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Centralisation or decentralisation of bureaucratic supply: The case of Italian health-care (1982-2005)

Abstract: The Italian health-care system is characterised by a rigid bureaucratic structure organised at a regional level and mostly financed by the central government's transfers. In this paper we develop a simplified two-stage stochastic model giving an explanation of how the regional government's preferences for differentiated health services may affect the health-care organisation. The model shows that the regional government prefers a centralised organisation in the presence of health services perceived as complementary (say, recovery in hospital and general practitioner visits), whereas it prefers decentralisation in the presence of health services perceived as substitute (say, visits to the specialist and the general practitioners). We use this prediction for an empirical analysis of the organisational structure of Italian health-care system. On the basis of a unique panel data set containing data on the Italian health-care system at a regional basis spanning from 1982 to 2005, we test with a random effect probit model the probability of observing a centralised (decentralised) health-care regional organization as depending on complementary (substitute) health services supplied at the regional level. Our estimates confirm the predictions of the model.

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1. Introduction

The aim of this paper is twofold. First, it aims at presenting a simple public choice theoretical model (see Sørensen, 2006, and Bates et al., 2011 for similar approaches), which tries to explain, at least partially, the link between politicians' preferences, health-care organisation and bureaucratic behaviour. Second, it aims at testing the model's predictions on data from the Italian public health-care system.

The basic idea is that the regional government's demand for specific health-care services is a key determinant of the organisational design of the bureaucratic supply for these services. This is because the regions, by means of their ruling politicians, can exert the power of designing or modifying the bureaucratic organisation (see Moe, 1984: 761).[1] The regional governments can in principle choose whether to deal with either a decentralised bureaucracy (with health-care services spread/diffused in the regional jurisdiction) or a centralised one (i.e., one single or few big hospitals in the regional jurisdiction) for the public provision of differentiated health services (such as recovery in hospital, visits to specialists and general practitioners, long-term care). Given the bureaucratic organisation of the Italian health-care system, health managers bargain with the regional government for their budget. Therefore, a rational government, when choosing the bureaucratic organisation, will try to anticipate the effects of its institutional design decision on the allocation of public funds as determined by its bargaining with the management. Our model predicts that a regional government demanding differentiated health-care services that it perceives as being complementary (say, the demands for patients' recovery in hospital and for general practitioners assistance) is more likely to organise the supply into a centralised hospital, other things being equal, as long as it can maximise the hospitals' outputs while minimising the hospitals' rents at the same time (see below). On the contrary, a regional government demanding health care services perceived as being substitute (say, the demands for specialists' visits and for general practitioners assistance) is more likely to decentralize the supply of these services over the regional jurisdiction (see below).

These theoretical predictions are empirically tested for the Italian regions over the period 1982-2005. In particular, we shall ascertain which regions are likely to be characterised by centralisation and the kind of relationship linking complementary/substitute activities with the services supplied by the hospitals. With this purpose, we shall estimate the factors affecting the probability of increasing the degree of centralisation of hospitals into each region. Dealing with longitudinal panel data, we shall use a random effects probit model that captures higher classes of

[1] The standard public choice approach models the interaction between politicians and bureaucrats under the assumption of exogenous institutional structures. More specifically, most of the literature originating from Niskanen (1971) assumes one government dealing with one bureau. Fedeli (1999) considers instead one government dealing with two competing bureaus.

regional centralisation as depending on a higher (lower) presence of complementary (substitute) activities. The results obtained seem to confirm the prediction of the theoretical model as far as the organisation of Italian hospitals is concerned.

The plan of the paper is as follows. Section 2 presents the theoretical model of the regional governments' choices related to the health-care system. Section 3 empirically tests the model with Italian data. Section 4 concludes with final remarks.

2. The model

The model presented in this section is a stochastic version of Fedeli and Santoni (2006) applied to health-care issues. Consider a regional government willing to offer two differentiated health-care services to its local population. These services can be produced either separately by two independent bureaus, each specialising in the supply of one service, or jointly by one single consolidated bureau. The bureaus are, for example, two local public health authorities (in Italy called *Aziende sanitarie locali*) supplying, say, primary care (e.g., visits to general practitioners) and secondary care (e.g., visits to specialists working in hospitals and recovery and medical assistance in hospital).[2] The government, on the basis of the people's preferences, can perceive these services as being either substitute or complementary sources of medical care (see Atella and Deb, 2008, Fortney et al., 2006, and Scott, 1996). The bureaucratic structure, the level of health-care services supplied, and - possibly- the political and bureaucratic rents observed in equilibrium are assumed to be the outcome of a two-stage sequential game. At stage one, the regional government chooses whether the services should be offered jointly by one consolidated bureau (e.g., one integrated public health authority or one hospital) or separately by two independent bureaus (e.g. two hospitals). In making this choice, the government is concerned about both the level of health-care services and the political rents it can extract from the budgetary process. In particular, the government evaluates health-care services on the basis of the people's/its own electoral constituency's preferences. At stage two, there is a compliance game à la Miller (1977) between the government and the bureau(s). The government chooses the bureaucratic budget, namely the fraction of the resources devoted to the production of each service, while the bureau(s) simultaneously chooses the fraction of this budget that is actually allocated to producing the service. A random shock to the demand for the publicly provided health-care services is assumed to occur between stage 1 and stage 2. Following Niskanen (1971: 29), the bureau(s) evaluates the health-care services it supplies on the basis of the government's demands, while aiming at gaining

[2] Alternatively, the two bureaucracies are one local government (called *Comune* in Italy) and one public health authority supplying, say, long-term care services to the ageing population or mental healthcare services by offering house care/nursing homes and hospital care. Finally, the two bureaus can be interpreted as hospitals.

rents from this activity at the same time. The government and the bureau(s) are assumed to be the residual claimants of the resources allocated to health-care services (see Shleifer and Vishny, 1994, for a discussion). Thus, in equilibrium, their compliance levels determine both the actual amounts of health-care services provided and the level of political and bureaucratic rents. Regarding the information structure, there is current-stage full information. At stage one, the government knows the distribution of the unexpected disturbance that realises subsequently. At stage two both the government and the bureau(s) have full information of the actual value of the disturbance. The next section, before introducing the shock, presents government and bureaucratic preferences in the deterministic case.

