



ISSN 2282-6483

Alma Mater Studiorum - Università di Bologna  
DEPARTMENT OF ECONOMICS

**Price Changes in Regulated  
Healthcare Markets: Do Public  
Hospitals Respond and How?**

Rossella Verzulli  
Gianluca Fiorentini  
Matteo Lippi Bruni  
Cristina Ugolini

*Quaderni - Working Paper DSE N°1041*



# Price Changes in Regulated Healthcare Markets: Do Public Hospitals Respond and How?

Rossella Verzulli<sup>#</sup>, Gianluca Fiorentini, Matteo Lippi Bruni, Cristina Ugolini

*Department of Economics, University of Bologna*

*Advanced School for Health Policy, University of Bologna*

## Abstract

This paper examines the behaviour of public hospitals in response to the average payment incentives created by price changes for patients classified in different Diagnosis Related Groups (DRGs). Using panel data on public hospitals located within the Italian region of Emilia-Romagna, we test whether a one-year increase in DRG prices induced public hospitals to increase their volume of activity, and whether a potential response is associated with changes in waiting times and/or length of stay. We find that public hospitals reacted to the policy change by increasing the number of patients with surgical treatments. This effect was smaller in the two years after the policy change than in later years, and for providers with a lower excess capacity in the pre-policy period, whereas it did not vary significantly across hospitals according to their degree of financial and administrative autonomy. For patients with medical DRGs, instead, there appeared to be no effect on inpatient volumes. Our estimates also suggest that an increase in DRG prices either decreased or had no impact on the proportion of patients waiting more than six months. Finally, we find no evidence of a significant effect on patients' average length of stay.

**JEL Classification:** Analysis of health care markets (I11); Health production (I12); Government policy, regulation, public health (I18).

**Key words:** DRG prices, average payment incentives, hospital behaviour.

---

<sup>#</sup> Corresponding author:

Rossella Verzulli, Department of Economics, University of Bologna, Piazza Scaravilli, 2, 40126, Bologna (Italy). E-mail: [rossella.verzulli@unibo.it](mailto:rossella.verzulli@unibo.it); tel. +39-051-2098135.

## 1. Introduction

Assessing whether and how financial incentives affect the behaviour of health-care suppliers is a key factor for implementing welfare-enhancing policies. Information asymmetries and potentially diverging objectives between financing institutions and providers generate considerable challenges for the design of optimal reimbursement schemes, and a substantial body of research has analysed the implications of different payment mechanisms for health-care delivery (Chalkley and Malcomson, 2000; 2012; McGuire, 2000).

In the hospital sector, a large stream of literature has focused on the switch from a retrospective cost-based reimbursement scheme to a prospective payment system (PPS). Under cost-based reimbursement, hospitals are paid according to their actual costs, thereby receiving little incentive to be efficient. By contrast, under PPS hospitals receive a fixed price per case treated, with the amount varying according to the diagnostic category (DRG) assigned to each patient. Several studies have investigated the impact of eliminating marginal reimbursements during the transition to PPS.<sup>1</sup> Most of them have found that a (neutral revenue) shift encourages hospital efficiency, although with potential unintended consequences on patient outcomes (Dranove, 2012). Yet relatively little attention has been drawn to the response of hospitals to changes in average reimbursement levels (DRG prices).

Theoretical work predicts that, under PPS, hospitals are incentivised to attract more patients in response to an increase in DRG tariffs (e.g. Hodgkin and McGuire, 1994). This issue is attracting growing interest, as the transition to PPS has been completely phased in, and subsequent adjustments of DRG prices may constitute an important lever to steer providers' decisions. Some evidence is available on the impact of changes in average payment levels on the behaviour of hospitals operating in market-oriented institutional settings (e.g. Gilman, 2000; Dafny, 2005; Lindrooth et al, 2007; He and Mellor, 2012). However, very little is known on the effect in national health-care systems, where the response of public hospitals to DRG price changes can hardly be determined a priori (Januleviciute et al, 2015). On the one hand, an increase in average payments may affect hospital activity when DRG tariffs are used to allocate public funding, especially if public hospitals are required to

---

<sup>1</sup> For a given DRG, hospitals do not receive additional payments when they face a cost per case higher than the PPS price.

meet break-even conditions and are allowed to use financial surpluses for investment in patient care. Hospitals' responsiveness to economic incentives is also expected to increase with the financial pressure exerted by restraints in public finances and by restrictive rules for bailing out hospital deficits.<sup>2</sup> On the other hand, public hospitals may be less responsive to economic incentives than private providers due to differences in their objective function that may arise from public accountability and social obligations.<sup>3</sup> It thus remains an open empirical question whether and how public hospitals react to changes in average payment incentives, and to what extent the evidence can be passed on across different institutional settings.

This paper examines a policy change implemented in the Italian region Emilia-Romagna, whereby the prices of a subset of DRGs were increased in 2007 by 6% on average, whereas they were kept constant for the remaining DRGs from 2005 to 2010. We exploit this policy change to investigate the implications of an increase in average payment levels on the performance of public hospitals as measured by different indicators, including volumes of activity, waiting times and length of stay. Specifically, we assess whether increasing DRG prices induced public hospitals to expand the number of patients in the affected DRGs relative to the unaffected ones, and we evaluate the impact on the proportion of patients waiting more than six months and on patients' average length of stay.

Our analysis exploits a one-time shock in DRG prices to test for differences between short- and medium-run effects, an important but often neglected issue. Moreover, we investigate a policy change encompassing a wide range of conditions, while some earlier research (e.g. Allen et al, 2016) covered a more narrow set of procedures. Further, we consider a richer set of performance indicators than those previously examined for NHS systems, and assess whether the policy had a greater impact on hospitals enjoying a higher degree of autonomy

---

<sup>2</sup> For a discussion on the role of soft budget constraints in the Italian public health sector, see Barbetta et al. (2007) and Bordignon and Turati (2009).

<sup>3</sup> Clark and Milcent (2014) find a significant gap in public-private employment levels in the French hospital sector associated to depressed local labour markets. The results suggest that public hospitals employment and local unemployment rates are positively correlated only in left-wing municipalities, with a larger correlation for tighter electoral races. Bloom et al (2015) show that hospital density in the UK is substantially higher in politically marginal constituencies, a feature attributed to the higher political costs of hospital closures. These pieces of evidence point to a significant influence of political factors on management practices in public hospitals.

over financial and organisational matters.<sup>4</sup> Finally, we examine whether the price change affected hospitals with larger unused capacity more.

Our findings indicate that, on average, hospitals responded to an increase in tariffs by raising the number of surgical (elective) treatments for the affected DRGs relative to the unaffected ones. This effect was smaller in the two years immediately after the price change and increased in the next two years: a 1% increase in the price of surgical DRGs raised the number of patients in affected DRGs by 1.7 and 4% in the short- and medium-run post-policy periods, respectively. Moreover, providers with higher excess capacity before policy implementation displayed a larger response, whereas we do not find differences in hospitals' response depending on their degree of administrative and financial autonomy. An increase in tariffs had no impact on the volumes of (elective) patients treated for medical DRGs. As for patients waiting more than six months, we find little evidence of a price effect, and no support emerges for the hypothesis that hospitals responded by altering patients' average length of stay.

