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Custom-made healthcare – An experimental investigation *

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Résumé / *Abstract*

In this paper, we investigate in a controlled laboratory experiment physician behavior in the case of payment heterogeneity. In the experiment, each physician provides medical care to patients whose treatments are paid for either under fee-for-service (FFS) or capitation (CAP). We observe that physicians customize care in response to the payment system. A FFS patient receives considerably more medical care than the corresponding CAP patient with the same illness and treatment preference. Physicians over-serve FFS patients and under-serve CAP patients. After a CAP payment reduction in the experiment we observe neither a quantity reduction under CAP nor a spillover into the treatment of FFS patients.

Highlights:

- Capitation or fee-for-service
- Payment heterogeneity: a within-subject design to create payment heterogeneity
- Fee regulation: a cut in the lump-sum payment under CAP

Keywords: Experimental Economics, Physician Reimbursement, Capitation, Fee-For-Service, Customization, Fee Regulation.

JEL codes: I12, I18

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1. Introduction

While there exists an extensive theoretical and empirical literature on the effects of financial incentives on physician behavior (e.g., Carlson et al. 2011; Dumont et al. 2008; Gosden et al. 2001; Gruber & Owings 1996; McGuire 2000; McGuire & Pauly 1991; Mitchell et al. 2002; Newhouse 1996; Newhouse & Marquis 1978; Shafrin 2010), the related research based on the method of experimental economics is rather limited.

An early experiment by Fan, Chen & Kan (1998) investigates physicians' provision of medical services under two alternative methods for controlling the cost of physician services under global budgeting, *expenditure target* and *expenditure cap*. Under an expenditure target, each physician faces a given quota of medical services at fixed fees. Services provided in excess of this quota are reimbursed at lower fees. The expenditure cap is a retrospective mechanism to determine the level of fees. It institutes a hard monetary total budget for all physicians under consideration for a specific time frame and assigns quality points to each medical service. To assess the point value and consequently the fee per unit of each service, the total budget is divided by the points accumulated by the physicians under consideration for services provided during the relevant period.

In a more recent paper, Hennig-Schmidt, Selten & Wiesen (2011, *HSW* hereafter) study the effect of two other payment systems on physician provision behavior. Applying a between-subject design, the authors examine physician behavior in a setting, in which physicians face a single payment system, either *fee-for-service* (*FFS*) or *capitation* (*CAP*). FFS constitutes a volume-based physician payment system in which physicians are paid separately for each unit of medical service rendered. Under CAP, physicians receive a lump-sum payment for the treatment of a patient, irrespective of the quantity of services rendered. In their experiment, medical students decide on the quantity of medical services to be provided to each virtual patient of a given patient list.

In our paper, we present an experiment that builds on the study by HSW (2011) and extends it in two directions, payment heterogeneity and fee regulation (i.e., a cut in the lump-sum payment under CAP). In the first extension, we implement a within-subject design to create payment heterogeneity. Thus, each physician faces patients whose treatments are paid for under FFS or CAP with the payment system varying on a patient-by-patient basis. We are particularly interested in whether physicians customize care in response to financial incentives at the individual patient level or provide *ready-to-wear treatment* (Frank & Zeckhauser 2007), implying a one-for-all approach, irrespective of the incentives presented by the individual patient.

In the second extension, we study the effect of a cut in payments to physicians in one of the payment systems (see McGuire & Pauly (1991) for an extensive theoretical analysis of payment cuts). Specifically, we announce at some point in time a reduction of the lump-sum payment under CAP. We investigate whether and how physicians react to such a reduction. We are particularly interested in whether physicians try to offset lost income by reducing the provision of care to CAP patients. Moreover, we examine whether the lump-sum payment reduction has any (spillover) effect on provision behavior under FFS.

Several authors have investigated the effects of payment systems on physician behavior. In a theoretical model, Ellis & McGuire (1986) demonstrate that FFS leads to an over-provision, whereas CAP results in an under-provision of medical services. Further theoretical papers by Newhouse (1996) and Ellis (1998) suggest that capitation leads to the selection of profitable (low-risk) and the avoidance of costly (high-risk) patients. There are also numerous empirical studies showing that physicians respond to the financial incentives presented by FFS and CAP. Hutchinson & Foley (1999) record that FFS physicians prescribe antibiotics at a much higher rate than their salaried colleagues. Devlin & Sarma (2008) report that Canadian primary care physicians paid via FFS provide more consultations per week than physicians paid via any other method, including CAP. In their controlled laboratory experiment, HSW (2011) document that physicians paid via FFS provide more medical services than those paid via CAP. They also indicate that FFS physicians tend to over-serve patients while capitated physicians have a propensity to under-serve patients.

With respect to our extension of the study by HSW concerning the case of payment heterogeneity, the existing literature shows more ambiguous results. Lungen et al. (2008), Schwierz et al. (2011) and Jürges (2009), for example, show that physicians customize care in accordance to the insurance status in Germany's two-tiered healthcare system (public or private insurance). Lungen et al. (2008) and Schwierz et al. (2011) report that privately insured patients (who are more lucrative to physicians) have considerably shorter waiting periods for appointments compared to those covered by statutory health insurance. Jürges (2009) documents more physician visits following an initial physician contact for patients covered by private insurance.

Research by Hirunrassamee & Ratanawijitrasin (2009) and Melichar (2009) also backs the hypothesis of customization on a patient-by-patient basis. In Thailand, FFS patients are reported to have greater access to more expensive items such as new drugs and more advanced diagnostic technology than patients whose treatments are paid via CAP and DRG, a case-based lump-sum payment system (Hirunrassamee & Ratanawijitrasin 2009). Melichar (2009) analyzes the effect of within-physician variation of the payment system on consultation length in the US and reports that physicians spend less time with their capitated than their non-capitated patients.

However, the existing literature does not universally support the idea of customization in the case of payment heterogeneity. Glied & Zivin (2002) suggest that physicians have a tendency to provide care geared towards the overall patient population. Although physicians do to some extent customize care at the individual patient level, a patient's insurance status is reported to carry less weight in the physician's treatment decision for the individual patient than the distribution of the insurance status of all patients treated by the physician. Landon et al. (2011) present similar empirical evidence indicating that physicians with a high proportion of CAP patients develop a one-for-all approach to providing care rather than customizing care on a patient-by-patient basis.

With respect to our second extension of the laboratory experiment by HSW (2011) concerning the effects of payment cuts on physician behavior, we find an extensive literature. In a theoretical model, McGuire (2000) suggests that a fee reduction concerning one of two services under consideration should lead to an increase in the quantity of the service whose fee remains unchanged (*cross-price effect*) due to income and substitution effects working in the same direction. However, the effect on the quantity of the service whose fee has been cut (*own-price effect)* is presumed to be ambiguous since income and substitution effects work in opposite directions.

The bulk of the empirical research focusing on fee changes investigates physician behavior in response to fee cuts under Medicare, a U.S. public insurance program covering the elderly and handicapped. Nguyen & Derrick (1997) find that physicians affected by Medicare fee cuts increase Medicare quantities considerably. The ability to create a quantity response appears to differ across medical specialties. Yip (1998) reports surgeons to increase the quantity of open-heart procedures provided to Medicare and non-Medicare patients in response to a considerable Medicare fee cut. Rice et al. (1999) and Tai-Seale et al. (1999) find evidence of a spillover effect of Medicare fee cuts into the market for non-Medicare services, noting that non-Medicare quantities increase to some extent as Medicare fees decrease. Analyzing outpatient hospital care, He & Mellor (2012) report that physicians respond to Medicare fee cuts by providing fewer services to Medicare and more services to non-Medicare patients.

In our experiment, we observe physicians to customize care in response to the payment system. Each FFS patient in the experiment receives considerably more medical care than the corresponding CAP patient with the same illness and treatment preference. On average, FFS patients receive more than twice as many medical services as CAP patients. In general, physicians over-serve FFS patients and under-serve CAP patients. We do not identify a behavioral response to the CAP payment cut. We neither detect a quantity offset under CAP nor a spillover into FFS. This might suggest that in our experimental model fee regulation can be used to some extent as a means to control spending on physician service without reducing the overall quantity of care.

This paper is organized as follows. Section 2 illustrates the design of our experiment and Section 3 presents the experimental procedure. The results are presented in Section 4. Section 5 offers concluding remarks.

2. The experiment

Participants are tasked with the allocation of medical care to 36 sequentially presented virtual patients in a heterogeneous payment environment. The presentation of the patients divided into two sequences of 18 patients, S1 and S2. In each of the two sequences, physicians face patients whose treatments are paid for under either FFS or CAP. Under FFS, participants are paid separately for each unit of medical services provided. Under CAP, participants receive a lump-sum payment, irrespective of the number of services provided. The payment system varies on a patient-by-patient basis. The two sequences, S1 and S2, consider similar patients and differ exclusively in the amount of the lump-sum payment under CAP.

Each participant decides on the quantity q (with $q \in \{0, 1, \ldots, 10\}$) of medical services to be provided to each of the patients. Only entire units of medical services can be provided to individual patients. Treatment choices both impact physician profit and patient benefit. Remuneration, profit and patient benefit are measured in Experimental Currency Unit (ECU).

The virtual patients are characterized by the three attributes, *payment system*, *illness* and *treatment preference*. The first attribute, payment system, is either FFS or CAP. The second patient attribute is illness. Patients suffer from one of three potential illnesses, A, B, or C. Illness impacts the FFS fee function and thus the physician’s profit function under FFS. We use three of the FFS fee functions examined by Hennig-Schmidt, Selten and Wiesen (2011). These FFS fee functions are derived from the EBM (Einheitlicher Bewertungsmaßstab), a German payment system covering ambulatory care for patients with statutory health insurance plans.

We use the same FFS fee functions for the characterization of patients in S1 and S2. For each illness, remuneration under FFS increases along with the number of medical services provided (see Table 1). Illness does not have an impact on remuneration under CAP. The lump-sum payment under CAP is independent of both illness and the number of services provided. However, it differs across S1 and S2; it decreases from 12.00 ECU in S1 to 9.60 ECU in S2 (a 20-percent decrease).

Table 1: Physician remuneration (in ECU)

			Quantity of medical services										
Rem. syst.	Seq.	Illness	0	1	2	3	4	5	6	7	8	9	10
FFS	S1,S2	A	0.00	1.70	3.40	5.10	5.80	10.50	11.00	12.10	13.50	14.90	16.60
FFS	S1,S2	B	0.00	1.80	3.60	5.40	7.20	9.00	10.80	12.60	14.40	16.20	18.30
FFS	S1,S2	C	0.00	2.00	4.00	6.00	8.00	8.20	15.00	16.90	18.90	21.30	23.60
CAP	S1	A,B,C	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
CAP	S2	A,B,C	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60

The third patient attribute is treatment preference. We distinguish between three patient types 1, 2 and 3, each characterized by a particular treatment preference, with different benefit functions ($B_1(q)$, $B_2(q)$, $B_3(q)$). These are adopted from HSW. The patient benefit function $B_i(q)$ describes the benefit a patient of type i ($i \in \{1, 2, 3\}$) draws from treatment quantity q and is measured in monetary terms (ECU). The different benefit functions imply that patients, independent of illness, respond differently to the quantity of treatment. The same benefit functions are used for the characterization of patients in S1 and S2.

