Prospective payment Systems and hospital heterogeneity

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Abstract

The purpose of this paper is to study hospital cost variability in the event of introduction of a Prospective Payment System (PPS) in France. We use a nested three dimensional database (stays-hospitals-years) in order to identify hospital unobservable heterogeneity and a transitory moral hazard component of cost variability. Econometric estimates are performed on a sample of 7,314 stays for acute myocardial infarction (AMI) observed in 36 French public hospitals over the period 1994 to 1997. Transitory moral hazard is far from negligible : its estimated standard error is about 50 % of the standard error we estimate for cost variability due to permanent unobservable heterogeneity between hospitals. Simulations show that a cost reduction of about 16 % can be expected from implementation of a payment system which allows for permanent unobserved heterogeneity and eliminates only transitory moral hazard.

Keywords : Hospital costs, Prospective Payment System, moral hasard, unbalanced panel data.

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1 Introduction

The purpose of this paper is to study hospital cost variability in the event of introduction of a Prospective Payment System (PPS) in France.

The yardstick competition model of Shleifer (1985) sets up the theoretical foundations of a fully prospective payment system. However, this model is based on rather unrealistic assumptions : homogeneity of hospitals, homogeneity of patients for the same pathology, …xed quality of care. Many studies have pointed out the possible negative e¤ects of careless implementation of a PPS. The risks of a fully prospective payment system are now well known : patient selection and lower care quality (Newhouse (1996)).

The principle of a mixed payment system, combining a lump-sum and a reimbursement of the actual cost of treatment is now generally accepted. However, the proportions of the lump-sum and the actua1 cost are de…ned very di¤erently depending on the theoretical model used, its main hypotheses and its parameterisation.

To what extent patient and hospital heterogeneity should be allowed for in a payment system? To what extent can hospital informational rents be identi…ed? In this paper, we address these questions in the case of France.

We take advantage of a three dimensional nested database (stays-hospitals-years) of 7,314 stays for acute myocardial infarction observed in 36 French public hospitals over the period 1994 to 1997. Information is recorded at three levels : stays are grouped within hospitals and hospitals are observed over several years. The complex structure of our panel data allows us to identify two components of the unexplained cost variability : transitory moral hazard and unobserved hospital heterogeneity.

The remainder of this article is organised as follows. In section 2, we describe the data, characterising the stays, the observed pathology, as well as the hospitals in the database. Section 3 gives theoretical background and de…nes econometric speci…cations that make it possible to analyse costs and identify the components of unexplained cost variability. Section 4 presents econometric methods, speci…cation tests and the results of the econometric application. Using the estimations, we propose in section 5 two methods of payment and simulate their implementation on the sample in order to evaluate potential budget savings.

2 Description of the data

We have at our disposal a sample of 7 314 stays for acute myocardial infraction (AMI) observed in 36 French public hospitals over the period 1994-1997. In France, public hospitals account for about 2/3 of total admissions for AMI. Our sample has been extracted from the PMSI[1] cost database. Classi...cation of stays by Diagnosis Related Group (DRG) is performed on the basis diagnoses and procedures implemented during the stay. Within a prospective payment system (PPS), the regulator would de...ne payments for each DRG. In order to obtain a high degree of patient homogeneity in terms of pathologies we selected patients aged at least 40 with acute myocardial infraction (AMI) as the main diagnosis and grouped in the same DRG : uncomplicated AMI (DRG 179).

For each stay, we have information about the cost of the stay, secondary diagnoses, procedures implemented, entry mode into the hospital (coming from home or transferred from another hospital), discharge mode (return home or transfer), length of stay, age and gender of the inpatient.

The database gives access to rich and detailed information about stays. However, the information about services provided is rather limited. We cannot follow the same inpatient through successive hospital stays. There is no information about the patient's quality of life after the stay, about readmission just after the observed stay, about infections contracted during the stay. In addition, we have no information about the quality of services provided in terms of comfort or alleviation of pain.

Participation in the cost database program is optional. The number of participating hospitals is limited. They consent to give detailed information about their costs, which means that they have accounting systems which enable them to give such information. Using an exhaustive database[2] of AMI patients, we have carried out a comparative analysis about patient characteristics and

[1] PMSI stands for the Programme de médicalisation des systèmes d'informations, which collects information about hospital activity.
[2] With no information about costs.

procedures implemented. This allows us to consider that our data are representative of AMI stays in French hospitals.

Our panel data exhibit a rather complex structure. Information is recorded at three levels : stays are grouped within hospitals and hospitals are observed over several years. The panel is unbalanced in several dimensions : not only does the number of stays recorded vary across hospitals for a given year but also the length of the observation period varies across hospitals. Basic features of the data are presented below. We …rst examine stays (the lowest level of observation), then we consider hospitals.

2.1 Patients

Most AMI patients (64.3 %) are grouped in DRG 179 (uncomplicated AMI). Together with drug therapy (aspirin, beta blockers, etc.), uncomplicated AMI patients can receive various treatments such as thrombolytic drugs, cardiac catheterization (hereafter denoted as CATH) and percutaneous transluminal coronary angioplasty (PTCA). Catheterization is a specialized procedure used to view the blood ‡ow to the heart in order to improve the diagnosis. Angioplasty (PTCA) appeared more recently than bypass surgery. It is an alternative, less invasive procedure for improving blood ‡ow in a blocked artery.

In France, the use of an innovative procedure such as catheterization or angioplasty do not lead to classi…cation of a stay into a speci…c DRG[3]. These innovative procedures are most often performed within DRG 179 : 76.1 % of CATHs and 82.8 % of PTCAs implemented for AMI patients are implemented within DRG 179. Since they do not lead to a classi…cation of the stay in a speci…c DRG, these costly procedures would not lead to a speci…c payment within the context of a prospective payment system. A payment system which does not take these procedures into account would therefore penalise the innovative hospitals which use them and give hospitals incentives to select patients.

[3] This is rather di¤erent from the US classi…cation, where stays with angioplasty are grouped in a speci…c DRG (DRG 112).

Basic features of the data are presented in table 1. Most of the patients are men. They are rather young. 89 % of patients come from home. 64 % of discharges are performed to return home and 36 % are transfers to another hospital[4]. Catheterization and angioplasty are implemented for, respectively, 38 % and 12 % of stays classi…ed in DRG 179.

2.2 Hospitals

Stays are recorded for 36 hospitals, over the period 1994-1997 (table 2). Not all the hospitals are observed over the whole period.

A sizeable proportion of hospitals never perform catheterization or angioplasty. These procedures require speci…c abilities and high-tech facilities. We have split our hospitals into two categories : innovative and non-innovative. For a given year, a hospital is considered innovative if it has performed catheterization for at least 2 % of the stays, or at least one angioplasty (with or without stent). On the basis of this de…nition, 20 hospitals are classi…ed as innovative and these hospitals account for 71.5 % of the recorded stays (table 2).

