Do Budget Constraints Limit Access to Health Care? Evidence from PCI treatments in Hungary

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Abstract

Under Hungary's single payer health care system, hospitals face an annual budget cap on most of their DRG-based reimbursements. In July 2012, percutaneous coronary intervention (PCI) treatments of acute myocardiac infarction (AMI) were exempted from that cap. We use countrywide individual-level patient data from 2009 to 2015 to map the effect of such a quasi-experimental change in monetary incentives on health provider decisions and health outcomes. We find that direct admissions into PCI-capable hospitals increase, especially in central Hungary, where hospitals can compete for patients. The proportion of PCI treatments at PCI-capable hospitals, however, does not increase, and neither does the number of patient transfers from non-PCI hospitals to PCI-capable ones. We conclude that only some patient pathways (plausibly influenced by hospital management) were affected by the shift in incentives, while physicians' decisions were not. We did not find any effect on health outcomes, such as 30-day readmissions or in-hospital mortality.

Keywords: hospital funding, budget caps, AMI, PCI, physician agency, inpatient care

JEL Classification: I110, I180

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1 Introduction

A better understanding of the effects of healthcare reimbursement regimes on provider behavior and health outcomes, and the channels through which they operate, is crucial for evidenced-based policymaking. While a restriction on hospital cost reimbursements beyond an arbitrary threshold can be questioned on ethical grounds, such a budget cap is considered an effective policy tool for cost containment (Moreno-Serra, 2014). There is still only limited evidence, however, about its potential impact on rationing health services or lowering the quality of care.

This study evaluates the effect of a systemwide change in hospital financing targeted to the treatment of acute myocardiac infarctions (AMI) on patient pathways, treatment decisions, and health outcomes in Hungary. Hungarian hospitals are reimbursed through a DRG-based system with a cap on the total yearly amount paid to the hospital. In July 2012, percutaneous coronary intervention (PCI) treatments of AMI were exempted from the cap and have been financed fully by the health insurance fund ever since. We use individual-level patient data from 2009 to 2015, covering all AMI cases in the country, to carry out an impact analysis of the regulatory change.

First, we find that the probability that patients get directly admitted to hospitals with PCI capabilities increased right after the financing change from a baseline of 68% to 76%. The only exceptions were those patients who lived in the immediate proximity of PCI-capable hospitals and already had high direct admission rates. At the same time, transfers from non-PCI hospitals to PCI-capable ones did not substantially decrease, hence the regulation change did result in more people getting timely access to PCI centers.

Second, the probability of receiving PCI treatment conditional on being admitted to a PCI hospital did not increase after the regulatory change. Overall, this still resulted in more AMI patients receiving PCI treatment, but the effect worked through the patient pathway channel, and not through a change in the decision-making of medical specialists.

Despite the increase in PCI treatments, we found no convincing evidence of improved outcomes in terms of 30-day readmissions or in-hospital mortality. This null result may be the outcome of our inability to fully control for treatment selection, or it might result from the limited net benefit that the additionally treated patients derive from PCI. Other unmeasured dimensions of patient care could have improved, of course, as more AMI patients ended up at larger and better-equipped hospitals.

Our overall conclusion is that applying a hospital-level budget cap does not seem to influence medical decision making (at least for potentially life-saving treatment), but can limit the effective population that a hospital serves. Consequently, lifting the budget cap for expensive emergency care services will likely improve access for those living in a greater distance from specialized centers.

In the following section, we review recent contributions to the literature on the incentive effects of budgetary control in health care, and explain how the current study enhances our understanding of the field.

1.1 Related literature

Quality measurement of AMI treatment has been in the focus of clinical quality improvement programs during the last two decades (Kessell et al., 2015). The uptake of PCI among AMI patients from the 1990s has been considered a great technological achievement and contributed to lower mortality rates, but also increased the average expenses of AMI treatments. For example, despite the hospital-level budgets used in France in the mid-1990s, angioplasty rates grew among AMI patients, indicating that hospitals tend to adopt superior technologies even if they are more expensive and might not be fully reimbursed (Dormont and Milcent, 2005).

A Taiwanese study about the introduction of global budgeting found that for-profit and private not-for-profit hospitals, in contrast to government-owned ones, increased treatment intensity among cardiac disease patients, but without improved outcomes (Kan et al., 2014). Higher-tier hospitals and medical centres gained additional patient volume, while local hospitals lost patients as a consequence of global budgeting (Chen and Fan, 2015). The initial introduction of regional budget caps also significantly increased the average claim per AMI patient (due to the cooperation problem inherent in system-wide global budgeting), while the allocation of fixed budget caps to individual hospitals had only a moderate effect (Hsu, 2014). An analysis of a policy change in the treatment benefit package in Shanghai, China—namely, involving heart stents in the public benefit package—suggested that the application of a global budget cap results in "provider gaming": stent usage decreased in the high reimbursement group of AMI patients (where a higher ratio of costs is reimbursed by the third party, also subject to the preset financial ceiling) (Yuan et al., 2014).

While for-profit hospitals treated AMI patients, including the use of interventional cardiac procedures, similarly to non-profit counterparts in a US study (Shah et al., 2007), or appeared to be less responsive to DRG price changes in Taiwan (Liang, 2015), most studies found that for-profit status or other types of financial pressures tend to have an impact on quality. In California, a higher number of uninsured patients and their uncompensated costs resulted in the increase of the mortality rate of insured heart attack patients as well (Daysal, 2012). Care quality in low-performing hospitals serving patients with lower socio-economic status could be improved by changing financial incentives (Jha et al., 2010). Worse financial position was found to have a moderate impact over patient safety and mortality (Bazzoli et al., 2008). By using quality data of heart attack and heart failure treatments, it was demonstrated that "the lack of financial strength may result in a lower standard of health care services" (Dong, 2015, p. 14). Hospitals having softer budget constraints and less zelous cost control practices appeared to show better mortality outcomes for elderly heart attack patients (Shen and Eggleston, 2009).

