	0.090	higher professional education	0,1
educ5	0.207	university degree	0,1
lifestyle	0.894	health-oriented lifestyle	0,1
age	50.355	age	[years]
sex	0.549	sex	0,1
foreign	0.096	foreign nationality	0,1
latin	0.377	French- or Italian-speaking area	0,1
urban	0.683	Residence in an urban area	0,1
spcdens	154.108	Number of specialists per 100,000 residents	\mathbb{N}_0
gpdens	45.332	Number of general practitioners per 100,000 residents	\mathbb{N}_0
pharmdens	23.637	Number of pharmacies per 100,000 residents	\mathbb{N}_0
health1	0.004	self-rated health (EHIS/MEHM) = very bad	0,1
health2	0.021	self-rated health (EHIS/MEHM) = bad	0,1
health3	0.098	self-rated health (EHIS/MEHM) = fair	0,1
health4	0.678	self-rated health (EHIS/MEHM) = good	0,1
health5	0.199	self-rated health (EHIS/MEHM) = very good	0,1
income	4.285	monthly equivalized household income	[1'000 CHF]
modalt	0.157	alternative insurance plan	0,1
dedhigh	0.672	deductible above minimum	0,1
<i>N</i>	8'704		

Sex: Because of pregnancy and gender differences in the incidence rates of various diseases, women use medical care differently from men and may also differ with respect to health literacy. As can be expected in a telephone interview, women were slightly overrepresented in our sample (54.9%).

Foreign nationality: Many studies show that inadequate health literacy is particularly prevalent among migrants (Berkman et al., 2011; Kirsch et al., 1993). Because migrants are more likely to be in medical treatment and are not familiar with the Swiss health care system (Guggisberg et al., 2011), a dummy for non-Swiss nationality was used. Foreigners were quite underrepresented in our sample, with a share of only 9.6%.

Language region: A study by Wang and Schmid (2007) showed pronounced regional differences in health literacy in Switzerland. Service utilization patterns also vary considerable across language regions (Lieberherr et al., 2010). The language region needed to be coded as a combined dummy for French- and Italian-speaking areas because the count data models did not converge with the inclusion of two separate dummies for French- and Italian-speaking areas; 37.7% of respondents lived in French- or Italian-speaking parts of Switzerland.

Urbanity: In general, health literacy and the utilization of outpatient services are both higher

in urban areas (Zahnd et al., 2009; Baschung et al., 2008). Thus, a dummy for residence in an urban area was added to the set of candidate variables; 68.3% of all respondents lived in urban areas in 2007.

Provider density: The provider density can increase the demand for medical care because physicians compensate for income losses by inducing more demand (Labelle et al., 1994) and because a high provider density reduces search costs (Pauly and Satterthwaite, 1981). We thus control for the number of general practitioners, specialists and pharmacies per 100,000 inhabitants (Swiss Federal Statistical Office, 2011). On average, the provider density in the canton of residence of the survey respondents was 154.1 specialists, 45.3 general practitioners and 23.6 pharmacies per 100,000 inhabitants.

Self-assessed health: Health can be correlated with the utilization of medical care in two opposite ways. On the one hand, the Grossman model predicts that people who maintain a high health stock need to invest more in their health (Breyer et al., 2004, 118); on the other hand, people typically use medical care when they are sick (Laporte, 2014). In the Swiss Health Survey, health was measured by the self-rated health question from the Minimum European Health Module (MEHM). Of the respondents, 87.7% rated their health as good or very good, 9.8% chose the central category, and only 2.5% reported bad or very bad health. We used the maximum health category as the baseline level because the likelihood functions of our count data models could not be maximized when the sample became "thinned out" due to very rare combinations of explanatory variables.

Income: According to Kirsch et al. (1993), individuals with low incomes are more frequently affected by inadequate health literacy, and income is known to be related to health care utilization in Switzerland (Van Doorslaer and Masseria, 2004). The income variable in the Swiss Health Survey was calculated as the monthly household income adjusted for the number of adults and children in the household. The average reported adjusted household income was CHF 4,285 per month.

Insurance plan: Health literacy may be associated with the choice of managed care health plans or higher deductibles, both of which create incentives for reducing the utilization of medical care. Two dummies indicating whether a respondent was enrolled in a managed care insurance plan or chose a deductible above the minimum size of CHF 300 for adults and CHF 0 for teenagers was used. Unfortunately, these variables could not be divided into subcategories because, in that case, the likelihood function of some count data models could not be maximized. Only 15.7%

of respondents were enrolled in an alternative health plan that restricted the consumers' choice or required them to contact a gatekeeper before visiting a physician. However, 67.2% of the respondents chose a deductible above the minimum.

6 Results

6.1 Model Specification

The model specification was performed in two steps: First, we compared the goodness of fit of five count data models for each dependent variable. Second, we assessed the benefit of higher-order terms of the two continuous variables, age and income, using the AIC.

6.1.1 Model selection

The LOG-ZTNB model fitted our data best and produced the lowest absolute values of the log-likelihood, the AIC and the BIC for all three dependent variables (table 3.2). The predicted probabilities from the LOG-ZTNB model are closer to the observed probabilities than the predicted probabilities from the other count data models (figure 3.3). A major advantage of the LOG-ZTNB model is that the predicted probability of zero outcomes from the logit model is exactly the observed proportion of zeroes in the data. The likelihood ratio test rejected the hypothesis that the dispersion parameter α in the NBRM equaled zero. A positive value of α indicated that the conditional variance of the number of physician visits was significantly larger than the conditional mean. The Vuong test suggested that addressing zeroes improved the model fit significantly, as the BIC values of the zero-inflated models were significantly smaller than those of the PRM and NBRM.

6.1.2 Higher-order terms of age and income

The AIC was also used to test whether higher-order terms of *age* and *income* improved the model fit significantly (table 3.3). According to the AIC, age should enter the models for all physicians and general practitioners in a quartic specification and the specialist model in a cubic specification. Income should enter all models in a quartic specification.

Table 3.2: Goodness of fit, Vuong test, overdispersion test

	(1) PRM	(2) NBRM	(3) ZIP	(4) ZINB	(5) LOG-ZTNB
All physicians					
ll	-33'650.53	-20'930.12	-31'611.97	-20'904.54	-20'576.87
AIC	67'339.06	41'900.24	63'299.94	41'887.08	41'231.74
BIC	67'473.42	42'041.67	63'568.66	42'162.87	41'507.53
Vuong alpha		1.02***	16.29***	3.21***	
General practitioners					
ll	-22'339.81	-16'644.42	-20'738.77	-16'628.1	-16'522.83
AIC	44'717.62	33'328.84	41'553.54	33'334.19	33'123.66
BIC	44'851.98	33'470.27	41'822.26	33'609.98	33'399.45
Vuong alpha		1.03***	15.69***	2.63***	
Specialists					
ll	-23'782.85	-11'949.98	-18'202.41	-11'895.56	-11'725.46
AIC	47'603.7	23'939.96	36'480.81	23'869.13	23'528.93
BIC	47'738.06	24'081.39	36'749.53	24'144.92	23'804.72
Vuong alpha		4.00***	16.58***	4.78***	

t-statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01

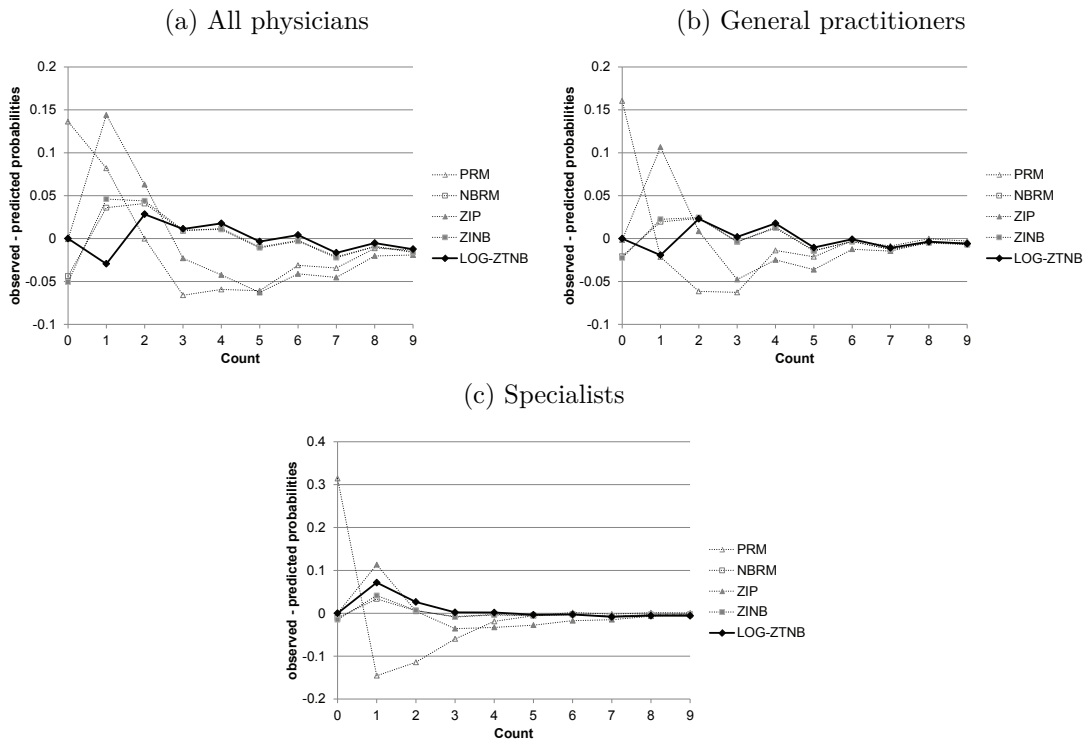


Figure 3.3: Difference between the predicted and observed probabilities of each number of physician visits

Table 3.3: Selection of higher-order terms

	All physicians		General practitioners		Specialists	
	AIC	BIC	AIC	BIC	AIC	BIC
<i>age</i>						
linear	41158.37	41471.73	39003.63	39298.83	28600.89	28922.14
quadratic	41081.07	41408.37	38906.39	39215.33	28603.03	28937.41
cubic	41081.11	41422.34	38905.87	39228.55	28583.36	28930.87
quartic	41065.79	41420.95	38887.46	39223.88	28586.35	28947.00
<i>income</i>						
linear	41158.37	41471.73	39003.63	39298.83	28600.89	28922.14
quadratic	41159.34	41479.78	39002.64	39297.84	28584.22	28905.47
cubic	41156.87	41484.17	39000.03	39308.97	28582.21	28916.59
quartic	41154.97	41482.27	38999.21	39308.15	28572.87	28907.25

Bold-face numbers designate the term that improves model fit most.

6.2 Regression results

The estimated average marginal effects suggest that health literacy is not significantly correlated with the probability of having visited a physician or with the number of physician visits among those who had visited a physician (table 3.4). The signs of the coefficients of the variables *hl3*, *hl4* and *hl5* are negative in the zero-truncated negative binomial regression of visits to all physicians and general practitioners and positive in the second-stage regression of visits to specialists. Although these signs indicate a systematic difference between people with the highest three levels of health literacy and those with lower levels, a Wald test of the joint significance of the variables *hl3*, *hl4* and *hl5* did not confirm this hypothesis.

Education is positively correlated with the probability of having visited a specialist and negatively with the number of follow-up visits to general practitioners. A possible interpretation of these results is that general practitioners more frequently refer their better-educated patients to a specialist. People who pursue a healthy lifestyle are more likely to visit a physician. Older people and women are more likely to have visited a physician and report more follow-up visits.

People living in the French- and Italian-speaking parts of Switzerland are more likely to have visited a specialist independent of the physician density. The number of follow-up visits to specialists, however, does not differ significantly across the language regions. These results suggest that residents of the French- and Italian-speaking parts of Switzerland are more likely to visit a specialist directly instead of seeking medical advice from a general practitioner first.