To complete our database, we have also recorded information about hospital type from the SAE survey[5]. There are three types of hospitals : a CHR[6] is a public teaching hospital which also carries out research ; a PRIV is a private not for pro…t hospital (PRIV hospitals have only recently been regulated through the global budget system and only partially so) ; PUB refers to other public hospitals[7]. Table 3 shows that all the CHR and most of the PRIV are innovative hospitals.

Table 4 shows correlation coe¢cients between hospital type, the dummy variable INNOV (which indicates that the hospital is innovative[8]) and averaged indicators computed at the hospital-year level (95 observations). CHRs are innovative and have a low rate of discharge through transfer to another hospital. Private not for pro…t hospitals (PR) are characterised by a high rate of use of

[4] AMI with death are grouped in another DRG (GHM 180). The average death rate for all AMI patients is about 9 %.

[5] The "Statistique Annuelle des Etablissements de santé" (SAE) is an annual survey which covers all French public hospitals.

[6] CHR stands for Centre Hospitalier Regional.

[7] Other indicators are available in the SAE survey, such as number of beds, occupation rate of beds, diversi…cation of activities within the hospital. However, a lot of missing observations prevent us to carry out a complete descriptive analysis. On a restricted number of observations, we …nd that CHRs are large hospitals with highly diverse activities. On the other hand, private not for pro…t hospitals (PRIVs) concentrate their services on a small number of activities.

[8] INNOV can vary over time : a hospital can be non-innovative one year, and perform high-tech procedures the year after.

innovative procedures and a high rate of admission through transfer from another hospital. Other publics hospitals are rather non innovative and are characterised by a small rate of use of innovative procedures. Patient flows towards innovative hospitals appear clearly in (i) the positive correlation coefficients we find between admission rate through transfer and CATH or PTCA rates; (ii) the negative correlation coefficients we find between discharge rate through transfer and CATH rate.

2.3 Costs

2.3.1 Historical context

In France, hospital budgets have been based on a global budget system for more than ten years, including the years 1994-1997 that we study. The French situation is rather odd because a suitable information system has been implemented since 1982 in order to establish a connection between the budget of a hospital and its activity. However, no real attempt at reform has been undertaken yet. Budgets have no direct link to the actual production of hospitals, which leads to inequity and inefficiency in the allocation of ressources (Mougeot (1999)).

In our sample, we have detailed information about costs per stay and these costs result from an activity financed on the basis of a global budget system.

2.3.2 Average costs

Table 5 gives average costs. The average cost per stay is equal to 27 535 FF (4 197 Euros) with a standard error of 18 777 FF (2 862 Euros). On average, a stay is more costly when an innovative procedure has been implemented. As concerns hospital characteristics, stays are more expensive in teaching and in private not for profit hospitals. The stays are also costlier in innovative hospitals.

3 Econometric specifications

3.1 Theoretical background

The theoretical models used to study hospital payment are devoted to the general problem of local monopoly regulation or focus more particularly on care provider payment systems. For a particular disease, one assumes that the cost of one stay in a hospital h is given by[9] : $C_h = c_h - e_h$, where c_h and e_h are private information of a hospital. c_h is a technology parameter which represents the hospital's cost characteristics. It is a decreasing function of hospital productivity. e_h represents the manager's effort at cost reduction. A hospital exerting effort level e_h incurs a disutility denoted by $\psi(e_h)$: $\psi(.)$ is a continous function with $\psi'(.) > 0$ and $\psi''(.) < 0$: The services provided by hospital h generate a surplus $S_h > 0$. In return, the regulator compensates the hospital through a monetary transfer P_h. Each hospital h chooses its level of effort in order to maximise its utility given by :

$$U_h = P_h - \psi(e_h) - C_h$$

The regulator has to define the levels of transfers which maximise social welfare subject to the constraint that hospitals must not be in state of bankruptcy (λ takes into account distortions from taxation) :

$$\text{Max} \sum_h (S_h + U_h - (1 + \lambda)P_h); \text{ subject to : } U_h > 0 \ \forall h$$

Each hospital is supposed to be a local monopoly. One assumes that there is no collusion between hospitals.

A prospective payment system (PPS) based on "yardstick competition" leads hospitals to exert the first-best level of effort and to have a balanced budget (with no rent and no deficit). A PPS is a fixed price contract. Since the payment is a lump-sum defined irrespective of actual cost, it gives the hospital a perfect incentive for cost reduction ($\psi'(e^*) = 1$). At this stage, the problem is solved in part only. Indeed, c_h is private information of the hospital : the level of the lump-sum fixed by the regulator can lead it to bankrupty or generate rents. Thus, the problem of the regulator is to find the level of payment equal to costs corresponding to efficient activity.

The yardstick competition model (Shleifer (1985)) solves the problem of informational asymmetries by assuming that the technology parameters of hospitals are all identical : $c_h = c \quad \forall h$. In this case, differences in costs are only caused by moral hazard : $C_h = c - e_h$. The yardstick competition scheme consists in offering to any hospital a payment defined as the average costs observed for all

[9] Many theoretical models define payment schemes for one hospital stay, for one pathology and for health care with a fixed level of quality. However, it is possible to consider extensions which introduce endogenous levels of number and quality of treatments (Ma (1994), Ellis (1998), Chalkley and Malcomson (2000)).

other hospitals at the end of the year. The payment is :

$$P_h = \xi(e^*) + \overline{C}_h; \quad \text{where } \overline{C}_h = \frac{\sum_{k \neq h} C_k}{H - 1}:$$

H is the number of regulated hospitals.

Here, $\overline{C}_h$ is defined so as not to be influenced by C_h : the result is a fixed price contract. Since the payment rule is announced at the beginning of the year, the average is finally equal to the cost corresponding to the first-best level of effort :

$$C_h = c - e^* = \overline{C}_h; \ \forall h$$

Transfers P_h are such that each hospital breaks even : $P_h = c - e^* + \xi(e^*)$: The expression of P_h show that this lump-sum is equal to the level of cost corresponding to efficient activity.

This ideal representation sets up the theoretical foundations of a fully prospective payment system. This model is based on rather unrealistic assumptions : homogeneity of hospitals, homogeneity of patients for the same pathology, fixed quality of care.

Many studies have underscored the great diversity in the conditions of care delivery for hospitals (teaching status, share of low income patients, local wage level, etc.). These studies point out the possible negative effects of careless implementation of a PPS. For instance, Pope (1990) shows that input prices can differ according to location, and that a hospital can be characterised by specific quality of services or severity of illness of admitted patients. The risks of a fully prospective payment system are now well known : patient selection and lower care quality (Newhouse (1996)).

In order to avoid these drawbacks, many authors have tried to improve the basic model by removing hypotheses such as patient homogeneity and hospital homogeneity (Keeler (1990), Pope (1990), Ma (1994, 1998), Ellis (1998) and Laffont and Tirole (1993)). Using various theoretical frameworks and hypotheses, these authors show that social welfare is improved by a mixed payment system combining a lump-sum and a reimbursement of the actual cost of treatment.