## **2. Related literature**

The first studies to analyse the hospitals' response to changes in average payments (price changes) at the diagnosis level utilise data covering the period of transition to PPS, and thus face the difficulty of disentangling the impact of simultaneous changes in average and marginal payment incentives (e.g. Newhouse, 1989; Cutler, 1995; Gilman, 2000). Dafny (2005) circumvents this problem by exploring the response of hospitals to changes in DRG prices in the *post*-PPS era. The contribution focuses on the behaviour of US Medicare program hospitals in response to a price change generated by the elimination of the age criterion in the description of DRG pairs, and shows a small impact in terms of volume of activity and intensity or quality of care. In more recent years, some studies have addressed DRG-specific responses of hospitals to price changes, mostly referring to the US context and examining the effect of reimbursement cuts by Medicare. Lindrooth et al (2007) find that hospitals with high-share Medicare patients decreased treatment intensity more than

---

<sup>4</sup> While the effects on hospital performance from granting more financial and operational freedoms have received some attention in the UK (Marini et al, 2008; Verzulli et al, 2010; Allen et al, 2012), this issue is still relatively unexplored in the Italian context.

others, as they experienced larger reductions in average reimbursements. Moreover, the reduction was larger for the more generously reimbursed diseases and for patients requiring higher intensity. Other papers explore the impact of reductions in Medicare payments on health outcomes. While some of them find no adverse effects in the short-run (Seshamani et al, 2006), others highlight higher mortality rates in the long-run for hospitals facing larger payment cuts (Wu and Shen, 2014). Outside the US, Liang (2015) estimates the substitution and complementarity across DRGs with different profitability for hospitals under a DRG-based payment scheme in Taiwan. The evidence supports both the hypothesis of positive own-price effects, with an increase in the share of patients for the more profitable DRGs, and of negative cross-price effects.

Whereas the aforementioned studies have focused on hospital behaviour within competitive markets, a more limited stream of research has analysed hospital response to DRG price changes in national health-care systems. To the best of our knowledge, only two contributions explicitly address this issue. Allen et al (2016) analyse the Best Practice Tariffs (BPTs) reform in England, whereby the prices of a small group of interventions were set proactively to reflect the costs of delivering best practices, instead of reactively on the basis of average hospital costs. The results suggest that the policy increased the rate of day cases for the targeted procedures, with no detrimental effect in terms of mortality and readmission rates. Finally, Januleviciute et al (2015) analyse hospital response following continuous refinements in DRG prices within the Norwegian health-care system. Their findings indicate that, on average, an increase in DRG prices by 10% increased the number of emergency and elective patients with medical treatments by about 0.8 and 1.3%, respectively; whereas there is little evidence that hospitals adjusted the volume of surgical activity. Interestingly, these findings partly diverge from ours as we highlight a significant impact of price changes on surgical procedures for elective patients, but no effects emerge either for elective medical DRGs or for non-elective procedures. Differences in the design of the policy intervention, in the regulatory arrangements and in providers' characteristics may explain part of the heterogeneity in the empirical results. Still, such mixed evidence confirms the importance of improving our understanding of the consequences of DRG price changes in NHS systems.

### 3. Data

We use data on inpatient discharges at public hospitals sited in Italy's region of Emilia-Romagna.<sup>5</sup> The Italian NHS provides universal and comprehensive care financed by general taxation, where provision of health-care services falls mainly under the responsibility of regional governments, and patients can freely choose hospital care from any publicly financed provider. The largest hospitals (Aziende Ospedaliere – AOs) are granted the status of autonomous Trusts and are extensively financed through the use of a DRG-based PPS. The remaining hospitals are managed by the Aziende Sanitarie Locali (ASLs), public enterprises mostly funded via a capitated budget and responsible for the delivery of care to their catchment population.<sup>6</sup> Once the resources are assigned to each ASL, DRG prices are used by ASLs to quantify the activity of hospitals under their direct control, and thus contribute to setting their separate budgets. Such arrangements point towards a relevant role of DRG prices in allocating the available resources across all public hospitals (Cappellari et al, 2014).

Our dataset combines patient records and DRG prices between 2005 and 2010. Patients data are drawn from the administrative hospital discharge dataset (*Schede di Dimissione Ospedaliera*, SDO). The SDO dataset contains patient-level information, including type of admission (elective or non-elective), booking date, date of admission and discharge, primary diagnosis (DRG), patient's municipality of residence, and a hospital identifier. The sample used for the main analysis consists of all acute patients residing in the hospital's catchment area who received an elective inpatient treatment between 2005 and 2010.<sup>7</sup> Then, we matched our sample of patient-level information with the price tariffs set by the Regional Government for all the DRGs in use between 2005 and 2010. The data were then aggregated at the hospital-DRG-year level, leaving us with a final sample of 14,516 observations. The

---

<sup>5</sup> This region is located in the North East of Italy, and has a total population of nearly 4 million people.

<sup>6</sup> The capitation formula depends on the population size, weighted by age-specific hospital utilization rates and risk-adjusted mortality rates, to account (at least partially) for the health-care needs of the population enrolled in each ASL.

<sup>7</sup> Our final sample covers all patients treated in the same area where they are enrolled, representing more than 80% of total cases. Hospital care for patients residing outside the region is reimbursed on the basis of a national price schedule and, therefore, these patients are not included in our analysis. Moreover, we excluded highly complex procedures, such as organ transplants and treatments for patients with major burns and trauma conditions, as they are funded on the basis of block contracts. We also excluded patients treated in community hospitals, since these (smaller) facilities deal only with low complexity cases, and are subject to a funding scheme that does not apply the DRG prices used to reimburse the larger providers.

number of hospitals covered in the analysis is 14, whereas the total number of DRGs is 279, divided between 164 affected DRGs and 115 unaffected DRGs.<sup>8</sup>

### *3.1 DRG prices*

Table I displays the summary statistics for the prices of medical and surgical DRGs (panel A and B, respectively), distinguishing between the affected DRGs (both pre- and post-shock) and the unaffected ones. Average values are plotted in Figure 1 showing that prices for affected DRGs increased by an average of 111 Euro for medical DRGs and of 121 Euro for surgical DRGs. The average price is always lower for affected DRGs than for the unaffected ones, suggesting that the DRGs targeted by the policy change covered on average less complex procedures. Table II shows the descriptive statistics for the ratio between the pre- and post-policy prices of the affected DRGs, whose tariffs increased by 6% on average, with a range between 4 and 30% for medical DRGs, and between 4 and 20% for the surgical ones.