The results concerning provider density must be interpreted with caution because it is only measured at the cantonal level and might be correlated with other canton-level characteristics. The density of general practitioners does not affect the probability of having visited a physician or the number of follow-up visits. It is possible that the supply of general practitioners was

Table 3.4: Average marginal effects

	All physicians		General practitioners		Specialists	
	logit Pr(y>0)	ztnb E(y y>0)	logit Pr(y>0)	ztnb E(y y>0)	logit Pr(y>0)	ztnb E(y y>0)
hl2	0.0140 (0.76)	-0.2683 (-0.81)	0.0060 (0.27)	0.0728 (0.34)	0.0158 (0.70)	-0.0000 (-0.83)
hl3	-0.0120 (-0.72)	-0.0095 (-0.03)	-0.0073 (-0.37)	-0.1168 (-0.66)	0.0017 (0.09)	0.0000 (0.68)
hl4	-0.0030 (-0.18)	-0.0586 (-0.18)	-0.0130 (-0.66)	-0.0113 (-0.06)	-0.0051 (-0.26)	0.0000 (0.49)
hl5	0.0055 (0.33)	-0.0107 (-0.03)	0.0036 (0.18)	-0.2079 (-1.19)	0.0015 (0.07)	0.0000 (1.49)
educ2	0.0247 (1.39)	-0.3522 (-1.21)	0.0091 (0.46)	-0.2968* (-1.73)	0.0609*** (3.48)	-0.0000 (-1.10)
educ3	-0.0077 (-0.26)	0.1845 (0.34)	-0.0185 (-0.57)	-0.2322 (-0.72)	0.0792** (2.53)	0.0000 (0.49)
educ4	0.0283 (1.31)	0.3921 (0.99)	-0.0066 (-0.26)	-0.3383 (-1.62)	0.0874*** (3.67)	0.0000 (0.50)
educ5	0.0237 (1.22)	-0.2703 (-0.83)	-0.0125 (-0.55)	-0.5004*** (-2.58)	0.1238*** (5.89)	0.0000 (0.02)
lifestyle	0.0676*** (4.73)	0.3691 (1.57)	0.0666*** (4.00)	0.1632 (0.94)	0.0372** (2.31)	0.0000 (1.39)
age	0.0005* (1.69)	0.0008 (0.17)	0.0026*** (7.07)	0.0155*** (3.97)	0.0007* (1.84)	-0.0000 (-1.40)
female	0.1304*** (15.34)	0.3511** (2.40)	0.0170* (1.69)	0.0841 (0.84)	0.0135 (1.31)	-0.0000 (-1.37)
foreign	0.0033 (0.24)	-0.1413 (-0.66)	0.0013 (0.08)	-0.0104 (-0.07)	-0.0139 (-0.81)	-0.0000 (-1.37)
latin	0.0258* (1.93)	-0.0905 (-0.40)	0.0038 (0.23)	-0.0900 (-0.65)	0.0487*** (2.88)	-0.0000 (-0.37)
urban	0.0156* (1.67)	0.1404 (0.90)	0.0008 (0.07)	-0.0210 (-0.21)	0.0134 (1.16)	0.0000 (1.48)
gpdens	0.0002 (0.22)	-0.0026 (-0.18)	-0.0001 (-0.12)	0.0038 (0.40)	0.0006 (0.61)	0.0000 (0.52)
specdens	0.0001 (0.62)	0.0046*** (2.86)	-0.0002* (-1.85)	0.0014 (1.11)	0.0005*** (4.44)	0.0000 (0.38)
pharmdens	0.0002 (0.24)	-0.0230** (-2.48)	0.0011 (1.45)	-0.0166** (-2.47)	-0.0013* (-1.80)	0.0000 (0.28)
health1	0.0000 (.)	12.2299*** (3.73)	0.0000 (.)	6.9038*** (3.96)	0.4312*** (5.18)	0.0000 (1.32)
health2	0.2464*** (21.11)	12.4899*** (9.30)	0.3065*** (10.65)	6.8161*** (7.83)	0.5390*** (16.81)	0.0000* (1.89)
health3	0.1844*** (13.11)	4.9071*** (12.59)	0.2705*** (14.74)	2.9404*** (12.57)	0.3090*** (15.03)	0.0000** (1.97)
health4	0.0602*** (5.41)	1.1171*** (10.90)	0.1002*** (7.73)	0.7480*** (10.95)	0.0935*** (7.67)	0.0000* (1.83)
income	0.0103*** (3.97)	0.0337 (0.75)	0.0075** (2.49)	-0.0404 (-1.19)	0.0201*** (6.60)	0.0000 (0.20)
modalt	0.0173 (1.61)	-0.4538*** (-2.64)	0.0360*** (2.79)	-0.2814*** (-2.72)	-0.0295** (-2.15)	-0.0000** (-1.99)
dedhigh	-0.0667*** (-7.62)	-0.7320*** (-4.76)	-0.0827*** (-7.65)	-0.3556*** (-3.47)	-0.0763*** (-6.72)	-0.0000* (-1.72)
N	8'670	7'048	8'670	5'814	8'704	3'169

t-statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01.

Marginal effects in the logit estimation are changes in the expected probability of positive use in percentage points. Marginal effects in the ZTNB estimation reflect the change in the expected number of visits.

†All 34 individuals with very poor health have seen a general practitioner and are thus dropped.

so high that variation in the density of general practitioners did not affect demand through an availability effect.

The density of specialists is positively correlated with the probability of having visited a specialist and negatively correlated with the probability of having visited a general practitioner. The number of visits to specialists, however, is not affected by the density of specialists. This result is in line with the hypothesis that a higher provider density reduces the search costs but not with the hypothesis of supplier-induced demand by specialists. The number of visits to all physicians, however, was positively correlated with the density of specialists, which suggests that general practitioners induce more demand when they lose patients to specialists.

In cantons with a higher density of pharmacies, people are less likely to have visited a specialist and have fewer follow-up visits to general practitioners. Among those who have visited a physician, a higher density of pharmacies is associated with fewer physician visits. The density of pharmacies could be correlated with the regulation of self-dispensation, which was not controlled for in this study.

Self-assessed health is negatively associated with the utilization of outpatient physician care. This result supports the hypothesis that people mostly use medical care when they are sick (Laporte, 2014).

Income is positively correlated with the probability of having visited a physician but not with the number of follow-up visits. The positive effect of income on the demand for physician visits could be the consequence of a higher return on good health in the labor market. The difference between the effects of income at the intensive and extensive margins may be associated with the minimum deductible of CHF 300 stipulated by the Swiss Health Insurance Act. While the first visit is likely to be paid for by the patients themselves, the deductible is satisfied after one or two consultations, and the patients only have to pay 10% of the costs of care. This explanation for the heterogeneity of the effects of income seems plausible in the face of the negative effect of higher deductibles on the utilization of outpatient physician care.

People who are insured in a managed care plan with either restricted choice of providers or the obligation to contact a gatekeeper before seeing a physician have significantly fewer follow-up visits when they are in treatment. This can be regarded as the savings due to the case management by the managed care organization. Respondents who are enrolled in a managed care health plan are also more likely to have seen a general practitioner and less likely to have seen a specialist because many managed care health plans require patients to visit a general

practitioner before they can use the services of a specialist.

7 Discussion

This study sought to investigate the effects of health literacy on the utilization of outpatient physician visits. The hurdle model approach allowed us to disentangle the effects of health literacy on the patients' decision to seek care and on the number of follow-up visits determined in an interaction between physicians and their patients. Health literacy did not show any significant effects on the utilization of outpatient physician visits, neither at the intensive nor at the extensive margin. Our results do not confirm the hypotheses that better-informed patients have lower demand for medical care and are less prone to demand inducement by physicians. We do find, however, evidence that better-educated people have higher demand for medical care. This finding is in line with the hypothesis from the Grossman model that better-educated people have higher demand for medical care because they experience higher returns on good health in the labor market.

The results of this study differ from those obtained by Schmid (2014), who investigated the association between health information and outpatient physician visits using the same dataset and the same count data model. His analysis showed that a high level of health information did not affect the probability of visiting a physician but decreased the number of follow-up visits among those who had visited a physician. The author assumed that better-informed people are less prone to demand inducement and interpreted this finding as evidence of supplier-induced demand in the Swiss outpatient sector. The present study differs from Schmid (2014) in two important respects. First, the focus of this study was on health literacy and not health information in general. Because of this focus, we only used the health literacy variable indicating the respondent's knowledge in the domain of "consumer and patient behavior in the health care and insurance system (e.g., communication with the physician, choice of health plan)" and examined the entire range of the self-assessed knowledge in patient behavior. Schmid (2014) constructed a binary measure of health information based on four health literacy variables and the respondents' opinion about the importance of critically questioning health information in the media. This measure only identifies the best-informed individuals and combines questions that are not directly related to the physician-patient interaction. Second, we sought to develop a parsimonious model, which was necessary to estimate all candidate count data models by

maximum likelihood, while Schmid (2014) used an extensive set of covariates to ensure that the effects of health information were not biased by omitted variables. A re-analysis of our model using the binary information variable proposed by Schmid (2014) produced the same results as our base case model, which indicates that the difference between our results and those of Schmid (2014) is rooted in the selection of the control variables.

In this study, we supported the theory-driven choice of the hurdle model with an empirical assessment of the model fit and specified the independent variables using likelihood-based tests. Note that this study has some limitations. First, the relatively small set of control variables could have led to omitted variable bias in the coefficient of the health literacy variable. Second, we did not account for the endogeneity of the health literacy variable because the likelihood function of the model could not be maximized when the residuals from a first-stage instrumental variable estimation of health literacy were used as covariates. Third, we did not control for possible interdependence of the visits to general practitioners and specialists.

Future research could focus on the interrelation among different services, on services that are known to be over- or under-used and on the contribution of health literacy to health inequalities in Switzerland. The interrelation among different types of services could be analyzed using simultaneous equation GMMs. Such analyses could reveal whether a conscious use of preventive interventions and outpatient services can prevent emergency admissions and inpatient stays (Windmeijer and Santos Silva, 1997). Examples of services that are potentially over-used in Switzerland include cesarean section deliveries, knee and hip arthroplasties and diagnostic imaging procedures. The contribution of health literacy to inequalities in health, medical service use and health care expenditures could be analyzed using inequality decomposition techniques (O'Donnell et al., 2008).

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Appendix

Original wording of the health literacy questions (SHS 2007)

German: Man hört häufig, dass das Gesundheitssystem immer komplizierter wird. Haben Sie das Gefühl, dass Sie genug wissen, um sich darin sicher zu bewegen? Wie sicher würden Sie sich in den vier nachstehenden Bereichen einschätzen:

1. Persönliches Gesundheitsverhalten (z.B. Ernährung, Bewegung)
2. Konsumverhalten (z.B. Einkauf gesunder Nahrungsmittel, Nahrungszusatzpräparate, frei verkäufliche Medikamente)
3. Konsumenten- und Patientenverhalten im Gesundheits- und Versicherungssystem (z.B. Wahl der Krankenversicherung, Kommunikation mit dem Arzt)
4. Als Bürger/in bei Abstimmungen zu Gesundheitsfragen

French: On entend souvent dire que le système de santé devient de plus en plus compliqué. Avez-vous le sentiment de le connaître suffisamment pour vous y retrouver ? Comment décririez-vous votre niveau de connaissances dans les quatre domaines suivants:

1. Comportement individuel en matière de santé (p.ex. alimentation, exercice physique)
2. Habitudes de consommation (p.ex. achat d'aliments bons pour la santé, de compléments alimentaires, médicaments en vente libre)
3. Comportement en tant que consommateur et patient face au système de santé et aux assurances (p.ex. choix de l'assurance-maladie, communication avec le médecin)
4. Connaissances en tant que citoyen(ne) lors de votations concernant le domaine de la santé

Italian: Spesso si sente dire che il sistema sanitario diventa sempre più complicato. Le sembra di avere conoscenze sufficienti per muoversi in modo competente in questo ambito? Quanto si considera sicuro nei seguenti quattro ambiti:

1. Comportamento personale nei confronti della salute (ad es. alimentazione, movimento)
2. Comportamento in materia di consumi (ad es. acquisto di cibi sani, integratori, medicinali in vendita libera)

3. Comportamento quale consumatore e paziente nei confronti del sistema sanitario e assicurativo (ad es. scelta dell'assicurazione malattie, comunicazione con il medico)
4. Competenza in occasione di votazioni inerenti a tematiche sanitarie

Count data models

The Poisson regression model

The probability density function of a Poisson-distributed random count variable y is defined by the mean $\mu = E[y]$.

$$\Pr(y|\mu) = \frac{\exp(-\mu)\mu^y}{y!} \quad (2)$$

The Poisson density function implies that the variance of y equals its mean.

$$\text{var } y = \mu \quad (3)$$

To control for the sources of heterogeneity in a set of observed values of y_i , the relationship between individual characteristics \mathbf{x}_i and the individuals' expected values μ_i can be modeled using an exponential link function.

$$\mu_i = E(y_i|\mathbf{x}_i) = \exp(\mathbf{x}_i\boldsymbol{\beta}) \quad (4)$$

The probability that an individual i with characteristics x_i exhibits a certain count outcome y_i is given by the probability density function (2), and the associated likelihood function of a set of observations is

$$L(\boldsymbol{\beta}|\mathbf{y}, \mathbf{X}) = \prod_{i=1}^N \Pr[y_i|\mu_i] = \prod_{i=1}^N \frac{\exp(-\mu_i)\mu_i^{y_i}}{y_i!} \quad (5)$$

The negative binomial 2 regression model

The Poisson regression model is based on the assumption that the conditional mean of a count data variable equals the conditional variance. In most practical applications, however, the conditional variance is greater (overdispersion) or smaller (underdispersion) than the conditional mean, and hence, the estimates from a Poisson regression are inefficient (Gourieroux et al., 1984). In the presence of overdispersion, the standard errors from the Poisson regression model are too small (Cameron and Trivedi, 1986).