2.1 Government and bureau(s) preferences with shocks to the demand for health-care services

The government preferences in the deterministic case are

$$MG = \underbrace{\alpha[Q_1 + Q_2] - \left[\frac{\beta\left(Q_1^2 + Q_2^2\right)}{2}\right] - 2\gamma Q_1 Q_2}_{\text{government's evaluation function of goods 1 and 2}} + \underbrace{\sum_{i=1}^{2}(R - B_i)}_{\text{political rents}} \quad (1)$$

In equation (1), the first term represents the government quadratic evaluation function of the bureaucratic production of the two differentiated health-care services Q_i , i=1,2, where $\alpha > 0$, β >0, $\beta^2 > 4\gamma^2$ and $\beta > 2|\gamma|$ (see Singh and Vives, 1984, for a discussion). We assume that this term reflects the preferences for health-care services of the patients (i.e. the government electoral constituency, the people) that can be inferred, say, from surveys. The second term represents the political rents that the government can obtain from the production of each service. These rents are equal to the difference between the exogenous and symmetric amount of resources officially allocated to the production of each service, R, and the budget the government assigns to the bureau(s) for this purpose, B_i. Whereas R is considered as an exogenous variable (coming from either the local taxpayer or the central government as a transfer),[3] B is endogenously determined as the outcome of a compliance game with the bureau(s) (see below). More specifically, $B_i = Rg_i$,

[3] In Italy, whereas healthcare expenditure responsibilities are decentralised at the regional or municipal level, revenue raising responsibilities are still in practice highly centralised. Despite reforms giving substantial financial autonomy to the regions since 1993 (i.e. the introduction of regional taxes on production activities, regional surtaxes on personal income and revenue sharing of the VAT), healthcare resources seem independent of the fiscal capacity of each region, being they based on historical spending and healthcare needs, see Francese and Romanelli (2011: 8). Basically, at least until 2005, but for a small period in the 1990s, Italian regions held the expectation of central government's intervention to bail out their past deficits, see Bordignon and Turati (2009).

where $g_i \in [0,1]$ is the share of resources the government allocates to the bureau(s) for producing the health-care service i=1, 2. Government's maximisation of (1) with respect to Q_i yields

$$V_i^M = \alpha - \beta Q_i - 2\gamma Q_j \quad (2)$$

In equation (2), $V^M{}_i$, i={1,2}, i≠j, represents the government willingness to pay for the health-care service Q_i when it also demands Q_j. For γ<0, the two services are complements. This is the case, for example, if the willingness to pay for general practitioners assistance increases when the demand for patients' recovery in hospital rises. For γ>0, they are substitutes. This is the case, for example, if the willingness to pay for visits to specialists in hospital falls when the demand for visits to primary care physicians rises (see Atella and Deb, 2008, for Italian evidence). For γ=0, they are independent.

Turning to the bureau(s) preferences, in the case of two independent bureaus they are as follows:

$$MH^{12}{}_i = \underbrace{V_i^M Q_i}_{\substack{\text{bureau-i's evaluation} \\ \text{of its own services}}} + \underbrace{B_i(1-h_i)}_{\text{bureau's rents}} \qquad i=1,2 \quad \text{and } i \neq j \quad (3)$$

In equation (3) the superscript "**12**" indicates 1 government dealing with 2 bureaus, whereas the subscript i indicates the bureau producing good i. In the case of one single consolidated bureau, its payoff corresponds to the sum of the two individual bureaus' payoff, namely

$$MH^{11} = \sum_{i=1}^{2} MH^{12}{}_i = \underbrace{\sum_{i=1}^{2} V_i^M Q_i +}_{\substack{\text{bureau's evaluation} \\ \text{of its own services}}} + \underbrace{\sum_{i=1}^{2} B_i(1-h_i)}_{\text{bureau's rents}} \quad (4)$$

In equation (4) the superscript "**11**" denotes 1 government dealing with 1 bureau supplying both types of health-care services. As previously mentioned, following Niskanen (1971) we assume that the bureau(s) evaluates its own activity on the basis of the government's preferences. This implies that, in equations (3) and (4), V_i^M reflects the government's willingness to pay for service i=1, 2. (This is given by equation 2 for the deterministic case, see below for the stochastic case). The bureau(s) produces the health-care service i=1, 2 by devoting a fraction $h_i \in [0,1]$ of the budget B_i it obtains from the government, while keeping the residual budget as its own rents. Production of bureaucratic activities occurs under a constant-return-to-labour technology. This implies the total cost function $TC_i = cQ_i$, where c>0, with c<α, represents the minimum (symmetric) cost of producing good i. This cost function can be seen as a good proxy of the short-run cost function for health-care services that are heavily labour intensive. We will exploit the cost function in solving the compliance game below.

Let us now consider the demand shocks. Following Klemperer and Meyer (1986), the random shock to the demand curve is alternatively modelled as follows. First, it is an intercept shock to the residual demand curve for each service (namely, one affecting linearly the reservation price given the demand curve for the other service). Second, it is a shock affecting the demand slope. This latter random disturbance is modelled such that the rotation of the demand curve about the vertical intercept occurs with both the government's reservation price and the degree of differentiation remaining unchanged. Such intercept and slope shocks might reflect, for example, the shocks to the demand for primary and secondary care that are associated with undocumented and documented migrant workers inflows and outflows in the region. Third, it is a disturbance affecting the degree of differentiation between health-care services. For example, shocks to the electorate's tastes may induce the government to revise its trade-off between primary care and secondary care. The next section determines the sub-game perfect Nash equilibrium of the sequential game solving the model by backward induction under these alternative assumptions on the demand shock.