Each of the three benefit functions is designed to have an interior global optimum at q_i*, which determines the treatment preference, i.e., the “right” amount of medical care for each patient type. Specifying global optima in the interior of the action space allows us to potentially observe over- and under-provision of medical care for each patient type.

The benefit functions for patients of type 1 and 2 are designed such that the monetary benefit drop-off from the optimal level is smaller in the case of over-provision than in the case of under-provision. The reverse holds for the monetary benefit of patients of type 3 (see Table 2). Figure 1 provides a graphical representation of the three benefit functions.

Table 2: Benefit functions for patient types 1, 2 and 3 (in ECU)

Patient type	Quantity of medical services 0	1	2	3	4	5	6	7	8	9	10
Type 1	0.00	0.75	1.50	2.00	7.00	10.00*	9.50	9.00	8.50	8.00	7.50
Type 2	0.00	1.00	1.50	10.00*	9.50	9.00	8.50	8.00	7.50	7.00	6.50
Type 3	0.00	0.75	2.20	4.05	6.00	7.75	9.00	9.45*	8.80	6.75	3.00

* Interior global optimum

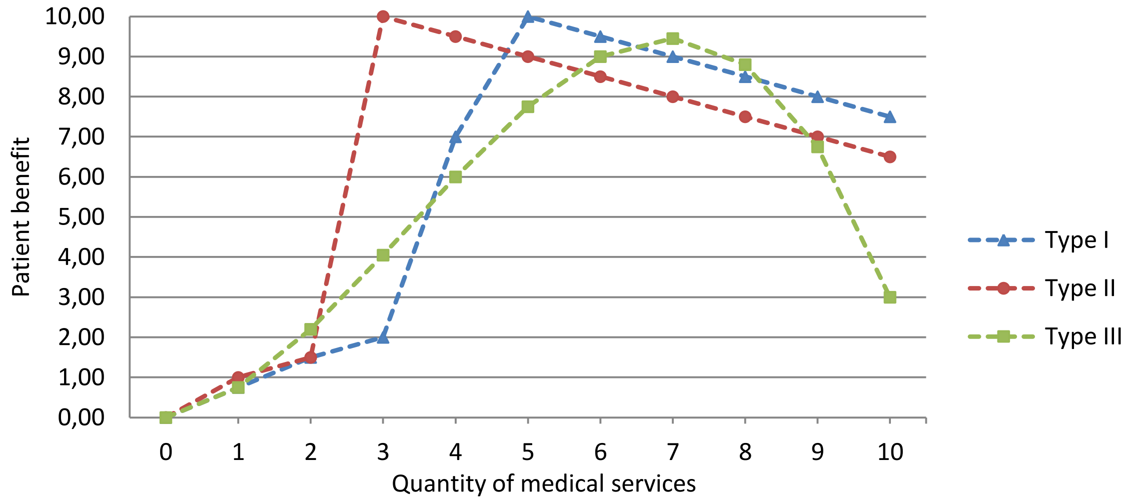

Figure 1: Patient benefit functions

The patients in our experiment are characterized by two payment systems, three illnesses and three types of treatment preferences. Each of the 2×3×3 combinations of payment system, illness and preferences represents an individual patient in each of the two sequences. Participants thus face a heterogeneous patient population with 18 individual patients showing different characteristics in each of the two sequences. By this design, half of the patients in a sequence are treated under FFS and the other half under CAP.

The patients are passive, fully insured and thus accepting any quantity of medical services provided. Physicians' treatment choices impact both patient benefit and physician profit. Physicians are confronted with a convex cost function given by $c(q_j) = 0.1\ q_j^2$, where q_j is the amount of medical services provided to patient j. This function is, again, adopted from HSW. Table 3 provides the cost of treatment for each quantity of medical services. The cost function remains unaffected by payment system, illness, patient type and sequence, implying that it is the same for the treatment of all patients in the experiment.

Table 3: Cost function

	Quantity of medical services										
	0	1	2	3	4	5	6	7	8	9	10
Cost c(q)	0.00	0.10	0.40	0.90	1.60	2.50	3.60	4.90	6.40	8.10	10.00

Physician profit under FFS varies across illness and is identical in both sequences. Profit under CAP remains unaffected by illness but varies across sequences (see Table 4). Figure 2 graphically displays the three FFS profit functions (for the three illnesses) and the two CAP profit functions (for the two sequences). The FFS fee functions are designed in such a way that the FFS profit functions display a trade-off between maximum patient benefit and the physician's profit maximum in all cases but one (FFS patient type 1 with illness A). Under CAP, physicians have to deviate from the profit maximizing quantity in order to create patient benefit.

Table 4: Physician profit

			Quantity of medical services										
Rem. syst.	Seq.	Illness	0	1	2	3	4	5	6	7	8	9	10
FFS	S1,S2	A	0.00	1.60	3.00	4.20	4.20	8.00	7.40	7.20	7.10	6.80	6.60
FFS	S1,S2	B	0.00	1.70	3.20	4.50	5.60	6.50	7.20	7.70	8.00	8.10	8.30
FFS	S1,S2	C	0.00	1.90	3.60	5.10	6.40	5.70	11.40	12.00	12.50	13.20	13.60
CAP	S1	A,B,C	12.00	11.90	11.60	11.10	10.40	9.50	8.40	7.10	5.60	3.90	2.00
CAP	S2	A,B,C	9.60	9.50	9.20	8.70	8.00	7.10	6.00	4.70	3.20	1.50	-0.40

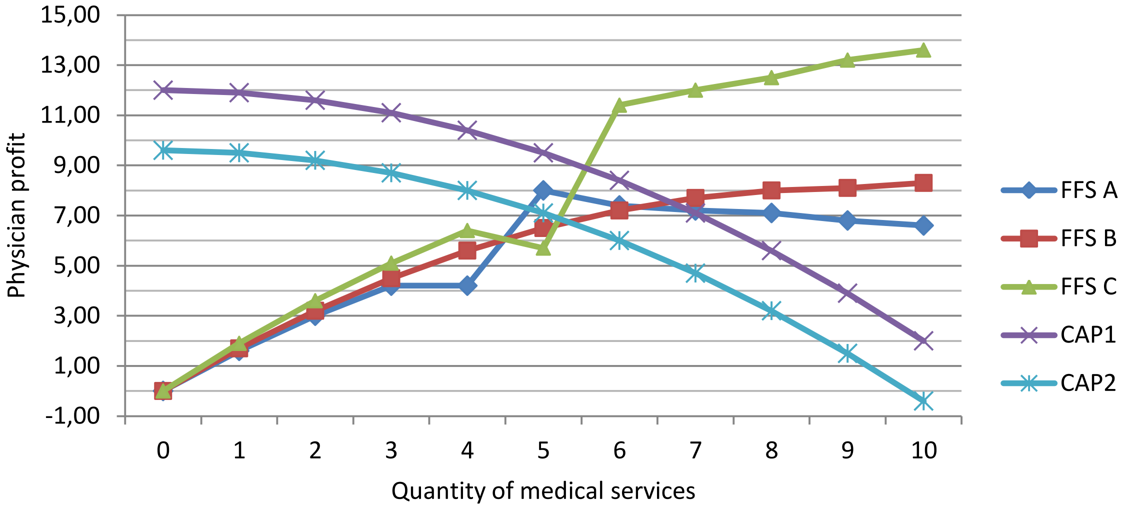

Figure 2: Physician profit functions

3. Experimental procedure

We conducted the experiment at the *Center for Interuniversity Research and Analysis on Organizations (CIRANO)* in Montreal, Canada, in October 2010. The experimental software is based on z-Tree (Fischbacher 2007).

In total, we collected independent observations from 23 (18 female and 5 male) students enrolled at McGill University in Montreal, Canada. Participants were selected from a subject pool of students who had voluntarily signed up to participate in experiments, in which they can earn money. They were selected based on their academic background in healthcare related disciplines, i.e. medicine, dentistry, nursing, psychology, pharmacology and life sciences. We count biology, biochemistry, chemistry and physics towards life sciences. We conducted two experimental sessions, with 13 participants in the first and 10 participants in the second session.

The procedure was as follows. Before the experiment, participants and the experimenter gather in a conference room where instructions (see Appendix A) are distributed and read out to participants. From this moment on, participants are not allowed to communicate with each other and instructed to refrain from publicly raising questions regarding the instructions. Each participant gets randomly assigned to one of the 20 isolated working stations featured in the laboratory. The setup of the working stations in the laboratory makes visual contact and communication between participants impossible.

After reading the instructions, participants get seated at their respective working stations and commence with a programmed questionnaire regarding the instructions. The experimenter is at hand to resolve any open question a participant might have regarding the instructions individually. The experiment begins, once all participants have correctly answered all questions of the questionnaire.

Participants are informed in the instructions that the aggregate patient benefit will be donated to a charitable healthcare organization. At the beginning of the experiment, participants thus select a charitable healthcare organization in order to encourage them to take patient benefit into account. They can choose among three organizations; Canadian Cancer Society, Multiple Sclerosis Society of Canada and Parkinson Society of Canada.

In the experiment, participants allocate medical services to 36 virtual patients in two consecutive sequences. Patients are presented one patient after another in each sequence. The order of patients is randomized in the first sequence (S1) and repeated in the second sequence (S2). The relevant payment system is revealed for each individual patient. Neither illness nor patient type, however, is specified in detail. Participants decide on the quantity of medical services based on numbers associated with illness and patient type related to possible treatments for a specific patient.

In between sequences, participants are notified of a lump-sum payment reduction (see Table 1). Participants carry on with the experiment after they have acknowledged the payment cut.

Physician profit and patient benefit are tallied separately for each participant and converted into CDN$ applying a conversion factor of CDN$ 0.04 per ECU. As communicated in the instructions, each participant privately receives, in cash, his or her payoff from the experiment in addition to a CDN$ 5 show-up fee at the end of the experiment. Patient benefit created by participants having selected the same charitable healthcare organization is pooled and donated publicly to the respective organization.

According to subject availability, we conducted two experimental sessions. Session 1 consisted of 13 and session 2 of 10 participants. Each session lasted approximately 75 minutes including the reading of the instructions, the questionnaire focusing on the comprehension of the instructions, the experiment, an ex-post questionnaire and the payout. Participants earned on average CDN$ 18.27 including the show-up fee. Donations (of the aggregate patient benefit) to charitable healthcare organizations totaled CDN$ 239.47. Ten participants chose the Canadian Cancer Society with donations totaling CDN$ 102.74. Seven participants chose the Multiple Sclerosis Society of Canada (CDN$ 72.28) and six participants chose the Parkinson Society of Canada (CDN$ 64.45). Additionally, one participant wanted his own earnings of CDN$ 15.32 to be donated to the Multiple Sclerosis Society of Canada. All donations were made online; participants received a digital copy of the respective receipts.