The following derivation of the negative binomial regression model is motivated by the introduction of *unobserved heterogeneity* as a source of overdispersion (Long, 1997). While the conditional mean in the Poisson regression model is given by $\mu = \exp(\mathbf{x}\boldsymbol{\beta})$, the conditional mean in the negative binomial regression model is represented by the random variable $\tilde{\mu}$, which includes a random error term ε that is assumed to be uncorrelated with \mathbf{x} . The error term accounts for the observed difference between the conditional variance and the conditional mean and allows us to control for *unobserved heterogeneity* from sources other than the variables included in the model.

$$\begin{aligned}
\tilde{\mu}_i &= \exp(\mathbf{x}_i\boldsymbol{\beta} + \varepsilon_i) \\
&= \exp(\mathbf{x}_i\boldsymbol{\beta}) \exp(\varepsilon_i) \\
&= \mu_i \exp(\varepsilon_i) \\
&= \mu_i \delta_i
\end{aligned} \tag{6}$$

Because δ_i is not observed in the data, the probability density function $\Pr(y|\mathbf{x}, \delta)$ cannot be computed directly. However, the probability density function $\Pr(y_i|\mathbf{x}_i)$ can be computed as the joint probability density function of $\Pr(y|\mathbf{x}, \delta)$ and the probability density function of the error term $g(\delta_i)$. The most common functional form of $g(\delta_i)$ is a gamma distribution with a shape parameter v .

$$g(\delta_i) = \frac{v^v}{\Gamma(v)} \delta_i^{v-1} \exp(-\delta_i v) \text{ for } v > 0 \tag{7}$$

$$\text{where } \Gamma(v) = \int_0^\infty t^{v-1} \exp(-t) dt$$

The probability density function $\Pr(y|\mathbf{x})$ is defined as the average of $\Pr(y|\mathbf{x}, \delta)$ for all possible values of δ weighted by the probability $g(\delta)$ of each value of δ .

$$\begin{aligned}
\Pr(y_i|\mathbf{x}_i) &= \int_0^\infty [\Pr(y_i|\mathbf{x}_i, \delta) \times g(\delta)] d\delta \\
&= \frac{\Gamma(v_i + y_i)}{\Gamma(v_i)\Gamma(y_i + 1)} \left(\frac{v_i}{v_i + \mu_i}\right)^{v_i} \left(\frac{\mu_i}{v_i + \mu_i}\right)^{y_i} \\
&= \frac{\Gamma(\alpha^{-1} + y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i}
\end{aligned} \tag{8}$$

$$\text{for } v_i = \alpha^{-1} \text{ and } \alpha > 0$$

The conditional variance of a variable that is distributed according to the probability density function (8) equals the conditional mean μ_i plus a quadratic term μ_i^2 multiplied by the dispersion parameter α . Positive values of α indicate *overdispersion*, and negative values indicate *underdispersion*. In the case of $\alpha = 0$, the negative binomial probability density function reduces to the Poisson probability density function. In a regression analysis, the estimate of α can thus serve as a test for *overdispersion*.

$$\text{Var}(y_i|\mathbf{x}) = \mu_i \left(1 + \frac{\mu_i}{\alpha^{-1}}\right) = \mu_i(1 + \alpha\mu_i) = \mu_i + \alpha\mu_i^2 \quad (9)$$

The negative binomial regression model can be estimated by maximum likelihood

$$\begin{aligned} L(\boldsymbol{\beta}|\mathbf{y}, \mathbf{X}) &= \prod_{i=1}^N \text{Pr}(y_i|\mathbf{x}_i) \\ &= \prod_{i=1}^N \frac{\Gamma(\alpha^{-1} + y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i} \end{aligned} \quad (10)$$

where $\mu = \exp(\mathbf{x}\boldsymbol{\beta})$.

The zero-inflated Poisson model

When the data include many observations of zero outcomes, the Poisson and negative binomial regression models tend to underpredict the probability of zero. In such cases, a finite mixture of a binary and a count data density function may fit the data better. In a finite mixture model, the zero outcomes are the consequence of two processes. One process determines the number of observed events, and a second process determines whether the outcome is positive. A finite mixture describes the data generation process well when the data include two groups of individuals. In the "zeroes-only" group, only zeros are realized, while in the "count" group, zeros and positive outcomes are realized. If the probability of being in the "zeros-only" group is determined by individual characteristics \mathbf{x}_i , the model is called a zero-inflated model (Lambert, 1992; Greene, 1994). In the zero-inflated Poisson model, the zeros can be generated by a Poisson process and by a second process determined by a logit or a probit function.

Let the outcome in the "count" group follow a Poisson density function.

$$\text{Pr}(y_i|\mathbf{x}_i) = \frac{\exp(-\mu_i)\mu_i^{y_i}}{y_i!} \quad (11)$$

The probability that we observe a zero outcome in the "count" group is given by

$$\Pr(y_i = 0|\mathbf{x}_i) = \exp(-\mu_i) \quad (12)$$

The probability of being in the "zeros-only" group is determined either by a logistic or a normal cumulative density function ψ .

$$\psi_i = F(\mathbf{z}_i\boldsymbol{\gamma}) \quad (13)$$

In the zero-inflated Poisson model, the variables z that determine the cumulative density function ψ need to be the same as the x 's in the Poisson model. A further restriction is that the parameters γ in the binary model are assumed to be multiples of the parameters β in the count model. Thus, the cumulative density function is determined by the variables x and the parameters β from the Poisson model and by the scalar τ .

$$\psi_i = F(\mathbf{x}_i[\tau\boldsymbol{\beta}]) \quad (14)$$

Although the assumption that the two data generation processes share the same parameters makes the zero-inflated models quite parsimonious, it is difficult to imagine a real-life application in which the parameters in the binary process are mere multiples of the parameters in the count process.

The probability of observing a zero (15) is the sum of the probability of being in the "zeros-only" group and the probability that the count process in the "count" group results in a zero. The probability of any positive outcome (16) is governed by the count process alone, given that the individual is not in the "zeros-only" group.

$$\Pr(y_i = 0|\mathbf{x}_i) = \psi_i + (1 - \psi_i) \exp(-\mu_i) \quad (15)$$

$$\Pr(y_i|\mathbf{x}_i) = (1 - \psi_i) \frac{\exp(-\mu_i) \mu_i^{y_i}}{y_i!} \text{ for } y_i > 0 \quad (16)$$

The likelihood function of the ZIP model is the product of individual probability functions ((15)) and ((16)), which depend on the observed number of counts (Greene, 1994).

$$L(\boldsymbol{\beta}, \boldsymbol{\gamma}|\mathbf{y}, \mathbf{X}, \mathbf{Z}) = \prod_{i=1}^N \Pr(y_i|\mathbf{x}_i, \mathbf{z}_i) \quad (17)$$

The zero-inflated negative binomial 2 model

The zero-inflated negative binomial model can be derived analogously to the zero-inflated Poisson model as a finite mixture of a binary density function and a negative binomial density function. The probability of $y = 0$ in the negative binomial density function is given by $(1 + \alpha\mu_i)^{-\alpha^{-1}}$. The sum of the probability of being in the "zeros-only" group and the probability of a zero outcome in the "count" group is therefore given by

$$\Pr(y_i = 0|\mathbf{x}_i) = \psi_i + (1 - \psi_i)(1 + \alpha\mu_i)^{-\alpha^{-1}} \quad (18)$$

and the probability density function of positive realizations of y is given by

$$\Pr(y_i|\mathbf{x}_i) = (1 - \psi_i) \frac{\Gamma(\alpha^{-1} + y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i} \text{ for } y_i > 0 \quad (19)$$

Zero-inflated models can be estimated by maximum likelihood (Greene, 1994).

$$L(\boldsymbol{\beta}, \boldsymbol{\gamma}|\mathbf{y}, \mathbf{X}, \mathbf{Z}) = \prod_{i=1}^N \Pr(y_i|\mathbf{x}_i, \mathbf{z}_i) \quad (20)$$

The logit-zero-truncated negative binomial 2 model

It is often assumed that the utilization of medical care is determined in a two-step process (Winkelmann, 2004; Gurmu, 1997; Howard et al., 2005; Mullahy, 1998; Salinas-Rodriguez et al.,

2009). The patient makes the decision to seek medical care, while the decision concerning further treatment is made jointly by the patient and physician. This idea motivates the use of a hurdle model. In a hurdle model, the zero outcomes are the consequence of a binary process alone, while the positive outcomes are the consequence of a zero-truncated count process. In contrast to the zero-inflated models, the variables in the binary model of a hurdle model are allowed to differ from the variables in the truncated count model.

The first part models the probability that the outcome is zero, $\Pr(y = 0) = f_1(0)$, according to the density function $f_1(\cdot)$. Provided that the outcome is positive, the positive counts come from the truncated density function $f_2(y|y > 0) = \frac{f_2(y)}{1 - f_2(0)}$, which is the probability of a certain outcome divided by the probability that the density function $f_2(\cdot)$ results in a positive value. To ensure that the sum of the probabilities of all possible outcomes sum to one, the truncated density function $f_2(y|y > 0)$ needs to be multiplied by the probability that the binary process results in a positive outcome, $\Pr(y > 0) = 1 - f_1(0)$. Thus, our model takes the form

$$g(y) = \begin{cases} f_1(0) & \text{if } y = 0, \\ \frac{1 - f_1(0)}{1 - f_2(0)} f_2(y) & \text{if } y \geq 1 \end{cases} \quad (21)$$

In the LOG-ZTNB hurdle model, the probability of having a positive number of counts is estimated by a logistic regression model and the expected number of counts, provided that a positive number of counts is observed, by a zero-truncated negative binomial 2 function. In the presence of over- and underdispersion, the use of a negative binomial density function is very important because the zero-truncated Poisson distribution would be not only inefficient but also inconsistent (Winkelmann and Zimmermann, 1995; Grogger and Carson, 1991).