A few other studies analysed the impact of price changes in DRG systems over hospital performance. While our case (lifting the budget cap) did not involve a direct price increase, it might be perceived similarly if budget limitations are binding. Increased reimbursement rates in Norway had a positive effect on the volume of medical DRGs (Januleviciute et al., 2016), or on both medical and surgical ones (Melberg et al., 2016). A general price increase in Italy stimulated the number of surgical DRGs, although the adaptation occured with a time lag of a few years (Verzulli et al., 2017).[1]

In summary, several studies in the literature suggest that a change in financing conditions can have an impact on treatment decisions. Nonetheless, there remains a lot to learn about the size and channels of the effect. By ex-

[1] Price increases might not lead to increases in quantity or quality of services, but can also trigger upcoding (Shin, 2019). Priority setting inside hospitals can also be a very complex process, with several factors at play (Barasa et al., 2014), thus changes in overall financial conditions of hospitals may influence various departments or emergency procedures differently.

amining a quasi-experimental financing change targeted at PCI treatments in Hungary, we aim to contribute to filling this research gap.

2 Background: hospital and AMI treatment financing in Hungary

2.1 General financing rules

Hungary adopted DRG-based payments for reimbursing hospital care in 1993. There have been several adjustments to the system over the years (e.g. to DRG codes and weights, or to reimbursement rules of transfer cases and readmissions), but the core elements of DRG-based financing have remained intact.

Oversight functions of the national health insurance fund administration body have been limited, contributing to the appearance of an unintended but predictable consequence, the "DRG creep" (Simborg, 1981). The volume of active hospital cases rose by 36% between 1993 and 2003, while the case-mix-index increased by 12% between 1993 and 1998 (Szummer, 2005). In response to the budgetary pressure, a limit on the sum total of reimbursed DRG weights was introduced in 2004, essentially setting an annual financial ceiling for each hospital (Endrei et al., 2014).

There were periods when the upper ceiling was fixed and no reimbursement was paid above the cap, and other periods when the ceiling was flexible with partial reimbursement (e.g. 60% reimbursement between 100-105% of the cap, but only 10% above 110%). While early research found that hospital managers initially perceived the budget cap as a temporary regulatory tool (Dankó et al., 2006), it has remained remarkably stable over the decades and became an integral part of the Hungarian health care reimbursement system.[2]

[2] The majority of hospitals in Hungary are public and have been afflicted by the symptoms of having soft budget constraints (Kornai, 2009; Kornai et al., 2003), such as constantly increasing hospital debts and repeated bailouts by the central government. Until the late 2000s, most hospitals were maintained by local governments. Starting in 2010, ownership was gradually transferred to the central state, with a new supervising agency established in 2012 (Hajnal and Rosta, 2016). Recent qualitative research (Krenyácz, 2017), however, showed that centralization has not resulted in stricter adherence to budgetary limits. Nevertheless, lobbying for extra reimbursements in times of need is costly, and its success is far from guaranteed.

2.2 Reimbursement for AMI treatment

Acute treatments of AMI are reimbursed under three DRG codes: 2070 stands for AMI without special treatment (e.g. without PCI), while 2081 and 2082 denote AMI treatment with PCI. Cost-weights of these three DRGs have remained fairly stable during the examined period. Until June 30, 2012, all three DRG codes were subject to the overall hospital budget cap. From July 1, 2012, codes 2081 and 2082 were removed from the cap and financed fully without limit.[3]

We do not have reliable cost data about the Hungarian DRGs, thus we cannot determine their net effect on the budget balance of the hospital. Based on our conversations with hospital financing experts, however, we can deduce that PCI treatments are generally "well-financed" and do not cause financial losses for hospitals—when fully reimbursed.

3 Data and methods

3.1 Data

Our original sample includes all inpatient cases between 2008 and 2015 in Hungary in which the main diagnosis falls in the I21 and I22 ICD-10 categories (acute myocardial infarctions – AMIs). The records are at the level of hospital department, which we aggregate into hospital cases, and contain the age, gender, and ZIP code of the patient, the date of arrival and discharge, as well as diagnoses, treatments, and DRG classification.[4] We link patient records over the entire 8-year period.

As a further aggregation level, we group consecutive hospital cases into a single AMI episode if the time spent at home between a hospital release and a subsequent admission is at most one day. We conduct our empirical

[3] In principle, 2081 refers to PCI with stents, and 2082 to PCI treatments without stents. In practice, 2082 generally also includes the use of drug-eluting stents (DES). DES procurement costs are not covered by the DRG system, but directly reimbursed to hospitals by the health insurance fund. Since the budget cap was lifted for both PCI treatments, we did not separate these two DRG codes in our analysis.

[4] The ICD version used in Hungarian hospital financing records does not separate ST-elevation (STEMI) and non-ST elevation (NSTEMI) forms of AMI, thus we are unable to perform a separate analysis. The indication and timing of PCI differs in these two cases, with PCI treatment bringing higher net benefits to STEMI patients. On an aggregate level, STEMI cases make up around just under half of all AMI episodes (Jánosi et al., 2017).

enquiries at the episode level.

There are 110 health care providers in our 8-year sample, 60 of which have at least 50 AMI patients per year. 16 hospitals have PCI centers (cath labs) throughout the entire period. One new lab was opened in 2011, and an additional two in 2013. All three new labs were placed in countryside hospitals to improve the accessibility of PCI treatments in the southern half of the country. The rest of the providers are not equipped to perform PCIs.

In order to concentrate on patients with unchanged PCI access conditions, we exclude all patients who live in the catchment areas of the newly opened cath labs, as well as the few patients who end up at the newly opened labs from farther away. The exclusion helps us avoid confounding the effects of the two supply-side shocks.

We also exclude each AMI episode that has a predecessor episode within one year, and drop all cases in 2008 for lack of information on predecessor episodes. Moreover, since our event study approach will present year fixed effects before and after the budget cap exemption on PCI treatments, and the exemption entered into force on July 1, 2012, we drop all cases ending before July 1, 2009 or after June 30, 2015.[5]

We create five main geographical subsamples from the main sample using the following steps. First, we separate the catchment area (*central Hungary*) of the PCI hospitals located in the capital from the catchment areas of PCI hospitals in the countryside, and further subdivide central Hungary into the capital (Budapest) and the capital's agglomeration. The latter consists of two counties around Budapest, with minor territorial adjustments.

The capital is home to 11 hospitals that have at least 100 AMI cases a year in our sample, and the five largest ones (in terms of AMI case numbers) have cath labs. The cath lab hospitals are geographically concentrated[6] and participate in a joint off-hours and weekend on-call rotation schedule. For almost all patients in central Hungary, any of the five cath labs in Budapest provide a reasonable alternative, hence separate cath lab catchment areas cannot be delineated.