4. Results

For a first impression on the decisions made by the physicians in the experiment, consider Figure 3, which provides the relative frequencies of quantity decisions [0, 1, …, 10] for FFS and CAP patients in S1, the first sequence of patients presented. Figure 3a shows the respective cumulative relative frequencies. If we interpret the cumulative frequencies as distribution functions of the treatment quantities under FFS and CAP, we may conclude that FFS first-order stochastically dominates CAP. A patient, who maximizes the expected quantity of medical services, would thus prefer the "gamble" FFS over the "gamble" CAP. On average, physicians provide 6.95 units (median 7.00; SD 2.25) of medical services to FFS patients and 3.22 units (median 3.00; SD 1.95) to CAP patients in that sequence.

Focusing our attention only on those decisions that maximize the physician's profit, we observe that physicians show a higher frequency of profit-maximizing decisions under FFS than under CAP. Concretely, 50.2 percent of the individual treatment decisions for FFS patients and 13.5 percent of those for CAP patients coincide with the physician's profit-maximizing treatment decision. Note that under CAP, profit maximization implies zero treatment.

At the same time, physicians show a higher frequency of decisions coinciding with the patient's right amount of medical care under CAP than under FFS. Concretely, 26.6 percent of the treatment decisions for FFS and 44.4 percent of those for CAP patients coincide with the patient's respective right amount of medical care.

The average physician profit is 9.08 ECU (SD 2.63) per FFS and 10.59 ECU (SD 1.36) per CAP patient. The average patient benefit is 8.04 ECU (SD 1.93) for FFS and 6.54 ECU (SD 3.99) for CAP patients.

The results of S2 are very similar to those of S1. Figure 4 provides the relative frequencies of quantity decisions for FFS and CAP patients, while Figure 4a shows the respective cumulative relative frequencies in S2. On average, physicians provide 6.90 units (median 7; SD 2.35) of medical services to FFS patients and 3.14 units (median 3; SD 1.95) units to CAP patients in S2.

48.3 percent of the individual treatment decisions for FFS patients and 15.5 percent of those for CAP patients coincide with the physician's profit-maximizing quantity.

24.2 percent of the treatment decisions for FFS patients and 42.5 percent of those for CAP patients coincide with the patient's respective right amount of medical care.

The average physician profit is 8.97 ECU (SD 2.84) per FFS and 8.23 ECU (SD 1.25) per CAP patient. The average patient benefit is 7.95 ECU (SD 2.07) for FFS and 6.39 ECU (SD 4.04) for CAP patients.

Table 5 provides an overview of the summary statistics. In the remainder of this Section we shall in detail analyze the over- or under-provision of patients under FFS and under CAP in both sequences (Section 4.1), and compare behavior across payment systems (Section 4.2) and sequences (Section 4.3). We shall investigate physician profit (Section 4.4) and patient benefit (Section 4.5) in detail. In Section 4.2 we shall attempt to classify the individual physicians according to their treatment behavior. Note that our nonparametric analyses are based on 23 independent observations and make use of the statistical analysis software *Statistica* (Release 9.1). All tests are two-sided.

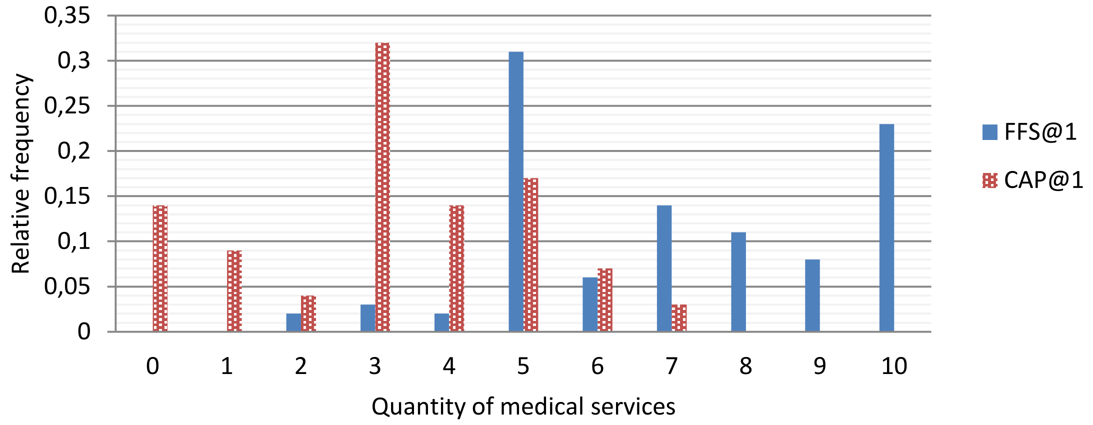

Figure 3: Relative frequency of quantity decisions for FFS and CAP patients in S1

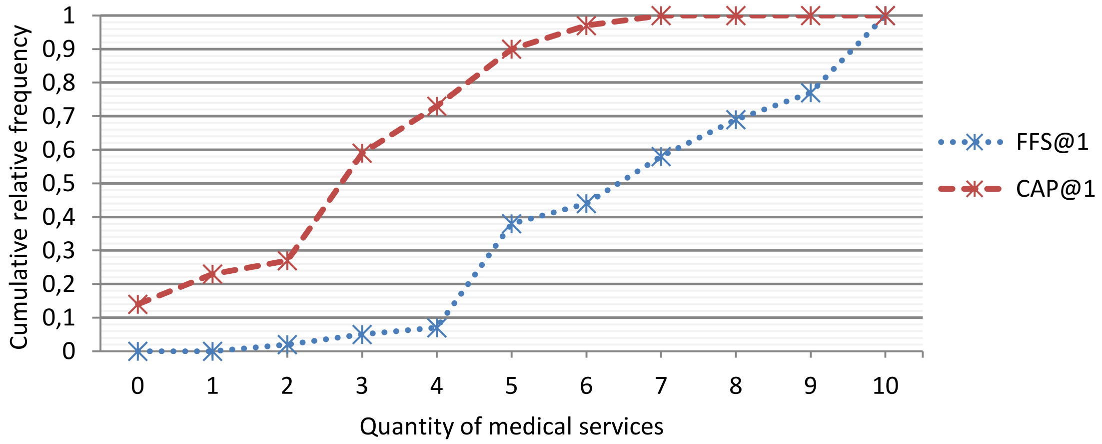

Figure 3a: Cumulative distribution of quantity decisions in S1

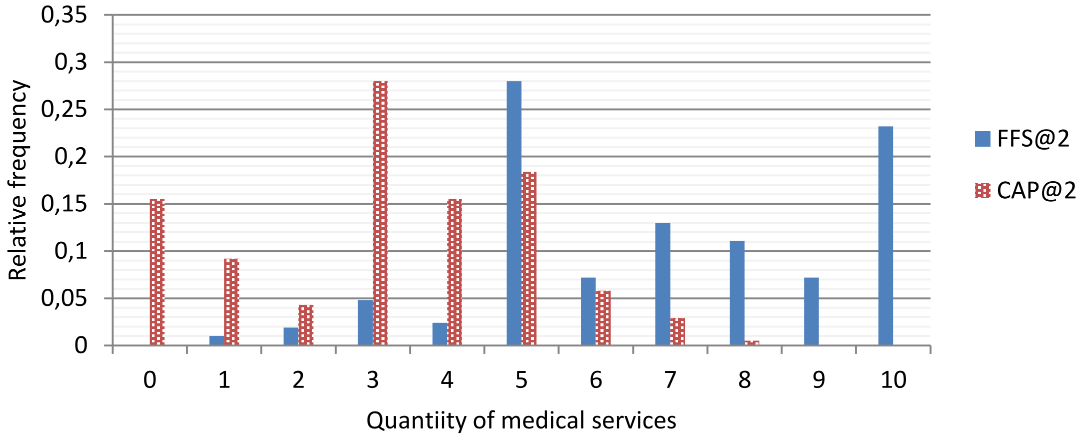

Figure 4: Relative frequency of quantity decisions for FFS and CAP patients in S2

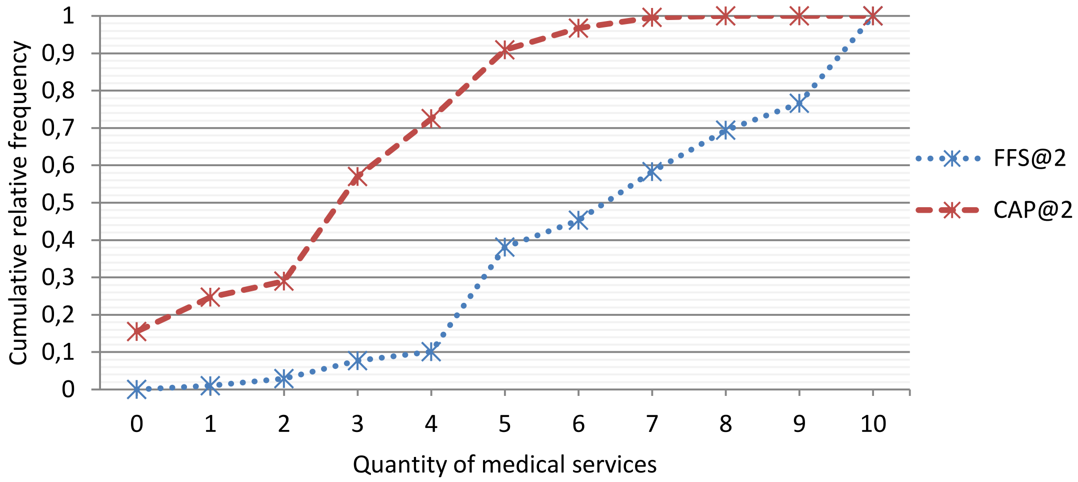

Figure 4a: Cumulative distribution of the quantity of medical services in S2

Table 5: Summary statistics

Quantity of treatment	FFS@S1	FFS@S2	CAP@S1	CAP@S2
Average	6.95	6.90	3.22	3.14
Median	7.00	7.00	3.00	3.00
SD	2.25	2.35	1.95	1.95
Profit	FFS@S1	FFS@S2	CAP@S1	CAP@S2
Average	9.08	8.97	10.59	8.23
SD	2.63	2.84	1.36	1.25
% Max profit[1]	50.2	48.3	13.5	15.5
Patient benefit	FFS@S1	FFS@S2	CAP@S1	CAP@S2
Average	8.04	7.95	6.54	6.39
SD	1.93	2.07	3.99	4.04
% Max patient benefit[2]	26.6	24.2	44.4	42.5

[1]Percent of individual treatment decisions coinciding with the profit-maximizing quantity.
[2]Percent of individual treatment decisions resulting in the maximum patient benefit.