### *3.2 Dependent variables*

Figure 2 plots the total number of yearly inpatient discharges by type of conditions and by treatment status between 2005 and 2010. For both medical and surgical treatments, the volume of activity is always higher for the affected DRGs than for the unaffected ones. We observe broadly parallel trends for both medical and surgical treatments between the affected and unaffected DRGs in the pre-policy years. Between 2007 and 2010, there was a small decline in the volume of medical treatments for patients in the group of affected DRGs, and no substantial change for patients in the unaffected DRGs. Conversely, we observe an increase in the number of surgical patients in the affected DRGs, and a slight decrease for those in the unaffected ones.

Figures 3-4 show the time trends in the proportion of patients waiting more than six months and the average length of stay.<sup>9</sup> As shown in Figure 3, the proportion of patients waiting

---

<sup>8</sup> Since not all DRGs were treated by each hospital during each year between 2005 and 2010, the total number of observations included in our dataset is lower than  $14 \text{ hospitals} \times 279 \text{ DRGs} \times 6 \text{ years}$ .

<sup>9</sup> Waiting times are calculated as the time span between the date of admission and the date of decision to admit.



more than six months is higher for surgical than for medical treatments. We observe no relevant changes for the affected medical DRGs; whereas the unaffected ones display a limited variation until 2008, with a slight increase for the remaining period. For surgical treatments, the affected and unaffected DRGs follow broadly similar trends, with an increase in the proportion of patients waiting more than six months from 2005 to 2009, and a small reduction from 2009 to 2010. Finally, we record only very small changes over time in the average length of stay for all DRG groups (Figure 4).

### *3.3 Hospital characteristics*

Our sample comprises 9 hospitals directly managed by ASLs and 5 AOs, with the latter having greater autonomy compared to ASL-run hospitals. We test whether AOs are more responsive to price changes relative to hospitals directly managed by ASLs. This offers the opportunity to analyse whether responsiveness to financial incentives increases with the administrative and financial autonomy enjoyed by hospitals. The manager's roles differ across the two types of organisations: while in AOs the manager is the principal at the top of a two-layer hierarchy, with the doctors being on the bottom layer, in ASL-run hospitals he is the middle principal in a three-layer hierarchy, with the Local Health Authority being on the top layer. Altering the decision-making hierarchy may affect the incentives of the different decision-makers with potential consequences on hospital performance (Giuffrida et al, 1999).

In addition, we explore possible differences in hospitals' responses due to different pre-policy conditions as expressed in terms of the proportion of occupied beds before policy implementation. One may expect the policy change to have a greater impact on hospitals having higher levels of unused capacity prior to the price increase. To test this assumption, we use a pre-policy measure provided by the Health Department and computed as the ratio between the number of occupied beds and available beds in 2006. The variable is reported by hospital and type of DRGs (medical and surgical). Table III shows the summary statistics: for patients with medical conditions (panel A), the proportion of occupied beds in 2006 was 88% on average (range 81-93%); for patients with surgical conditions (panel B) the proportion of occupied beds was 75% on average (range 69 - 83%). We assigned the values of the proportion of occupied beds reported by a single hospital for the groups of

medical and surgical DRGs in 2006 to the same hospital and type of DRGs in all years between 2005 and 2010. We then divided the sub-sample of surgical DRGs by low, medium and high tertiles of the occupancy rate distribution, and find that, for surgical patients, the proportion of occupied beds fell within one of the following ranges: up to 70% (low tertile), between 71 and 80% (medium tertile), and over 80% (high tertile). Since for medical procedures the proportion of occupied beds was always higher than 80%, we only focus on surgical treatments to test for the influence of different pre-policy bed occupancy rates.

#### 4. Estimation strategy

Our baseline specification draws on Dafny (2005), with some modifications that account for the specific features of our data. It can be represented as follows:

$$\begin{aligned} \ln(y)_{jht} = & Z_{jh} + T_t + \beta_1 \Delta \ln(p)_j \times (Short\_run)_t + \beta_2 \Delta \ln(p)_j \times (Medium\_run)_t \\ & + \beta_3 H_h \times T_t + \beta_4 DRG_j \times T + \varepsilon_{jht} \end{aligned} \quad (1)$$

Eq. (1) is estimated for different dependent variables: the number of inpatient discharges; the proportion of patients waiting more than six months; and the average length of stay. We consider patients with the  $j$  DRG condition treated at hospital  $h$  in year  $t$ . The number of inpatient discharges and the average length of stay are included in log terms, whereas the proportion of patients waiting more than six months is expressed in percentage points. This allows to interpret the estimated coefficients as elasticities.

Among the explanatory variables, we include DRG-by-hospital fixed effects,  $Z_{jh}$ , capturing time-invariant idiosyncratic characteristics of DRG  $j$  in hospital  $h$ ; and year fixed effects (with the baseline year set to 2006),  $T_t$ , which control for shocks common to all DRGs in all hospitals. The key explanatory variables are  $\Delta \ln(p)_j \times (Short\_run)_t$  and  $\Delta \ln(p)_j \times (Medium\_run)_t$ . The first component of these interactions,  $\Delta \ln(p)_j$ , measures the difference  $\ln(p)_{jpost\_shock} - \ln(p)_{jpre\_shock}$ , where  $p_{jpost\_shock}$  is the price of DRG  $j$  in the post-policy years, and  $p_{jpre\_shock}$  is the price of the same DRG before policy implementation. Thus,  $\Delta \ln(p)_j$  takes a value greater than zero for the DRGs targeted by the price change, and zero otherwise. In order to examine the effect of the price change in the

short- and medium-run post-policy periods, we interact  $\Delta\ln(p)_j$  with the dummies  $(Short\_run)_t$ , equal to one in the first two years after policy implementation (2007 and 2008), and zero otherwise; and  $(Medium\_run)_t$ , equal to one in the two subsequent years (2009 and 2010), and zero otherwise. Finally, we include the interactions of hospital dummies with year fixed effects,  $H_h \times T_t$ , in order to control for possible time-varying hospital characteristics common to all DRGs (for instance, available beds and staff employed), and the set of interactions between each DRG and a linear time trend,  $DRG_j \times T$ , which ensure that the estimated effects do not reflect unobserved DRG characteristics affecting the dependent variables in the form of linear time trends.<sup>10</sup>

We next estimate the following regression to investigate potential heterogeneous responses across hospitals by legal status:

$$\begin{aligned} \ln(y)_{jht} = & Z_{jh} + T_t + \beta_1 \Delta\ln(p)_j \times (Short\_run)_t + \beta_2 \Delta\ln(p)_j \times (Medium\_run)_t \\ & + \beta_3 \Delta\ln(p)_j \times (Short\_run)_t \times ASL_h + \beta_4 \Delta\ln(p)_j \times (Medium\_run)_t \times ASL_h \\ & + \beta_5 H_h \times T_t + \beta_6 DRG_j \times T + \varepsilon_{jht} \end{aligned} \quad (2)$$

where  $ASL_h$  is a dummy variable taking the value one for ASL hospitals, and zero otherwise. Thus, the coefficients  $\beta_3$  and  $\beta_4$  now capture the differential effect (if any) for ASL hospitals relative to AOs in the short- and medium-run post-policy periods, respectively.