The countryside is set up differently. PCI centers are located in large towns scattered around the rest of the country. In most cases, catchment

[5]As a result, we end up with exactly three years of pre-exemption and three years of post-exemption data and do not have to complicate the analysis with the inclusion of seasonal effects.

[6]They are all located within a circle with a diameter of less than 10 miles.

areas can be clearly separated from one another (often along county borders), and the share of people for whom more than one cath lab offers a reasonable alternative is small. We analyze the countryside separately from central Hungary, because the lack of alternative PCI providers might lead to different reactions to changes in hospital financing.

In the second step, we take Budapest and the countryside, and divide both into two subgroups along ZIP codes. One subgroup of ZIP codes in both Budapest and the countryside contains people who are located closer to a PCI than to a non-PCI hospital, while the other subgroup contains people who live closer to non-PCI hospitals. We will refer to these subgroups as *near-PCI* and *near-nonPCI* patients for the rest of the paper. As we demonstrate shortly, primary access to PCI-capable facilities is markedly different in the two subgroups, hence our interest in analyzing them separately.

The share of near-PCI patients is 36% in the capital and 44% in the countryside. In the agglomeration, near-PCI patients make up only about 5% of the sample, so we do not separate them from near-nonPCI patients. Nevertheless, a capital/agglomeration distinction is potentially important among near-nonPCI patients, since the two areas are typically covered by separate ambulance services.

3.2 Descriptive statistics

Table 1 shows descriptive statistics for selected variables at the AMI episode level for central Hungary and the countryside separately. Patients are similar in terms of age and gender across the two subsamples, but countryside patients have to travel 50% more on average to reach a cath lab hospital. Despite greater distances in the countryside, the lower density of hospitals also means that more people end up in cath labs than in central Hungary (81% vs 74%).

Looking at relative distance, patients living closer to PCI than to non-PCI hospitals get more frequent access to PCI-facilities, even taking hospital transfers into account. The difference is especially marked in the countryside, where 95% of near-PCI patients end up in cath labs, compared to 70% of near-nonPCI patients.

On the other hand, the overall chance of getting PCI treatment is close to equal in central Hungary and the countryside (58-59%). Although the cath lab admission differences between near-PCI and near-nonPCI patients also reappear in treatment decisions, they do so to a much lower extent.

Patients are moved between hospitals slightly more often in central Hungary, but the average length of AMI episodes is similar to the countryside. Readmission and in-hospital mortality patterns are also comparable.[7]

3.3 Methods

The first methodological issue we face in our impact assessment is that several of our outcome variables of interest show visible trends in the 3 years before the budget cap exemption. A simple comparison of before-after means would result in significant differences by virtue of the pre-existing trends.

We deal with this problem by first estimating a univariate regression of each outcome variable on a daily linear trend using the pre-exemption data only. If the estimated pre-trend is significant at the 5% level, we project it onto the post-change years, remove the estimated/projected trend from the entire sample, and use the de-trended outcome variable in the subsequent analysis. If the trend is not significantly different from zero, we use the outcome variable as it is observed. In all of our results below, dependent variables should therefore be understood as de-trended versions of themselves, and treatment effects as measuring changes from what would have happened, had the pre-existing trend continued and the hospital financing system remained unchanged.

After removing the estimated and projected pre-trend, we run the following linear model for the five geographical subsamples separately:

$$Y_i = \alpha + \beta T_i + \gamma B_i + \delta X_i + u_i \tag{1}$$

where i indexes AMI episodes and Y_i is an indicator variable for a (de-trended) outcome of interest, such as whether the patient was admitted to a cath lab directly, whether she received PCI treatment, or whether she was readmitted within 30 days with another AMI episode.

T_i is our treatment effect variable. In the simplest case, it is an indicator that takes the value of 1 for AMI episodes that fell under the budget cap

[7] Our measure of in-hospital mortality is at the AMI episode level. It exceeds the usual hospital-level mortality measures because transfer patients (who survive at least one within-episode hospital stay by definition) only have their last hospital stay of the episode included in the calculation.

Table 1: Means of selected variables at the AMI episode level in central Hungary and the countryside between July 1, 2009 and June 30, 2015.

	Central Hungary	Countryside
Patient age	68.73	67.18
	(0.08)	(0.06)
Share of females	0.422	0.424
	(0.003)	(0.002)
Distance to closest cath lab (mins)	22.12	31.87
	(0.12)	(0.10)
Cath lab admission share	0.742	0.813
	(0.003)	(0.002)
−near-PCI patients	0.796	0.949
	(0.005)	(0.002)
−near-nonPCI patients	0.728	0.704
	(0.003)	(0.003)
PCI treatment share	0.578	0.595
	(0.003)	(0.002)
−near-PCI patients	0.590	0.632
	(0.006)	(0.003)
−near-nonPCI patients	0.575	0.566
	(0.003)	(0.003)
Episode length (days)	10.19	10.13
	(0.10)	(0.06)
Hospital cases per episode	1.230	1.158
	(0.003)	(0.002)
30-day readmissions (with AMI)	0.029	0.022
	(0.001)	(0.001)
In-hospital mortality	0.125	0.136
	(0.002)	(0.002)
Observations	28,976	44,639

Note: Standard errors of the variable means are in parentheses. near-PCI patients are those whose ZIP code is closer to a cath lab than to a non-PCI hospital. The reverse is true for near-nonPCI patients.

exemption rule of PCI treatments, and zero otherwise. For our event study regressions, we use year fixed effects relative to the time of regulation change to differentiate between short-term (one year) and long-term (three year) changes.[8]

We use two time-based indicator variables (B_i) to capture any potential end-of-period effects that could theoretically arise from budgetary restrictions at the hospital level: (1) last 5 days of each month, and (2) last month of the fiscal year (October) for the hospitals. The performance volume limits are broken down to monthly quotas, hence the inclusion of the last-5-days control. The monthly quotas are non-transferable within the year at the hospital level (although remaining quotas can be used in later months), but they still might be subject to internal negotiation at the department level.[9]

Finally, X_i contains gender and age interval[10] controls, as well as cath lab or cath lab catchment area fixed effects[11] and a dummy variable for weekend admissions. u_i is the usual error term.