4.1 Over- or under-provision of medical services

In this sub-section of our paper, we investigate whether FFS results in an over-provision and CAP in an under-provision of medical services as indicated by Ellis & McGuire (1986) and HSW (2011).

Figure 5 presents initial evidence. For each of the two sequences, S1 and S2, and for each of the teo payment systems, FFS and CAP, it exhibits for each individual patient, characterized by the combination of illness and treatment preference, the average quantity of medical services provided by the experimental physicians. It shows customization in response to the heterogeneity in the payment system; but it also suggests ready-to-wear treatment for patients with illness B or C under FFS, whose treatment provides maximal physician profits at maximal quantity, and patients of type 1 and 3 under CAP. Under CAP, a level of treatment for type 2 patients similar to the one observed for types 1 and 3 would be above the treatment that maximizes the patient's benefit. Figure 5 also indicates for each patient the profit-maximizing quantity and the right amount of medical care. The latter allows us to evaluate over- or under-provision of patients.

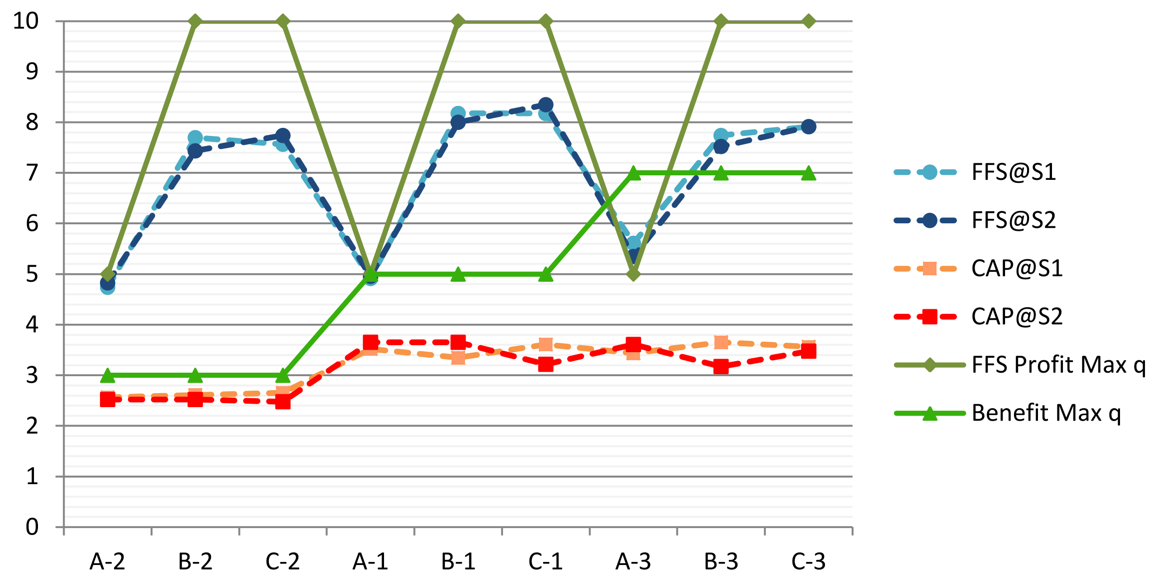

Figure 5: Average quantities of medical services per individual patient
(Characterized by illness [A – C] and patient type [1 – 3])

We observe that for seven of the nine patients under FFS, the average quantity of treatment in either sequence exceeds the corresponding right amount of medical care. Obviously, FFS patients are over-served in those cases, where the profit-maximizing quantity exceeds the patient's optimal quantity of treatment.

We also observe that, in each sequence, the average quantity of treatment provided to the six FFS patients with a profit-maximizing quantity of 10 is roughly the same (around 8), irrespective of the patient's illness and preference for medical attention. This implies that the extent of the over-provision to these patients is higher, the lower the patient's need for medical attention. For instance, FFS patients B-3 and C-3, in need of extensive medical attention, receive only little more medical service than optimal, whereas FFS patients B-2 and C-2, in need of limited medical attention, are considerably over-served.

Two FFS patients in either sequence, characterized by the attributes A-1 or A-3, receive less medical service than optimal. While the FFS patient characterized by A-1 is only marginally under-served (their right amount of medical services coincides with the profit-maximizing quantity), the FFS patient characterized by A-3 receives considerably fewer services than would be optimal for her or him (the optimal amount of medical care for this FFS patient exceeds the profit-maximizing quantity).

CAP patients are in all cases under-served. Average quantities of medical services provided to the nine CAP patients in either sequence lie clearly below the respective right amount of care. In each sequence, the average quantity of medical services provided to CAP patients of type 1 and 3 is roughly the same, irrespective of the patient's need for medical attention. The degree of under-provision depends on the patient type. CAP patients of type 3, in need of extensive medical attention, are considerably under-served, while CAP patients of type 2, in need of minor medical attention, are under-served to a considerably lower degree.

To gain statistical evidence on under- or over-provision of medical attention to FFS and CAP patients, we consider the average treatment decisions by the individual physicians. Table C.1 (Appendix C) provides, for each physician, the average treatment quantity along with the mean deviation from the right amount of medical services over all decisions regarding patients of the same payment system (FFS or CAP) and sequence (S1 or S2). It is obvious that in both sequences of the experiment more services than optimal are given to FFS patients: In each sequence, the mean deviation from the right amount of medical service for FFS patients is positive for 21 of the 23 physicians, while one is negative and one is zero. This implies that physicians significantly tend to over-provide (S1, S2: p = 0.00007; binomial tests). The p-values for the Wilcoxon signed-ranks test are p = 0.00009 and p = 0.00024 for S1 and S2, respectively.

Analysis of the mean deviation for CAP patients shows that CAP patients receive significantly fewer services than optimal in each sequence. The mean deviation is negative for 21 (22) physicians in S1 (S2), implying that physicians significantly tend to under-provide (S1: p = 0.00007; S2: p = 0.00001; binomial test).The p-values for the Wilcoxon signed-ranks test are 0.00009 and 0.00004 for S1 and S2, respectively.

Similar results can be found by considering the individual patient characterized by illness and patient type. For each patient, we calculate the average of the physicians' individual treatment decisions relative to the patient's right amount of care. Table C.2 (Appendix C) provides the p-values of the Wilcoxon signed-ranks test for the individual patients in FFS@S1, FFS@S2, CAP@S1,and CAP@S2. Requiring significance at the 10-percent level, we observe a statistically significant difference for eight of the nine FFS patients in either sequence. These eight FFS patients are characterized by the attributes B-1, C-1, A-2, B-2, C-2, A-3, B-3 and C-3. Seven of them are over-served in each sequence. The remaining one, characterized by the attributes A-3, is under-served in each sequence. For the ninth FFS patient, A-1, individual treatment decisions do in neither sequence significantly deviate from the right amount of medical care. The right amount of medical care for this patient coincides with the profit-maximizing quantity.

The evaluation of the individual treatment decisions to each of the CAP patients shows that physicians provide significantly fewer services than optimal to almost all CAP patients in the experiment. Requiring significance at the 10-percent level, we find a significant difference for all CAP patients in S1. In S2, physicians significantly under-serve eight of the nine CAP patients. We observe neither significant under- nor over-provision for the patient characterized by the attributes C-2.

Result 4.1: *In a heterogeneous payment environment, physicians over-serve patients whose treatments are paid for under FFS and under-serve those whose treatments are paid for under CAP. Over- and under-provision depends on the patient type and thus on the patient's need for medical attention. Under FFS, over-provision is higher, the lower the need for medical attention. Under CAP, under-provision increases as the need for medical attention increases. Our results are consistent with the theoretical projections by Ellis & McGuire (1986) and replicate the experimental results on physician behavior in a homogeneous payment environment by HSW (2011).*

4.2 Comparison across payment systems

In this subsection we investigate the question discussed above, whether in a heterogeneous payment environment, physicians customize care or apply a one-for-all approach.

Figure 5 above shows that, in either sequence, each individual FFS patient receives considerably more medical attention than her or his CAP counterpart of the same type and with the same illness. On average, physicians provide 6.95 (6.90) units of medical services to FFS patients and 3.22 (3.14) units to CAP patients in S1 (S2). They thus provide on average more than twice as many medical services to FFS patients than to CAP patients in either sequence.

Table C.1 (Appendix C) provides, among others, for each physician, the average quantity of medical services provided to FFS and CAP patients in each of the two sequences. A Wilcoxon signed-ranks test based on these averages shows that physicians provide, in each sequence, significantly more medical services to FFS patients than to similar CAP patients (S1: $p = 0.00003$; S2: $p = 0.00005$).

To compare treatment behavior across payment systems, we furthermore consider individual treatment choices for pairs of patients with the same illness and patient type in each of the two sequences. We find, in either sequence, individual treatment quantities for each of the FFS patients to be significantly higher than the quantities for the corresponding CAP patient (S1: $p \leq 0.00109$; S2: $p \leq 0.00792$; Wilcoxon signed-ranks tests; refer to Table C.3 Appendix C).

The regressions in Table D.1 (Appendix D) also confirm our finding that physicians customize care in response to the payment system. In each of nine regressions, we explain the quantity of medical services to one of the patients, characterized by illness and treatment preferences. Each regression comprises four similar patients under both payment systems and in both sequences of the experiment and thus includes the dummies FFS@S1 (for the payment system FFS in S1), FFS@S2 and CAP@S2. It follows that the constant in each regression measures the quantity provided under CAP in S1. Our regression results are in keeping with the above presented non-parametric analysis: FFS patients receive more medical services than matching CAP patients. The coefficients for the FFS@S1 and FFS@S2 dummies in each of the nine regressions are positive and highly significant ($p < 0.01$). In each of the nine regressions, we do not observe a significant difference in the quantities provided under CAP in S1 and S2.

Result 4.2: *Our findings refute the notion that physicians develop a one-for-all approach to providing medical care as suggested by e.g., Glied & Zivin (2002), Landon et al. (2011) and the norms hypothesis (Newhouse & Marquis 1978). Physicians do customize care in response to the payment system in a heterogeneous payment environment as reported by Melichar (2009) and Hirunrassamee & Ratanawijitrasin (2009) among others. In each sequence, physicians provide more medical services to FFS than to CAP patients. These findings confirm the experimental results by HSW (2011); the payment system clearly affects physicians' behavior.*

4.3 Differences in treatment across sequences

A major concern of our study is the analysis of a potential impact of a lump-sum payment reduction on physician provision behavior. We investigate whether it leads to a quantity reduction to the CAP patients and/or a spillover with regard to the treatment of the FFS patients. Note that the patients' right amount of medical care and the profit maximizing quantity remain unaffected by the CAP reduction.