Binary part

In the logit regression model, positive outcomes can be seen as a realization of a Bernoulli-distributed random variable Y_i that produces a positive number of counts with probability p_i and a zero with probability $1 - p_i$.

$$P(Y_i = y_i) = p_i^{y_i} (1 - p_i)^{1 - y_i} \quad (22)$$

In the logit model, the response between the linear predictors and the odds is modeled multiplicatively.

$$\frac{p_i}{1 - p_i} = \exp(x'_i \beta) \quad (23)$$

This can be reformulated to solve for p_i .

$$p_i = \frac{\exp(x'_i \beta)}{1 + \exp(x'_i \beta)} \quad (24)$$

The likelihood function of the binary part for i independent binomial observations is the product of the associated probability density functions ((22)).

$$\mathcal{L}(y, p) = \prod [p_i^{y_i} (1 - p_i)^{1 - y_i}] \quad (25)$$

Conditional part

If the positive counts follow a negative binomial distribution, the associated random variable y takes the probability distribution

$$\Pr(y_i | \mathbf{x}_i) = \frac{\Gamma(\alpha^{-1} + y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i} \right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i} \right)^{y_i} \quad (26)$$

The probabilities of zero and positive outcomes are

$$\Pr(y_i = 0 | \mathbf{x}_i) = (1 + \alpha \mu_i)^{-\alpha^{-1}}$$

and (27)

$$\Pr(y_i > 0 | \mathbf{x}_i) = 1 - (1 + \alpha \mu_i)^{-\alpha^{-1}}$$

The conditional probability of each positive outcome given that the outcome is positive is

computed using the law of conditional probability: $Pr[A|B] = Pr[A \text{ and } B]/Pr[B]$.

$$\Pr(y_i|y_i > 0, \mathbf{x}_i) = \frac{\frac{\Gamma(\alpha^{-1} + y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i}}{1 - (1 + \alpha\mu_i)^{-\alpha^{-1}}} \quad (28)$$

The conditional mean is given by

$$E(y|y_i > 0, \mathbf{x}_i) = \frac{\mu_i}{\Pr(y_i > 0|\mathbf{x}_i)} \quad (29)$$

The estimation of the zero-truncated negative binomial model involves the maximization of the log of the likelihood function (30) based on the conditional probability from (28).

$$L(\boldsymbol{\beta}, \alpha|\mathbf{y}, \mathbf{X}) = \prod_{i=1}^N \Pr(y_i|y_i > 0, \mathbf{x}_i) \quad (30)$$

The expected number of counts is jointly determined by the probability of positive outcomes and the conditional mean (29). The marginal effects can be obtained from the derivation of this function.

$$E(y|\mathbf{x}) = \Pr(y > 0|\mathbf{x})E(y|y > 0, \mathbf{x}) \quad (31)$$

Part IV

The effects of organized screening programs on the demand for mammography in Switzerland

Abstract

The objective of this study is to estimate the causal effect of organized mammography screening programs on the proportion of women between 50 and 69 years of age who have ever used mammography. We exploit the gradual implementation of organized screening programs in 9 Swiss cantons using a difference-in-difference approach. An analysis of 4 waves of the Swiss Health Survey shows that 3.5 to 5.4 percentage points of the 87.9% utilization rate in cantons with screening programs in 2012 can be attributed to these organized programs. This relatively small effect indicates that some women's non use of mammography is not the consequence of a lack of information or financial barriers to access to care.

JEL-Classification: I11, I18

Keywords: mammography, screening, Switzerland, difference-in-difference

1 Introduction

Breast cancer is the most frequent cancer affecting women in Switzerland (Swiss Federal Statistical Office, 2011). Because it can develop earlier than other types of cancer, it is the greatest cause of death in women under 70 years old. Mammography is a type of low-energy X-ray that examines the human breast, and it is currently the most common technique for the detection of breast cancer in industrialized countries (Perry et al., 2008). Many European countries have implemented organized mammography screening programs with the aim of detecting neoplasms at an early stage when medical treatment is more effective (Morrison, 1992). In this study, we investigate the effects of organized mammography screening programs on the probability of having ever used mammography.

A study analyzing the effects of organized mammography screening programs requires a clear definition of screening mammography. Mammography can be used for screening purposes in women who have no signs or symptoms of cancer and for diagnostic purposes after a sign or history of cancer. Screening mammography can occur within an organized program or as opportunistic screening initiated by a woman or a physician. In this paper, we compare organized screening programs to opportunistic screening according to the definitions in table 4.1.

Table 4.1: Definitions of screening and diagnostic mammography (Zwahlen et al., 2004; Perry et al., 2008; Vainio et al., 2002)

Organized mammography screening

Organized mammography screening programs are public health interventions designed for the systematic early detection of malignomas in a well-defined target population. Organized mammography screening programs include periodic invitations to all women in the target population and quality-assured examinations. The interval of the screening should be chosen such that a new tumor can be detected although it has not yet become symptomatic (Zelen and Feinleib, 1969). European guidelines recommend a screening mammography every two years between the ages of 50 and 69 (Perry et al., 2008). Within an organized screening program, access to care should be guaranteed at no cost for women in the target population. Monitoring of the utilization of screening and of clinical outcomes is an important element of organized screening programs.

Opportunistic mammography screening

Opportunistic mammography screening refers to the use of mammography by asymptomatic women who have not received an invitation letter. Opportunistic mammography screening may be initiated by a patient or by a physician. In contrast to organized screening programs, opportunistic mammography screening is not necessarily monitored or checked for quality. In the absence of an organized program, cost-free access to care may not be guaranteed for women with no signs of cancer.

Diagnostic mammography

Diagnostic mammography is performed after a suspicious screening mammogram or if a woman shows some sign of cancer. Diagnostic mammography is usually done more carefully than screening mammography and is often followed by an ultrasound examination, magnetic resonance imaging or a biopsy (Smith et al., 2007). In Switzerland, only one of five women receiving a mammography in 2012 did so for diagnostic purposes (Swiss Federal Statistical Office, 2014).

2 Literature

The effectiveness of an organized mammography screening program to prevent breast cancer-related deaths depends on the effect of the organized program on screening uptake, the diagnostic accuracy of the procedure and the achieved reduction in breast cancer-related mortality. Most studies evaluating mammography screening focus on the effects of the procedure in the screened population or, equivalently, the *number needed to screen* (NNS) to prevent one breast cancer-related death. The NNS is a relevant outcome when mammography is compared to other diagnostic technologies for the detection of breast cancer in asymptomatic women. A comparison between organized mammography screening programs and opportunistic screening, however, should consider the *number needed to invite* (NNI) to prevent one breast cancer-related death. The NNI is generally lower than the NNS because it not only depends on absolute risk reduction in the screened population but also relies on the ability of organized screening programs to motivate women to participate (Broeders et al., 2012). The effects of organized screening programs on screening rates are therefore critical to engaging in an informed debate about the benefits of these programs.

The diagnostic accuracy of mammography is measured by the number of correctly detected positive and negative cases of breast cancer. A recent systematic review reported a rate of sensitivity (true positive rate) between 64% and 67% and specificity (true negative rate) between 85% and 97% (Robertson et al., 2011). Hence, mammography produces a considerable number

of false positive and false negative diagnoses. Over a 10-year period, 49% of all screened women receive a false positive diagnosis (Elmore et al., 1998). In addition, mammography detects neoplasms that would never cause problems (overdiagnoses). The consequences of false positive diagnoses and overdiagnoses are anxiety, higher costs and damage from interventions for benign and non-obligate precursor lesions (Gram and Slenker, 1992; Lerman et al., 1991; Jørgensen and Gøtzsche, 2009). False negative diagnoses, by contrast, lead to undertreatment of neoplasms associated with higher mortality and treatment costs.

The absolute reduction of the risk of breast cancer-related deaths depends on the relative risk reduction that results from mammography screening and on the absolute risk of breast cancer-related deaths in the screened population. A systematic review of randomized trials estimated a 20-35% reduction in breast cancer mortality in the screened population at 14 years follow-up (Elmore et al., 2005). The most recent Cochrane review by Gøtzsche and Jørgensen (2013) reported a pooled relative risk reduction of only 19% over 13 years. The authors showed that the reviewed studies were biased in favor of screening because they misclassified the cause of death and that studies with inappropriate randomization tend to report higher risk reductions. Although a relative risk reduction of approximately 20% appears impressive at first sight, it translates into a modest absolute risk reduction considering the low absolute breast cancer mortality rate. With a 3% cumulative risk that a 40-year-old woman will die from breast cancer, a biennial screening between the ages of 50 and 69 saves only 2.2 lives per 1,000 screened women (Hendrick and Helvie, 2012). This small benefit comes at a cost: for every life saved, 10 healthy women will be treated unnecessarily, and more than 20% of the screened women experience psychological distress (Gøtzsche and Jørgensen, 2013).

The effect of an organized program on mammography uptake is the difference between the observed screening rate in the target population and the counterfactual screening rate in the absence of the program in the same population. To the best of our knowledge, there is only one study investigating the effects of organized screening programs on mammography use in a representative population survey in Europe. Wübker (2014) assessed the effects of organized screening programs on the proportion of regularly screened women in 13 European countries on the basis of the SHARE dataset. He estimated that screening programs explain a large proportion of the variation in screening rates between countries and concluded that organized programs are effective in increasing the screening rate. Although Switzerland was included in the analyzed dataset, the study did not allow for conclusions regarding the effects of cantonal screening pro-

grams in Switzerland, and the reported statistical associations could not be interpreted causally because of the cross-sectional design of the study.

The objective of our study is to estimate the effects of organized screening programs on Swiss women's propensity to begin using mammography. In the first step, we exploit the gradual implementation of organized mammography screening programs in 9 Swiss cantons to estimate their causal effects using a difference-in-difference framework. In the sensitivity analysis, we relax the assumption of a common trend in the participation rate between screening and non-screening cantons and use women between 40 and 49 years of age as an additional comparison group in a difference-in-difference-in-difference specification.

3 Policy background

Breast cancer accounts for approximately one third of all newly detected neoplasms among women in Switzerland (figure 4.1a) (National Institute for Cancer Epidemiology and Registration, 2015b). The incidence rate in the general female population increased continuously between 1988 and 2012 (figure 4.1b). One reason for this trend was the pronounced increase in the age group of 60- to 69-year-old women between the years 1988 and 2000. The Italian and French speaking (latin) regions of Switzerland exhibited higher cancer incidence rates than the German speaking region throughout the entire period of 1988 - 2012. An estimated number of 32'643 patients lived with an up to ten year old diagnosis of breast cancer in 2015 (National Institute for Cancer Epidemiology and Registration, 2015b). The prevalence rate among 50- to 59-year-old women decreased over the period 2005 - 2015 while it increased markedly in women over 60 years between 2000 and 2005 and continued to increase in 70- to 79-year-old women until 2010 (figure 4.1c). This persistence of the trend towards higher prevalence rates in older patients could originate from a cohort effect. The incidence rates are unlikely to be affected by advances in cancer therapy or the implementation of organized mammography screening programs. The general increase in the prevalence rate and the shift towards older patients, however, could be the consequence of reduced mortality rates due to more effective therapies or early detection.

Organized mammography screening programs were gradually implemented by the health administrations of 9 cantons, hereafter called screening cantons (figure 4.2). The earliest initiative was a pilot project in three regions of the canton of Vaud (VD) beginning in 1993 (Faisst and Ricka-Heidelberger, 2001). The first organized programs were installed in the three (partly)

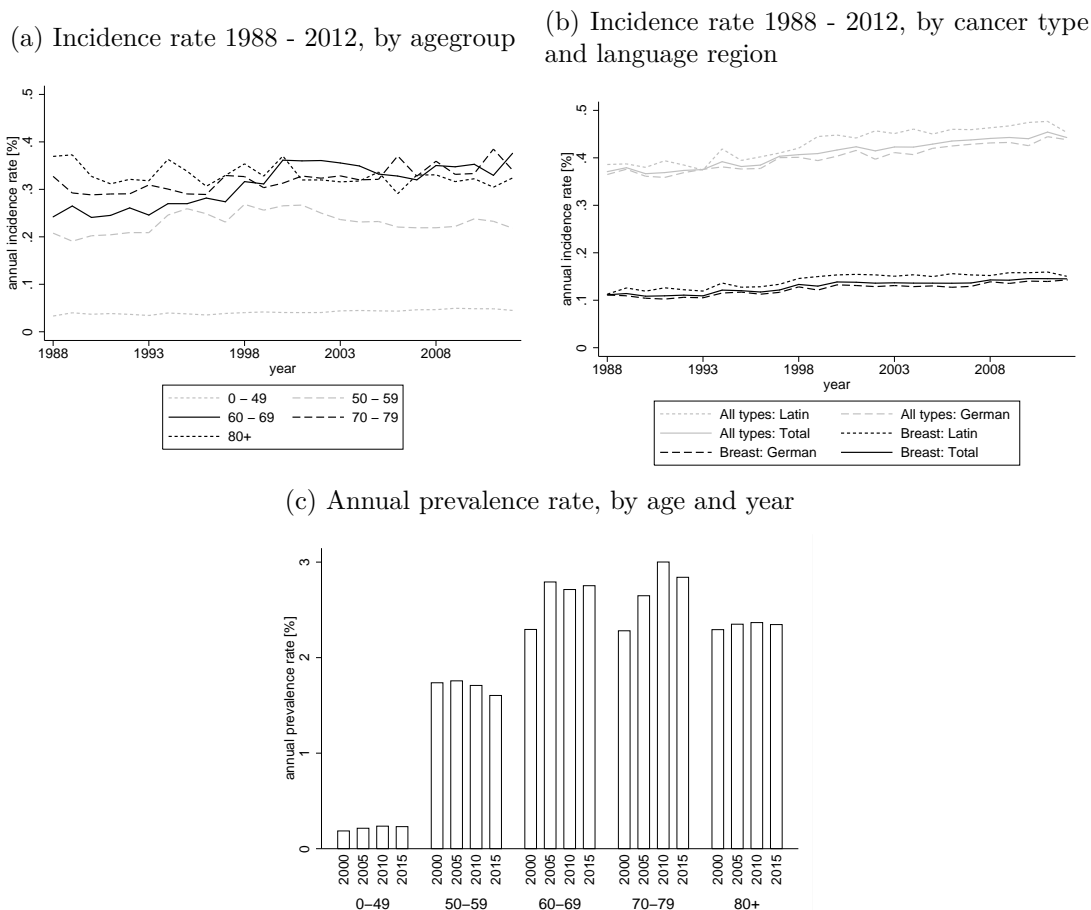


Figure 4.1: Breast cancer incidence and prevalence rates in the Swiss female population (source: National Institute for Cancer Epidemiology and Registration (2015a), own presentation)

French speaking cantons of Genève (GE), Vaud (VD) and Valais (VS) in 1999. Between 2000 and 2012, the cantons of Fribourg (FR), Jura (JU), Neuchâtel (NE), St. Gallen (SG), Graubünden (GR), and Thurgau (TG) introduced organized programs at different points in time. The cantonal screening programs differed in their characteristics, but all included informational measures, reimbursement policies and managed provision of the procedure. Table 4.2 summarizes the general characteristics of the 9 screening programs.