2.2 The choice of bureaucratic organisation with additive uncertainty

Assuming a linear random shock to the vertical intercept, the demand for health-care services becomes

$$V_i^M = \alpha + \varepsilon - \beta Q_i - 2\gamma Q_j \qquad (2')$$

where i=1, 2; ε is a random variable with $E(\varepsilon) = 0$ and $E(\varepsilon^2) = s^2$. Following Klemperer and Meyer (1986), we assume that the support of the shock is small enough that prices and health-care service levels (thus compliance levels) are always positive. The shock occurs after the government has already chosen the bureaucratic structure at stage one and is common information henceforth. Solving by backward induction, consider now stage two of the game, when the realisation of the demand shock is common knowledge and the bureaucratic structure is given. Assuming that the government allocates the share $g_i \in [0,1]$ of resources R to the bureau(s) as health-care budget and that the bureau(s) actually devotes a fraction $h_i \in [0,1]$ of this budget to producing the services, given that total production costs are $TC_i = cQ_i$, we can write $h_i g_i R = cQ_i$, implying $Q_i = h_i g_i R / c$, for i=1, 2. Using this fact, substituting equation (2'), into equations (3) and (4), the bureau(s) preferences can be formulated in terms of compliance strategies g_i and h_i (see Miller, 1977) and the value of the shock ε:

$$MH^{12}{}_i = (\alpha + \varepsilon)\left(\frac{g_i h_i R}{c}\right) - \beta\left(\frac{g_i h_i R}{c}\right)^2 - 2\gamma\left(\frac{g_i h_i R}{c}\right)\left(\frac{g_j h_j R}{c}\right) + R g_i (1 - h_j) \qquad (3')$$

$$MH^{11} = (\alpha + \varepsilon)\left[\left(\frac{g_1 h_2 R}{c}\right) + \left(\frac{g_2 h_2 R}{c}\right)\right] - \beta\left[\left(\frac{g_1 h_2 R}{c}\right)^2 + \left(\frac{g_2 h_2 R}{c}\right)^2\right] - 4\gamma\left(\frac{g_1 h_2 R}{c}\right)\left(\frac{g_2 h_2 R}{c}\right) \tag{4'}$$
$$+ R\left[g_1(1-h_1) + g_2(1-h_2)\right]$$

where equations (3') represents the preferences of the two independent bureaus, while equation (4') gives the preferences of one single consolidated bureau. Similarly, using equation (1), after appropriate substitutions the government's payoff in terms of compliance is

$$Mg = \alpha \sum_{i=1}^{2}\left(\frac{g_i h_i R}{c}\right) - \frac{\beta}{2}\sum_{i=1}^{2}\left(\frac{g_i h_i R}{c}\right)^2 - 2\gamma \prod_{i=1}^{2}\left(\frac{g_i h_i R}{c}\right) + \sum_{i=1}^{2}\left(R(1-g_i)\right) \tag{5}$$

Note that the realised value of the random shock has no effect on the government's payoff. However, by affecting the equilibrium compliance levels, it will influence the value function of the government's payoffs in the compliance game, which we consider in turn. The government chooses g_i and g_j by maximising equation (5), given h_i and h_j. When there is one single bureau, this simultaneously chooses h_i and h_j so as to maximise equation (4'), given g_i and g_j. The symmetric Nash equilibrium solution for this case is

$$\begin{aligned}\hat{g}_1^{11} = \hat{g}_2^{11} &= \frac{[\alpha^2 - (\varepsilon - c)^2]}{4R(\beta + 2\gamma)} \\ \hat{h}_1^{11} = \hat{h}_2^{11} &= \frac{2c}{\alpha + \mathrm{c} - \varepsilon}\end{aligned} \tag{6}$$

When there are two independent bureaus, each chooses simultaneously its own compliance variable h_i by maximising equation (3'), given the compliance levels of both the other bureau h_j and the government g_i and g_j. The symmetric Nash equilibrium solution for this case is

$$\begin{aligned}\hat{g}_1^{12} = \hat{g}_2^{12} &= \frac{(\alpha - c + \varepsilon)(\alpha\beta + (\beta + 2\gamma)(c - \varepsilon))}{4R(\beta + \gamma)^2} \\ \hat{h}_1^{12} = \hat{h}_2^{12} &= \frac{2c(\beta + \gamma)}{(\alpha\beta + (\beta + 2\gamma)(c - \varepsilon))}\end{aligned} \tag{7}$$

At stage one the government knows the distribution of the random shock affecting the equilibrium compliance and its own payoffs at stage two. Thus, when choosing the bureaucratic organisation, it must compute the expectations of its own payoffs in both of these cases. By substituting

equation (6) back into (5) and taking expectations, the government's expected payoff under bureaucratic consolidation is

$$E(\hat{M}G^{11}) = 2R + \frac{(\alpha - c)^2}{4(\beta + 2\gamma)} + \frac{s^2}{4(\beta + 2\gamma)} \tag{8}$$

since $\mathrm{E}(\varepsilon) = 0$ and $\mathrm{E}(\varepsilon^2) = s^2$. Equation (8) shows that additive uncertainty about demand increases the government's expected payoff over and above its deterministic payoff by a term that is proportional to the variance of the shock. Moreover, uncertainty distorts the government's trade-off between utility from political rents and utility from the outputs in favour of the former. Appendix 1 discusses this result further and provide a comparison with the deterministic case.

Similarly, by substituting (6) back into (5) and taking expectations, the government's expected payoff when negotiating with two independent bureaus is

$$E(\hat{M}G^{12}) = 2R + \frac{(\alpha - c)^2 (\beta + 2\gamma)}{4(\beta + \gamma)^2} + \frac{s^2 (\beta + 2\gamma)}{4(\beta + \gamma)^2} \tag{9}$$

Uncertainty (through the effect of the variance of the shock) raises the government's expected payoff over and above its deterministic level. By comparing (8) and (9), it follows that at stage one of the game the government chooses bureaucratic consolidation if and only if

$$E(\hat{M}G^{11}) - E(\hat{M}G^{12}) = -\gamma[(\alpha - c)^2 + s^2]\left[\frac{(2\beta + 3\gamma)}{4(\beta + \gamma)^2 (\beta + 2\gamma)}\right] \tag{10}$$

yielding

Proposition 1. *If the residual demand for health-care services is subject to a continuous random shock to the vertical intercept, which is unexpected by the government when choosing the bureaucratic structure, the government's optimal choice is bureaucratic centralisation when the goods are complements and bureaucratic independence when they are substitutes. This incentive is increasing in the variance of the shock.*

Uncertainty on the demand side increases the government's incentive to bureaucratic centralisation or independence in the same direction as found in Fedeli and Santoni (2006) for the deterministic case. The same qualitative effect is obtained when the random disturbance affects the slope of the inverse demand curve for each of the two health-care services, without affecting the degree of substitutability of services. Appendix 2 reports the details of this solution.