Finally, we investigate whether the response of hospitals varies depending on the proportion of occupied beds reported one year before policy implementation. This is done by estimating:

$$\begin{aligned} \ln(y)_{jht} = & Z_{jh} + T_t + \beta_1 \Delta\ln(p)_j \times (Short\_run)_t + \beta_2 \Delta\ln(p)_j \times (Medium\_run)_t \\ & + \beta_3 \Delta\ln(p)_j \times (Short\_run)_t \times MO_h + \beta_4 \Delta\ln(p)_j \times (Short\_run)_t \times HO_h \\ & + \beta_5 \Delta\ln(p)_j \times (Medium\_run)_t \times MO_h + \beta_6 \Delta\ln(p)_j \times (Medium\_run)_t \times HO_h \\ & + \beta_7 H_h \times T_t + \beta_8 DRG_j \times T + \varepsilon_{jht} \end{aligned} \quad (3)$$

---

<sup>10</sup> Note that the hospital and DRG main effects are absorbed into the DRG-by-hospital fixed effects,  $Z_{jh}$ . Following previous studies (e.g. Dafny, 2005; Januleviciute et al, 2015), we use DRG-specific linear time trends as a feasible alternative to DRG-year interactions.

where  $MO_h$  and  $HO_h$  are dummy variables for each hospital  $h$ , which take value one for hospitals within the medium and high tertiles of the occupancy rate distribution, and zero otherwise.<sup>11</sup> Thus, the coefficients  $\beta_1$  and  $\beta_2$  now capture the effect of a price increase for hospitals within the low tertile of the occupancy rate distribution (the reference category) in the short- and medium-run respectively. The additional effects for those falling within the medium and high tertiles are given by, respectively,  $\beta_3$  and  $\beta_5$  in the short-run, and  $\beta_4$  and  $\beta_6$  in the medium-run. If larger responses occur for hospitals characterised by higher levels of unused capacity before policy change, the estimated coefficients  $\beta_3$ - $\beta_6$  will be negative. We present here the results of Eq. (3) only on the sub-sample of surgical patients since, as previously highlighted, for medical patients the proportion of occupied beds reported by hospitals in year 2006 was always higher than 80% across all sample hospitals.

## 5. Results

Table IV presents the results for Eq. (1), estimated for medical and surgical DRGs separately. The dependent variable for the estimates reported in the first two columns is the number of inpatient discharges. Our findings indicate that an increase in medical DRG prices did not lead to significant changes in the volume of medical activity for the affected DRGs relative to the unaffected ones. By contrast, we find that a 1% increase in the price of surgical DRGs increased the volume of surgical activity for the affected DRGs, as compared to the unaffected ones, by an amount of 1.7% in the short-run and 4% in the medium-run. The remaining columns of Table IV display the results for the other outcomes of interest, and show that an increase in DRG prices had a negative but not significant impact on the proportion of patients waiting more than six months, and a positive but, again, not significant impact on average length of stay.

We then examine the influence of hospital legal status using the specification proposed in Eq. (2). As Table V shows, we do not find significant differences in the response patterns between the two groups of hospitals for any outcome considered, suggesting that the reaction of public hospitals to changes in DRG prices does not seem to be affected by the degree of their administrative and financial independence.

---

<sup>11</sup> See section 3.3 for the details on how these variables were generated.

Table VI shows the results from Eq. (3) where we consider the role of pre-policy levels of unused capacity. With respect to the volume of surgical activity, we find evidence that an increase in DRG prices led to a larger response for hospitals holding a higher excess capacity before policy change. Specifically, hospitals falling within the lowest tertile of the occupancy rate distribution (our baseline category) display a positive and significant impact both in the short- and in the medium-run post-policy periods by an amount equal to 2.6 and 6%, respectively. This effect is significantly lower for hospitals within the medium tertile, and becomes statistically insignificant for hospitals with a bed occupancy rate higher than 80% (highest tertile).<sup>12</sup> In terms of the proportion of patients waiting more than six months, the policy change had a negative and significant (at the 10% level) impact for hospitals with the lowest bed occupancy rates, whereas the effect becomes statistically insignificant for hospitals holding higher bed occupancy rates. Finally, our results on the average length of stay suggest that an increase in DRG prices produced no significant effect irrespective of the pre-policy levels of unused capacity.<sup>13</sup>

Finally, we test the restriction imposed by Eq. (1)-(3), where we estimated the impact of the price increase on our outcome variables by grouping years 2007-2008 into short-run post-policy period, and years 2009-2010 into medium-run post-policy period. By doing so, we are implicitly assuming that the effect of the price increase was not significantly different between 2007 and 2008, and between 2009 and 2010. In Table VII, we show the results from a more flexible estimation specification, where we replaced the interaction terms  $\Delta \ln(p)_j \times (Short\_run)_t$  and  $\Delta \ln(p)_j \times (Medium\_run)_t$  with the set of interactions  $\sum_{t=2007}^{2010} \Delta \ln(p)_j \times T_t$ , where  $T_t$  is a dummy variable for year  $t$ . The results provided by this flexible specification show the similarity of the effects between years 2007 and 2008, and between 2009 and 2010.<sup>14</sup>

---

<sup>12</sup> Bearing in mind that the total effect for these hospitals is captured by the sum  $(\beta_1 + \beta_3)$  in the short-run, and by  $(\beta_1 + \beta_5)$  in the medium-run.

<sup>13</sup> We also repeated the regression analysis on the sub-sample of medical DRGs, after grouping the occupancy rate distribution that we observe for these treatments by low, medium and high tertiles. In general, we do not detect any significant difference in the response of hospitals according to their proportion of occupied beds reported in the pre-policy period. The only exception is in terms of volume of activity: we find a positive but not significant effect for hospitals falling within the low and medium tertiles, and a significantly smaller effect for the remaining hospitals. These results are available upon request.

<sup>14</sup> We find no significant difference between the effects in 2007 and 2008, and between the effects in 2009 and 2010.

## 6. Validity of the estimation specification

The identification of the causal effect of the price change is challenged by the underlying non-random selection of the targeted DRGs, a limitation shared by most large scale policy interventions. However, the policy design and the identification strategy allow us to account for policy endogeneity.

The targeted DRGs were identified according to data on costs aggregated at the specialty level and collected from a subset of regional hospitals in 2005, two years before the policy change. This provided policymakers only with rough indications on the cost-compensation gap across DRGs. Moreover, the available information on costs was partially outdated in 2007. Given this background, the policymaker's decision was to implement tariff changes that were largely uniform across DRGs rather than to fine-tune the adjustments according to DRG-specific tariff-cost gaps, thus leading to changes in tariffs that were poorly correlated to the actual costs experienced in the majority of hospitals in 2007.<sup>15</sup>

Besides the institutional features discussed above, the empirical strategy further mitigates possible concerns over potential endogeneity issues. First, we explicitly account for possible differences in the dependent variables between affected and unaffected DRGs that may have been caused by factors other than the policy change. For this purpose, we control for fixed differences in hospital performance between the two diagnoses groups via the DRG-by-hospital fixed effects. Thus, all time-invariant differences between DRGs that may affect the outcome variables of interest will be absorbed into the DRG-by-hospital fixed effects. Time-varying changes common to all DRGs are captured by the year fixed effects. Moreover, we followed prior studies (e.g. Dafny, 2005; Januleviciute et al, 2015) by including DRG-specific time trends in order to control for the possible variation in hospital performance across DRGs over time.