4 Results

We present our results in four stages. First, we describe the evolution of overall PCI treatment probability before and after the budget cap exemption was instituted. In the second and third steps, we investigate potential mechanisms: changes in patient pathways through the health care system and changes in treatment patterns conditional on admission to a PCI hospital. Finally, we look at the effects on two health outcome indicators: 30-day readmissions with another AMI episode and in-hospital mortality during the original episode.

We perform each of our analyses on the five geographical subsamples introduced earlier, as well as on the full sample, and present results side-by-

[8] We choose the 12 months preceding the regulation change (from July 1, 2011 until June 30, 2012) as our reference year, relative to which all the other year fixed effect coefficients are estimated.

[9] We have no hard data on how (or even whether) the hospitals in our sample distribute and enforce the overall performance volume limit internally.

[10] We group patient age into one of the following seven categories: less than 60 years, 60-85 years in 5-year age groups, and more than 85 years.

[11] If the outcome variable refers to transportation patterns (e.g. whether a patient was admitted to a cath lab), we use catchment area fixed effects that depend on patient ZIP codes. If the outcome variable refers to treatment decisions conditional on hospital acceptance (e.g. whether a patient who was admitted to a specific cath lab received PCI), we use hospital level fixed effects.

side. We first look at a simple binary treatment variable (signifying a period of 3 years before and 3 years after the regulation change). Whenever we find statistically and economically meaningful differences, we further investigate the resulting patterns by substituting the binary treatment variable with year fixed effects. Our criteria for attributing a change in an outcome variable to the change in financing regime are: (1) the effect should show up right after the regime change, and (2) it should not disappear in later years. We also consider causality more plausible whenever the outcome variable shows no pre-trend. Table 2, which we will refer to repeatedly, summarizes our main results with binary treatment. The online appendix contains details about each of our additional claims.

4.1 Aggregate effects on PCI treatment probability

Row 1 of Table 2 shows the before-after difference in aggregate PCI treatment shares in the various samples. On a countrywide level, PCIs increase by 3.3 percentage points (pp) relative to a pre-existing trend of +1.1 pp per year (pp/y) and a baseline of around 56%. The increase is present almost uniformly in the five subsamples, except for near-PCI patients in the countryside, where we observe a slow-down of an otherwise strong pre-trend of +2.7 pp/y.

The clearest gains can be seen in the three subsamples of central Hungary, especially among the near-nonPCI patients of Budapest and the agglomeration, where the pre-trends are absent and the effect size is almost twice as high (5.4-6.6 pp) as the country average.

Figure 1 shows more details about the temporal structure of the observed changes. Although the three post-treatment years are everywhere jointly nonzero, the individual years are not always so. The increase in PCI treatment among near-nonPCI patients in central Hungary, however, seems robust. To a lesser extent, near-nonPCI patients in the countryside also benefit.

4.2 Admission pathways

Most AMI patients are admitted to cath labs either directly, or by transfer from a non-PCI hospital.[12] Since treatment by PCI is most effective in a

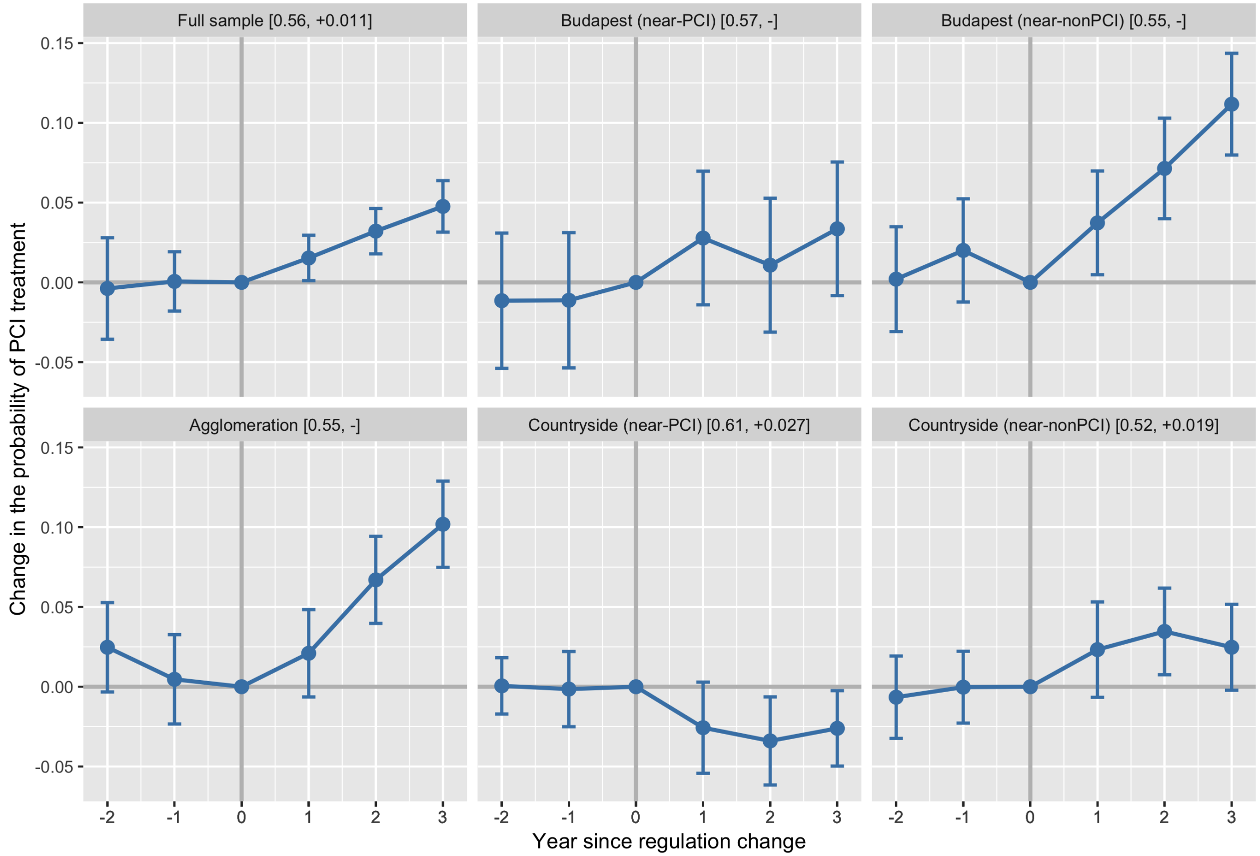
[12]Typical admission pathways are: (1) single hospital case in a cath lab or non-PCI institution; (2) admission to a cath lab, then transfer to a non-PCI hospital more local