2.3 The choice of bureaucratic organisation with uncertainty on the degree of health-care differentiation

This section considers uncertainty on the degree of substitutability between the two services, implying:

$$V_i = \alpha - \beta Q_i - 2(\gamma + \varepsilon)Q_j \qquad (2''')$$

The random shock is now assumed to be uniformly distributed with $\varepsilon \sim U(\varepsilon_L, \varepsilon_H)$, ε_L<0 and ε_H>0.[4] In this case, the demand for both health-care services turns out to be positive if the following parametric restriction is satisfied: $\beta^2 > 4(\gamma + \varepsilon)^2$. In turn, this restriction implies that $-[4\beta + \gamma] < \varepsilon < 4\beta - \gamma$, given also that $\beta>2|\gamma|$ for the second order condition to be satisfied.

Solving as usual the model by backward induction under current-stage full information (see section 2.2 above for details), the symmetric Nash equilibrium solution for the compliance game under bureaucratic consolidation is

$$\begin{aligned} \tilde{g}_1^{11} = \tilde{g}_2^{11} &= \frac{(\alpha - c)[(\alpha + c)(\beta + 2\gamma) + 4\alpha\varepsilon]}{4R[\beta + 2\gamma + 2\varepsilon]^2} \\ \tilde{h}_1^{11} = \tilde{h}_2^{11} &= \frac{2c(\beta + 2\gamma + 2\varepsilon)}{(\alpha + c)(\beta + 2\gamma) + 4\alpha\varepsilon} \end{aligned} \qquad (11)$$

Substituting (11) back into (5), yields the corresponding value function for the government

$$\tilde{M}G^{11} = 2R + \frac{(\alpha - c)^2(\beta + 2\gamma)}{4(\beta + 2\gamma + 2\varepsilon)^2} \qquad (12)$$

Similarly, the symmetric Nash equilibrium solution for the compliance game with two independent bureaus yields

$$\begin{aligned} \tilde{g}_1^{12} = \tilde{g}_2^{12} &= \frac{(\alpha - c)[\alpha\beta + c(\beta + 2\gamma) + 2\alpha\varepsilon]}{4R[\beta + \gamma + \varepsilon]^2} \\ \tilde{h}_1^{12} = \tilde{h}_2^{12} &= \frac{2c(\beta + \gamma + \varepsilon)}{\alpha\beta + c(\beta + 2\gamma) + 2\alpha\varepsilon} \end{aligned} \qquad (13)$$

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[4] The special case in which the support of the shock is as follows: $\varepsilon_L = -\varepsilon_H > 0$ is analysed below.

Substituting (13) back into (5), the government's value function at stage two is

$$\widetilde{M}G^{12} = 2R + \frac{(\alpha - \mathrm{c})^2(\beta + 2\gamma)}{4(\beta + \gamma + \varepsilon)^2} \tag{14}$$

At stage 1 the government takes the expectation of equations (12) and (14). Accordingly it chooses bureaucratic consolidation if and only if it holds true the condition below (see Appendix A.3 for derivations)

$$E(\widetilde{M}G^{11}) - E(\widetilde{M}G^{12}) = -\frac{(\alpha - \mathrm{c})^2(\beta + 2\gamma)}{4}\left[\frac{\beta(2\gamma + \varepsilon_H + \varepsilon_L) + 3\gamma(\gamma + \varepsilon_H + \varepsilon_L) + 3\varepsilon_H\varepsilon_L}{(\beta + \gamma + \varepsilon_{\mathrm{H}})(\beta + \gamma + \varepsilon_{\mathrm{L}})(\beta + 2\gamma + 2\varepsilon_{\mathrm{H}})(\beta + 2\gamma + 2\varepsilon_{\mathrm{L}})}\right] > 0 \tag{15}$$

The sign of equation (15) depends on the sign of: $-\left[\beta(2\gamma + \varepsilon_H + \varepsilon_L) + 3\gamma(\gamma + \varepsilon_H + \varepsilon_L) + 3\varepsilon_H\varepsilon_L\right]$. If we further assume that $\varepsilon_L = -\varepsilon_H > 0$, it follows that $E(\varepsilon) = 0, E\left(\frac{\gamma + \varepsilon}{\beta}\right) = \frac{\gamma}{\beta}$ with $\varepsilon \sim U(-\varepsilon_H, \varepsilon_H)$.

In this special case, the government expects that the degree of product differentiation is on average equal to γ. It turns out that: Sign of $E(MG^{11}) - E(MG^{12})$ = Sign of $\left[\varepsilon_H{}^2 - \gamma\left(\gamma + \frac{2}{3}\beta\right)\right]$, yielding

Proposition 2: *If the demand for health-care services is subject to a continuous random shock affecting the degree of substitutability between the goods with uniform distribution and zero mean, the government will* unambiguously *choose bureaucratic consolidation, if and only if:* $4\beta - \gamma > \varepsilon_{\mathrm{H}} \equiv \varepsilon_{\mathrm{H}}{}^* > \sqrt{\gamma\left(\gamma + \frac{2}{3}\beta\right)}$ *for γ>0 (if* $4\beta - \gamma > \varepsilon_{\mathrm{H}} \equiv \varepsilon_{\mathrm{H}}{}^* > 0$ *otherwise).*

In Proposition 2 the first inequality follows from the restrictions imposed on the demand parameter, while the second inequality follows from equation (15). Proposition 3 gives the cut-off values of the upper limit of the uniform distribution such that the government prefers consolidation even when health-care services are substitutes. Some numerical example can help to interpret this condition. Set β=1, implying -1/2<γ<1/2 from the parametric restrictions on government's demand. For γ=1/3, the government chooses bureaucratic consolidation if the inequality $3.67>\varepsilon_H>0.57$ holds. For γ=1/4, the relevant inequality is $3.75>\varepsilon_H>0.48$. Thus, the higher is the expected degree of substitutability γ, the more restrictive the condition becomes.