Reconsidering Figure 5 and comparing the average quantities for patients with matching payment system, illness and treatment preferences across sequences, we find that physician treatment behavior towards FFS and CAP patients remains practically unaffected by the lump-sum payment reduction in S2.

A comparison of the average quantities provided by each physician to patients of the same payment system across sequences substantiates this observation. Neither for FFS nor for CAP patients do we find a significant difference in the treatment behavior across sequences. The p-values for the Wilcoxon signed-ranks test are 0.77611and 0.59006, respectively.

Accordingly, we analyze individual treatment decisions for matching pairs of patients (illness and treatment preferences) of the same payment system across sequences. A comparison of individual treatment decisions across sequences shows no significant difference in treatment behavior toward FFS or CAP patients across sequences (FFS: $p \geq 0.26039$; CAP: $p \geq 0.26039$; Wilcoxon signed-ranks tests; see Table C.4, Appendix C).

The regression results discussed in Section 4.2 above (see also Table D.1 Appendix D) provide additional evidence that the lump-sum payment reduction has no significant impact on physician treatment behavior under CAP. None of the regressions shows a significant difference in the CAP quantities provided in S1 and S2.

Result 4.3: *Physicians' provision behavior remains virtually unaffected by an ex-ante payment reduction under capitation. Physicians do not alter their treatment behavior toward FFS and CAP patients in order to recoup lost income. We neither observe a decline in treatment quantities regarding CAP patients nor a spillover effect into the FFS payment system. These findings are in stark contrast to the evidence presented by, e.g., Yip (1998), Rice et al. (1999) and He & Mellor (2012).*

4.4 Physician profit

In the experiment, physicians, on average, take home 331.81 ECU (median 340.50 ECU; SD 31.76 ECU), implying that the average physician profit amounts to 88.8% of the maximum attainable profit of 373.80 ECU. The observed individual overall physician profits (ranging from 257.10 ECU to 373.80 ECU) are significantly smaller than the maximum attainable profit ($p = 0.00003$, Wilcoxon signed ranks test). One single participant, physician #7, earns the maximum attainable profit, while a (small) number of physicians come very close to it.

Figure 6 exhibits the individual physician profits relative to the maximum attainable profit, by sorting the physicians with respect to their relative overall profits. We observe five out of the 23 physicians (#2, #21, #16, #4 and #7; 21.7% of all physicians) to achieves 95% or more of the maximum attainable overall profit, two other physicians (#8 and #18) are extremely close.

To compare profits under FFS and CAP, reconsider Table 5 above: physicians earn on average 9.08 ECU (8.97 ECU) per FFS patient and 10.59 ECU (8.23 ECU) per CAP patient in S1 (S2). Under FFS, the observed averages are 8.9% (10%) lower than the average maximum attainable profit of 9.97 ECU per patient (recall that a patient's illness impacts the FFS profit function); under CAP the observed averages are 11.8% (14.3%) lower than the maximum profit of 12.00 ECU (9.60 ECU) per patient (profit under CAP remains unaffected by illness; lump-sum payments differ across sequences) in S1 (S2). In each sequence, we find individual physicians' average profits per FFS and CAP patient to be significantly lower than the respective maximum profits (p=0.00003 for FFS@S1 and FFS@S2; p=0.00004for CAP@S1 and CAP@S2; Wilcoxon signed-ranks tests).

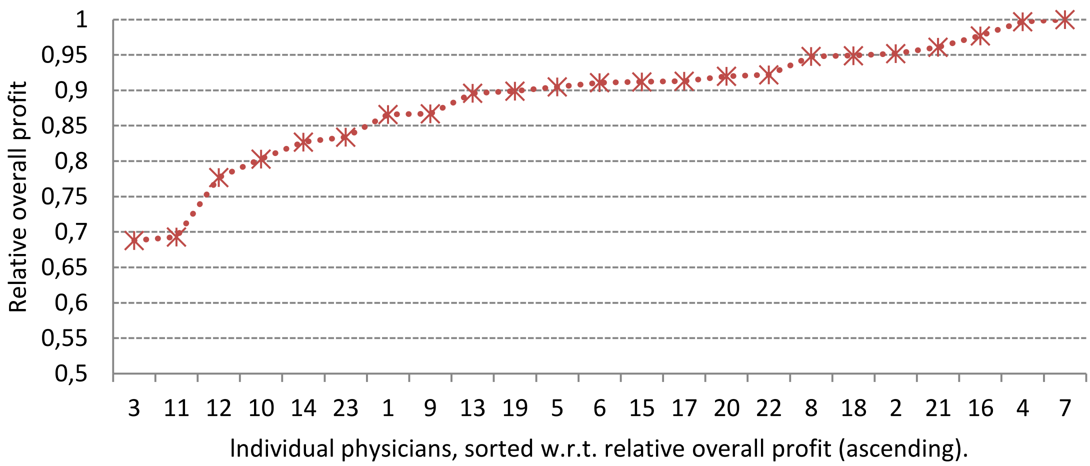

Figure 6: Overall profit relative to the overall profit maximum

We can also show that physicians give up relatively more money relative to the maximum attainable profit under CAP than under FFS. Considering, for each physician, the relative deviation of her or his profit from the maximum attainable profit, averaged over all patients of the same payment system, we find the relative deviation under CAP to be significantly larger than under FFS (S1: p = 0.00088; S2: p = 0.00406; Wilcoxon signed-ranks tests).

To investigate, whether the payment system affects the decision to choose the profit-maximizing treatment quantity, reconsider Table 5 above. It reveals that, under FFS, approximately every other individual treatment decision in each sequence equals the respective profit maximizing quantity. In contrast, fewer than one in seven (six) individual treatment decisions result in maximum physician profit under CAP in S1 (S2). Wilcoxon signed-ranks tests based on the percentage of profit-maximizing decisions by each physician show that the relative share of profit-maximizing treatment decisions in each sequence is significantly larger under FFS than under CAP (S1: p = 0.00006; S2: p = 0.00009).

In Section 4.3, we report that our reduction in the CAP lump-sum payment does not affect physicians' treatment behavior, neither under CAP nor FFS. Consequently, requiring significance at the 10-percent level, we find no difference in the individual physicians' average profits per FFS patient across sequences (Wilcoxon signed-ranks test). Individual physicians' average profits per CAP patient are significantly smaller in S2 as compared to S1 (p = 0.00003, Wilcoxon signed-ranks test). This follows directly from the reduction in the lump-sum payment.

In keeping with the above result regarding the CAP lump-sum payment reduction, the reduction does neither affect the choice of profit-maximizing treatment quantities under FFS and CAP. While slightly fewer individual treatment decisions under FFS and slightly more individual decisions under CAP are profit maximizing in S2 than in S1 (see Table 5), we find no significant difference in the individual physicians' relative frequency of profit maximizing treatment decisions under FFS and CAP across sequences (FFS: p = 0.72677; CAP: p = 0.59396).

Result 4.4: *In the experiment, about one-third of the physicians are found to achieve (almost) 95 percent or more of the maximum attainable profit and can be assumed to quite rigorously maximize their overall profit. The payment system used to pay for a patient's treatment influences the physicians' choices of their profit-maximizing treatment quantities: while about half of all decisions under FFS are payoff maximizing, payoff maximization occurs only occasionally under CAP. The CAP lump-sum payment reduction has no impact on the relative frequency of profit-maximizing treatment decisions, neither under CAP nor under FFS.*

4.5 Patient benefit

We report in Section 4.1 above that physicians tend to over-serve patients under FFS and under-serve those under CAP. In this sub-section, we investigate how this actually impacts the patients' benefit under the two payment systems. Furthermore, we are interested in the impact of the payment reduction on the patients' benefit.

Table 5 above shows an average patient benefit of 8.04 ECU (7.95 ECU) for FFS patients and 6.54 ECU (6.39 ECU) for CAP patients in S1 (S2). The observed average benefits are thus somewhat lower for the CAP patients than for the FFS patients. Had physicians always acted in the patients' best interest providing in each instance the right amount of medical care, both FFS and CAP patients could have received a maximum average benefit of 9.82 ECU (recall that the experimental design distinguishes between three patient types with different benefit functions). Consequently, these averages show that patients on average do not receive the maximum benefit (and thus the optimal care, as indicated in Section 4.1.) on a regular basis.

To substantiate the latter finding, we consider, for each physician, the average benefit received by FFS and CAP patients in each of the two sequences. Wilcoxon signed-ranks tests, based on comparisons of these averages with the maximum average patient benefit, show that patients, under each payment system in each sequence, receive a significantly smaller benefit from medical treatment than in case of optimal treatment (FFS@S1, FFS@2, CAP@1, CAP@2: p = 0.00003).

Table 5 provides the physicians' relative shares of individual treatment decisions that result in optimal patient benefit. In each sequence, we find that roughly one in four individual treatment decisions (S1: 26.6%; S2: 24.2%) for FFS patients result in optimal patient benefit. On the contrary, 44.4% (42.5%) of the individual treatment decisions for CAP patients result in optimal treatment. Comparing, for each physician, the relative share of optimal treatment decisions across payment systems, we find, for each sequence, the physicians' relative share of optimal treatment decisions to be significantly larger for CAP than for FFS patients (S1: p = 0.00023; S2: p = 0.00042; Wilcoxon signed-ranks tests).

To further assess the impact of the payment system on patient benefit, we investigate the patient benefit loss (difference between the (maximum) attainable patient benefit and the observed actual patient benefit) relative to the maximum attainable benefit. Analyzing the relative patient benefit loss averaged over all individual treatment decisions under the same payment system and sequence, we find in each sequence that FFS patients fare considerably better than CAP patients in spite of a higher proportion of optimal treatment decisions for Cap than for FFS patients as noted above.

Table 6 reports the relative patient benefit loss averaged over patients of the same illness but distinguished by type and the combination of payment system and sequence. It shows that in each sequence FFS patients of type 1 (in need of intermediate medical attention) and type 3 (in need of extensive medical attention) do considerably better than their CAP counterparts. On the contrary, CAP patients of type 2 (in need of minor medical attention) fare better (in S1) or roughly the same (in S2) as their FFS counterparts.

Table 6: Relative patient benefit loss

	FFS@S1	FFS@S2	CAP@S1	CAP@S2
Type 1	0.136	0.146	0.387	0.363
Type 2	0.209	0.209	0.162	0.211
Type 3	0.198	0.216	0.46	0.481
Average	0.181	0.19	0.336	0.352

Similar evidence can be found when analyzing, for each physician, the relative patient benefit loss averaged over patients of the same type and payment system. A comparison across payment systems shows that, in each sequence of the experiment, FFS patients of type 1 and 3 fare considerably better than their CAP counterparts (the respective p-values for the Wilcoxon signed ranks tests for S1 (S2) are 0.00173 (0.00428) for patients of type 1 and 0.00011 (0.00006) for patients of type 3). The contrary is true for patients of type 2: CAP patients do better than their FFS counterparts in S1 (p = 0.08830; requiring significance at the 10% level) and the same in S2 (p = 0.40774; Wilcoxon signed-ranks test).