Second, we also consider the possibility that time-varying (unobserved) confounding factors may be correlated to both increases in DRG tariffs and differential trends in hospital performance between affected and unaffected DRGs in the pre-policy period. We test for this by performing a falsification test similar to the one adopted in previous studies

---

<sup>15</sup> The tariff increase was in most cases set at the uniform rate of 4%. Moreover, it was not replicated in the following four years, confirming that it was intended as a one-time price shock.

(Clemens et al, 2014, among others). We check for pre-existing trends correlated with price changes by adding to the baseline specification illustrated in Eq. (1) the interaction between the log ratio in the DRG prices after and prior to the policy change,  $\Delta \ln(p)_j$ , and a dummy variable for the pre-policy year 2005. The premise is that, since DRG prices did not change before 2007, we should not expect to find a significant coefficient for this interaction term. By contrast, the presence of a significant effect would be consistent with the hypothesis of different pre-existing trends in the dependent variables which would challenge the identification of the estimated impact of the policy change. The results of this falsification test are presented in Table VIII: the interaction coefficients with year 2005 are not statistically significant, while the estimated coefficients for the other key covariates remain stable. As we find no evidence that the price change was correlated with pre-existing trends in the dependent variables, this result supports our identification strategy.

To reinforce the contention that our results are not capturing a spurious effect, we also repeat our analysis on non-elective patients. Since non-elective patients need immediate treatment (within 48 hours), hospitals cannot rely on waiting times to ration demand for these patients. As long as the provision of non-elective care is outside hospital control, one should expect price changes to generate a smaller (or no) impact on non-elective treatments. On the contrary, in the case of a spurious price effect, price changes may be found to affect both elective and non-elective admissions. The results from this placebo-test are reported in Table AI in the Appendix. For non-elective patients we find no significant effect on any outcome of interest, a result which goes in favour of our claim of a genuine causal effect induced by the change in DRG prices.

## **7. Discussion and conclusions**

This paper investigated the impact of a policy change implemented in Italy's region Emilia-Romagna, which increased the price of a subset of DRGs by 6% on average. We evaluated whether the price increase affected the performance of public hospitals differently between affected and unaffected diagnoses. Specifically, we examined hospital response in terms of the number of inpatient discharges, proportion of patients waiting more than six months, and average length of stay. Differently from most of the literature, we considered a context with

dominant public suppliers. Although the mandate to meet the health needs of the reference population and the political accountability of public hospitals may weaken their responsiveness to financial incentives, variations in DRG prices may still matter also within national health-care systems where tariffs are used to allocate public funds, in particular if public hospitals are allowed to retain financial surpluses for improving health-care services.

Our contribution to the literature spans several dimensions: we presented comprehensive evidence on the impact of an increase in DRG prices on the performance of public hospitals as measured by the number of inpatient discharges, waiting times and length of stay; we explored potential differences between short- and medium-run effects and investigated whether the magnitude of the response is affected by hospital legal status; finally, we analysed the role of unused capacity as a factor that may contribute to explaining the variation in hospital responses. We find that, on average, public hospitals did respond to the increase in DRG prices by significantly expanding their volume of activity provided to surgical (elective) patients for the diagnoses affected by the price change relative to the unaffected ones. This effect also increased from the short- to the medium-run: a 1% increase in the price of surgical DRGs led to an increase in the number of patients treated with the affected DRGs relative to the unaffected ones by 1.7% in the short-run and by 4% in the medium-run. This suggests that it may take some time for hospitals to fully adjust their activity in response to price increases. We do not reject the hypothesis of homogeneous responses by hospital legal status, while we find evidence of heterogeneous responses according to hospitals' excess capacity in the pre-policy period, with the hospitals characterised by a lower proportion of occupied beds being relatively more responsive. For medical DRGs, we find no significant effect in terms of volume of activity. Since hospitals were found to have a higher proportion of occupied beds for these diagnoses, this finding is consistent with the expectation that hospitals with higher unused capacity before policy implementation were more reactive to the change.

In terms of waiting times, we find little evidence of a price effect. In principle, the stimulus to increase hospital activity in response to the policy change may induce hospitals to shorten waiting times. Although not statistically significant in the majority of cases, the direction of our findings support this hypothesis for patients that reported longer waiting times (in our study, for surgical than medical patients), and that the negative effect on waiting times



increases with the level of unused capacity reported before policy implementation. Finally, we find no evidence of any impact of the price change on the average length of stay.

Our study bears also some limitations. First, we did not have information with which to test whether increases in DRG prices translated into changes in other important aspects of hospital performance including clinical outcomes. Moreover, we cannot observe the underlying costs dynamics, and this prevented us from examining whether responses across hospitals depend on the gap between DRG prices and actual costs. Despite this, an analysis of the impact of a one-time change in DRG tariffs provides potentially relevant policy insights under PPS within NHS-based systems, where DRG tariffs may serve as a key tool to steer hospital activity.

Taken together, our findings suggest that DRG tariffs affect the decisions of public hospitals and can be exploited to encourage the delivery of certain treatments. Such effects may vary over time and according to the pre-policy conditions under which hospitals operate, as we find a greater impact in the medium-run and for providers with a higher unused capacity before policy implementation.

### **Acknowledgements**

We are grateful for helpful suggestions received by Rowena Jacobs, Søren Rud Kristensen, Irene Mammi, Davide Raggi, Luigi Siciliani and by participants at the iHEA World Congress in Dublin, at the AIES Conference in Venice and at a seminar held at the Department of Economics of the University of Bologna. The research was funded by the Health Department of Emilia-Romagna (Italy) and we thank Eugenio Di Ruscio who coordinated the project for the Health Department. The views expressed are those of the authors and not necessarily those of the funders.