From the theoretical model, it is possible to derive two testable predictions. The government has an incentive to consolidate the bureaucratic supply of health-care services when, first, it perceives them as complement, other things being equal; second, positive realisations of the demand side shock, under some conditions, may induce consolidation, other things being

equal. The next section aims at testing these predictions by considering health care data for the Italian regions in 1982-2005.

3. Testing the model for the Italian health-care services (1982-2005)

In this section we present an empirical test of the theoretical model presented in section 2 above. We use a unique newly built yearly panel dataset containing health-care data and economic, political and institutional variables for all the Italian regions from 1982 to 2005.

The main theoretical prediction of the paper is that the government has an incentive to consolidate bureaus supplying complementary activities. In the context of the Italian health system, we should thus observe that complementary health services determine consolidation or centralisation, whereas substitute services are more likely to determine separation or decentralisation. Moreover, in the presence of demand shocks altering the degree of substitutability between health care services, our model predicts that the government might be induced to consolidate/centralize. In order to empirically test this prediction, dealing with longitudinal panel data, we refer to a random effects probit model as follows.

$$\begin{aligned} Y^*_{it} &= X_{it}\beta + u_{it} \\ Y_{it} &= 0 \quad if \quad Y^*_{it} \leq 0 \\ &= 1 \quad if \quad Y^*_{it} > 0 \end{aligned} \qquad (16)$$

$i=1,...N$ and $t=1,...T$

Where Y* denotes the unobservable variable, Y is the observed outcome, X is the observable time varying and time invariant vector of strictly exogenous characteristics that influence Y*. β is the vector of coefficients associated with the X. The error term can be decomposed into two components

$$u_{it} = \alpha_i + \eta_{it}$$

α_i denotes the individual specific unobservable effect and the u_{it} is a random error. In the case of probit random effects, it is assumed that η_{it} is i.i.d. N(0,1) and that, conditional on X_{it}, $\alpha_i s$ are IN(0, σ^2_α) and are independent of the η_{it} s and the X_{it} s.

As for our binary dependent variable, in the absence of microeconomic data on health service organizations per region, we classify regions into centralised and decentralised units - however, we shall perform sensitivity analysis to account for the arbitrariness of such classification. More specifically, we take as a proxy of consolidation/centralisation of the health-

care system the concentration of hospitals in each Italian region. We refer to the number of public and private hospitals, where the private hospitals considered are those that, under a legal agreement with the public health system, are allowed to supply public health-care services to the population as well as the public hospitals. Thus, given the number of public and private hospitals per 10,000 inhabitants (*N.Hospitals),* we build a set of binary variables as depicted in Table 1 below. The variable of interest for our basic specification is *Hosp_bin_M* representing the maximum degree of centralisation of public and private hospitals in the region (see the last row of Table 1). Regions with the maximum degree of centralisation are identified as having as a yearly average less than 0.1 hospitals per 10,000 inhabitants, otherwise the region is classified as being decentralised. In this respect given that the Italian national health system is mostly financed by the central government (and only partially by the regions which however make the organizational decision) the choice of big centralized hospitals vs. small size hospitals diffused in the regional jurisdiction is an issue of health policy of the regional government and it is not due to budget contraints.

Table 1. Italian regions 1982-2005: distribution of hospitals per 10,000 inhabitants

Variable	Description|	Obs	Mean	Std. Dev.	Min	Max
Hosp_bin_A **MIN centralisation**	Hosp_bin_A =0 if *N.Hospitals>2* Hosp_bin_A =1 otherwise	480	99.8%	0.045644	0	1
Hosp_bin_B	Hosp_bin_B =0 if *N.Hospitals>0.6* Hosp_bin_B =1 otherwise	480	97.7%	0.149794	0	1
Hosp_bin_C	Hosp_bin_C =0 if *N.Hospitals>0.5* Hosp_bin_C =1 otherwise	480	95.0%	0.218172	0	1
Hosp_bin_D	Hosp_bin_D =0 if *N.Hospitals>0.4* Hosp_bin_D =1 otherwise	480	87.5%	0.331064	0	1
Hosp_bin_E	Hosp_bin_E =0 if *N.Hospitals>0.3* Hosp_bin_E =1 otherwise	480	58.1%	0.493869	0	1
Hosp_bin_F	Hosp_bin_F =0 if *N.Hospitals>0.25* Hosp_bin_F =1 otherwise	480	23.3%	0.423394	0	1
Hosp_bin_G	Hosp_bin_G =0 if *N.Hospitals>0.21* Hosp_bin_G =1 otherwise	480	15.6%	0.363471	0	1
Hosp_bin_H	Hosp_bin_H =0 if *N.Hospitals>0.2* Hosp_bin_H =1 otherwise	480	14.2%	0.349072	0	1
Hosp_bin_I	Hosp_bin_I =0 if *N.Hospitals>0.18* Hosp_bin_I =1 otherwise	480	10.6%	0.308479	0	1
Hosp_bin_L	Hosp_bin_L =0 if *N.Hospitals>0.15* Hosp_bin_L =1 otherwis	480	7.9%	0.27028	0	1
Hosp_bin_M **MAX centralisation**	Hosp_bin_15 =0 if *N.Hospitals>0.1* Hosp_bin_15 =1 otherwise	480	7.1%	0.256814	0	1

Note: each row classifies observations as follows. A region is defined as being centralised if, in a given year, it has less that X% public and private hospitals per 10,000 inhabitants, where X% is equal to 2 (MIN centralisation), 0.6, 0.5 and so on up to 0.1 (MAX centralisation). In this case, this observation takes on a value of 1.