The principle of a mixed payment system is now generally accepted. However, the proportions of the lump-sum and the actua1 cost are defined very differently depending on the theoretical model used, its main hypotheses and its parameterisation. Moreover, its definition can depend on unobservable variables or functions (such as the effort disutility function, in Laffont and Tirole's model). This leads to empirical questions that we take up in the case of France : how can we identify the costs corresponding to efficient activity ? To what extent patient and hospital heterogeneity should be allowed for in a payment system ?

3.2 Specification of the cost function

Our observations are at the individual level of hospital stay[10]. As stated above, the costs we observe result from activity financed on the basis of a global budget system. Cost variability is therefore influenced by several factors : (i) patient characteristics, (ii) hospital characteristics (infrastructure, economies of scale, economies of scope), (iii) inefficiency (which is more or less possible, depending on the generosity obtained by the hospital manager from the regulator when bargaining for the budget).

Let us denote $C_{i;h;t}$ the cost of stay i in hospital h during the year t. We consider the following model :

$$C_{i;h;t} = X'_{i;h;t}\gamma_t + W'_{h;t}\alpha + Q'_h\lambda + a + c_t + \eta_h - \varepsilon_{h;t} + u_{i;h;t} \quad (1)$$

$X'_{i;h;t}$ represents individual patient characteristics, such as cross effects age x gender, admission and discharge modes, length of stay. The explanatory variables $W'_{h;t}$ and Q'_h are observable hospital characteristics : the type (teaching, private not for profit or other public hospital), innovative or non innovative, implementation rate of high-tech procedures, rates of admission or discharge through transfer. a is a constant.

We have chosen a linear specification for the cost function. The dependent variable is $C_{i;h;t}$ and not $Log(C_{i;h;t})$. It is well known that health care expenditures generally have a very asymetric distribution. In our case, however, the distribution is truncated on the right because of the selection of stays grouped in DRG 179 (uncomplicated AMI). More costly stays are grouped in other DRGs : complicated AMI or AMI treated by bypass surgery. Therefore, the tests we have carried out on the

[10] Therefore, our approach is different of papers which evaluate efficiency using data relative to average costs per hospital. A synthetic survey of this literature can be found in Linna (1998).

distribution of $C_{i,h,t}$ have led us to the conclusion that it is closer to a normal than to a lognormal distribution.

Given patient characteristics, cost variability can stem from hospital characteristics such as hospital type (CHR, PRIV, PUB) and size, diversification of activities, quality of services provided (performance of innovative procedures, comfort, alleviation of pain), skill level of nurses and doctors, quality of hospital management. Some of these factors are observable, some of them cannot be observed.

In this paper, we assume that the regulator has the same position as the econometrician. More exactly, we assume that the regulator has the PMSI data in order to set the payments. Therefore, the sharing out of variables between observable and unobservable components is the same for the regulator and the econometrician. The observable characteristics for the patients are the variables $X'_{i,h,t}$, and for the hospitals the variables $W'_{h,t}$ et Q'_h. Given the observable characteristics, cost variability depends, in the specification (1), on the term :

$$c_t + \eta_h - \varepsilon_{h,t} + u_{i,h,t}.$$

c_t is a fixed temporal effect which can be linked to technological progress, the pace of price growth and the general trend of hospital budgets.

We take into account unobservable patient heterogeneity with the random error term $u_{i,h,t}$, which is assumed to be iid $(0, \sigma_u^2)$. $\varepsilon_{h,t}$ is a perturbation supposed to be iid $(0, \sigma_\varepsilon^2)$ and uncorrelated with $u_{i,h,t}$.

a) Interpretation of hospital specific effects η_h

Unobservable hospital heterogeneity is specified by hospital specific effects η_h, which can be assumed to be random or fixed. η_h can be seen as the result of three components :

$$\eta_h = \eta_h^{as} + \eta_h^{mh} + \eta_h^{q}.$$

Consider the theoretical framework of an agency relationship between the regulator and the hospital, where the regulator has poor information about the effort at cost reduction provided by the hospital manager (moral hazard) and about the hospital characteristics explaining its efficiency (adverse selection). Within this framework, the components of η_h can be interpreted in the following way : η_h^{as} is an adverse selection parameter. The hospital's activity is more or less costly, depending on its infrastructure or on the existence of economies of scale or of scope[11]. η_h^{mh} represents long term moral hazard : the hospital management can be permanently inefficient. The term η_h^{q} takes into account the quality of care services.

b) Interpretation of $\varepsilon_{h;t}$

The perturbation $\varepsilon_{h;t}$ is defined as the deviation, ceteris paribus, for a given year, of hospital h's cost in relation to its average cost level. Thus, it can be interpreted as an indicator of transitory effort at cost reduction, i.e as an indicator of transitory moral hazard. For instance, the manager can be more or less rigorous when bargaining prices for supplies or for services delivered to the hospital by outside firms[12].

Of course, $\varepsilon_{h;t}$ will also be influenced by omitted variables and measurement errors, which are the ordinary components of any perturbation. But measurement errors are likely to be of slight importance. Indeed, $\varepsilon_{h;t}$ is replicated for each stay in the same hospital h during the same year t. Within this framework, a measurement error can only be a systematic error in patient registration, or an error in hospital classification. These two possibilities are unlikely. Let us turn now to the other possible component of $\varepsilon_{h;t}$, i.e. the omitted variables. They are necessarily shocks which affect the hospital h in a given year t. It may be, for instance, an electrical failure. We think that the regulator would be well advised to classify these incidents *a priori* as moral hazard, in order to give hospitals incentives to declare them, when the extra costs they induce are justifiable and exceptional.

On the whole, one can interpret the perturbation $\varepsilon_{h;t}$ as an indicator of transitory moral hazard, linked to the effort at cost reduction performed by the manager. Our econometric estimation allows us to estimate the the variance of $\varepsilon_{h;t}$; and therefore to identify the transitory moral hazard. We do not identify all moral hazard because there is long term moral hazard η_h^{mh} in the hospital specific effects η_h. However, the preceding arguments allow us to consider that the variance of $\varepsilon_{h;t}$ is entirely

[11] We used the indicators available for a restricted number of observations in the SAE survey, in order to find empirical evidence of a link between hospital size (and diversification of activities) and the level of costs, but did not obtain significant results.

[12] Within the context of global budget, the resulting inefficiency is the inefficiency permitted by the level of the allocated budget.

attributable to moral hazard.

4 Estimation and results

4.1 Econometric methods

In the model (1) the hospital specific effects η_h can be assumed to be random or fixed.

Assuming that η_h is random comes down to assuming that unobserved heterogeneity has an influence on costs only at the level of second order moments (on their variance) and is not correlated with observed characteristics $X'_{i,h,t}, W'_{h,t}$ and Q'_h. One has :

$$C_{i,h,t} = X'_{i,h,t}\gamma_t + W'_{h,t}\alpha + Q'_h\lambda + a + c_t + \underbrace{\eta_h - \varepsilon_{h,t} + u_{i,h,t}}_{v_{i,h,t}} ; \qquad (2)$$

with η_h iid $(0, \sigma_\eta^2)$.