## References

- Allen P, Keen J, Wright J, Dempster P, Townsend J, Hutchings A, Street A, Verzulli R. 2012. Investigating the governance of autonomous public hospitals in England: multi-site case study of NHS Foundation Trusts. *Journal of Health Services Research and Policy* **17**(2): 94-100.
- Allen T, Fichera E, Sutton M. 2016. Can payers use prices to improve quality? Evidence from English hospitals. *Health Economics* **25**: 56-70.
- Barbetta GP, Turati G, Zago A. 2007. Behavioral differences between public and private not-for-profit hospitals in the Italian national health service. *Health Economics* **16**: 75-96.
- Bloom N, Propper C, Seiler S, van Reenen J. 2015. The Impact of competition on management quality: Evidence from public hospitals, *Review of Economic Studies* **82**: 457-489.
- Bordignon M, Turati G. 2009. Bailing out expectations and public health expenditure. *Journal of Health Economics* **28**: 305-321.
- Cappellari L, De Paoli A, Turati G. 2014. Do market incentives in the hospital industry affect subjective health perceptions? Evidence from the Italian PPS-DRG reform. IZA Discussion Paper 8636.
- Chalkley M, Malcomson JM. 2000. Government purchasing of health services. In (eds) Culyer AJ, Newhouse JP. *Handbook of Health Economics*, volume 1, chapter 15: 847-890. Elsevier.
- Chalkley M, Malcomson JM. 2012. Contracts, information and incentives in health care. In (ed) Jones AM. *The Elgar Companion to Health Economics*, chapter 22: 240-249. Edward Elgar.
- Clark AE, Milcent C. 2011. Public employment and political pressure: The case of French hospitals, *Journal of Health Economics* **30**: 1103-1112.
- Clemens J, Gottlieb J. 2014. Do physicians' financial incentives affect medical treatment and patient health? *American Economic Review* **104**(4): 1320-1349.
- Cutler DM. 1995. The incidence of adverse medical outcomes under prospective payment *Econometrica* **63**: 29-50.
- Dafny LS. 2005. How do hospitals respond to price changes? *American Economic Review* **95**(5): 1525-47.
- Dranove D. 2012. Health care markets, regulators, and certifiers. In (eds) McGuire T, Pauly M, Barros PP. *Handbook of Health Economics*, volume 2, chapter 10: 639-690. Elsevier.
- France G, Taroni F, Donatini A. 2005. The Italian health-care system. *Health Economics* **14**:187-202.
- Gilman BH. 2000. Hospital response to DRG refinements: the impact of multiple reimbursement incentives on inpatient length of stay. *Health Economics* **9**: 277-294.

- Giuffrida A, Lapecorella F, Pignataro G. 1999. Efficiency of health care production in different hierarchically structured hospitals. CHE Research Paper 14.
- He D, Mellor JM. 2012. Hospital volume responses to Medicare's outpatient prospective payment system: Evidence from Florida, *Health Economics* **31**: 730-743.
- Hodgkin D, McGuire TG. 1994. Payment levels and hospital response to prospective payment. *Journal of Health Economics* **13**: 1-29.
- Januleviciute J, Askildsen JE, Kaarbøe O, Siciliani L, Sutton M. 2015. How do hospitals respond to price changes? *Health Economics* DOI: 10.1002/hec.3179.
- Liang L. 2015. Do diagnosis-related group-based payments incentivize hospitals to adjust output mix? *Health Economics* **24**(4): 454-469.
- Lindrooth R, Bazzoli G, Clement J. 2007. The effect of reimbursement on the intensity of hospital services. *Southern Economic Journal* **73**(3), 575-587.
- Lo Scalzo A, Donatini A, Orzella L, Cicchetti A, Profili S, Maresso A. 2009. Italy: Health system review. *Health Systems in Transition* **11**(6)1-216.
- Marini G, Miraldo M, Jacobs R, Goddard M. 2008. Giving greater financial independence to hospitals – does it make a difference? The case of English NHS Trusts. *Health Economics* **17**: 751-77.
- McGuire TG. 2000. Physician agency. In (eds) Culyer AJ, Newhouse JP. *Handbook of Health Economics*, volume 1, chapter 9: 461-536. Elsevier.
- Newhouse JP. 1989. Do unprofitable patients face access problems? *Health Care Financing Review* **11**(2): 33-42.
- Nobilio L, Ugolini C. 2003. Selective referrals in a hub and spoke institutional setting: the case of coronary angioplasty procedures. *Health Policy* **63**(1):95-107.
- Seshamani M, Schwartz JS, Volpp KG. 2006. The effect of cuts in Medicare reimbursement on hospital mortality. *Health Services Research* **41**(3): Part I, 683-700.
- Sood N, Buntin MB, Escarce JJ. 2008. Does how much and how you pay matter? Evidence from the inpatient rehabilitation care prospective payment system. *Journal of Health Economics* **27**: 1046-1056.
- Verzulli R, Jacobs R, Goddard M. 2011. Do hospitals respond to greater autonomy? Evidence from the English NHS. University of York CHE Research Paper 64.
- Wu VY, Shen YC. 2014. The long-term impact of medicare payment reductions on patient outcomes. *Health Services Research* **49**(5): 1596-615.

**Table I.** Descriptive statistics for DRG prices (Euro)

	No. of DRGs	Mean	SD	Min	Max
<u>Panel A: Medical DRGs</u>					
<i>Affected DRGs</i>					
Pre-shock	114	1978.32	830.95	687.92	5195.48
Post-shock	114	2088.86	853.58	715.44	5403.30
<i>Non-affected DRGs</i>					
Pre-shock and post-shock	59	2479.40	1035.09	440.79	5283.31
<u>Panel B: Surgical DRGs</u>					
<i>Affected DRGs</i>					
Pre-shock	50	2324.82	1201.95	570.55	5906.47
Post-shock	50	2446.25	1237.51	593.37	6142.73
<i>Non-affected DRGs</i>					
Pre-shock and post-shock	56	3407.71	2222.62	787.59	10146.54

**Table II.** Descriptive statistics for the ratio between post- and pre-policy prices of affected DRGs (Euro)

	No. of DRGs	Mean	SD	Min	Max
<u>Panel A: Medical DRGs</u>					
$(p_{jpost\_shock}/p_{jpre\_shock})$	114	1.06	0.06	1.04	1.30
<u>Panel B: Surgical DRGs</u>					
$(p_{jpost\_shock}/p_{jpre\_shock})$	50	1.06	0.04	1.04	1.20

**Table III.** Hospital bed occupancy rates, 2006 data

	Obs.	Mean	SD	Min	Max
<u>Panel A: Medical DRGs</u>					
Bed occupancy rates	1420	87.72	3.09	81.36	92.90
<u>Panel B: Surgical DRGs</u>					
Bed occupancy rates	1070	75.29	5.36	69.12	83.48

**Table IV.** Average price effects on the number of inpatient discharges, % of patients waiting more than six months and average length of stay

	ln(number of inpatient discharges)		% patients waiting more than six months		ln(average length of stay)	
	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs
$\Delta \ln(p) \times (\text{Short\_run})$	-0.214 (0.628)	1.733** (0.584)	-0.050 (0.073)	-0.170 (0.165)	0.115 (0.265)	0.095 (0.486)
$\Delta \ln(p) \times (\text{Medium\_run})$	0.281 (0.915)	3.973*** (1.127)	-0.101 (0.159)	-0.175 (0.300)	0.329 (0.611)	0.041 (0.703)
Hospital-DRG F.E.	Y	Y	Y	Y	Y	Y
Year F.E.	Y	Y	Y	Y	Y	Y
Hospital $\times$ Year interaction	Y	Y	Y	Y	Y	Y
DRG trends	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.765	0.863	0.199	0.414	0.467	0.659
Obs.	8251	6265	8251	6265	8251	6265

Notes: \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01. Robust standard errors clustered at the hospital level are in parentheses.