Figures 7 and 8 show the average relative benefit loss per patient, characterized by illness and type, in S1 and S2, respectively. It can be observed that seven out of nine CAP patients in each sequence suffer a greater average relative benefit loss than their FFS counterparts in the same sequence. Only two CAP patients in each sequence, B-2 and C-2, suffer a smaller average benefit loss than the respective FFS counterparts. Two out of three patients of type 2 incur smaller losses under CAP than under FFS, while capitation always leads to larger losses than FFS for patients of type 1 and 3.

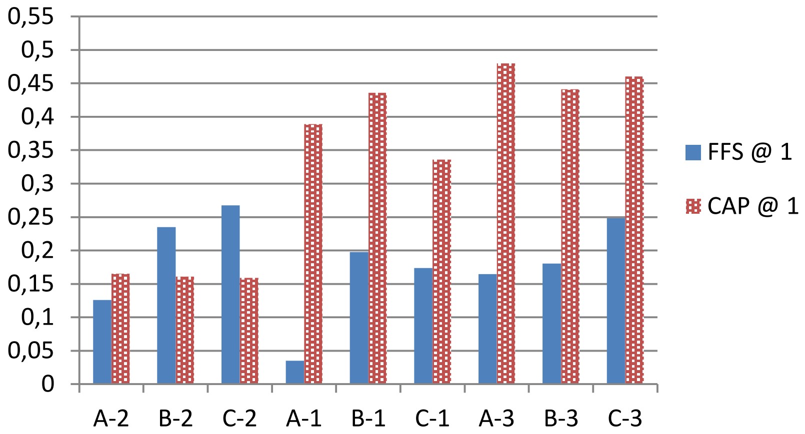

Figure 7: Average relative benefit loss per patient in S1

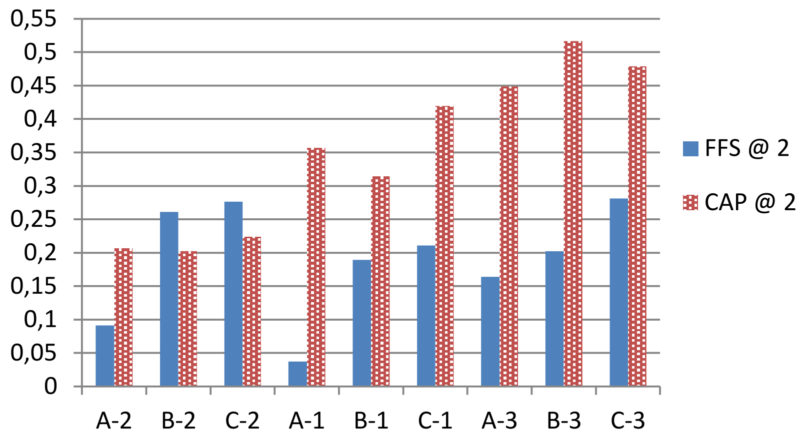

Figure 8: Average relative benefit loss per patient in S2

A comparison of the relative benefit losses for matching pairs of FFS and CAP patients reveals that, in each sequence, CAP patients of **type 3** experience significantly larger benefit losses than their FFS counterparts (S1: $p < 0.001$; S2: $p < 0.01$; Wilcoxon signed-ranks tests; refer to Table C.6, Appendix C). In each sequence, two out of three CAP patients of **type 1** endure significantly larger relative benefit losses than their matching FFS counterparts. In S1, we find significantly larger losses for CAP patients 1A ($p = 0.00098$) and 1B ($p = 0.05340$); in S2, CAP patients 1A ($p = 0.00147$) and 1C ($p = 0.06804$; all Wilcoxon signed ranks test) fare worse than their matching FFS counterparts. In both sequences, we require significance at the 10% level. These results suggest that patients in need of intermediate or extensive medical attention fare better under FFS.

In the experiment, we do not find a significant difference in the relative benefit loss for most of the patients of **type 2**, suggesting that the payment system does not have an effect on the benefit of these patients in need of relatively little medical attention (see Table C.6, Appendix C). We discover a significant difference for only one particular pair of a FFS and CAP patient in S1: patient CAP-C-2 suffers a significantly lower benefit loss than the matching FFS patient (p= 0.07314; Wilcoxon signed-ranks test).

We also investigate the effect of the lump-sum payment reduction under CAP on patient benefit. The nonexistence of a significant behavioral volume response (Result 4.3) suggests that the patient benefit of FFS and CAP patients should remain largely unaffected. A comparison of the average patient benefit for patients of the same remuneration system across sequences provides support for this prediction. We find no important change in the average patient benefit for FFS and CAP patients following the lump-sum payment reduction (refer to Table 5). For statistical evaluation, we consider, for each physician, the average patient benefit for patients of the same payment system across sequences. The analysis shows no significant difference, neither for FFS nor CAP patients. The p-values for the Wilcoxon signed-ranks test are 0.36523and 0.90318, respectively.

We report an insignificant change in the relative share of individual treatment decisions leading to optimal patient benefit for both FFS and CAP patients (see Table 5). Comparing, for each physician, the relative share of optimal treatment decisions for patients under the same payment system across sequences, we find no significant difference (FFS: p =0.37395; CAP: p = 0.97735; Wilcoxon signed-ranks tests).

A comparison of the average relative patient benefit loss for each patient type under FFS and CAP across sequences reveals insignificant changes in response to the lump-sum payment reduction. FFS patients of type 1 and 3 fare slightly worse in S2 compared to S1 (see Table 6). The average relative patient benefit loss for patient type 2 under FFS remains unaffected. Under CAP, patients of type 1 fare slightly better, patients of type 2 and 3 fare slightly worse in S2 compared to S1. We do not find a significant difference across sequences when comparing, for each physician, the relative patient benefit loss averaged over patients of the same type and payment system across sequences (FFS : type 1: p = 0.39673; type 2: p = 0.92498; type 3: p = 0.40805; CAP: type 1: p = 0.98112, type 2: p = 0.39803; type 3: p = 0.47240).

Result 4.5: *In spite of a higher proportion of optimal treatment decisions for CAP than for FFS patients, patients end up with a significantly lower benefit under CAP than under FFS. Benefit losses are significantly higher for CAP than for FFS patients for those patients with a considerable need of medical attention (two-third of our patients); this is not true for those with a low need of medical attention (one third of our patients). This suggests that the overall benefit loss will depend on the* *specific mix of patients with different needs. The reduction in the CAP lump-sum payment shows no effect in the treatment decisions, neither for patients under CAP nor under FFS.*

4.6 Individual physician behavior

In this subsection, we attempt a classification of physicians with respect to treatment behavior. To examine, whether individual physicians show any tendencies in regard to maximizing patient benefit or physician profit, we thus construct two evaluation criteria. The first criterion serves to investigate whether a physician shows a tendency to maximize patient benefit. This criterion applies for the treatment of both CAP and FFS patients. We calculate, for each physician, the average quantities provided to patients of the same patient type, payment system and sequence. This yields us, for each combination of payment system and sequence, three measures, one for each patient type. Based on these the measures, we conclude that a physician displays benefit orientation (under a payment system in a given sequence) if the average quantity of medical service increases along with the patient type's need for medical attention.

The second criterion serves to identify a potential tendency to maximize physician profit. This criterion applies for the treatment of FFS patients. We compare, for each physician in a sequence, the average quantities provided to FFS patients suffering from illness A with the quantities averaged over FFS patients suffering from illness B or C. We conclude that a physician displays profit orientation if the average quantity provided to patients suffering from illness B or C (which should be maximally treated to maximize the physician's profit) exceeds the average quantity provided to patients suffering from illness A (which should be treated with 5 units to maximize the physician's profit).

Note that we apply qualitative measures for both criteria. For profit orientation we require that averages increase along the patient type's need for medical attention. However, we do not require average quantities to exactly match the optimal quantities for the respective patient types. The same is true for our profit-orientation criterion: we do not require the average quantities for FFS patients suffering either from illness A, or illness B or C, to match the respective profit maximizing quantities. We simply require that the averages for FFS patients suffering from illness B or C to exceed the average quantity for patients suffering from illness A.

Table 7 shows, for each individual physician, the observed tendencies (benefit orientation under CAP and FFS, and profit orientation under FFS) in each of the two sequences. A "check" stipulates that the individual physician displays the respective orientation. An “x” implies that the individual physician does not show the respective orientation.

Table 7: Behavioral tendencies

	Patient benefit orientation		*Profit orientation*	*Patient benefit orientation*		*Profit orientation*
Physician #	CAP@1	FFS@1	FFS@1	CAP@2	FFS@2	FFS@2
1	✓	x	✓	✓	x	✓
2	**X**	x	✓	**X**	x	✓
3	**X**	✓	**X**	**X**	x	**X**
4	**X**	x	✓	**X**	x	✓
5	✓	x	✓	**X**	x	✓
6	**X**	x	✓	**X**	x	✓
7	**X**	x	✓	**X**	x	✓
8	**X**	x	✓	**X**	x	✓
9	**X**	✓	✓	**X**	✓	✓
10	✓	✓	**X**	✓	✓	✓
11	✓	✓	**X**	✓	✓	**X**
12	✓	✓	✓	✓	✓	✓
13	✓	x	✓	**X**	x	✓
14	✓	x	✓	✓	✓	✓
15	**X**	x	✓	**X**	x	✓
16	**X**	x	✓	**X**	x	✓
17	✓	✓	✓	**X**	x	✓
18	**X**	x	✓	**X**	x	✓
19	✓	x	✓	**X**	x	✓
20	**X**	x	✓	**X**	x	✓
21	**X**	x	✓	**X**	x	✓
22	**X**	x	✓	✓	x	✓
23	✓	✓	✓	✓	✓	✓

We now classify the physicians broadly into three categories, *benefit maximizers*, *profit maximizers* and (*regular*) *mixed-motives deciders*. We identify a physician as a *benefit maximizer* if the physician (in a given sequence) satisfies benefit orientation under each payment system while not fulfilling profit orientation. In S1 (S2), we find two (one) benefit maximizer(s).

We identify a physician as a *profit maximizer* if the physician's provision behavior satisfies profit orientation while not fulfilling benefit maximization. We find eleven (fourteen) profit maximizers in S1 (S2).[1]

We identify a physician as a (*regular*) *mixed-motives decider* if the physician's observed treatment behavior satisfies benefit orientation under CAP, exclusively, and fulfills profit maximization under FFS. We observe five (two) mixed-motives deciders in S1 (S2).