As for the vector X of strictly exogenous characteristics that might influence Y*, we have to consider those variables capturing complementary and substitutability of the health-care services and the shock on the demand for health services as predicted by the model. Moreover we

have to control for a number of political/economic/institutional features of the Italian health-care system that may affect regional governments' preferences, thus their organisational choices.

In order to consider empirical proxies for the complementary and the substitutability of the health care services, we use three different explanatory variables, each capturing different aspects of the complementary/substitutability dimension. The first variable is **Ratio_med,** the ratio between the number of general practitioners per 10,000 inhabitants and the number of public specialists working in hospitals per 10,000 inhabitants. In this respect, we already noticed that Atella and Deb (2008) find that in Italy the general practitioners and public specialists working in hospitals are substitute sources of medical care from the point of view of the patients. As a consequence, we should expect that an increasing value for this ratio (e.g., more general practitioners given the specialists) is associated with an increasing demand for substitute health care services and thus, according to our theoretical model, should be negatively correlated with our measure of centralisation. On the basis of the institutional characteristics of the Italian health-care service system, we identify a second empirical proxy capturing complementary health-care services. In Italy, a patient's recovery in hospital belonging to the publicly provided health-care system is usually decided and has to pass through the general practitioners. In this respect, general practitioners act as "gatekeepers" of recovery services in hospitals. Therefore, recovery in hospital and general practitioners can be considered complementary services. We take as a proxy of hospital recovery the number of beds in hospitals. Thus, the ratio between the number of general practitioners per 1,000 inhabitants and the number of beds in hospitals per 1,000 inhabitants, denoted by **Me_gen_letti,** is a measure of complementary sources of medical care. As a consequence, we should expect that an increase in **Me_gen_letti** is positively correlated with our measure of centralisation. The last empirical proxy capturing the complementarity/substitutability dimension is constructed as follows. Visits by specialist doctors working in hospitals can be considered as substitutes for recovery in hospital. This is because, as noticed for the ratio_med variable, doctors working in hospital, other than for medical care to recovered patients, also act as specialists for visits to outsiders patients, with the specialist visit often reducing the need for recovery. Thus, the ratio between the number of specialists working in hospitals per 1,000 inhabitants and the number of beds in hospitals per 1,000 inhabitants, denoted by **Me_Hosp_letti,** can be considered as a further measure of substitute sources of medical care. This implies that we should expect that an increase in the ratio **Me_Hosp_letti** is negatively correlated with our measure of centralisation.

The shock to the demand for health services is represented by the variable **sana_2002**. This is a time dummy variable taking on the value of 1 since 2003 and capturing the impact of the biggest immigration amnesty, regularising about 702,156 undocumented workers out of the

1,486,392 undocumented workers regularised in Italy over the sample period (see Fasani, 2009).[5] This new legislation to regulate undocumented immigration in Italy came into force in August 2002, followed by a decree on procedures for regularizing the situation of undocumented immigrants already in the country in September 2002. In particular, the law no. 189 of 30th July 2002, known as the "Bossi-Fini law" after the names of the politicians who proposed it, amended the previous immigration law and introduced new clauses. A decree-law issued by the cabinet on 6th September 2002 provided for the regularization of the position of two types of undocumented immigrant workers: those employed as domestic workers and home-helpers and the dependent workers involved in other kinds of sub-ordinate employment. Immigrants whose residence permits had expired could also regularize their situation, provided that they have not received a deportation order. All regularized immigrants workers received a residence permit with a duration equal to the duration of their employment contract. The residence permit gave them the right to directly access the public health-care system (see Devillanova, 2008, on undocumented immigrants access to health-care in Italy). Notice that, because after the regularization these workers became also able to apply for "reconjunction", i.e. their wive/husband and children living outside Italy could join them after the amnesty, and as long as reconjunction took place in the years following the immigration amnesty, the demand shock occurred not only in 2003, but also in 2004 and 2005 that is what we assume.

In our regressions, we control for a set of variables that are traditionally credited to influence the health-care system and that may also have an impact on our measure of centralisation of health-care services. In particular, we take into consideration the traditional structural, socio-economic and demographic characteristics of a region (i.e. log of regional GDP per capita, population and ageing population, mortality and infant mortality rates). In this respect, notice that the variable related to ageing population *(pop_over_65*, namely the proportion of people aged 65 or more in each region) takes almost constant values over the sample period and is almost the same for all the regions. This suggested us to exclude this variable from the final estimation.

Finally, we control and test in turn for a set of political and institutional dummies, which may also affect our measure of centralisation. They are defined as follows: **(i)** the type of electoral system under which the regional government was elected. This is considered by means of two dummy variables. The first regional dummy variable *(electoral_law)* takes on value of 0 under the proportional system and value equal to 1 under the plurality system. The regional electoral system changed from proportional to mixed plurality in 1994. The second regional dummy variable has to

[5] Five immigration amnesties were introduced in Italy over the sample period (1986, 1990, 1995, 1998. 2002). The 2002 amnesty mainly interested workers living in the North and Center of Italy (about 81% of the total). For this reason we also tested the model with regional time dummies. However, the results are very similar to the one reported below, and we have omitted them here. They are available from the authors on request.

do with the direct election of the president of the region, who becomes formally and substantially responsible of regional administration. In 1999 direct presidential election was introduced for the Italian regions with ordinary bylaw and in 2001 for the Italian regions with straordinary bylaw (i.e. Valle d'Aosta, Trentino Alto-Adige, Friuli, Sardegna, Sicilia). We capture the change in the electoral law related to the election of the president of the region by means of the dummy *president_elec*. This takes on value 1 since the year of direct election of the president of the region. This means that for regions with ordinary bylaw, the variable takes on value 0 up to 1998; in the regions with extraordinary bylaw, the variable takes on value 0 up to 2000. **(ii)** The test has been also carried out considering all types (political colours) of regional ruling coalitions. In this respect, a set of variables depicting the ruling party over time has been built, distinguishing between centre-left wing parties' coalitions and centre-right wing parties' coalitions (see Table 2 above for details). Moreover, a further set of variables combining the ruling party and the electoral system (proportional or plurality electoral system) over time is built, capturing the following features: in the period of proportional electoral system, we distinguish the regional governments ruled by either the Democratic Christian party, the Communist party alone and with the Socialist party, centre-left coalitions (with the Democratic Christian party), or Local Autonomies (i.e., Union Valdotain, Lega Lombarda and SVP in Trentino-Alto Adige); during the period of plurality electoral system the regional government coalitions are simply separated into two main groups, i.e., the centre-right and the centre-left ruling coalitions. **(iii)** Political and local elections are captured by the variable *elez* that takes on value 1 for the years of general political election and/or local elections and 0 otherwise.