Estimation methods are not straightforward for two reasons : (a) our error component model exhibits a nested (hierarchical) structure since the perturbation is written as : $v_{i,h,t} = \eta_h + \varepsilon_{h,t} + u_{i,h,t}$; (b) our panel data is unbalanced : not only does the number of stays recorded vary across hospitals for a given year but also the length of the observation period varies across hospitals. Therefore, our model is different from the unbalanced nested error component model considered by Baltagi, Song and Jung (2001). For our case, Antweiler (2001) shows that data cannot be easily moulded into a feasible generalized least squares transformation for OLS estimation and that maximum likelihood estimation (MLE) provides a suitable alternative. Under the assumption of normality, a consistent and efficient estimator is given by this MLE.

One can also assume that η_h is a fixed effect. In this case, the model includes hospital dummies (to estimate the fixed effects η_h) and it is not possible to identify the parameters λ. A consistent and efficient estimator is given by the FGLS applied to the following model :

$$C_{i,h,t} = X'_{i,h,t}\gamma_t + W'_{h,t}\alpha + a + c_t + \eta_h \underbrace{- \varepsilon_{h,t} + u_{i,h,t}}_{\xi_{i,h,t}} \qquad (3)$$

4.2 Specification tests

Hospital specific effects η_h take unobservable hospital characteristics (long term moral hazard, infrastructure, care quality) which can be correlated with explanatory variables, into account. For instance, care quality may be higher in a teaching hospital. In order to test for the independence of η_h and to examine whether hospital specific effects are fixed or random, we have used a specification test which is an extension of the test proposed by Mundlak (1978) for the standard error component model. We assume that a correlation between η_h and the explanatory variables can be written as a regression of the form : $\eta_h = X'_{.,h,.}\pi_1 + W'_{h,.}\pi_2 + \beta_h$, where β_h is iid $(0,\sigma^2)$ and assumed to be uncorrelated with $\varepsilon_{h,t}$ nor with $u_{i,h,t}$. In this framework, the independence test of η_h is equivalent to the test for $H_0 : \pi_1 = \pi_2 = 0$ in the model :

$$C_{i,h,t} = X'_{i,h,t}\gamma_t + W'_{h,t}\alpha + X'_{.,h,.}\pi_1 + W'_{h,.}\pi_2 + a + c_t + \underbrace{\beta_h - \varepsilon_{h,t} + u_{i,h,t}}_{\zeta_{i,h,t}} \qquad (4)$$

This test leads us to reject the hypothesis of independence between η_h and the explanatory variables (table 7'). Therefore, we will prefer model (3) , where η_h is fixed. This model is a standard error component model, with a perturbation equal to $-\varepsilon_{h,t} + u_{i,h,t}$. In this case, feasible generalized least squares lead to a consistent and asymptotically efficient estimate if $\varepsilon_{h,t}$ is not correlated with the explanatory variables. A Hausman test allowed us to validate the hypothesis that the effects $\varepsilon_{h,t}$ are random and not correlated with the explanatory variables (table 7').

The tests described above are relevant if the explanatory variables are also uncorrelated with the perturbation $u_{i,h,t}$. This perturbation reflects patient characteristics which are unobservable for the econometrician, but can be observed by the doctor and therefore influence the cost of the stay. The explanatory variables are not exogenous if they are correlated with these characteristics. For example, the patient's preferences or risk adversion can influence the length of the stay. Various Hausman tests have allowed us to validate the hypothesis that the variables $X'_{i,h,t}$ and $W'_{h,t}$ are exogenous (table 7'). Thus, the model (3) can be consistently estimated by the FGLS.

4.3 Results

Tables 6, 7 and 7' present the estimates of the models (2) and (3), and the associated speci…cation tests.

Two speci…cations, related to di¤erent lists of explanatory variables Q_h and W_{ht} for the hospital characteristics, were estimated. Model (A) includes indicators close to veri…able characteristics such as hospital type, the variable indicating whether or not the hospital is innovative and average rates of admission and discharge through transfer. Model (B) includes additional variables such as rates of use of innovative procedures, which can be more directly decided on by the hospital.

In order to simplify our presentation, we do not report in table 7 the estimated coe¢cients of the individual characteristics $X^0_{i;h;t}$: indeed the various cross-e¤ects have led to a total number of 32 variables. In order to give an idea of the in‡uence on costs of individual characteristics, of time dummies and of the length of the stay, we report in table 6 the estimation of a simpler model, where cross-e¤ects have been reduced to age x gender e¤ects[13]. The in‡uence of individual stay characteristics con…rm the results generally obtained when studying costs of stays for acute myocardial infarction. The most costly stays are observed for men and cost is a decreasing function of age. One additional day induces, ceteris paribus, an average additional cost of about 2 500 FF. In addition, the estimation of an incomplete speci…cation using only individual patient characteristics $X^0_{i;h;t}$ as explanatory variables reveals that 54.2 % of cost variability can be explained by observable patient heterogeneity. A payment system which would not take this heterogeneity into account would give hospitals incentives to select patients.

The likelihood ratio test leads us to reject the hypothesis that hospital speci…c e¤ects ´$_h$ are random. However, the results obtained on both speci…cations (2) and (3) are worthy of comment. We will then focus on the …xed e¤ects model.

Estimated coe¢cients of observable hospital characteristics are reported in table 7. The estimates of the random e¤ects model show that costs of teaching hospitals (CHR) and costs of private not for pro…t hospitals (PRIV) do not di¤er signi…cantly from those of other public hospitals. This result seems rather surprising : the French hospital administration (Direction des hôpitaux (1996))

[13] The results are quite similar, but easier to read, than those of a model comprising all the detailed cross-e¤ects.

evaluates a 13 % extra cost for teaching hospitals ; for teaching hospitals in Spain, Lopez-Casasnovas and Saez (1999) estimated, using a rather different method, a significant extra cost of about 9 %. As regards PRIV hospitals, the French federation of private not for profit hospitals declares that wages are 14 % higher in their sector, inducing 7 % higher costs (Apparitio, Brocas and Moisdon (1999)).

On the other hand, the estimate of the random effect model leads to a positive and significant influence (2 825 FF) of the capacity to implement innovative procedures (INNOV). Comparing this coefficient to the average cost of a reference AMI stay (27 535 FF), we obtain an extra cost of 10.2 % for innovative hospitals[14]. It is interesting to note that all the teaching hospitals (CHR) in our sample are innovative (table 3). Since the variable CHR has no significant effect, our results therefore mean that hospitals which are innovative are more expensive than others, whether they are CHR or not : the extra cost is more directly linked to innovative activity than to hospital status.