A small number of physicians do not fall into any of the three categories. Three (four) physicians satisfy both benefit orientation (for CAP and FFS) and profit maximization at the same time. In addition, we find a single physician (#9) to satisfy, in each sequence, benefit orientation for FFS (but not for CAP) patients and profit orientation at the same time. Another physician (#3) displays a benefit orientation for FFS patients in S1 and no tendencies in S2.

Result 4.6: *One out of two physicians can be classified as profit maximizer.Benefit maximizers occur but are rare. The remaining physicians show mixed motives; only a few of them show them in a regular manner.*

5. Conclusion

This work adds to the existing experimental research on physician treatment behavior by incorporating heterogeneity of the payment system, a prominent feature characterizing markets for physician services in a number of countries (e.g., the United States). It also investigates the effect of a payment reduction in such an environment. It thus complements the existing empirical and theoretical literature on the effects of financial incentives on physician behavior.

This kind of experimental research is basic economic research and does not assess actual physician behavior in the real world. Although it does not allow for direct application to real-world issues, the results might provide valuable insights to those, who attempt to design new institutions. Laboratory experiments allow us to test the functioning of institutions that do not exist yet in real life. They

[1]It is reassuring that all seven physicians that we identified as profit-maximizing physicians in Section 4.4 above due to the fact that their profit was at or beyond 95 percent of the optimal profit, are identified as profit maximizers by the criterion used in this subsection. All profit maximizers with the exception of two (physicians #13 and #19) reach (on average over the two sequences) at least 90 percent of the optimal profit.

allow for much tighter control than field experiments. Laboratory experiments are thus to be considered as a useful complement to empirical studies or field experiments.

To effectively design healthcare policy, it requires an in-depth consideration of the effects of heterogeneity of the payment system on physician provision behavior. Potential system-wide effects of fee regulation, targeting the reimbursement of the treatment of one subgroup of patients, should be taken into consideration.

In our experimental environment, we find that physicians customize care in response to heterogeneity of the payment system. A patient's medical treatment is clearly affected by the payment system used to compensate the attending physician. In the experiment, a FFS patient receives considerably more medical care than the corresponding CAP patient with the same illness and treatment preference. We also observe physicians to over-serve FFS patients and under-serve CAP patients. Over- and under-provision depend on the patient's need for medical attention. Under FFS (CAP), over-provision (under-provision) decreases (increases) as the patient's need for medical attention increases. Patients in need of considerable medical attention appear to fare considerably better under FFS than under CAP.

In our experimental design, we assume patients to be passive. If we eased this assumption, we would expect reputational effects to come into play (see, e.g., Dranove, 1988). Perceived over- or under-providers could thus expect patients to be more likely to reject treatment recommendations, which in turn could potentially limit such physician behavior.

Our results suggest that, in our experimental model, fee regulation can be used to some extent as a means to control physician spending, since we do not identify a behavioral response to the CAP payment cut. Physicians do not recoup lost income by altering treatment behavior towards CAP and/or FFS patients. Patient benefit under FFS and CAP thus appears to remain unaffected by fee regulation.

In keeping with the observations by HSW (2011), our results let us conclude that neither payment system, neither FFS nor CAP, encourages physicians to provide optimal care from a patient's perspective. This would support a move away from pure payment systems towards hybrid compensation schemes that blend the high- and low-intensity incentives embedded in FFS and CAP. Experimental economics provides a great tool to further investigate in that direction.

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Appendix A: Instructions

EXPERIMENT INSTRUCTIONS

You are participating in an experiment in which you will make independent and anonymous decisions. Depending on these decisions you can earn money.

All amounts in the experiment are denoted in ECU (Experimental Currency Units). The ECU that you earn in the experiment will be converted into $ CAD with a factor 1 ECU = 0.02 $ CAD and paid to you in addition to a show-up fee of 5 $ CAD in cash at the end of the experiment.

YOUR DECISIONS

In the experiment you will be in the role of a physician making medical decisions for virtual patients. These decisions will impact your profit as a physician as well as the patient benefit.

You will be responsible for the medical treatment of 36 virtual patients and decide for each individual patient on the number of medical services that you want to provide to this patient. The treatment can consist of an amount between zero (including) and ten (including) units of medical services.

The virtual patients will be presented to you one patient after the other. Each patient suffers from one out of three potential illnesses and belongs to one out of three patient types. We shall specify neither the illnesses nor the patient types in more detail. You won't know the illness or type of a patient; you will only see numbers associated with illness and type related to possible treatments for the specific patient.

YOUR REMUNERATION

Your treatment will be remunerated either based on a Fee-for-Service (FFS) or a CAPITATION system. The remuneration system will vary across patients; the presentation of each patient includes information on the respective remuneration system.

If you treat a patient, for whom your services are remunerated based on FFS, each unit of service that you provide will be paid separately. Your remuneration thus increases with the number of services. In addition, your remuneration depends on the patient's illness.

If you treat a patient for whom your services are remunerated by CAPITATION, you will receive a fixed payment of 12 ECU for this patient. This lump-sum payment is independent of the number of services provided by you and of the patient's illness. You receive this payment even if you decide to provide zero service.

YOUR COSTS AND PROFIT

With your decision on the number of medical services that you want to provide to a patient you also determine your costs of treating this patient. The treatment costs increase with the number of services.

Your profit per patient is determined by your remuneration minus your treatment costs for this patient.

MONETARY PATIENT BENEFIT

Your decision on the number of medical services that you want to provide to a patient also determines the benefit that this patient gets from your treatment. This benefit depends on the patient type and the number of services but not on the illness.

YOUR INFORMATION

In the experiment we shall confront you with decision situations as in the following two examples. The examples consider the FFS and the CAPITATION remuneration scheme, respectively. In the experiment we shall present you a sequence of 36 such decision situations.

In the first example you have to make a decision on the number of services for a patient under FFS. The table shows you for each potential number of services (between zero and ten) that you provide to this patient with his or her specific illness your respective remuneration, your treatment costs, your profit (remuneration minus costs), and the monetary patient benefit that depends on the patient type You will be asked to enter your decision on the number of services units in the box below the table. Please choose an integer number between zero and ten. To confirm your decision, please click on “OK”.

Example FFS

Number of Services	Remuneration	Costs	Your Profit	Patient Benefit
0	0.00	0.00	0.00	0.00
1	1.70	0.10	1.60	0.75
2	3.40	0.40	3.00	1.50
3	5.10	0.90	4.20	2.00
4	5.80	1.60	4.20	7.00
5	10.50	2.50	8.00	10.00
6	11.00	3.60	7.40	9.50
7	12.10	4.90	7.20	9.00
8	13.50	6.40	7.10	8.50
9	14.90	8.10	6.80	8.00
10	16.60	10.00	6.60	7.50

Please enter the number of services that you want to provide to this patient:

OK

The second example requires a treatment decision for a patient under CAPITATION. Here again you are provided for each number of services units the corresponding information on remuneration, costs, profit and monetary patient benefit.

Example CAPITATION

Number of services	Remuneration	Costs	Your profit	Patient benefit
0	12.00	0.00	12.00	0.00
1	12.00	0.10	11.90	1.00
2	12.00	0.40	11.60	1.50
3	12.00	0.90	11.10	10.00
4	12.00	1.60	10.40	9.50
5	12.00	2.50	9.50	9.00
6	12.00	3.60	8.40	8.50
7	12.00	4.90	7.10	8.00
8	12.00	6.40	5.60	7.50
9	12.00	8.10	3.90	7.00
10	12.00	10.00	2.00	6.50

Please enter the number of services that you want to provide to this patient:

OK

PAYMENT

At the end of the experiment your individual profit resulting from the treatment of all 36 patients will be summed up, converted into $ CAD [1 ECU = 0.02 $ CAD] and paid to you in cash.

Since there are no real patients participating in this experiment, we shall donate the sum of patient benefits to a charitable healthcare organization. In this way your treatment decisions create benefit to real patients.

At the beginning of the experiment, you may decide on the charitable healthcare organization to which you want to donate. You can choose among:

- CANADIAN CANCER SOCIETY(www.cancer.ca)
- MULTIPLE SCLEROSIS SOCIETY OF CANADA (www.mssociety.ca)
- PARKINSON SOCIETY OF CANADA (www.parkinson.ca)

The patient benefits resulting from your decisions will we added up for all patients, converted into $ CAD with the same conversion factor as your own profit and paid to the organization of your choice.

The total patient benefit that has been created by all participants having chosen the same charitable healthcare organization will be donated online to the respective organization. We will do the payment in front of you at the end of the session.

Please turn now to the computer with your participation number and click on “Start”. You will be requested to answer a number of questions related to the understanding of these instructions. If you should have remaining questions, we will come to your workplace and answer them individually. As soon as all participants will have correctly answered all questions, the experiment can start.

Appendix B: Order of patients

	Patient number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PS*	CAP	FFS	FFS	CAP	FFS	CAP	FFS	CAP	CAP	CAP	FFS	FFS	FFS	FFS	CAP	FFS	CAP	CAP
Illness	B	A	B	A	B	A	C	B	C	A	A	C	A	C	C	B	C	B
Type	1	3	2	1	1	3	1	2	1	2	2	2	1	3	3	3	2	3
S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Patient	CAP-B -1@S1	FFS-A-3@S1	FFS-B-2@S1	CAP-A-1@S1	FFS-B-1@S1	CAP-A-3@S1	FFS-C-1@S1	CAP-B-2@S1	CAP-C-1@S1	CAP-A-2@S1	FFS-A-2@S1	FFS-C-2@S1	FFS-A-1@S1	FFS-C-3@S1	CAP-C-3@S1	FFS-B-3@S1	CAP-C-2@S1	CAP-B-3@S1

*Payment system

	Patient number																	
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
PS*	CAP	FFS	FFS	CAP	FFS	CAP	FFS	CAP	CAP	CAP	FFS	FFS	FFS	FFS	CAP	FFS	CAP	CAP
Illness	B	A	B	A	B	A	C	B	C	A	A	C	A	C	C	B	C	B
Type	1	3	2	1	1	3	1	2	1	2	2	2	1	3	3	3	2	3
S	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Patient	CAP-B -1@S2	FFS-A-3@S2	FFS-B-2@S2	CAP-A-1@S2	FFS-B-1@S2	CAP-A-3@S2	FFS-C-1@S2	CAP-B-2@S2	CAP-C-1@S2	CAP-A-2@S2	FFS-A-2@S2	FFS-C-2@S2	FFS-A-1@S2	FFS-C-3@S2	CAP-C-3@S2	FFS-B-3@S2	CAP-C-2@S2	CAP-B-3@S2

*Payment system

Appendix C: Data tables

Table C.1: Quantity q and mean deviation from the optimal quantity q*, by physician, sorted with respect to overall profit (ascending)