Table 2. Summary statistics of the considered variables. Italian regions 1982-2005.

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
log_GDP_PC	Logarithm of per capita regional GDP at 2005 prices	480	9.013977	0.923793	6.649795	11.58097
anno	Linear time trend	480	1993.5	6.929408	1982	2005
pop	Regional population	480	2844780	2234619	112262	9393092
pop_over65	People over 65 (share of population)	480	0.443417	5.834425	0.05315	127.9837
n_posti_le~o=BEDS	number of public hospital beds per 1000 inhabitants	480	6.799214	4.137987	1.279338	38.813
strutt_pubbl_priv_sh N.HHospitals	Number of public and private hospitals per 1000 inhabitants	480	0.032183	0.034959	0.003407	0.699938
medici_gen	Number of general practitioners per 1000 inhabitants	480	0.893594	0.476716	0.227788	3.914717
medici_pubbl	Number of public doctors per 1000 inhabitants	480	1.728428	1.043802	0.323913	8.562508
medici_Hosp	Number of hospital doctors per 1000 inhabitants	480	1.804906	1.083537	0.464004	9.206496
t_mort	Mortality rate for 1000 inhabitants.	480	9.921686	1.546319	7.170178	14.473
t_mort_inf	Infant mortality rate for 1000 children born in the same year	480	6.675555	2.784406	1.758	15.1414
me_Hosp_letti	Ratio between the number of specialists working in hospitals and the number of beds per 1,000 inhabitants	480	0.291859	0.111432	0.107864	0.62886
me_gen_letti	Ratio between the number of general	480	0.143167	0.048356	0.036557	0.288353

	practitioners and the number of beds per 1,000 inhabitants					
ratio_med	Ratio between the number of general practitioners and the number of public specialists working in hospitals	480	0.51432	0.132881	0.187371	0.987473
sana_2002	Time dummy variable taking on the value of 1 since 2003 and capturing the impact of the biggest undocumented immigration amnesty.	480	0.125	0.331064	0	1
Electoral_law	Dummy= 0 under the proportional system and equal to 1 under the plurality system (regions with special Bylaw included)	480	0.427083	0.495171	0	1
c_destra_gov	Dummy=1 for right-wing regional ruling coalition (since 1995)	480	0.202083	0.401973	0	1
c_sin_gov	Dummy=1 for left-wing regional ruling coalition (since 1995)	480	0.285417	0.452084	0	1
pci_gov	Dummy=1 for communist party at the regional government (since 1995)	480	0.04375	0.204752	0	1
pci_psi_gov	Dummy=1 for communist and socialist ruling coalition (since 1995)	480	0.04375	0.204752	0	1
penta_gov	Dummy=1 for DC PSI PSDI PRI PLI regional ruling coalition (since 1995)	480	0.36875	0.482969	0	1
svp_dc_gov	Dummy=1 for SVP (local autonomous party) and DC ruling coalition in Trentino Alto Adige	480	0.022917	0.149794	0	1
un_vald_gov	Dummy=1 for Union Valdotain (local autonomous party) ruling the region Valdaosta	480	0.00625	0.078892	0	1
Sinis_gov	Dummy=1 for traditional regional "Red" ruling coalitions up to 1994, with regional "Red" ruling coalitions made up by the following parties: PCI alone, PCI and PSI and centre-left coalition after 1994.	480	0.4	.4904091	0	1
president_elec	For the changes in the electoral law related to the election of the president of the region, the dummy takes on value 1 since the direct election of the president of the region (this means that in regions with ordinary bylaw it takes on value 0 up to 1998; in regions with straordinary bylaw it takes on value 0 up to 2000).	480	0.270833	0.444854	0	1
elez	Dummy =1 for Political and/or Regional Election Year, 0 otherwise	480	0.439583	0.496854	0	1

Data Sources. Political variables: Ministero degli Interni; Demografic variables and regional GDP: ISTAT; Health care data: Ministero della Salute and Italian Court of Auditing.

As previously mentioned, the dataset is a yearly panel data for the 20 Italian regions for the period 1982-2005. The main variables tested and summary statistics are reported in Table 2 above. In the following we shall consider only the significant results. Other tests are available from authors on request.

The regression results of the Random effects probit model for baseline estimation, max centralisation, are reported in Table 3 below.

Table 3. Random effects probit regression for max centralisation: dependent variable Hosp_bin_M

Random-effects probit regression	Number of obs = 480
Group variable: cod_reg	Number of groups = 20
Random effects u_i ~ Gaussian	Obs per group: min = 24
	avg = 24.0
	max = 24
	LR chi2(9) = 46.61
Log likelihood = -14.12763	Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sana_2002	5.628048	2.692566	2.09	0.037	.3507164	10.90538
sinis_gov	3.358423	2.759014	1.22	0.224	-2.049146	8.765991
t_mort	1.760771	1.444263	1.22	0.223	-1.069932	4.591475
t_mort_inf	-3.169695	1.249254	-2.54	0.011	-5.618188	-.7212018
log_GDP_PC	-13.88162	4.368714	-3.18	0.001	-22.44414	-5.319098
elez	4.797356	2.112491	2.27	0.023	.6569484	8.937763
me_Hosp_letti	-204.5167	66.35372	-3.08	0.002	-334.5676	-74.46579
me_gen_letti	505.8542	143.5039	3.53	0.000	224.5916	787.1167
ratio_med	-140.1905	39.89357	-3.51	0.000	-218.3805	-62.00056
_cons	154.3755	49.84451	3.10	0.002	56.68201	252.0689
/lnsig2u	5.343765	.4269023			4.507052	6.180478
sigma_u	14.46718	3.088036			9.521246	21.98233
rho	.9952449	.0020203			.9890894	.9979348