**Table V.** Responses to the policy change by legal status

	ln(number of inpatient discharges)		% patients waiting more than six months		ln(average length of stay)	
	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs
$\Delta \ln(p) \times (\text{Short\_run})$	-0.207 (0.699)	1.961** (0.697)	-0.030 (0.069)	-0.363* (0.200)	0.429 (0.354)	0.085 (0.592)
$\Delta \ln(p) \times (\text{Short\_run}) \times \text{ASL}$	-0.011 (0.784)	-0.381 (0.626)	-0.034 (0.075)	0.325 (0.206)	-0.545 (0.325)	0.020 (0.448)
$\Delta \ln(p) \times (\text{Medium\_run})$	0.251 (1.216)	3.721** (1.622)	-0.104 (0.153)	-0.200 (0.414)	0.622 (0.669)	-0.283 (0.797)
$\Delta \ln(p) \times (\text{Medium\_run}) \times \text{ASL}$	0.054 (0.859)	0.428 (1.224)	0.007 (0.063)	0.043 (0.353)	-0.500 (0.367)	0.551 (0.394)
Hospital-DRG F.E.	Y	Y	Y	Y	Y	Y
Year F.E.	Y	Y	Y	Y	Y	Y
Hospital $\times$ Year interaction	Y	Y	Y	Y	Y	Y
DRG trends	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.765	0.863	0.199	0.414	0.467	0.659
Obs.	8251	6265	8251	6265	8251	6265

Notes: \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Robust standard errors clustered at the hospital level are in parentheses.

**Table VI.** Responses to the policy change by bed occupancy rate

	ln(number of inpatient discharges)	% patients waiting more than six months	ln(average length of stay)
	Surgical DRGs	Surgical DRGs	Surgical DRGs
$\Delta \ln(p) \times (\text{Short\_run})$	2.595** (1.078)	-0.251* (0.135)	0.563 (0.631)
$\Delta \ln(p) \times (\text{Short\_run}) \times \text{MO}$	-0.781 (0.741)	0.027 (0.289)	-0.877 (0.498)
$\Delta \ln(p) \times (\text{Short\_run}) \times \text{HO}$	-1.926** (0.865)	0.232 (0.326)	-0.532 (0.424)
$\Delta \ln(p) \times (\text{Medium\_run})$	5.980*** (1.530)	-0.287 (0.382)	0.767 (0.713)
$\Delta \ln(p) \times (\text{Medium\_run}) \times \text{MO}$	-2.331** (0.940)	0.0987 (0.519)	-1.306** (0.467)
$\Delta \ln(p) \times (\text{Medium\_run}) \times \text{HO}$	-3.845*** (0.770)	0.248 (0.519)	-0.876 (0.504)
Hospital-DRG F.E.	Y	Y	Y
Year F.E.	Y	Y	Y
Hospital $\times$ Year interaction	Y	Y	Y
DRG trends	Y	Y	Y
Adj. R-squared	0.864	0.413	0.659
Obs.	6265	6265	6265

Notes: \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Robust standard errors clustered at the hospital level are in parentheses.

**Table VII.** Flexible specification

	ln(number of inpatient discharges)		% patients waiting more than six months		ln(average length of stay)	
	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs
$\Delta \ln(p) \times (\text{Year}2007)$	0.117 (0.746)	2.029** (0.818)	0.067 (0.114)	-0.241 (0.224)	0.030 (0.433)	-0.069 (0.523)
$\Delta \ln(p) \times (\text{Year}2008)$	0.485 (0.993)	3.197** (1.410)	0.289 (0.204)	-0.444 (0.308)	-0.294 (0.671)	0.179 (0.564)
$\Delta \ln(p) \times (\text{Year}2009)$	1.099 (1.251)	5.657** (2.091)	0.292 (0.314)	-0.492 (0.393)	-0.141 (1.069)	0.116 (0.687)
$\Delta \ln(p) \times (\text{Year}2010)$	1.516 (1.601)	5.814* (2.779)	0.414 (0.428)	-0.548 (0.570)	-0.185 (1.357)	-0.193 (0.846)
Hospital-DRG F.E.	Y	Y	Y	Y	Y	Y
Year F.E.	Y	Y	Y	Y	Y	Y
Hospital $\times$ Year interaction	Y	Y	Y	Y	Y	Y
DRG trends	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.765	0.863	0.199	0.414	0.467	0.659
Obs.	8251	6265	8251	6265	8251	6265

Notes: \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Robust standard errors clustered at the hospital level are in parentheses.



**Table VIII.** Falsification test of pre-existing trends correlated with the price changes

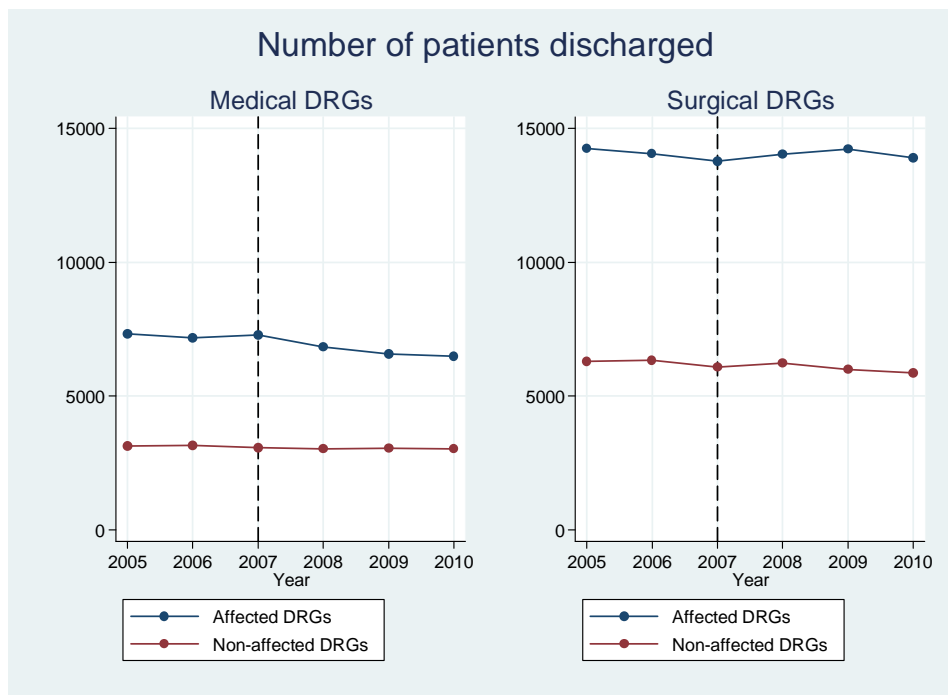
	ln(number of inpatient discharges)		% patients waiting more than six months		ln(average length of stay)	
	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs
$\Delta \ln(p) \times (\text{Pre\_policy})$	0.392 (0.400)	0.662 (0.749)	0.173 (0.113)	-0.130 (0.159)	-0.187 (0.297)	-0.030 (0.252)
$\Delta \ln(p) \times (\text{Short\_run})$	-0.287 (0.626)	1.619** (0.616)	-0.082 (0.080)	-0.148 (0.169)	0.150 (0.254)	0.100 (0.501)
$\Delta \ln(p) \times (\text{Medium\_run})$	-0.064 (0.968)	3.416** (1.218)	-0.253 (0.165)	-0.066 (0.348)	0.494 (0.529)	0.067 (0.812)
Hospital-DRG F.E.	Y	Y	Y	Y	Y	Y
Year F.E.	Y	Y	Y	Y	Y	Y
Hospital $\times$ Year interaction	Y	Y	Y	Y	Y	Y
DRG trends	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.765	0.863	0.199	0.414	0.467	0.659
Obs.	8251	6265	8251	6265	8251	6265

Notes: \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Robust standard errors clustered at the hospital level are in parentheses.