	FFS@S1						CAP@S1					
	Quantity q			Deviation from q*			Quantity q			Deviation from q*		
Physician #	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
3	3.67	5.00	2.6	-1.33	-1.00	2.69	2.67	3.00	1.00	-2.33	-1.00	2.24
11	5.00	5.50	1.73	0.00	0.00	0.00	5.56	5.00	2.40	0.56	0.00	1.67
12	6.22	7.00	1.64	1.22	0.00	1.92	5.00	5.00	1.73	0.00	0.00	0.00
10	5.56	5.00	1.42	0.56	0.00	0.73	4.67	5.00	1.32	-0.33	0.00	0.50
14	5.67	6.00	0.87	0.67	0.00	1.50	4.56	5.00	1.59	-0.44	0.00	0.73
23	5.78	6.00	0.97	0.78	1.00	1.56	4.44	5.00	1.13	-0.56	0.00	0.88
1	6.56	7.00	1.24	1.56	2.00	2.24	4.56	5.00	1.24	-0.44	0.00	0.73
9	5.56	5.50	1.01	0.56	0.00	1.42	3.89	4.00	0.78	-1.11	0.00	1.45
13	7.11	6.00	1.62	2.11	1.00	2.57	4.67	5.00	1.32	-0.33	0.00	0.50
19	7.44	8.00	1.94	2.44	2.00	2.70	4.33	4.00	1.22	-0.67	-1.00	0.71
5	7.44	8.00	1.94	2.44	2.00	2.79	3.78	4.00	0.67	-1.22	-1.00	1.20
6	7.89	9.50	2.26	2.89	3.00	2.76	1.00	1.00	0.00	-4.00	-4.00	1.73
15	7.00	8.00	1.73	2.00	2.00	2.45	3.67	4.00	0.71	-1.33	-1.00	1.41
17	7.11	7.50	1.54	2.11	2.00	1.83	3.78	4.00	0.67	-1.22	-1.00	1.20
20	7.22	8.00	2.49	2.22	2.00	2.49	2.78	3.00	2.28	-2.22	-1.00	2.86
22	7.89	6.00	2.32	2.89	2.00	3.22	3.44	3.00	1.01	-1.56	-1.00	1.74
8	8.11	6.00	2.37	3.11	2.00	3.10	2.33	3.00	1.22	-2.67	-3.00	2.12
18	8.00	8.00	2.45	3.00	3.00	3.24	1.56	0.00	1.94	-3.44	-5.00	3.36
2	8.00	5.00	2.35	3.00	2.00	3.16	3.00	3.00	1.00	-2.00	-2.00	2.00
21	7.67	8.00	2.24	2.67	2.00	3.24	1.89	1.00	1.90	-3.11	-2.00	3.18
16	8.33	8.00	2.5	3.33	3.00	3.04	1.89	2.00	1.54	-3.11	-3.00	2.98
4	8.22	8.5	2.44	3.22	3.00	2.91	0.56	1.00	0.53	-4.44	-5.00	1.94
7	8.33	10.00	2.5	3.33	3.00	3.04	0.00	0.00	0.00	-5.00	-5.00	1.73

Table C.1: Quantity q and mean deviation from the optimal quantity q*, by physician, sorted with respect to overall profit (ascending) (cont.)

	FFS@S2						CAP@S2					
	Quantity q			Deviation from q*			Quantity q			Deviation from q*		
Physician #	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
3	2.11	2.00	0.78	-2.89	-2.00	2.26	1.22	1.00	0.67	-3.78	-3.00	1.56
11	5.00	5.00	1.73	0.00	0.00	0.00	5.00	5.00	1.73	0.00	0.00	0.00
12	5.56	6.00	1.67	0.56	0.00	1.51	4.67	5.00	1.41	-0.33	0.00	0.71
10	5.89	6.00	1.27	0.89	1.00	1.05	4.67	5.00	1.32	-0.33	0.00	0.50
14	6.00	7.00	1.58	1.00	0.00	1.58	4.78	5.00	1.48	-0.22	0.00	0.44
23	5.89	6.00	1.05	0.89	1.00	1.05	4.67	5.00	1.32	-0.33	0.00	0.50
1	6.89	7.00	1.36	1.89	2.00	1.96	4.44	5.00	1.13	-0.56	0.00	0.88
9	5.44	6.00	1.13	0.44	0.00	1.51	3.67	4.00	0.50	-1.33	-1.00	1.32
13	7.89	8.00	1.62	2.89	3.00	2.37	3.44	1.00	2.35	-2.67	-2.00	2.55
19	7.33	8.00	1.87	2.33	2.00	2.74	4.00	4.00	0.87	-1.00	0.00	1.32
5	7.22	8.00	1.72	2.22	2.00	2.54	4.11	4.00	1.54	-0.89	-1.00	1.96
6	6.33	6.00	2.40	1.33	1.00	3.28	2.33	1.00	2.50	-2.67	-4.00	2.78
15	7.00	8.00	1.58	2.00	2.00	2.24	3.33	4.00	1.00	-1.67	-1.00	2.00
17	7.33	8.00	1.87	2.33	2.00	2.45	3.67	4.00	0.50	-1.33	-1.00	1.32
20	8.00	10.00	2.45	3.00	3.00	3.24	2.89	3.00	1.90	-2.11	0.00	2.85
22	8.11	9.00	2.20	3.11	2.00	2.98	4.00	4.00	0.87	-1.00	-1.00	1.12
8	8.11	10.00	2.42	3.11	3.00	3.14	3.56	3.00	1.13	-1.44	0.00	2.19
18	7.33	7.00	2.24	2.33	2.00	3.39	2.67	3.00	2.18	-2.33	0.00	3.12
2	8.00	9.00	2.35	3.00	2.00	3.16	2.89	3.00	0.60	-2.11	-2.00	1.96
21	8.22	10.00	2.44	3.22	3.00	3.07	2.11	2.00	1.54	-2.89	-3.00	2.42
16	8.33	10.00	2.50	3.33	3.00	3.04	1.22	0.00	1.64	-3.78	-5.00	3.27
4	8.33	10.00	2.50	3.33	3.00	3.04	0.11	0.00	0.33	-4.89	-5.00	1.76
7	8.33	10.00	2.50	3.33	3.00	3.04	0.00	0.00	0.00	-5.00	-5.00	1.73

Table C.2: P-values for Wilcoxon signed-ranks tests, comparing individual treatment decisions with the respective right amount of care (under-/over-provision per patient type)

	Illness and patient type								
	A-1	B-1	C-1	A-2	B-2	C-2	A-3	B-3	C-3
FFS@S1	-*	0.00016	0.00009	0.00007	0.00004	0.00007	0.00223	0.01565	0.02313
FFS@S2	0.65472	0.00016	0.00009	0.00009	0.00011	0.00007	0.0002	0.08539	0.01738
CAP@S1	0.00098	0.01006	0.00147	0.06789	0.06789	0.06789	0.00009	0.00006	0.00006
CAP@S2	0.00713	0.00335	0.00066	0.0464	0.04312	0.14221	0.00006	0.00004	0.00009

* N = 1

Table C.3: P-values for Wilcoxon signed-ranks tests, comparing individual treatment decisions for matching pairs of FFS and CAP patients

	Illness and patient type								
	A-1	B-1	C-1	A-2	B-2	C-2	A-3	B-3	C-3
S1	0.00098	0.00026	0.00009	0.00007	0.00004	0.00009	0.00109	0.00006	0.00009
S2	0.00792	0.00009	0.00006	0.00006	0.00009	0.00007	0.00065	0.00006	0.00013

Table C.4: P-values for Wilcoxon signed-ranks tests, comparing individual treatment decisions for matching pairs of patients across sequences

	Illness and patient type								
	A-1	B-1	C-1	A-2	B-2	C-2	A-3	B-3	C-3
FFS	-	0.44127	0.34545	0.71500	0.26039	0.47553	0.88886	0.61030	0.83846
CAP	0.76710	0.47691	0.26039	0.78740	0.58388	0.50019	0.76710	0.34325	0.66035

Table C.6: P-values for Wilcoxon signed-ranks tests, relative benefit losses resulting from individual treatment decisions for matching pairs of FFS and CAP patients, across payment systems

	Illness and patient type								
	A-1	B-1	C-1	A-2	B-2	C-2	A-3	B-3	C-3
S1	0.00098	0.05340	0.15600	0.16978	0.14854	0.07314	0.00071	0.00009	0.00025
S2	0.00147	0.39053	0.06804	0.47614	0.27897	0.27358	0.00060	0.00007	0.00381

Table C.7: P-values for Wilcoxon signed-ranks tests, benefit losses resulting from individual treatment decisions for matching pairs of patients of the same payment system, across sequences

	Illness and patient type								
	A-1	B-1	C-1	A-2	B-2	C-2	A-3	B-3	C-3
FFS	-*	0.37426	0.05917	0.46521	0.95277	0.41482	0.88864	0.54082	0.30806
CAP	0.63559	0.19733	0.28632	0.50019	0.58388	0.22492	0.76710	0.40694	0.63777

*N = 1

Appendix D: Regressions

Table D.1: Effects of payment systems on the quantity of medical services provided

Variable	A1	A2	A3	B1	B2	B3	C1	C2	C3
FFS@S1	1.39130***	4.82609***	4.56522***	2.17391***	5.08696***	4.91304***	2.17391***	4.08696***	4.34783***
	(0.40954)	(0.65618)	(0.58126)	(0.29004)	(0.57254)	(0.61683)	(0.57606)	(0.62293)	(0.64808)
FFS@S2	1.43478***	4.65217***	4.73913***	2.26087***	4.82609***	5.08696***	1.91304***	3.86957***	4.34783***
	(0.40954)	(0.65618)	(0.58126)	(0.29004)	(0.57254)	(0.61683)	(0.57606)	(0.62293)	(0.64808)
CAP@S2	0.13043	0.30435	-0.39130	-0.04348	-0.08696	-0.17391	0.17391	-0.47826	-0.08696
	(0.40954)	(0.65618)	(0.58126)	(0.29004)	(0.57254)	(0.61683)	(0.57606)	(0.62293)	(0.64808)
Constant	3.52174***	3.34783***	3.60870***	2.56522***	2.60870***	2.65217***	3.43478***	3.65217***	3.56522***
	(0.28959)	(0.46399)	(0.41101)	(0.20509)	(0.40485)	(0.43616)	(0.40734)	(0.44048)	(0.45826)
Observations	92	92	92	92	92	92	92	92	92
F(3,88)	7.25820	32.67219	46.55417	39.77154	50.92005	45.39446	7.78906	30.79480	30.61457
Prob > F	0.00021	0.00000	0.00000	0.00000	0.00000	0.00000	0.00011	0.00000	0.00000
Adj-R-Squaed	0.17103	0.51080	0.60029	0.56105	0.62203	0.59408	0.18288	0.49552	0.49401
Root MSE	1.38883	2.22521	1.97114	0.98356	1.94159	2.09177	1.95351	2.11245	2.19774
				0.57552	0.63449	0.60746	0.20982	0.51215	0.51069

We use CAP in S1 as reference variable. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1