In Switzerland, payment for mammography is regulated by the TARMED fee-for-service tariff system (TARMED Suisse, 2012). At an average value of CHF 0.90 for a TARMED tariff point, a mammogram with an evaluation of the pictures by one physician costs CHF 147.-. Each additional assessment by another physician costs an extra CHF 35.-. Within organized screening programs, each mammogram must be assessed by at least two physicians, sometimes even three, which leads to an average cost of approximately CHF 200.- per screening mammogram (Swiss Medical Board, 2013).

Before 1999, mammography was reimbursed by statutory health insurance only if it was for

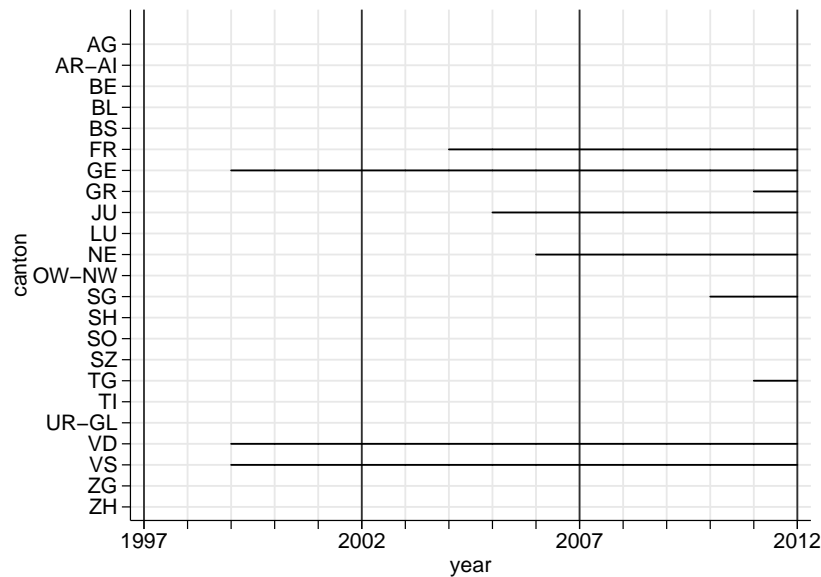


Figure 4.2: Introduction of organized screening programs by canton (source: Own presentation, www.swisscancerscreening.ch, State Council of the Canton of Basel-Stadt (2012))

Table 4.2: Characteristics of Swiss organized mammography screening programs

Target population:	All women between 50 and 69 years of age
Invitation letters:	All women in the target population receive biennial invitation letters followed by reminder letters. In some screening cantons, the invitation letters contain a predetermined appointment with a radiologist or a list of preferred radiologists. Certain programs provide a web- or phone-based booking system.
Health questionnaire:	With the invitation letter, the women receive a medical questionnaire that they must bring to the consultation with the radiologist.
Information campaign:	All programs include information flyers and brochures that are distributed among the population or in medical practices. All organized programs have webpages that are listed on www.swisscancerscreening.ch .
Preferred providers:	Most screening cantons publish a list of preferred providers.
Quality assurance:	The certified providers receive special training and are regularly monitored for quality.
Electronic patient data:	The medical files created in the consultations with the radiologists must be stored electronically.
Evaluation:	The screening programs were evaluated by Swiss Cancer Screening (Bulliard et al., 2010). The outcomes included the number of screenings, the diagnostic accuracy, the characteristics of the detected carcinomas and the subsequent service utilization for cancer treatment.

diagnostic purposes or if a woman had a family history of breast cancer. Beginning in 1999, screening mammograms became covered by statutory health insurance if they were conducted in a screening canton (Faisst and Ricka-Heidelberger, 2001). Beginning in 2001, screening mammography also became exempt from a deductible in screening cantons. Thus, women living in screening cantons had to pay an out-of-pocket expense of only 10% of the costs, whereas women in non-screening cantons had to bear the full costs of the screening themselves (Swiss Federal Department of Home Affairs, 2014). In the canton of Valais (VS) and Genève (GE), even the

out-of-pocket expenses were covered by the government or the local chapter of the Swiss Cancer League (Faisst and Ricka-Heidelberger, 2001).

4 Methods

The objective of this study is to estimate the effect of organized mammography screening programs on the utilization rate in screening cantons. The dependent variable y_i indicates whether a woman has ever undergone a mammography. Economic theory suggests that patients decide when to seek medical care, whereas physicians influence treatment decisions such as the number and interval of follow-up visits (Deb and Trivedi, 2002; Mullahy, 1998). The unobserved latent propensity y_i^* to have ever used mammography can therefore be interpreted as a function of the demand for mammography. A woman chooses to undergo her first mammography ($y_i = 1$) if her net benefit from undergoing the procedure is positive ($y_i^* > 0$), and she will choose no mammography ($y_i = 0$) otherwise.

$$y_i^* = x\beta + u \tag{1}$$

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \tag{2}$$

4.1 Model specification

The empirical approach of this study explores the gradual implementation of organized screening programs in 9 Swiss cantons using a difference-in-difference model in a repeated cross-section of four survey waves (1997, 2002, 2007, 2012). The policy effect is identified by the change in the utilization rate of 50- to 69-year-old women after the introduction of these organized programs.

The variable s_i indicates whether an organized mammography screening program was active in a respondent's canton at the time of the interview. To control for canton and time fixed effects, we include binary indicators of the canton of residence c_i and the year of the survey wave t_i . Individual characteristics x_i are used to adjust for compositional changes in the populations of screening and non-screening cantons and standard errors were clustered at the cantonal level. This model identifies the average effect of all organized screening programs on the screening rate under the assumption that the screening and non-screening cantons shared the same general

trend described by β_t .

Because a woman who became a user of mammography cannot reverse this decision, the effect of an organized program on the utilization rate should increase over time. We test for this trend by introducing a variable d_i to indicate the number of years that an organized program has been active in the canton of residence at the time of the interview. Using this specification, we divide the effect of the organized programs into an immediate effect β_s and a long-term trend β_d . As the number of women who did not yet undergo their first mammography decreases, the increase in the policy effect is expected to diminish. We therefore assess the fit of non-linear specifications of d_i using the modified Hosmer-Lemeshow test.

$$P[y_i = 1|x_i, c_i, t_i, s_i, d_i] = \alpha + x_i\beta_x + c_i\beta_c + t_i\beta_t + s_i\beta_s + d_i\beta_d + u_i \quad (3)$$

We use this difference-in-difference model to estimate the proportion of the utilization rate in screening cantons in 2012 that can be attributed to the organized screening programs or, in other words, the average treatment effect on the treated (*ATEET*). The *ATEET* is the average difference between the predicted probability of women living in screening cantons in 2012 to have ever used mammography and the counterfactual probability of these women choosing to undergo mammography in the absence of the organized program. The year 2012 was used to hold the incremental effect of the time trend constant in this exercise.

$$\begin{aligned} ATEET &= \mathbb{E}\{\hat{P}^{s_i=1, t_i=2012}[y_{ict} = 1|x_i, c_i, t_i, s_i, d_i] \\ &\quad - \hat{P}^{s_i=1, t_i=2012}[y_{ict} = 1|x_i, c_i, t_i, s_i = 0, d_i = 0]\} \end{aligned} \quad (4)$$

The choice of the binary indicator of being a user of mammography as the dependent variable has important implications for the interpretation of β_s and β_d . The coefficients β_s and β_d measure only the effect of the organized programs on the participation decisions of women who would never have undergone a mammography without the program. The binary dependent variable y_{ict} does not measure whether the programs motivate women to have more than one mammogram. Hence, our study cannot inform policy makers about the effects of organized programs on the proportion of regularly screened women or on the frequency of mammography screening in the target population.

4.2 Functional form

The estimation of a difference-in-difference specification with a binary dependent variable poses certain difficulties when choosing an appropriate empirical model. In this study, we consider the linear probability model and the unconditional fixed effects logit model.

4.2.1 The linear probability model

The linear probability model is a popular choice for the estimation of difference-in-difference models with binary dependent variables because it is easy to interpret and fulfills the standard difference-in-difference assumptions (Lechner, 2010). In a linear probability model, the parameters of the linear additive index function in equation (3) are estimated by ordinary least squares (OLS), and the ATE can be easily computed as $\hat{\beta}_s + \bar{d}\hat{\beta}_d$.

$$ATE = \hat{\beta}_s + \bar{d}\hat{\beta}_d \quad (5)$$

A disadvantage of the linear probability model is that it is inefficient when the errors are non-normal or heteroskedastic, and it may yield biased and inconsistent parameter estimates when the model makes out-of-range predictions (Horrace and Oaxaca, 2006).

4.2.2 The fixed effects logit model

The logit model is a possible solution to the problem of out-of-range predictions because it accounts for the bounded nature of the dependent binary variable. The regression coefficients β of a logit model cannot be interpreted in terms of probabilities but can be used to compute the average marginal effects, B_k .

$$B_k = \frac{\Delta \mathbb{E} \left[\text{logit}(\alpha + \sum_{k=1}^K x_{ik}\beta) \right]}{\Delta x_k} \quad (6)$$

Non-linear binary choice models have two major limitations when estimating difference-in-difference specifications. First, the causal effect of the policy intervention is not identified by the coefficients β_s and β_d because their marginal effects depend on the expected outcomes of individuals, which are not constant across the treated population (Lechner, 2010). Instead, the

causal policy effect is identified by the incremental effect of β_s and β_d , i.e., by the *ATE* (Ai and Norton, 2003). Because the *ATE* is always positive when both β_s and β_d are positive, the signs of these coefficients can still be interpreted if they are in the same direction, and the standard errors can be computed by the delta method (Puhani, 2012).

$$\begin{aligned} \widehat{ATE}(s = 1, t = 2012) = & \mathbb{E} \left[\text{logit}(\hat{\alpha} + x_i \hat{\beta}_x + c_i \hat{\beta}_c + \hat{\beta}_{2012} + \hat{\beta}_s + d_i \beta_d) \right] \\ & - \mathbb{E} \left[\text{logit}(\hat{\alpha} + x_i \hat{\beta}_x + c_i \hat{\beta}_c + \hat{\beta}_{2012}) \right] \end{aligned} \quad (7)$$

A second limitation of non-linear models is that difference-in-difference models are a type of fixed effects model that introduce the *incidental parameters problem*. The maximum likelihood estimation of fixed effects models "need not be consistent" because the number of parameters increases with the number of groups (Neyman and Scott, 1948). Although a small simulation study by Heckman (1981) found the bias in a fixed effects probit model with 8 observations per group to be surprisingly small, subsequent research by Greene (2004) showed that this result was incorrect. A more recent study by Katz (2001) suggested that the unconditional fixed effects logit estimator can safely be used when the group size exceeds 16 observations. Although the evidence is inconclusive, we argue that the average number of 93.6 women per canton and year (table 4.9 in the appendix I) is sufficiently large to yield consistent and efficient parameter estimates.