Table 2: Summary of changes in AMI-related health care variables before and after the budget cap exemption of PCI treatments

	Full sample	Budapest (near-PCI)	Budapest (near-nonPCI)	Agglomeration	Countryside (near-PCI)	Countryside (near-nonPCI)
PCI: all patients	0.033***	0.032**	0.066***	0.054***	−0.028**	0.030***
	(0.008)	(0.012)	(0.009)	(0.008)	(0.013)	(0.009)
	[0.56, +0.011]	[0.57, −]	[0.55, −]	[0.55, −]	[0.61, +0.027]	[0.52, +0.019]
Cath lab (c.l.) admissions	0.048***	0.068***	0.081***	0.066***	−0.004	0.039***
	(0.007)	(0.010)	(0.009)	(0.007)	(0.005)	(0.012)
	[0.75, +0.007]	[0.76, −]	[0.68, −]	[0.70, −]	[0.94, +0.007]	[0.65, +0.021]
Direct c.l. admissions	0.077***	0.086***	0.096***	0.075***	−0.006	0.073***
	(0.009)	(0.011)	(0.009)	(0.008)	(0.005)	(0.015)
	[0.68, −]	[0.69, −]	[0.58, −]	[0.62, −]	[0.93, +0.009]	[0.56, +0.012]
PCI: cath lab patients	−0.001	−0.023	−0.003	0.010	−0.026	0.009
	(0.011)	(0.015)	(0.017)	(0.015)	(0.017)	(0.011)
	[0.74, +0.007]	[0.75, −]	[0.80, −]	[0.78, −]	[0.64, +0.024]	[0.80, −]
30-day readmissions	−0.000	−0.004	0.002	0.002	−0.002	0.000
	(0.001)	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)
	[0.03, −]	[0.03, −]	[0.03, −]	[0.03, −]	[0.02, −]	[0.03, −]
In-hospital mortality	−0.003	−0.021**	−0.021***	−0.010*	0.011*	−0.017***
	(0.002)	(0.009)	(0.007)	(0.005)	(0.006)	(0.004)
	[0.14, −0.004]	[0.14, −]	[0.14, −]	[0.12, −]	[0.14, −0.009]	[0.15, −]
Num. obs.	73,615	5,631	9,822	13,523	19,853	24,786

Note: Each cell in the table shows the estimated binary treatment effect (β) on different outcome variables and in different geographical samples according to equation (1). The daily linear trend of the before period—if significantly different from zero at the 5% level—has been removed from the dependent variable prior to the estimation. If location-based fixed effects are included in the regression (see Tables A2-A10 in the online appendix for details), the parentheses show standard errors clustered at the level of the fixed effects variable. Otherwise, the parentheses show robust standard errors. The brackets show the unconditional pre-treatment mean of the outcome variables, followed by the removed pre-trend (if any) on a per-year basis. Sample sizes are shown in the bottom row, except for "PCI: cath lab patients", where Table A6 contains the relevant numbers.

Figure 1: Year fixed effects on PCI treatment probability in different geographical subsamples before and after the budget cap exemption



Note: The figure shows the estimated year fixed effects (β) and 95% confidence intervals on the outcome variable in different geographical samples according to equation (1). Pre-treatment years: -2, -1, 0 (reference). Post-treatment years: $+1$, $+2$, $+3$. The daily linear trend of the before period—if significantly different from zero at the 5% level—has been removed from the dependent variable prior to the estimation. The brackets in the subfigure headers show the sample-specific unconditional pre-treatment mean of the outcome variable, followed by the removed pre-trend (if any) on a per-year basis. See Table A2 in the online appendix for further details.

short time window following the onset of the AMI episode in the case of STEMI and high-risk NSTEMI patients, people taken directly to a cath lab hospital have a higher chance of receiving PCI than those who are only later—or never—transferred.

PCI rates among AMI patients can therefore be increased by admitting more patients to cath labs directly. This channel requires no change in the decision-making process of a cardiologist in a cath lab hospital. Rather, it is the result of coordination between hospital management and local ambulance or primary care services.[13]

A second channel by which overall PCI rates can increase is by transferring a higher share of patients who are initially admitted to non-PCI hospitals to a cath lab. Here, the medical specialist in the first institution is more involved in the decision making, but potential limits on hospital transfers could still involve a higher-level agreement between the sending and the receiving hospital's managements.

As Table 2 shows, both the frequency of overall cath lab admissions (Row 2) and of direct cath lab admissions (Row 3) increase markedly (by 4.8-7.7 pp on a countrywide level) relative to the ex ante period, with the exception of near-PCI countryside patients who are already almost hitting the 100% upper bound on admissions.[14] The overall and the direct admission estimates are also typically close to each other, which means that the increase in direct admissions does not result in a corresponding decrease in non-PCI to PCI hospital transfers (although a limited amount of substitution is visible).[15]

Figure 2, again, shows more details about the temporal structure of the observed changes for overall cath lab admissions. The outcome variable

to the patient's residence; (3) admission to a local non-PCI hospital, then transfer to a cath lab, possibly followed by a re-transfer to the original institution. More complicated patterns are also observable, but only in a small minority of episodes.

[13]Increasing the chance of PCI treatment by increasing direct admissions only works if ambulance personnel or primary care doctors have insufficient information to perfectly anticipate the subsequent decisions of cardiologists about who would eventually receive PCI and who would not, and to sort and transport patients accordingly. We believe this to be a safe assumption.

[14]The recorded ZIP code in our data refers to the patients' officially registered residence, which may be different from where they are at the moment of their heart attack in a non-trivial number of cases (e.g. due to commuting, weekend or vacation travel, or out-of-date residence information).

[15]See Table A5 and Figure A2 in the online appendix for more evidence concerning changes in hospital transfer case numbers.

jumps by around 5 pp in central Hungary in the first ex post year, then continues to increase by another 5 pp in the next two years. Again, there is no pre-trend, strengthening the case for causality. near-nonPCI patients in the countryside also benefit consistently, although the relatively constant year effect estimates become imprecise in later years.