The estimates of the random effect model lead also to a positive effect of the variable TI, indicating that hospitals which accept a high proportion of admissions through transfer have higher costs.

Our estimation procedure allows us to identify two components of the unexplained cost variability : transitory moral hazard and unobserved hospital heterogeneity. Indeed, the MLE leads to an estimation of σ_η, the standard error of the hospital specific effects η_h when they are assumed to be random. And with MLE, we have also estimated σ_ε, the standard error of the perturbation $\varepsilon_{h,t}$, that we have interpreted as an indicator of transitory moral hazard. The influence of this transitory moral hazard on cost variability is far from negligible : its estimated standard error (2 689 or 2 811) is about 50 % of estimated σ_η (5 883 or 5 146).

These results have to be confirmed because, as stated above, the hypothesis of random hospital effects is rejected by our specification test (table 7'). Therefore, we now focus our comments on the estimates of the model where hospital effects η_h are supposed to be fixed.

[14] This positive effect appears when estimating model A, but becomes negative with the estimation of model B, where rates of use of innovative procedures are part of its explanatory variables. Actually, the negative effect of INNOV is then totally counterbalanced by the positive coefficients of the rates of use. On the whole, being an innovating hospital always induces an extra cost.

It is not possible to identify the influence of the constant variables Q_h^0 from the estimate of the fixed effects model. In addition, we do not find any significant effect of the variable INNOV, once we have taken permanent differences in average costs into account through the fixed effects.

The fixed hospital effects specification allows us to obtain consistent estimates of the terms $\eta_h; \varepsilon_{h;t}$ and of their standard errors σ_η and σ_ε: The correlation between $\hat{\eta}_h$ and $\hat{\varepsilon}_{h;t}$ is very small (-0,001 for models A and B) and is not significant. The estimated value of σ_ε is quite similar to the one estimated by the maximum likelihood estimator : 2 618 or 2 923 (models A or B). As regards σ_η; one finds estimates which are about 1000 FF larger[15] : 6 932 ou 6512 (models A or B). The magnitude of cost variability attributable to transitory moral hazard is still sizeable : σ_ε is equal to about 50 % of σ_η:

To get an idea of the magnitude of the standard errors σ_η and σ_ε; one can compare them to the standard error of stay costs : 18 777 FF (for an average cost equal to 27 535 FF). In graph 1 and 2, we relate the estimated effects $\hat{\eta}_h$ and $\hat{\varepsilon}_{h;t}$ to the corresponding average cost per hospital $C_{:;h;:}$ and average cost per hospital per year $C_{:;h;t}$[16]. The observations have been sorted by increasing average cost. We notice that hospital specific effects are linked to average cost per hospital but are far from explaining them entirely (graph 1). Graph 2 illustrates how regular the average costs are, in comparison to transitory moral hazard fluctuations. The interpretation is the following. Average costs $C_{:;h;t}$ reflect the allocated budgets. The current system gives hospitals fairly steady budgets, whereas they deal with a fluctuating casemix, which is more or less costly from one year to the next. The gap between budgets and costs allows hospitals to perform inefficiently.

5 Simulations of different methods of payment

Our econometric estimates encourage the implementation of a prospective payment system. Indeed, our results have revealed that transitory moral hazard is far from negligible. As stated above, the problem of the regulator is to find the level of payment equal to costs corresponding to efficient activity.

[15] This difference can be interpreted as resulting from the effect of hospital type : though unsignificant, this influence was captured by the variables Q_h^0 in the random effects model. It is integrated in the η_h in the fixed effects model.

[16] These graphs are shown for model A.

5.1 Taking or not unoservable hospital heterogenity into account : two methods of payment

Consider the model (3) with hospital fixed effects :

$$C_{i;h;t} = X'_{i;h;t}\gamma_t + W'_{h;t}\beta + a + c_t + \eta_h + \xi_{i;h;t}$$

with $\xi_{i;h;t} = -\varepsilon_{h;t} + u_{i;h;t}$.

a) First method of payment

In order to reduce as much as possible the transitory moral hazard, we suggest the regulator to adopt the following method of payment :

$$P^1_{i;h;t} = X'_{i;h;t}\hat{\gamma}_t + W'_{h;t}\hat{\beta} + \hat{a} + \hat{c}_t + \hat{\eta}_h + \underset{h;t}{Min}\,\hat{\xi}_{:;h;t}\ ; \qquad (5)$$

where we are using the FGLS estimates (see table 7) of model (3). $\hat{\xi}_{i;h;t}$ is a consistent estimator of $\xi_{i;h;t} = -\varepsilon_{h;t} + u_{i;h;t}$. Consider the hospital means defined by $\hat{\xi}_{:;h;t} = \frac{1}{N_{h;t}}\sum_{i=1}^{N_{h;t}}\hat{\xi}_{i;h;t}$, where N_{ht} is the number of stays recorded in hospital h in year t. Computing means at the hospital level allows us to avoid taking the sample distribution of stays within each hospital into account. The payment is then defined as the expectation of the cost corresponding to efficient activity. Since $\hat{u}_{:;h;t} \xrightarrow{P} 0$ when N_{ht} is large, $\underset{h;t}{Min}\,\hat{\xi}_{:;h;t}$ is a consistent estimator of $\underset{h;t}{Min}\,(-\varepsilon_{h;t})$, that is, of the maximal cost reduction effort.

With the method of payment P^1, the regulator takes observable characteristics $X'_{i;h;t}$ and $W'_{h;t}$ into account. In addition, payment P^1 allows for permanent unobserved hospital heterogeneity η_h, whatever its origin (long term moral hazard, adverse selection or high care quality). On the other hand, this payment method still gives incentives to hospitals : cost deviations attributable to transitory moral hazard are not reimbursed.

b) Second method of payment

The first method of payment that we have suggested can be criticized because it is respecful of the differences η_h, which can be interpreted as reflecting differences in care quality as well as in efficiency. One can design another method of payment, which takes observable patient and hospital characteristics into account, but "crushes" unobserved heterogeneity $\eta_h - \varepsilon_{h,t}$:

$$P^2_{i,h,t} = X'_{i,h,t}\hat{\gamma}_t + W'_{h,t}\hat{\alpha} + \hat{a} + \hat{c}_t + \underset{h,t}{Min}\left\{\hat{\eta}_h + \hat{\xi}_{.,h,t}\right\} \quad (6)$$

Using $\underset{h,t}{Min}\left\{\hat{\eta}_h + \hat{\xi}_{.,h,t}\right\}$ to compute the payment comes down to take as reference point the hospital for which the sum of unobservable characteristics η_h and transitory moral hazard $\varepsilon_{h,t}$ is minimal. Indeed, $\hat{\xi}_{.,h,t}$ being a consistent estimator of $-\varepsilon_{h,t}$, one has :

$$\underset{h,t}{Min}\left\{\hat{\eta}_h + \hat{\xi}_{.,h,t}\right\} \xrightarrow{P} \underset{h,t}{Min}\{\eta_h - \varepsilon_{h,t}\}.$$