4.3 Specification tests

We compare the fit of the linear probability model and the fixed effects logit model using three residual-based tests (the Pregibon link test, the Ramsey RESET test and the modified Hosmer-Lemeshow test) and show the consequences of misspecification for the parameter estimates. The link test checks the linearity of the response on the scale of estimation by regressing the raw scale variable y on the predicted value of $x\beta$ and $(x\beta)^2$ (Pregibon, 1980). An insignificant and small coefficient of $(x\beta)^2$ indicates the linearity of responses. The RESET test also includes the cubic and quartic terms of $x\beta$, which should be individually and jointly insignificant (Ramsey, 1969). The modified Hosmer-Lemeshow test checks the linearity of the residuals over the predicted probability (Hosmer Jr and Lemeshow, 2004). We also use the modified Hosmer-Lemeshow test to assess the linearity of the residuals over the continuous explanatory variables *duration*, *age*,

income and *weekly alcohol consumption* and to test the benefits of higher-order terms of these variables.

4.4 Sensitivity analysis

4.4.1 Effect heterogeneity across socioeconomic groups

In the first sensitivity analysis, we assess the heterogeneity of the policy effects across socioeconomic groups. Researchers have shown that women with higher incomes and better education are more likely to be screened (Wübker, 2012; Puddu et al., 2009; Carrieri and Wübker, 2013). It is possible that these inequalities reflect differences in constraints rather than differences in preferences. The heterogeneity of the policy effects across socioeconomic groups is thus an important outcome in an evaluation of organized screening programs.

We add interaction terms between the *screening* variable s_i and indicators of the educational level e_i and the position in the income distribution r_i to the base case model in equation 3. We also include the interaction terms of e_i and r_i with the canton and time fixed effects c_i and t_i to adjust the policy effects for inter-temporal and geographical variation in the association between mammography use and socioeconomic status. To ensure simplicity, we neglect the duration of the organized programs d_i in this sensitivity analysis.

$$\begin{aligned}
 P[y_i = 1|x_i, c_i, t_i, s_i, d_i] = & \alpha + x_i\beta_x + c_i\beta_c + t_i\beta_t + s_i\beta_s \\
 & + e_i\beta_e + r_i\beta_r + e_i c_i\beta_{ec} + e_i t_i\beta_{et} + r_i c_i\beta_{rc} + r_i t_i\beta_{rt} \\
 & + e_i s_i\beta_{es} + r_i s_i\beta_{rs} + u_i
 \end{aligned} \tag{8}$$

4.4.2 Placebo intervention tests

In the second sensitivity analysis, we test the common trend assumption by two placebo intervention tests. The first placebo intervention emulates the introduction of the organized programs 5 years before their actual implementation. The leading placebo intervention variable thus takes the value of one in the wave before an organized screening program has been implemented in a screening canton. This variable captures deviating trends in screening cantons before the introduction of organized programs.

The second placebo intervention test is based on 1'000 estimations of the regression model including a random placebo intervention variable in the comparison group. The random placebo intervention variable is constructed at the cantonal level and takes the value of one if an interview was carried out after a randomly determined placebo intervention year in the canton of residence. The random placebo variable is only correlated with the actual screening variable through time and thus captures changes in the difference between non-screening cantons and screening cantons over time that are unrelated to the presence of organized programs in screening cantons.

4.4.3 Difference-in-difference-in-difference estimation

In the third sensitivity analysis, we relax the common trend assumption and estimate a difference-in-difference-in-difference specification in which women between the ages of 40 and 49 years who do not receive invitation letters and who must pay for screening mammograms themselves constitute an additional comparison group. This model describes how the organized programs affect the difference in the utilization rate between the group of women aged 50 to 69 (i.e., the target group) and those aged 40 to 49 (i.e., the comparison group).

Let g_i be an indicator of belonging to the target group. The coefficient β_g measures the average difference in mammography use between the target group and the comparison group. Because the initial difference between the target and comparison groups may not be the same in the screening and non-screening cantons, we observe the interaction of g_i with the cantonal fixed effects c_i . We also allow for differential trends through an interaction between g_i and the year of the survey wave t_i .¹ The coefficient β_s captures the change in the average utilization rate of the comparison group during the introduction of the organized programs. The coefficient β_{sg} measures how the organized programs affect the difference between the target and comparison groups. This model identifies the causal policy effect in the target group under the assumption that the difference between the target and comparison groups would have evolved similarly in the screening and non-screening cantons.

$$\begin{aligned}
 P[y_i = 1 | x_i, c_i, t_i, g_i, s_i] & \\
 & = \alpha + x_i\beta_x + c_i\beta_c + t_i\beta_t + g_i\beta_g + s_i\beta_s + g_i c_i \beta_{gc} + g_i t_i \beta_{gt} + s_i g_i \beta_{sg} + u_i
 \end{aligned} \tag{9}$$

¹The duration of the organized programs cannot be used as an explanatory variable in this specification because it would be highly collinear with $g_i t_i$.

Under the relaxed common trend assumption, the coefficient β_s captures the difference in time trends, and the coefficient β_{sg} measures the causal policy effect on the utilization rate in screening cantons adjusted for the differential time trends if the organized programs did not have any spillover effects on younger women. The *ATE* is then defined as the incremental effect of β_{sg} .

5 Data

This study combines four waves of the Swiss Health Survey (1997, 2002, 2007, 2012) (Swiss Federal Statistical Office, 2014). The first wave (from 1997) describes the situation in which no screening programs had been installed. The respondents of the Swiss Health Survey were selected randomly from the population aged 15 years and older living in private households. After an initial telephone interview, the respondents were sent a written questionnaire for questions that were difficult to answer on the phone or that required the consultation of documents. The respondents were not interviewed repeatedly, and they were included in only one of the four survey waves.

The sample of this study includes 13,874 women between 40 and 69 years of age. In the base case analysis, we use only the 8,609 women between 50 and 69 and compare the evolution of the utilization rate in the screening and non-screening cantons. In the sensitivity analysis, we include the 5,265 women between 40 and 49 years of age as an additional control group. The sample weights provided with the Swiss Health Survey are not used because our sample may not be representative due to missing values. All results apply only to our sample.

The binary dependent variable *evermam* indicates whether a woman has ever undergone mammography. This variable is the only measure of screening uptake that is recorded consistently in all four survey waves. The variable of interest is the dummy variable *screening*, which takes the value of one if an organized program has been installed in the canton of residence at the time of the interview and zero otherwise. The variable *duration* measures the number of years since the introduction of the organized mammography screening program. The age of the women is an important control variable because it measures the duration of the period of opportunity to become a mammography user. The other covariates include demographic and socioeconomic characteristics, information on health-related behavior (smoking, drinking, physical activity, body weight, health-oriented lifestyle), and variables describing the women's medical

Table 4.3: Variable description

variable	description	range/unit
evermam	ever had a mammography	{0,1}
target	age at the time of the interview = 50 to 69 years	{0,1}
screening	organized program established in the canton of residence at the time of the interview	{0,1}
duration	time since the establishment of the organized program at the time of the interview	[years]
age	age in the year of the interview	[years]
married	marital status	{0,1}
urban	living in an urban area	{0,1}
foreign	foreign nationality	{0,1}
educ1	highest education = mandatory schooling	{0,1}
educ2	highest education = professional education	{0,1}
educ3	highest education = a-level degree	{0,1}
educ4	highest education = higher professional education	{0,1}
educ5	highest education = university degree	{0,1}
working	working a paid job	{0,1}
income	monthly gross income adjusted for the number of household members	[CHF 1,000]
smoker	regular smoker	{0,1}
alcohol	weekly alcohol intake	[g]
movdays0-7	physical activity over 0-7 days	{0,1}
overweight	body mass index ≥ 25	{0,1}
obese	body mass index ≥ 30	{0,1}
lifestyle	health-oriented lifestyle	{0,1}
health1	self-rated health = 1 (very poor)	{0,1}
health2	self-rated health = 2	{0,1}
health3	self-rated health = 3	{0,1}
health4	self-rated health = 4	{0,1}
health5	self-rated health = 5 (very good)	{0,1}
badhealth	self-rated health $\in \{1, 2\}$	{0,1}
hormones	currently in hormone therapy	{0,1}
cancer	treated for cancer during the last 12 months	{0,1}
dedhi	deductible above the minimum at the time of the interview	{0,1}
suppins	supplementary private insurance plan	{0,1}
modalt	alternative managed care insurance plan	{0,1}

history (self-rated health, history of cancer, hormone therapy). To control for geographic variation in supply-side factors, we use an indicator of residence in an urban area. Physician density is available only at the cantonal level and would be absorbed by the canton fixed effects. Binary variables describing the insurance plans of the respondents provide information regarding the effects of compensation modalities.

6 Results

6.1 Descriptive statistics

The proportion of women between 50 and 69 years of age who have ever undergone mammography increases from 58% in 1997 to 80% in 2007 and then remains constant until 2012 (table 4.4). Among 40- to 49-year-old women, the average utilization rate decreases from 47% in 1997 to 42% in 2002 and then remains at this level until 2012. Screening cantons exhibit a higher utilization rate than non-screening cantons even before the introduction of the first organized programs (figure 4.3). The screening and non-screening cantons exhibit a similar pattern among women in the target group (50 to 69 years), but the utilization rates evolve differently in the comparison group (40 to 49 years). The deviating trends in the comparison group demonstrate the need to relax the common trend assumption in the sensitivity analysis. However, the observed time trends do not provide evidence of a violation of the common trend assumption because organized programs have been implemented gradually and because the composition of the target population could have changed differently in screening and non-screening cantons.

Because of the gradual implementation of the organized screening programs, the proportion of women living in a canton with an established screening program increases from 0% in 1997 to 40% in 2012. The women's educational level, labor market participation and income increase markedly over the four survey waves (table 4.4). This trend is no surprise, as the 1997 cohort consists of women who were born between 1928 and 1947, whereas the 2012 cohort includes primarily women who were born after the Second World War. The other covariates do not exhibit clear trends but still vary substantially over time and might have changed in different ways in the screening and non-screening cantons. This hypothesis underscores the need for regression analysis to correct for compositional changes in the target population in the screening and non-screening cantons.

Table 4.4: Unweighted sample means by age group and year

	50 - 69 years old				40 - 49 years old			
	1997	2002	2007	2012	1997	2002	2007	2012
evermam	0.58	0.73	0.80	0.80	0.47	0.42	0.41	0.42
screening	0.00	0.16	0.32	0.40	0.00	0.18	0.30	0.40
duration	0.00	0.48	1.92	3.25	0.00	0.53	1.75	3.28
age	58.91	59.07	59.30	58.46	44.23	44.13	44.16	44.63
married	0.56	0.58	0.58	0.62	0.63	0.63	0.61	0.68
urban	0.71	0.76	0.71	0.72	0.68	0.71	0.68	0.69
foreign	0.11	0.07	0.05	0.07	0.11	0.08	0.10	0.15
educ1	0.29	0.22	0.13	0.12	0.15	0.11	0.06	0.05
educ2	0.60	0.64	0.64	0.55	0.64	0.67	0.62	0.53
educ3	0.05	0.05	0.03	0.10	0.07	0.06	0.04	0.10
educ4	0.04	0.05	0.08	0.09	0.07	0.08	0.09	0.11
educ5	0.03	0.04	0.12	0.14	0.07	0.08	0.18	0.21
working	0.43	0.48	0.53	0.65	0.74	0.78	0.82	0.86
income	3.75	4.13	4.44	4.59	3.70	4.10	3.82	3.88
smoker	0.20	0.23	0.21	0.24	0.37	0.35	0.30	0.25
alcohol	6.48	7.38	6.36	5.97	6.37	6.40	5.12	5.06
movdays0	0.49	0.43	0.33	0.38	0.41	0.35	0.28	0.30
movdays1	0.17	0.18	0.17	0.17	0.23	0.21	0.21	0.20
movdays2	0.11	0.15	0.18	0.20	0.16	0.19	0.20	0.25
movdays3	0.08	0.10	0.13	0.12	0.07	0.11	0.14	0.13
movdays4	0.04	0.03	0.04	0.03	0.03	0.04	0.05	0.04
movdays5	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03
movdays6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
movdays7	0.09	0.09	0.09	0.06	0.07	0.07	0.08	0.04
overweight	0.29	0.30	0.27	0.26	0.19	0.17	0.16	0.20
obese	0.11	0.10	0.10	0.11	0.05	0.07	0.06	0.08
lifestyle	0.92	0.94	0.93	0.92	0.92	0.92	0.92	0.91
health1	0.04	0.04	0.03	0.04	0.03	0.03	0.02	0.03
health2	0.17	0.14	0.11	0.15	0.11	0.10	0.06	0.09
health3	0.57	0.61	0.67	0.46	0.58	0.63	0.71	0.43
health4	0.22	0.21	0.19	0.34	0.27	0.25	0.21	0.45
badhealth	0.21	0.18	0.14	0.20	0.15	0.12	0.08	0.11
hormones	0.20	0.33	0.19	0.14	0.06	0.08	0.04	0.05
cancer	0.04	0.04	0.03	0.04	0.03	0.02	0.02	0.02
dedhi	0.46	0.48	0.47	0.48	0.48	0.52	0.57	0.60
suppins	0.53	0.45	0.45	0.30	0.51	0.42	0.33	0.22
modalt	0.04	0.05	0.15	0.43	0.04	0.07	0.18	0.47
<i>N</i>	1335	2604	2132	2538	775	1393	1331	1766