4.3 Treatment decisions conditional on cath lab admission

After admission to a hospital with PCI capabilities, the cardiologist on duty decides whether PCI treatment is warranted for a patient. Although the decision is primarily a medical one, the patient-specific benefit of the intervention varies continuously along a scale, rather than being a black-or-white matter (see (Chandra and Staiger, 2007) for a model-based approach). As a result, there are borderline cases with minimal net benefit of PCI relative to traditional treatment, where secondary considerations, such as the hospital's financial return to performing PCIs, might swing the balance left or right.[16] Since the budget cap exemption of PCI treatments (weakly) increases the financial return to performing a PCI, we might expect to see a positive effect on PCI frequency conditional on being admitted to a cath lab.

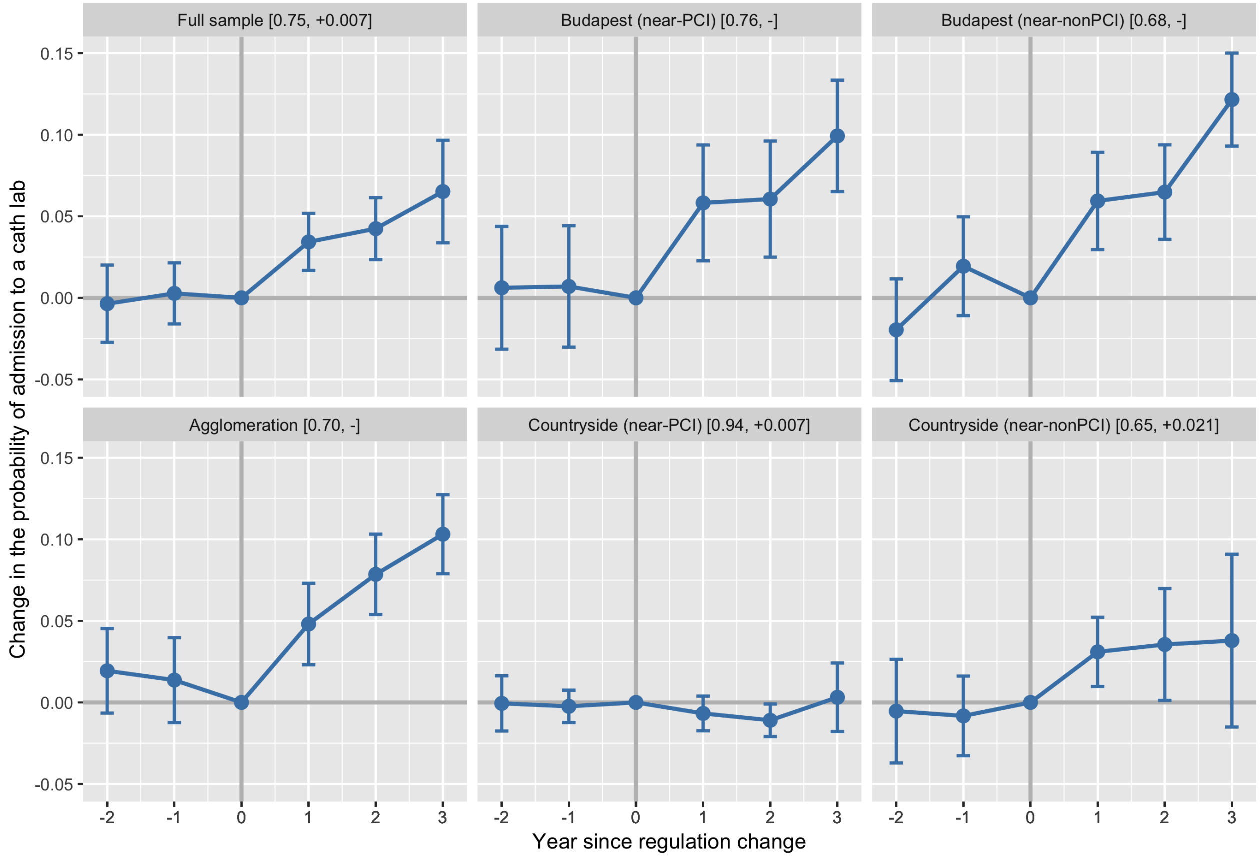
There is, however, a countervailing force as well, which stems from patient selection at the transportation phase. We have shown in the previous section that more AMI patients end up in cath labs after the regulation change. Since patient selection is based on a subset of PCI appropriateness indicators, the additional patients admitted to cath labs after the regulation change may be less suitable for PCI treatment than the average patient in the cath lab.[17] We might, therefore, expect a slight decline in the frequency of PCI treatment among the cath lab hospitals' admitted patients.

Row 4 of Table 2 summarizes the evidence on PCI treatment decisions conditional on cath lab admission. The majority of the point estimates are mildly negative, but none of them are significant at conventional levels. We would see a similar picture if we conditioned on direct and indirect

[16] In addition to patient characteristics, (Chandra and Staiger, 2007) propose that hospital specialization in more or less invasive AMI treatment methods also plays a role in selecting the most advantageous treatment. In particular, they show that the relative benefit of the two treatments is small enough for many people such that they would always benefit more from the one that their hospital is specialized in.

[17] For example, the guidelines clearly specify that patients with STEMI, a condition that ambulance personnel can check for, must be transported to a cath lab hospital.

Figure 2: Year fixed effects on overall cath lab admission rates in different geographical subsamples before and after the budget cap exemption



Note: The figure shows the estimated year fixed effects (β) and 95% confidence intervals on the outcome variable in different geographical samples according to equation (1). Pre-treatment years: -2, -1, 0 (reference). Post-treatment years: $+1$, $+2$, $+3$. The daily linear trend of the before period—if significantly different from zero at the 5% level—has been removed from the dependent variable prior to the estimation. The brackets in the subfigure headers show the sample-specific unconditional pre-treatment mean of the outcome variable, followed by the removed pre-trend (if any) on a per-year basis. See Table A3 in the online appendix for further details.

cath lab admissions separately, and also if we looked at more detailed event study graphs. Our results are therefore not inconsistent with the postulates that (1) the additionally admitted cath lab patients after the budget cap exemption are at least somewhat less appropriate for PCI treatment than the average admitted cath lab patient, and (2) medical specialists are not affected by the hospital-level financial incentives provided by the budget cap exemption in their treatment choices.

4.4 Health outcomes

We now turn to the analysis of observable medical outcomes before and after the regulation change. The short time elapsed since the intervention under scrutiny and the available data only allow us to track two early indicators of treatment quality and potential health outcomes: readmissions after an AMI episode and in-hospital mortality during each hospital case. We examine both of them separately for each geographical group.