Implementing this second method of payment comes down to interpret all hospital unobserved heterogeneity as resulting from moral hazard.

c) Share of retrospective payment in the first method of payment P^1

The method of payment P^2 can be seen as a prospective payment, relaxed by the kind of risk adjustment resulting from the fact that we take observable patient heterogeneity into account. On the other hand, the payment P^1 is partly retrospective because costs differences due to the hospital effects η_h are reimbursed. More exactly, one can distinguish in the method of payment P^1 the following prospective and retrospective components :

$$P^1_{i,h,t} = \underbrace{X'_{i,h,t}\hat{\gamma}_t + W'_{h,t}\hat{\alpha} + \hat{a} + \hat{c}_t + \underset{h,t}{Min}\,\hat{\xi}_{.,h,t}}_{\text{Prospective}=F_{i,h,t}} + \underbrace{\hat{\eta}_h}_{\text{Retrospective}}. \quad (7)$$

Let us consider the classical expression of mixed payment as a weighted average of a lump-sum F and the actual cost of treatment C : $P = \mu F + (1-\mu)C$. Using the expression (7), one can compute $\mu_{i,h,t} = \frac{P^1_{i,h,t} - C_{i,h,t}}{F_{i,h,t} - C_{i,h,t}}$ and evaluate the sample mean $\hat{\mu}$. We have obtained (for model A) : $\hat{\mu} = 44{,}7\,\%$, with a standard error of 12,8 %. We have to underline that this evaluation is not a method of payment. It results from an ex post computation, which allows us to know the weight of retrospective payment induced by the implementation of the method P^1.

5.2 Potential budget savings

We can simulate payments P^1 and P^2. Payment P^1 de…ned by (5) exerts a softer constraint on hospitals than a payment of type P^2: Indeed, payment P^2 ignores all unobserved heterogeneity (´$_h$ i "$_{h;t}$). With payment P^1, the regulator takes unobservable heterogeneity constant over the period into account, whether it is due to ine¢cient management or to particularly good care quality.

In Table 8, potential budget savings are computed by measuring the di¤erence between total costs and total payments in relation to implementation of the proposed payment systems. We can observe that the bracket de…ned by P^1 and P^2 is quite wide : payment P^1 leads to potential savings of about 16 %; payment P^2 leads to potential savings of between 42 % and 46 %, depending on the particular model used (B or A).

P^1 is indeed the least constraining payment system. Yet, it still leads to substantial potential savings (16%) because it provides su¢cient incentives to reduce costs due to transitory moral hazard "$_{h;t}$. We thus recommend this method of payment. It avoids using the hospital with the poorest care quality as a benchmark for cost. It takes permanent unobservable di¤erences of quality between hospitals into account. This strategy is advisable, given that quality is a variable that cannot be veri…ed by the regulator.

The next step is to determine which model should be used to establish payment.

- In our estimations and simulations, we have taken the length of stays into account. Nevertheless, the type of payment system that we suggest implementing should not be retrospective in the sense that it should be calculated by stay and not by day. Therefore, we propose reimbursing on the basis of the estimated coe¢cient of the length of stay in the cost function multiplied by a suitable indicator of the length of stay (an average indicator taking di¤erences in patient and hospital characteristics into account).
- We think that model A is preferable to model B. The main di¤erence between the two is that model B integrates characteristics that can be manipulated, such as the frequency of innovative procedures. The reason for integrating procedure rates into the payment system is to avoid patient selection and skimping on treatment. On the other hand, there is a risk

of creating incentives for excessive use of procedures (McClellan, 1997). We notice that procedure rates are not significant when estimating fixed effects model and that differences in potential budget savings through implementation of model A or model B are insignificant. These evaluations are obtained from data relative to a period when hospitals were regulated through a global budget and when financial considerations had little influence on the decision to perform innovative procedures. Within this context, we can observe that payments based only on the INNOV variable (model A) are as close to the actual cost as payments computed from the INNOV variable and the rate of innovative procedures (model B).

Given these results, we suggest calculating payments with model A, which uses only the variable indicating that the hospital is innovative. The main interest of this variable is that it cannot be manipulated in the short run. The regulator knows if the hospital has the ability to perform innovative procedures or not. The hospital has no incentive to perform unnecessary procedures in order to obtain higher reimbursements. Over our estimation period, when hospitals has no incentives to manipulate procedure rates, payments are equally close to the actual cost, whether the procedure rate is included in the model or not.

Table 9 records correlation coefficients between costs and payments. Results confirm our comments. A high correlation means that the incentive for selecting patients is limited. We can observe that the substantial budget savings calculated in table 8 are linked to a high correlation, especially in the between dimension, which is based on the yearly mean by hospital.

6 Conclusion

Hospital heterogeneity is a major issue in defining an optimal reimbursement system. In order to avoid the drawbacks of a fully prospective payment system, namely patient selection and lower care quality, many authors have suggested using a system which combines a lump-sum and reimbursement of actual treatment cost. However, implementation of such a system is not easy, in particular as regards characterisation and estimation of the optimal proportions of the lump-sum and actual cost. In this paper, we have applied an econometric approach to the design of a payment system which allows for hospital heterogeneity.

We take hospital heterogeneity into account through observable hospital characteristics and hospital speci…c e¤ects. We obtain two alternative payment systems. The …rst system takes all unobservable hospital heterogeneity into account, provided that it is time-invariant, whereas the second ignores unobservable heterogeneity.

The …rst method of payment seems advisable to us : it has the great advantage of reimbursing high quality care. In addition, it potentially leads to substantial savings because it provides su¢cient incentives to reduce costs that are due to transitory moral hazard. Moreover, this payment system is easy to implement, provided the regulator has information about costs of hospital stays. One drawback of this payment system is that it would give higher reimbursements to hospitals which are costlier due to permanently ine¢cient management. The choice between the methods of payment P^1 and P^2 depends on the weights assigned to e¢ciency and care quality in the social objective function used by the regulator.

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Table 1: Patient characteristics

	Number of stays	Proportion (%)
Gender		
men	5 400	73.8
women	1 914	26.2
Age		
40-64	1 861	25.4
65-74	2 733	37.4
75-84	2 271	31.1
85 and over*	449	6.1
Length of stay		
one day	439	6.0
between 2 and 7 days	2 460	33.6
between 8 and 14 days	3 234	44.2
over 14 days	1 181	16.2
Admission		
home	6 493	88.8
Other hospital	821	11.2
Discharge		
Other hospital	2 612	35.7
home	4 702	64.3
Procedures		
CATH	2 788	38.1
PTCA	853	11.7
Stent	374	5.1

Cost Database: 7 314 stays, 1994-1997

*: Patients aged of 100 years and over have been removed from our sample.