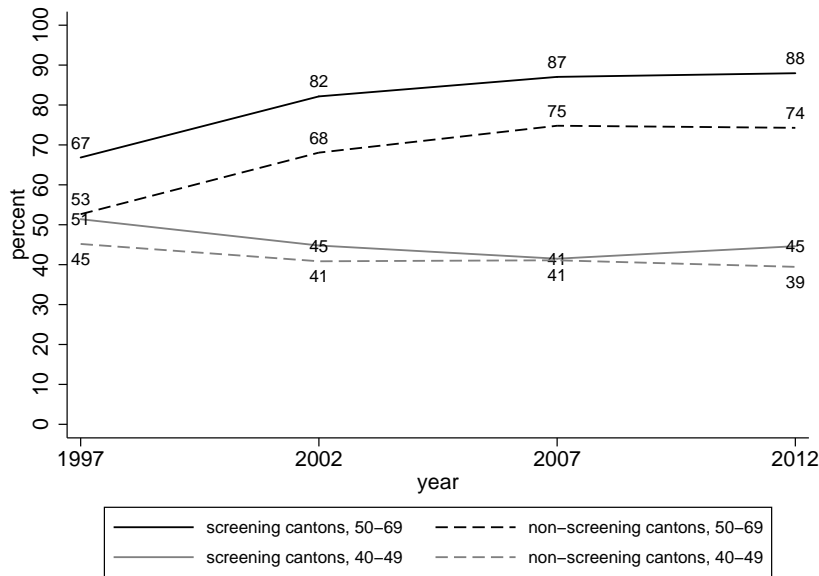


Figure 4.3: Proportion of mammography users [%] by age group, screening versus non-screening cantons

6.2 Model specification

The linear probability model fails all three residual-based tests. Both the link test and the RESET test reject the linearity of y_i over the linear predictor $x_i\hat{\beta}$ (table 4.10 in appendix II). The coefficients of $x_i\hat{\beta}$ are different from one, and the higher-order terms are (jointly) significant. The modified Hosmer-Lemeshow test shows an inverse u-shaped pattern for the residuals over the predicted probability (figure 4.6 in appendix II).

The fixed effects logit model passes all three residual-based tests. The coefficients of $x_i\hat{\beta}$ are close to one, and the effects of higher-order terms of $x_i\hat{\beta}$ are small and non-significant. The modified Hosmer-Lemeshow test shows a linear pattern of residuals with no significant deviation from zero. The logit model yields a lower value of the log-likelihood than the linear probability model (table 4.11 in appendix II), which confirms the results of the residual-based specification tests. The modified Hosmer-Lemeshow tests of the linearity of responses over quantiles of continuous covariates (*age*, *income*, *alcohol*, *duration*) favor a quadratic specification of age and a cubic specification of income.

Based on these tests, we determine that the fixed effects logit model with higher-order age and income terms fits our data best. In the next section, we first present the results from the logit model and then assess how the estimates of the allegedly misspecified linear probability model deviate from these results.

6.3 Regression results

The fixed effects logit model estimates a significant and positive average marginal effect (4.6 percentage points) for the organized programs on mammography uptake. The coefficient of the program duration is close to zero and is not significant. These estimates indicate that the organized programs have only an immediate effect and do not increase the utilization rate after the year of their introduction. In 2012, only 3.5 percentage points of the average screening rate in the screening cantons can be attributed to the organized screening programs (table 4.6).

Table 4.5: Average marginal effects of independent variables on the probability of having ever used mammography, base case estimates

	LPM		FE logit	
	coef.	<i>p</i> -value	coef.	<i>p</i> -value
screening	0.018	0.455	0.046**	0.022
duration	-0.006	0.168	0.001	0.863
age	0.003***	0.008	0.003***	0.006
married	0.042***	0.000	0.042***	0.000
urban	0.037***	0.008	0.037***	0.010
foreign	0.007	0.653	0.006	0.748
educ2	-0.003	0.796	-0.007	0.531
educ3	0.010	0.667	0.009	0.712
educ4	-0.000	0.982	-0.004	0.842
educ5	-0.031*	0.099	-0.035	0.101
working	0.010	0.445	0.011	0.420
income	0.004*	0.052	0.006**	0.023
smoker	-0.006	0.595	-0.006	0.573
alcohol	0.001	0.140	0.001*	0.097
movdays1	0.032***	0.007	0.030***	0.008
movdays2	0.030*	0.058	0.031**	0.044
movdays3	0.030**	0.041	0.031**	0.024
movdays4	0.023	0.233	0.023	0.202
movdays5	-0.008	0.780	-0.010	0.721
movdays6	0.020	0.620	0.021	0.588
movdays7	0.024	0.149	0.021	0.184
overweight	0.016	0.163	0.016	0.160
obese	-0.014	0.341	-0.012	0.358
lifestyle	0.033	0.109	0.039*	0.080
health2	-0.030*	0.073	-0.036*	0.083
health3	-0.046***	0.001	-0.051***	0.002
health4	-0.068***	0.001	-0.076***	0.000
hormones	0.140***	0.000	0.141***	0.000
cancer	0.110***	0.000	0.112***	0.000
dedhi	-0.018**	0.041	-0.020**	0.030
suppins	0.059***	0.000	0.057***	0.000
modalt	-0.014	0.356	-0.016	0.305
canton	FE		FE	
year	FE		FE	
N	8609		8609	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are computed using the delta method.

FE fixed effects

As anticipated, the probability of mammography uptake increases with age (+ 0.3 percent-

Table 4.6: Predicted probabilities of women living in screening cantons in 2012 having ever used mammography, base case estimates

	LPM	FE logit
treated	0.862	0.879
counterfactual	0.896	0.844
ATET	-0.034	0.035

age points per year). Married women are more likely (+4.2 percentage points) to have ever used mammography. Education does not exhibit a significant effect on the screening rate, and the effect of monthly income is weak, with only +0.6 percentage points per CHF 1,000. Women who are physically active 1 to 3 days a week are 3.0 to 3.1 percentage points more likely to have used mammography than are completely inactive women. Similarly, a health-oriented lifestyle is associated with a higher probability of mammography uptake (+3.9 percentage points). Healthier women exhibit a lower participation rate, and women with a history of cancer or hormone therapy are more likely to have used mammography. Although mammography is performed on an outpatient basis and is covered by basic health insurance, supplementary hospital insurance plans increase the probability of mammography use (+5.7 percentage points), whereas high deductibles decrease it (-2.0 percentage points). Women who are more sensitive to costs and have higher deductibles may tend to refuse mammography screening because of its questionable cost-effectiveness ratio. Supplementary hospital insurance plans may be positively associated with mammography use because they measure the willingness to pay for insurance against future risk, which is the purpose of mammography screening. However, the characteristics of insurance plans are likely to be endogenous, as they depend on a woman’s health history and her previous service use.

6.4 Model comparison

The comparison between the results of the fixed effects logit model and the linear probability model shows the consequences of misspecification. The linear probability model produces a small and non-significant estimate of the immediate effect of the organized programs and a negative long-term effect (tables 4.5). These results are not only in contrast to the findings from the fixed effects logit model but also contradictory, as the opposite signs would indicate that the programs motivated some women to begin using mammography in the first year while deterring the remaining non-users from undergoing their first mammography in the following years. The *ATET* from the linear probability model is estimated at -3.4 percentage points (table 4.6).

6.5 Sensitivity analysis

6.5.1 Effect heterogeneity across socioeconomic groups

In the first sensitivity analysis, we assess the heterogeneity of the policy effects across socioeconomic groups. The fixed effects logit model with interactions between the *screening* variable and indicators of education and income shows substantial heterogeneity in the policy effects across socioeconomic groups (figure 4.4). The average marginal effect of the organized screening programs on the utilization rate is strongest among women with a professional education (apprenticeship) and weakest among women with a higher-level professional education. Women with a higher-level professional education could either be less susceptible to information campaigns or have high screening rates even in the absence of an organized screening program. Women with a university degree also respond positively to the organized screening programs, but the effect is rather uncertain because of the small group size.

The policy effects vary substantially over the income distribution but do not follow a clear pattern. The level of responsiveness is particularly high among the poorest 30% of women. The large effects for underprivileged women could be a consequence of the cost-free access guaranteed within organized screening programs. Women in the upper middle class who earn more than the poorest 50% also respond well to the policy, whereas the richest women and median income earners are not more likely to initiate screening after the introduction of the organized programs.

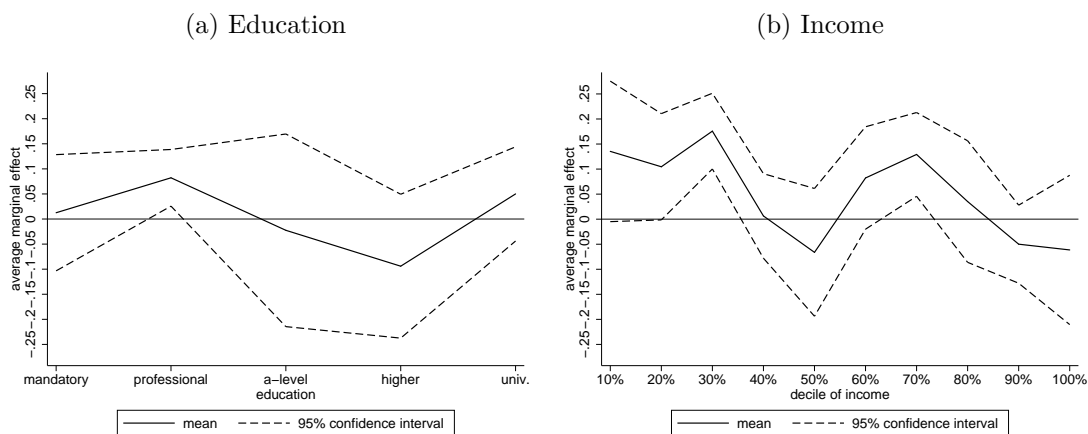


Figure 4.4: Average marginal effects by education and income

6.5.2 Placebo intervention tests

The first placebo intervention emulates the introduction of organized programs 5 years before their actual implementation and is used to test for deviating trends in screening programs prior

to the introduction of the programs. The coefficient of the leading placebo intervention is non significant and close to zero and the average marginal effect of the organized programs is not affected by the addition of the leading placebo variable (table 4.7). In the model with leading placebos, the predicted probabilities and the *ATE* are identical to the base case estimates (table 4.8).

The second placebo intervention test is based on 1'000 estimations of the base-case model including an indicator of randomly assigned placebo screening programs in non-screening cantons. The mean of all 1'000 average marginal effects of the organized programs equals the base case estimate and none of the 1'000 marginal effects lie below zero. The mean of the average marginal effects of the random placebo programs is zero, the 95% percentiles include zero and the p-values are distributed evenly between zero and one (figure 4.5). The predicted probabilities and the *ATE* only differ marginally from the base case estimates (table 4.8). In summary, the placebo intervention tests do not provide evidence that our regression results are biased by deviating time trends in screening and non-screening cantons.