4.4.1 Readmissions

The frequency of 30-day readmissions is an often used indicator of AMI treatment quality (Krumholz et al., 2009). Since we are able to track people over time, we can link AMI episodes and mark the ones that are followed within 30 days of a patient's release by another AMI admission.[18] In line with our methodology so far, we change the dependent variable in equation (1) to this 30-day AMI readmission indicator.

Row 5 of Table 2 shows the resulting estimates for the different samples. All of the binary treatment coefficients are imprecisely estimated and show no systematic relationship to our cath lab admission and PCI treatment results. We conclude that the behavioral reactions associated with the regulation change have no effect on 30-day AMI readmissions.

4.4.2 In-hospital mortality

Corresponding results for an indicator of in-hospital mortality during AMI episodes are shown in Row 6 of Table 2. Although the overall average effect

[18] Recall that in our main analysis, we do not include AMI episodes that have a predecessor episode within 365 days, thus the episodes that are marked as *being* 30-day readmissions are also not part of the regression samples. Hence we do not track multi-layered readmission frequencies (readmissions of readmissions).

is not significantly different from zero, we do see significant and sizeable effects in each of the five geographic subsamples. Moreover, the direction of the estimates is consistent with the change in PCI treatment probability (Row 1) in each case, although we cannot tell whether it is the treatment or the identity of the hospital that makes the difference.[19]

Despite the encouraging consistency of the binary treatment estimates on in-hospital mortality in Table 2, we are reluctant to conclude that the change in AMI treatment financing has undoubtedly led to better AMI survival chances in Hungary. A visual inspection of the event study graphs in Figure A7 in the online appendix reveals that mortality has been declining before the regulatory change in all of the subsamples where Table 2 shows an improvement. While the ex ante decline was not marked enough to be picked up as a pre-existing trend at the 5% level, should we have treated it as a trend, its continuation in the post-intervention period would have been sufficient to explain enough of the before-after difference to make the remainder negligible.

5 Discussion and conclusions

This paper investigated whether hospital-level budget caps limited the use of PCI for AMI patients before they were relaxed in a targeted way in mid-2012. Our analysis contributes to the literature by evaluating whether budgetary control motivates hospitals to restrict access to potentially life-saving emergency care.

We showed that there were different channels through which the change of financing rules could affect hospital behavior. First, more patients ended up at PCI hospitals after the policy change. The effect was stronger in the capital region, where several PCI hospitals operate in close proximity to each other, and even stronger for those who live relatively farther away from cath labs.

Second, transfers between hospitals did not change, indicating that cath lab hospitals are only able to expand their market share if they are able to attract more patients as the first point of inpatient care. Since our case covers an emergency treatment, it is often the ambulance services that decide

[19] In contrast to the specialization argument put forth by (Chandra and Staiger, 2007), cath lab hospitals in Hungary are considered to be generally better equipped to treat AMI patients than non-PCI hospitals, regardless of the appropriateness of PCI.

about the order in which target hospitals are approached for admission. A growing direct admission rate may be the result of better coordination with ambulance services.

Our patient pathway findings can be interpreted as hospitals expanding their market share among those patients whose treatment became potentially more profitable. Conversely, the financial constraints put on PCI treatments before mid-2012 seem to have played a role in deterring those patients who could more conveniently be treated by nearby non-PCI hospitals.

Furthermore, PCI rates among patients directly or indirectly admitted to hospitals with cath labs have not increased. This result suggests that the market expansion of PCI hospitals was not well targeted at those patients who truly required PCI, but merely aimed to attract more AMI patients.[20] These findings altogether suggest that *medical* decisions about the treatment of AMI patients have not been influenced by external financial controls; the majority of the increase in the PCI rate came from the increasing direct admission rate.

Finally, outcome indicators such as the 30-day readmission rate and in-hospital mortality did not improve markedly at the introduction of the new financing regime. This does not rule out, however, that other unmeasured dimensions of patient care could have improved as more AMI patients ended up at better-equipped cath lab hospitals. Nevertheless, our results are consistent with a recent analysis based on cause-of-death statistics in Hungary: distance from cath labs was not a strong a factor in the territorial heterogeneity of AMI mortality (Uzzoli et al., 2017).

A few potential limitations of our study must also be noted. We used administrative data originally produced by hospitals for reimbursement purposes, thus changes in financing rules may change how cases are coded, too (e.g. fully reimbursed PCI DRGs may more often be used). While there might be borderline cases in reality, we did not notice any unexpected increase in case numbers.

Several other factors may also influence our dependent variables in general (e.g. centralization in the Hungarian hospital sector, diffusion of knowledge and expertise) or locally (e.g. changes in medical personnel, manage-

[20] Such targeting may not even be possible due to informational constraints at the point of direct admission decisions.

ment, or internal budgetary customs), that we are unable to measure. Some of these factors are already present in the location-specific fixed effects, while other factors would require data collection about hospital, department, or individual level characteristics. Further research could examine why individual hospitals react differently to regulatory changes.

Still, our study can inform policy makers about the general impact of budget caps on access to superior treatment options. Our main conclusion is that applying a hospital-level budget cap does not seem to influence medical decision making (at least, in the case of a potentially life-saving treatment), but will limit the effective catchment area a hospital serves. Consequently, lifting the budget cap for expensive emergency care services may improve access of those living in a greater distance from better-equipped specialized centres.

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References

Barasa, Edwine W, Sassy Molyneux, Mike English and Susan Cleary (2014), 'Setting healthcare priorities in hospitals: A review of empirical studies', *Health Policy and Planning* **30**(3), 386–396.

Bazzoli, Gloria J, Hsueh-Fen Chen, Mei Zhao and Richard C Lindrooth (2008), 'Hospital financial condition and the quality of patient care', *Health Economics* **17**(8), 977–995.

Chandra, Amitabh and Douglas O Staiger (2007), 'Productivity spillovers in health care: evidence from the treatment of heart attacks', *Journal of Political Economy* **115**(1), 103–140.

Chen, Bradley and Victoria Y Fan (2015), 'Strategic provider behavior under global budget payment with price adjustment in taiwan', *Health Economics* **24**(11), 1422–1436.

Dankó, Dávid, Norbert Kiss, Márk Molnár and Éva Révész (2006), 'A teljesítményvolumen-korlát hatásai a kórházak magatartására a HBCs alapú finanszírozás kontextusában. II. rész', *IME Informatika és Menedzsment az Egészségügyben* **5**(9), 5–12.