Table 2: Hospitals of the cost database

Years	Number of hospitals	Whose innovative hospitals	Number of stays	Share % of stays in innovative hospitals
1994	21	12	1 669	70.2
1995	27	16	2 028	69.7
1996	17	10	1 267	78.3
1997	30	18	2 350	70.5
1994-1997	36	20[1]	7 314	71.5

Cost Database: 7 314 stays, 1994-1997

*: Patients aged of 100 years and over have been removed from our sample.

Table 3 : Innovative and non-innovative hospitals

	Innovative	Non-innovative	Total (hospitals * years)
CHR (teaching hospital)	9	0	9
PUB (other public hospital)	35	35	70
PR (Private not for profit)	12	4	16
Total	56	39	95

Cost Database: 7 314 stays, 1994-1997

[1] These hospitals are innovative hospitals on all their years of presence in the sample.

Table 4 : Correlation coefficients between average hospital characteristics

	INNOV	TI	TX	MLOS	MCATH	MPTCA	MSTENT
CHR	27.0	ns	-39.6	19.8[2]	32.3	ns	ns
PUB	-30.4	-29.9	30.7	ns	-58.2	-51.9	-32.9
PR	ns	45.0	ns	ns	43.3	54.5	40.1
INNOV	100	ns	-45.1	25.5	73.7	35.7	24.8

*95 Hospital * years from the costdatabase; ns: non statistically significant correlation coefficient (P<0.05).*

*The following variables are recorded in the SAE database or computed for the 95 hospitals * years of the cost database (1994-1997):*

CHR: Regional Hospital Center (teaching and research activity), PUB: other public hospital, PR: private not for profit hospital.

INNOV: innovative hospital (i.e. having the ability to perform a PTCA or a CATH).
TI: admission rate of patients being transferred from another hospital (average per hospital and per year).
TX: discharge rate of patients being transferred to another hospital (average per hospital and per year).
MLOS: length of stays (average per hospital and per year).
MCATH: CATH rate (average per hospital and per year).
MPTCA: PTCA rate of patient (average per hospital and per year).
MSTENT: STENT rate of patient (average per hospital and per year).

Table 5 : Average costs (FF)

	Average cost (FF)
Overall mean (standard error)	27 535 (18 777)
Men	27 162
Women	28 850
40-64	26 922
65-74	27 769
75-84	29 389
85 and over	27 254
With Cath	33 446
With Ptca	37 653
With Stent	39 214
Without procedure	24 048
Teaching hospital (CHR)	34 140
Private not for profit (PR)	30 371
Other public hospital (PUB)	25 034
Innovative hospital	29 213
Non-innovative	23 561

[2] The correlation coefficient is significant at 5,44%.

Table 6 : Influence on cost variability of patient characteristics, length of stay and time

	Estimated coefficient
Age*sex	
Man : 40-64 years	reference
Man : 65-74 years	-1 449.9**
Man : 75-84 years	-3 542.1**
Man : 85 years and over	-7 204.8**
Woman : 40-64 years	-2 603.8**
Woman : 65-74 years	-2 796.2**
Woman : 75-84 years	-4 718.3**
Woman : 85 years and over	-8 700.3**
Length of stay	2 480.9**
Time dummies	
Year 1994	reference
Year 1995	1 708.5*
Year 1996	5 042.0**
Year 1997	3 827.3**

Cost Database: 7 314 stays, 1994-1997

** : the coefficient is significant (1 %), * : the coefficient is significant (5 %).

Estimation by feasible generalized least square (residuals: $-\varepsilon_{h,t} + u_{i,h,t}$) for a model with fixed hospital effect η_h .

Table 7: Cost function estimates

		Random hospital effects (η_h) *(Model (2)), MLE* $C_{i,h,t} = X'_{i,h,t}\gamma_t + W'_{h,t}\alpha + Q'_h\lambda + c_t + (\eta_h + \varepsilon_{h,t} + u_{i,t,h})$		*Fixed hospital effects* (η_h) *(Model (3)), FGLS* $C_{i,h,t} = X'_{i,h,t}\gamma_t + W'_{h,t}\alpha + c_t + \eta_h + (\varepsilon_{h,t} + u_{i,t,h})$	
		(A)	*(B)*	*(A)*	*(B)*
$X'_{i,h,t}$	Individual characteristics	Coefficients not recorded to make the table easier to read		Coefficients not recorded to make the table easier to read	
Q'_h	CHR	2 479.53 (4 018.29)	582.21 (3 664.61)	-	-
	PR	4 361.28 (2 886.05)	1 038.25 (2 740.26)	-	-
$W'_{h,t}$	INNOV	2 825.69* (1180.40)	-433.73 (1 431.68)	2 221.98 (1 648.08)	1 951.96 (2 129.31)
	TI	15 617.34** (4 578.02)	12 902.69** (4 432.51)	1 683.65 (7 200.93)	1 713.48 (7 959.58)
	TX	-4 410.39 (3 184.83)	-1 093.70 (3 225.36)	-4 428.95 (4 035.05)	-3 778.79 (4 582.67)
	RCATH		11 245.30** (3 409.22)	-	933.97 (4 721.73)
	RPTCA	-	2 344.77 (5 409.48)	-	12 393.42 (11 833.28)
	RSTENT	-	-1 708.53 (6 367.79)	-	-7 652.46 (7 423.12)
σ_v		10 478	10 468	10 461	10 461
σ_η		5 883	5 146	-	-
σ_ε		2 689	2 811	2 618	2 923

Cost Database: 7 314 stays, 1994-1997

All the estimations have year dummies

** : The coefficient is significant (1 %), *: the coefficient is significant (5 %)

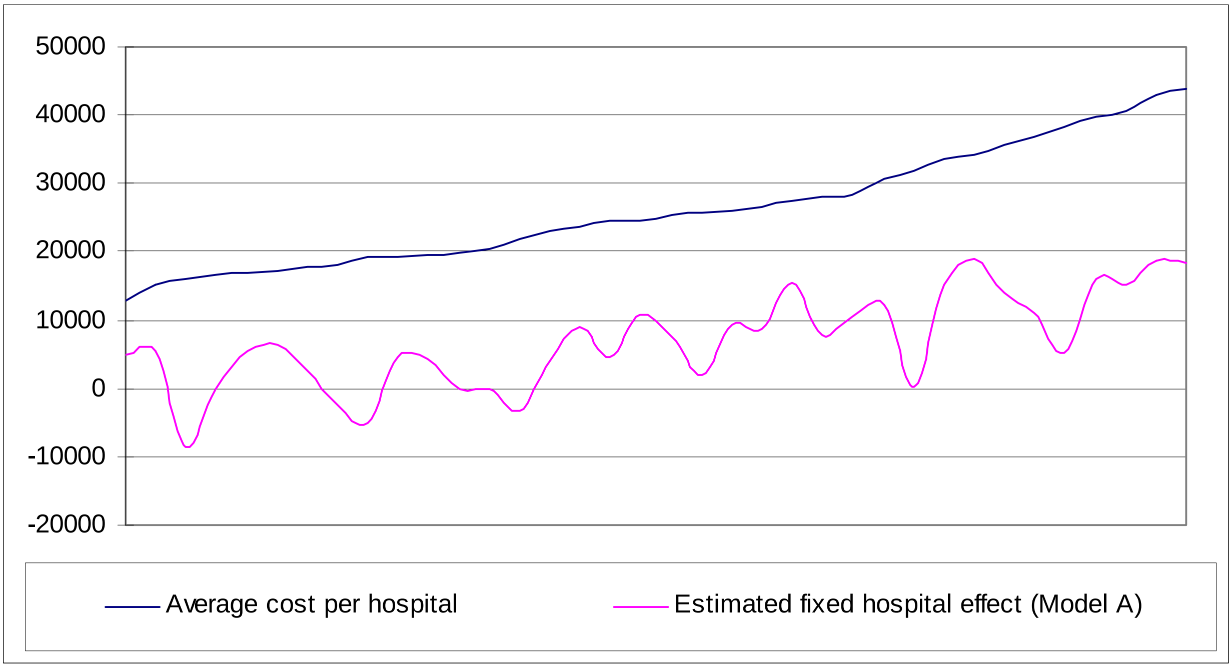
Table 7': Cost function estimates – Statistics and tests