Table 4.7: Average marginal effects of screening variables on the probability of having ever used mammography, sensitivity analyses

	FE logit			
	coef.	p-value	95% ll	95% ul
Base case				
screening	0.046	0.022	0.007	0.085
duration	0.001	0.863	-0.009	0.011
Leading placebo intervention in screening cantons				
screening	0.046	0.009	0.012	0.080
duration	0.001	0.856	-0.009	0.010
leading placebo	0.001	0.977	-0.036	0.037
Random placebo intervention in non-screening cantons				
screening	0.046	0.000	0.031	0.060
duration	0.001	0.157	-0.001	0.003
random placebo	0.000	0.482	-0.043	0.041
Difference-in-difference-in-difference				
screening	-0.029	0.198	-0.072	0.015
target	0.083	0.000	0.047	0.119
target × screening	0.089	0.024	0.012	0.166

In the random placebo test, p-values indicate the proportion of all coefficients < 0, and 95% credible intervals indicate 2.5 and 97.5 percentiles over all iterations.

6.5.3 Difference-in-difference-in-difference estimation

In the third sensitivity analysis, we estimate a difference-in-difference-in-difference model in which women between 40 and 49 years of age serve as an additional comparison group. The positive marginal effect of the variable *target* shows that women in the target group are more

Table 4.8: Predicted probabilities of women living in screening cantons in 2012 having ever used mammography, sensitivity analyses

	Base case	Leading placebo		Random placebo		DDD
	screening	screening	placebo	screening	placebo	screening
treated	0.879	0.879	0.862	0.879	0.744	0.878
counterfactual	0.844	0.844	0.862	0.843	0.743	0.824
ATET	0.035	0.035	0.000	0.036	0.001	0.054

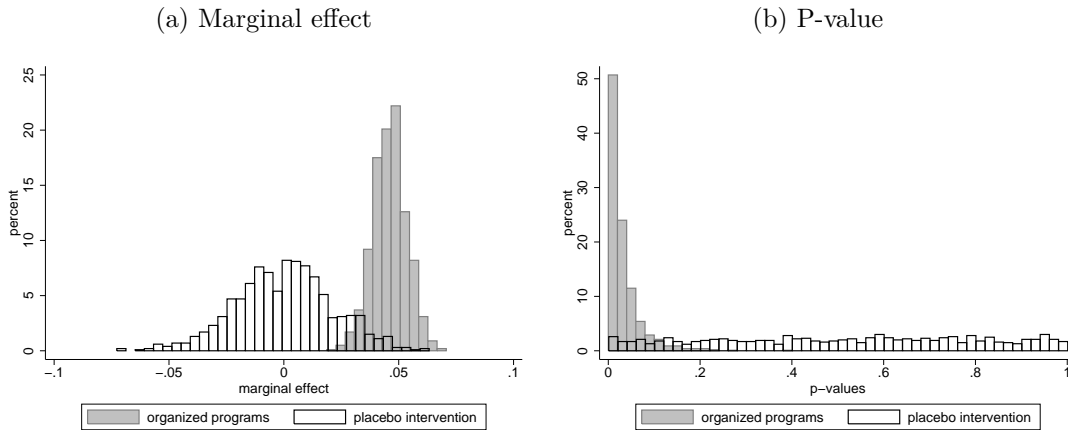


Figure 4.5: Frequency distribution of the results from the random placebo test

likely to have used mammography (table 4.7). The average marginal effects of *screening* and *target×screening* suggest that the utilization rate in the comparison group decreases by 2.9 percentage points after the introduction of an organized program, whereas the difference between the target and comparison groups increases by 8.9 percentage points (table 4.8).

If we believe that the comparison group is suitable for estimating general trends in the screening and non-screening cantons and that the organized programs did not have any spillover effects on women in the comparison group, then the negative coefficient of *screening* indicates that the time trend was more downward sloping in the screening cantons. Under the assumption of deviating trends, the coefficient of the interaction term *target×screening* can be interpreted as the corrected policy effect in the target group, which is approximately twice as large (0.089 vs. 0.046) as the base case estimate. The *ATET* under the relaxed common trend assumption is estimated at 5.4 percentage points.

7 Discussion

This study estimates the causal effect of organized mammography screening programs on the probability that 50- to 69-year-old women have ever used mammography. This probability is interpreted as an indicator of the demand for mammography. The base case analysis shows that

the organized screening programs account for 3.5 percentage points of the utilization rate in the screening cantons in 2012. This effect is relatively small considering that 87.9% of all women living in screening cantons in 2012 have undergone mammography. We further estimate that the organized programs increase the screening initiation rate only during the first year after their implementation. However, the large time intervals and the different timing of the organized programs and the survey waves might also be responsible for the absence of an effect of the duration the programs. In addition, households could move between cantons within large time intervals which can not be controlled for using repeated cross-sections.

The placebo intervention tests suggest that the base case results are not affected by deviating time trends in screening and non-screening cantons. However, the difference-in-difference-in-difference estimation shows that the base case results might be biased downward by 1.9 percentage points because the general time trend in the absence of organized programs might be more negative in the screening cantons. Although the difference-in-difference-in-difference specification relaxes the common trend assumption the estimates may still be biased by cohort effects.

The results of this study have two important policy implications. First, we can conclude that organized screening programs are weak policy instruments for promoting the use of preventive health services when the utilization rate is already high. The fact that those women who have never used mammography are not motivated to initiate screening suggests that their lack of use is not the consequence of insufficient information or financial barriers to access to care. From an economic perspective, it is questionable whether public health programs should attempt to change the opinions of well-informed rational agents. Second, the finding that the programs motivate new users of mammography only in the first year after their introduction suggests that one invitation letter per woman offering a cost-free mammography (e.g., at her 50th birthday) would have the same effect on the proportion of mammography users as the current programs with repeated invitation letters.

In 2013, the Swiss Medical Board (2013) published a health technology assessment of screening mammography in Switzerland and recommended to suspend the cantonal organized programs. One reason for this negative recommendation was the modest clinical efficacy of screening mammography. The net medical benefit of organized screening also determines the clinical relevance of our own results. If screening mammography creates more benefit than harm but incurs additional costs (Elmore et al., 2005), the estimated effects of organized programs on

screening initiation should be used to compare organized programs with opportunistic screening and to consider the number needed to invite to prevent a breast cancer related death in the calculation. A potential cost-effectiveness analysis should then include the costs of both the organized programs and the executed mammograms. If organized screening programs even do more harm than good because of false positive diagnoses and overdiagnoses (Gøtzsche and Jørgensen, 2013) they should be suspended regardless of the results of this study.

The model comparison generates an important methodological insight. Although it is popular to use linear probability models to estimate difference-in-difference specifications, we find a serious misspecification bias in the estimates of the policy effects. The well-specified fixed effect logit model produces a positive and significant estimate of the effect of organized mammography screening programs, whereas the allegedly misspecified linear probability model leads to a null result and a negative time trend. This difference demonstrates that applied research must be careful when using linear probability models in policy evaluation studies with binary dependent variables.

The econometric model used in this study allows for identifying the causal effect of organized screening programs on the utilization rate. The specification is more robust to exogenous shocks in the screening cantons than a standard pre-post treatment-control design because the organized programs were introduced at different points in time. We also choose the empirical model based on residual-based specification tests and relax the vital common trend assumption using younger women as a comparison group in a difference-in-difference-in-difference specification. Note that this analysis has some limitations. First, our analysis relies on a small number of cantons and time periods, which may lead to a downward bias in the standard errors as a result of serial correlation (Bertrand et al., 2004). Although this bias means that the effect of organized mammography screening programs may not be significant, this limitation does not change the conclusion that the organized programs had little effect on the demand for mammography. Second, we observe only a binary indicator of mammography use consistently in all four survey waves. Therefore, our study informs policy makers only about the effects of organized programs on women's propensity to begin screening but does not reveal the frequency of mammography use or the number of regularly screened women. Third, our study can not identify the effects of different characteristics of the organized programs. A possible hypothesis is that organized programs also increased the demand for mammography because of quality improvements or changed recommendations by referring general practitioners. Fourth, we cannot discriminate

between screening and diagnostic mammography. It is conceivable that the invitation letters also motivate women with signs or a history of cancer to undergo diagnostic mammography.

Future research could focus on those waves of the Swiss Health Survey containing information regarding the purpose and frequency of mammography use. Such a study could adopt the identification strategy used in the sensitivity analysis of this study and compare the difference between the target and comparison groups across cantons. Socioeconomic inequality in mammography uptake and the contribution of organized screening programs to this inequality are further topics of research that deserve more attention in the future.

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Appendix

Appendix I: Number of observations per canton and year

Table 4.9: Number of observations per canton and year

Canton	50 - 69 years old					40 - 49 years old				
	1997	2002	2007	2012	total	1997	2002	2007	2012	total
AG	94	147	165	143	549	64	59	85	118	326
AR-AI	5	37	65	58	165	5	25	39	39	108
BE	180	231	215	210	836	101	104	140	140	485
BL	40	148	62	98	348	18	62	21	63	164
BS	22	152	38	130	342	11	58	25	68	162
FR	29	112	102	124	367	15	76	77	96	264
GE	125	148	110	122	505	72	85	61	86	304
GR	45	39	25	84	193	28	22	15	47	112
JU	16	81	45	58	200	6	46	30	48	130
LU	83	129	122	136	470	50	73	91	106	320
NE	38	111	80	73	302	14	44	40	45	143
OW-NW	7	45	15	9	76	12	23	8	11	54
SG	55	125	82	64	326	24	63	55	46	188
SH	13	37	26	10	86	9	16	9	8	42
SO	22	134	44	33	233	21	80	30	34	165
SZ	16	22	44	60	142	16	16	56	47	135
TG	20	39	40	136	235	19	31	27	95	172
TI	111	195	159	187	652	69	110	100	140	419
UR-GL	17	55	52	66	190	8	36	40	52	136
VD	114	154	179	205	652	49	91	93	153	386
VS	101	116	163	140	520	59	71	96	83	309
ZG	18	114	19	130	281	10	78	11	67	166
ZH	164	233	280	262	939	95	124	182	174	575
total	1335	2604	2132	2538	8609	775	1393	1331	1766	5265

Appendix II: Specification tests

Table 4.10: Model comparison using the link test and the RESET test

	LPM		FE logit	
	coef.	<i>p</i> -value	coef.	<i>p</i> -value
Link test				
$x\hat{\beta}$	2.103***	0.000	0.947***	0.000
$x\hat{\beta}^2$	-0.755***	0.000	0.027	0.281
RESET test				
$x\hat{\beta}$	-1.816	0.389	0.965***	0.000
$x\hat{\beta}^2$	6.226	0.172	0.056	0.378
$x\hat{\beta}^3$	-4.988	0.233	-0.029	0.517
$x\hat{\beta}^4$	1.172	0.397	0.006	0.524
$x\hat{\beta}^2, x\hat{\beta}^3, x\hat{\beta}^4$		0.000		0.592

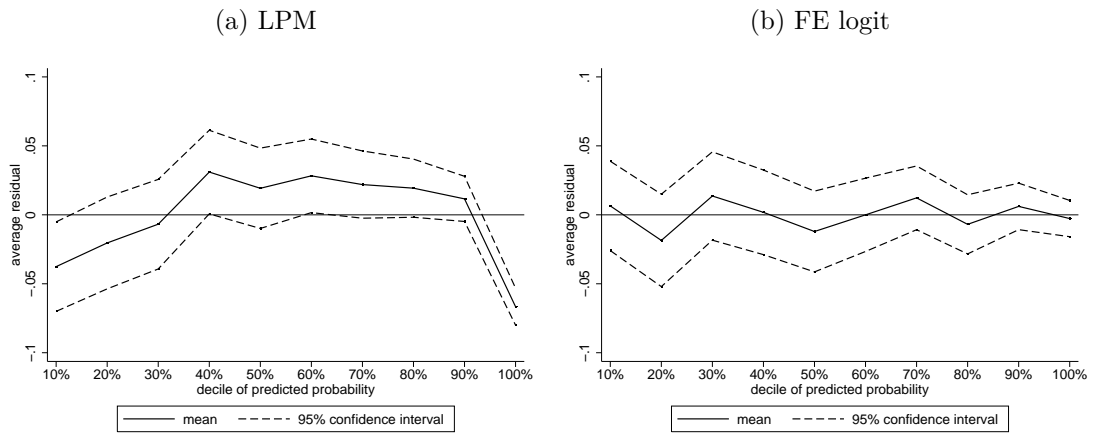


Figure 4.6: Modified Hosmer-Lemeshow test: mean residuals (95% confidence intervals) over deciles of the predicted probability

Table 4.11: Information criteria

	LPM	FE logit
log-likelihood	-4371	-4188
AIC	8786	8419
BIC	8941	8575

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