Daysal, N. Meltem (2012), 'Does uninsurance affect the health outcomes of the insured? Evidence from heart attack patients in California', *Journal of Health Economics* **31**(4), 545–563.

Dong, Gang Nathan (2015), 'Performing well in financial management and quality of care: evidence from hospital process measures for treatment of cardiovascular disease', *BMC Health Services Research* **15**(1), 45.

Dormont, B and C Milcent (2005), 'Innovation diffusion under budget constraints: Microeconometric evidence on heart attack in France', *Annales d'Economie et de Statistique* (79-80), 697–726.

Endrei, Dóra, Antal Zemplényi, Bálint Molics, István Ágoston and Imre Boncz (2014), 'The effect of performance-volume limit on the DRG based acute care hospital financing in Hungary', *Health Policy* **115**(2-3), 152–156.

Hajnal, G. and M. Rosta (2016), 'A New Doctrine in the Making? Doctrinal Foundations of Sub-National Governance Reforms in Hungary (2010-2014)', *Administration & Society* .

Hsu, Pi Fem (2014), 'Does a global budget superimposed on fee-for-service payments mitigate hospitals' medical claims in Taiwan?', *International Journal of Health Care Finance and Economics* **14**(4), 369–384.

Jánosi, András, Péter Ofner, Fahmi Al-Maktari, Erik Hajkó, Krisztina Hati, Zoltán Járai, Mihály Józan-Jilling, Róbert Gábor Kiss, Gerda Lóczi, Géza Lupkovics et al. (2017), 'A szívinfarktus miatt kezelt betegek ellátása magyarországon. a nemzeti szívinfarktus regiszter 2015. évi adatainak elemzése', *Orvosi Hetilap* **158**(3), 90–93.

Januleviciute, Jurgita, Jan Erik Askildsen, Oddvar Kaarboe, Luigi Siciliani and Matt Sutton (2016), 'How do hospitals respond to price changes? evidence from norway', *Health Economics* **25**(5), 620–636.

Jha, Ashish K., E. John Orav and Arnold M. Epstein (2010), 'The effect of financial incentives on hospitals that serve poor patients', *Annals of Internal Medicine* **153**(5), 299–306.

Kan, Kamhon, Shu-Fen Li and Wei-Der Tsai (2014), 'The impact of global budgeting on treatment intensity and outcomes', *International Journal of Health Care Finance and Economics* **14**(4), 311–337.

Kessell, Eric, Vishaal Pegany, Beth Keolanui, Brent D Fulton, Richard M Scheffler and Stephen M Shortell (2015), 'Review of Medicare, Medicaid, and commercial quality of care measures: considerations for assessing accountable care organizations', *Journal of Health Politics, Policy and Law* **40**(4), 761–796.

Kornai, János (2009), 'The soft budget constraint syndrome in the hospital sector', *International Journal of Health Care Finance and Economics* **9**(2), 117–135.

Kornai, János, Eric Maskin and Gérald Roland (2003), 'Understanding the Soft Budget Constraint', *Journal of Economic Literature* **41**(4), 1095–1136.

Krenyácz, Éva (2017), Use of controlling system in Hungarian health care institutions: paradox of rise and fall, PhD thesis, Corvinus University of Budapest.

Krumholz, Harlan M, Angela R Merrill, Eric M Schone, Geoffrey C Schreiner, Jersey Chen, Elizabeth H Bradley, Yun Wang, Yongfei Wang, Zhenqiu Lin, Barry M Straube et al. (2009), 'Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission', *Circulation: Cardiovascular Quality and Outcomes* pp. 407–413.

Liang, Li-Lin (2015), 'Do diagnosis-related group-based payments incentivise hospitals to adjust output mix?', *Health Economics* **24**(4), 454–469.

Melberg, Hans Olav, Camilla Beck Olsen and Kine Pedersen (2016), 'Did hospitals respond to changes in weights of diagnosis related groups in norway between 2006 and 2013?', *Health Policy* **120**(9), 992–1000.

Moreno-Serra, Rodrigo (2014), 'The impact of cost-containment policies on health expenditure', *OECD Journal on Budgeting* **13**(3), 1–29.

Shah, Bimal R., Seth W. Glickman, Li Liang, W. Brian Gibler, E. Magnus Ohman, Charles V. Pollack, Matthew T. Roe and Eric D. Peterson (2007), 'The Impact of For-Profit Hospital Status on the Care and Outcomes of Patients With Non-ST-Segment Elevation Myocardial Infarction. Results From the CRUSADE Initiative', *Journal of the American College of Cardiology* **50**(15), 1462–1468.

Shen, Yu-Chu and Karen Eggleston (2009), 'The effect of soft budget constraints on access and quality in hospital care.', *International Journal of Health Care Finance and Economics* **9**(2), 211–32.

Shin, Eunhae (2019), 'Hospital responses to price shocks under the prospective payment system', *Health Economics* **28**(2), 245–260.

Simborg, DW (1981), 'DRG creep: a new hospital-acquired disease.', *The New England Journal of Medicine* **304**(26), 1602.

Szummer, Csaba (2005), 'A HBCs-rendszer mûködési zavarai és azok megszüntetési lehetôségei', *IME Informatika és Menedzsment az Egészségügyben* **4**(2), 17–23.

Uzzoli, Annamária, József Vitrai and Gergely Tóth (2017), 'Az egészségügyi ellátáshoz való hozzáférés területi egyenlőtlenségeinek vizsgálata az akut miokardiális infarktus okozta halálozás adatainak felhasználásával', *Egészségfejlesztés* **58**(3), 7–17.

Verzulli, Rossella, Gianluca Fiorentini, Matteo Lippi Bruni and Cristina Ugolini (2017), 'Price changes in regulated healthcare markets: Do public hospitals respond and how?', *Health Economics* **26**(11), 1429–1446.

Yuan, Suwei, Yan Liu, Na Li, Yunting Zhang, Zhe Zhang, Jingjing Tao, Lizheng Shi, Hude Quan, Mingshan Lu and Jin Ma (2014), 'Impacts of health insurance benefit design on percutaneous coronary intervention use and inpatient costs among patients with acute myocardial infarction in Shanghai, China', *PharmacoEconomics* **32**(3), 265–275.