	(A)	(B)		(A)	(B)
Log likelihood	- 44 506.42	- 44 497.11	R^2	68.5	68.5
Likelihood ratio test $(P > \chi^2)^{\#}$	7 228 (0.000)	7 246 (0.000)	Wald test $(P > \chi^2)$	13 005 (0.000)	12 913 (0.000)
Likelihood ratio test for independence of η_h $(P > \chi^2)$	67.2 (0,0003)	71.8 (0,0005)	Hausman test[¤] for independence of $\varepsilon_{h,t}$ $(P > \chi^2)$	30.8 (0,5255)	

[#] Significance level.

[¤] The usual statistics of the Hausman test eliminates automatically the variables $W'_{h,t}$. So, there is no difference between the tests on models A and B. This test is equivalent to a test for independence between $X'_{i,h,t}$ and $\varepsilon_{h,t}$. To test for the exogeneity of $W'_{h,t}$ we have used another Hausman's specification test that compares an estimator that is known to be consistent and efficient under the null and alternative hypotheses (here, the error component two-stage least square estimator, EC2SLS (Baltagi, 1981)) with an estimator which is efficient under the null hypothesis (here, feasible generalized least squares estimator, FGLS). Instruments are the patient demographic characteristics and the fully-interacted of the secondary diagnoses, gender and age of the patient. The test provides evidence that we cannot reject the null hypothesis: the variables $W'_{h,t}$ and $X'_{i,h,t}$ .are exogenous.

Graph 1 :



Graph 2 :

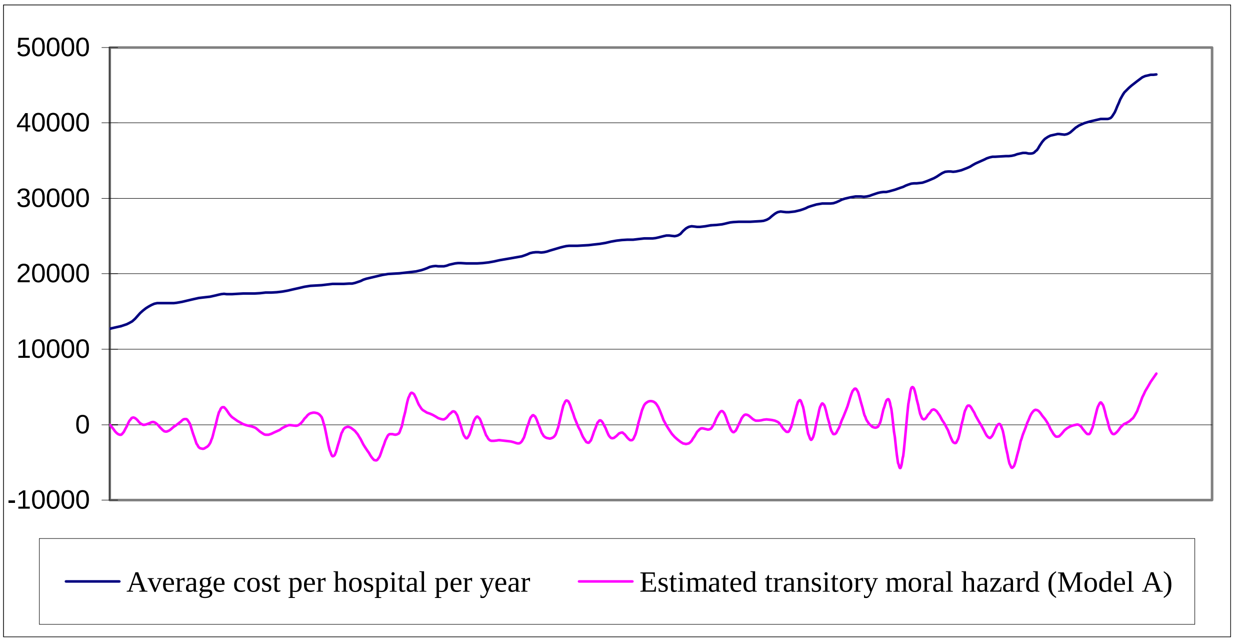


Table 8: Potential budget savings (%)

Model	*The budget saving is defined by :* $ebg = \frac{\sum_{i,h,t}\left(C_{i,h,t} - P_{i,h,t}\right)}{\sum_{i,h,t}\left(C_{i,h,t}\right)}$.		*The budget saving is defined by :* $eb_{h,t} = \frac{C_{h.t} - P_{h.t}}{C_{h.t}}$			
	(A)	*(B)*	*(A)*		*(B)*	
			Mean	*Standard -error*	*Mean*	*Standard -error*
Payment P^1	16,4	16,6	18,4	11,9	18,6	11,8
Payment P^2	46,1	42,0	45,0	24,8	43,1	22,5

Cost Database*: 7 314 stays, 1994-1997*

Paiements $P_{i,h,t}$ *are computed from the fixed hospital effects model.*

Table 9: Correlation between proposed payments $P_{i,h,t}$ and observed costs $C_{i,h,t}$

Model		Overall correlation $\rho(P_{i,h,t}, C_{i,h,t})$	Between hospital correlation $\rho(P_{.,h,t}, C_{.,h,t})$
(A)	Payment P^1	81,6	94,6
	Payment P^2	71,9	50,1
(B)	Payment P^1	81,8	94,9
	Payment P^2	74,4	59,2

Cost Database*: 7 314 stays, 1994-1997*

Paiements $P_{i,h,t}$ *are computed from the fixed hospital effect model.*

$C_{.,h,t}$ *is the cost average computed at hospital–level:* $C_{.,h,t} = \frac{1}{N_{h,t}} \sum_{i=1}^{N_{h,t}} C_{i,h,t}$.