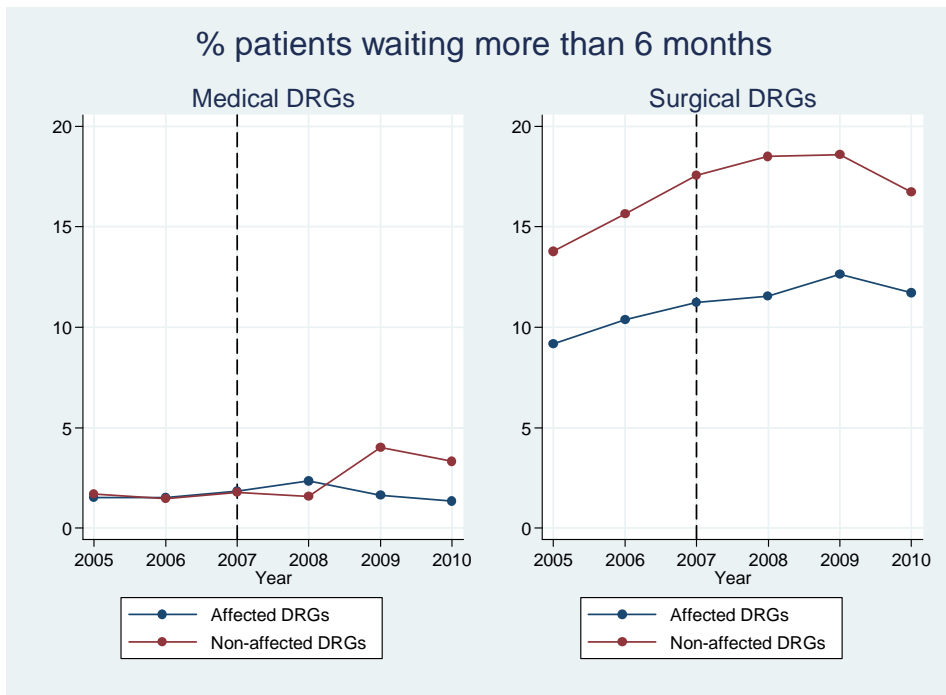
**Figure 1.** Mean prices of affected and non-affected DRGs, by year and type of DRG



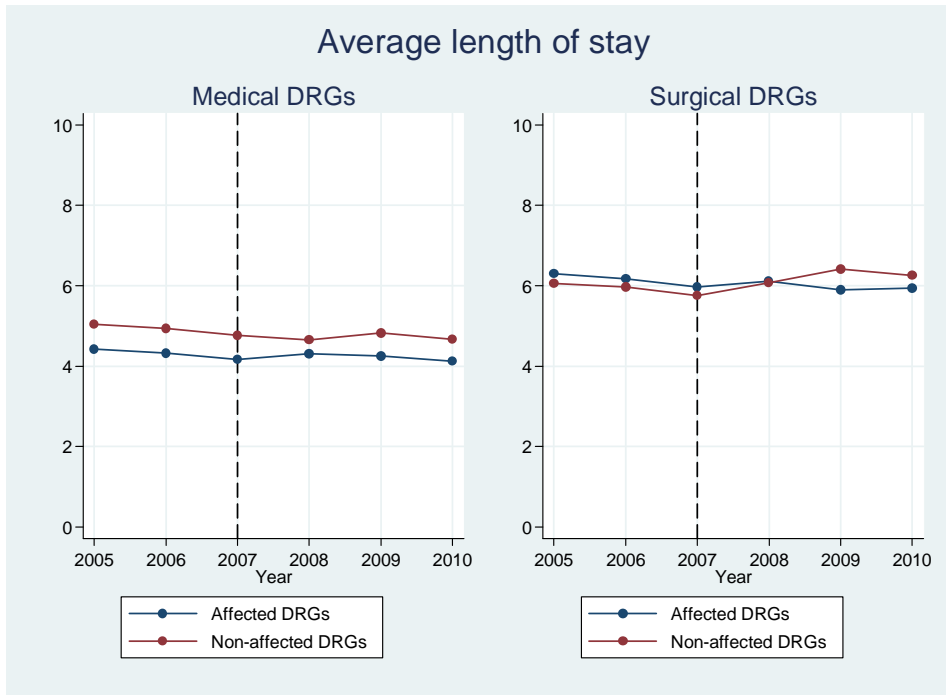
**Figure 2.** Number of elective inpatient discharges at all hospitals, by year and type of DRG



**Figure 3.** Percentage of elective patients waiting more than six months at all hospitals, by year and type of DRG



**Figure 4.** Average length of stay for patients discharged at all hospitals, by year and type of DRG



**Table AI.** Falsification test on the sub-sample of non-elective patients

	ln(number of inpatient discharges)		ln(average length of stay)	
	Medical DRGs	Surgical DRGs	Medical DRGs	Surgical DRGs
$\Delta \ln(p) \times (\text{Pre\_policy})$	0.411 (0.245)	0.484 (0.311)	-0.075 (0.134)	0.270 (0.325)
$\Delta \ln(p) \times (\text{Short\_run})$	-0.336 (0.382)	0.259 (0.622)	0.137 (0.117)	0.034 (0.257)
$\Delta \ln(p) \times (\text{Medium\_run})$	-0.679 (0.714)	-0.047 (1.234)	0.445 (0.272)	-0.722 (0.438)
Hospital-DRG F.E.	Y	Y	Y	Y
Year F.E.	Y	Y	Y	Y
Hospital $\times$ Year interaction	Y	Y	Y	Y
DRG trends	Y	Y	Y	Y
Adj. R-squared	0.907	0.860	0.702	0.724
Obs.	13328	5217	13328	5217

Notes: \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Robust standard errors clustered at the hospital level are in parentheses.



Alma Mater Studiorum - Università di Bologna  
DEPARTMENT OF ECONOMICS

Strada Maggiore 45  
40125 Bologna - Italy  
Tel. +39 051 2092604  
Fax +39 051 2092664  
<http://www.dse.unibo.it>