Likelihood-ratio test of rho=0: chibar2(01) = 122.64 Prob >= chibar2 = 0.000

As regards the maximum degree of centralisation of health-care services, it turns out that the variables capturing complementary and substitutability between health services are all statistically significant at the 1% level and correctly signed according to the predictions of the model. In particular, **Ratio_med,** the ratio between the number of general practitioners and the number specialist doctors working in hospitals, that according to Atella and Deb (2008) are substitute sources of medical care, takes on a negative sign. When this ratio increases (thus increasing the substitutability) the probability of observing centralisation reduces. The variable **Me_Hosp_letti,** i.e. the ratio between the Number of public specialists working in hospitals and the number of hospital beds (taken as a proxy for recovery), further measuring substitute sources of medical care, also takes on a negative sign. Finally, the variable capturing complementary services of medical care, i.e, **Me_gen_letti** or the ratio between the number of general practitioners and the number of hospital beds (taken as a proxy for recovery) is positively signed, as expected.

The shock on the demand for health care as represented by the variable **sana_2002,** capturing the pressure of regularised immigrants that since 2003 were fully entitled to the services of the Italian national health-care system, is significant at the 5% level or less and is positively signed, implying that it induced on centralisation on average.

As for the socio-economic control variables that we considered in the final specification of the model, it turns out that among those related to the quality of the health-care services, namely infant mortality rate and mortality rate, only the former results significant at about the 1% level. The negative sign of infant mortality rate suggests us that children health-care is perceived as an issue to be better dealt with a decentralisation/diffusion of the specific services in the territory.

The log of per capita GDP is significant at the 1% level with negative sign. Increasing the local GDP reduces the probability of observing centralisation. This may capture the idea that the richer is the region the higher is the demand both for health services and for their diffusion in the region.

Finally, regarding the political economy variables, it turns out that for the max centralisation the elections' years are significant and positively signed, whereas the fact that the regional government is ruled by a centre-left coalition is not significant. However, for lower degree of centralisation (see Tables 4 to 7 in Appendix 4) the opposite occurs with regional government ruled by centre-left coalition resulting significantly and positively signed, whereas the variable election is not significant.

As long as our dependent variable is constructed, we need to explore the sensitivity of our results to different variable formulations. Therefore, as a robustness check, we estimate the model with lower degrees of centralisation. The results are reported in Appendix 4, see Table 4 to 7. Basically, these results confirm our previous estimates, especially regarding the effects of substitute/complementary sources of health-care on bureaucratic centralisation, with the exception of the significance of the variable related to political and local elections. This variable, for lower degrees of centralisation, is no longer significant, while the variable capturing regional governments ruled by centre-left coalitions becomes significant with a positive sign.

5. Summary of the results and preliminary conclusions

This paper has considered a stylised model of the determination of health-care organisation by a regional government, bargaining over the budget allocation with the health-care management possibly supplying a mix of health services. In our model, the central government can choose whether to deal with a consolidated bureau or with two competing organizations for the public provision of differentiated outputs. Our model predicts that, if the government sees the bureaucratic outputs as complements (respectively, substitutes), it will prefer dealing with a consolidated medical organization (respectively, separated hospital implying diffusion of the health care services in the regional jurisdiction). The model's prediction has been tested by using a panel data set for the 20 Italian regions over the period 1982-2005.

Three main health-care activities have been identified as being complement/substitute for each other. First, the ratio between the number of general practitioners and the number of public specialists working in hospitals per 10,000 inhabitants (**Ratio_med**). In this respect, Atella and Deb (2008) find that in Italy the general practitioners and the public specialists working in hospitals are substitute sources of medical care for the patients. Second, the ratio between the number of general practitioners and the number of beds in hospital (**Me_gen_letti**,) is a measure of complementary sources of medical care, given that in Italy a patient's recovery in hospitals

belonging to the public health-care system is usually decided and has to pass through the general practitioner. Third, the ratio between the number of specialists working in hospitals and the number of recoveries (**Me_Hosp_letti**) can be considered as a further measure of substitute sources of medical care. This is because visits by specialist doctors working in hospitals can be seen as a substitute for recovery in hospital. Actually, doctors working in hospital, other than for medical care to recovered patients, also act as specialists for visits to outsider patients, with the specialist's visit often reducing the need for recovery. The shock to the demand for health services has been also proxied by means of a time dummy variable taking on the value of 1 since 2003 and capturing the impact of the biggest undocumented immigration amnesty, regularising in 2002 about 47% of the total number of undocumented workers regularised in Italy over the 1982- 2005 sample period.

The random effects probit regression results – that took into account also of other political economic and demographic covariates - show, first, that the likelihood of observing centralisation is increased, other things being equal, when the index capturing complementary activities rises, whereas such a likelihood is reduced by a higher index for substitute activities. Second, the probability of observing centralisation increases in the presence of a shock to demand as that being determined by the immigration amnesty.

As for the control variables that we considered, it turns out that, among those related to the quality of the health-care services, the infant mortality rate suggests us that children health-care is perceived as an issue to be better dealt with a decentralisation/diffusion of the specific services in the territory. The log of per capita GDP is always significant, indicating that increasing the local GDP reduces on average the probability of observing centraliation. This effect may capture the fact that a richer region demands both more health-care services and more diffusion in the region's territory at the same time. As for the political economy variables, it turns out that the elections' years have a significant and positively signed effect on the maximum degree of centralisation, whereas the political colour of the regional government is only significant for lower degrees of centralisation.

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APPENDICES

APPENDIX 1 Comparing the stochastic and deterministic solution with one consolidated bureau

Section 2.2 of the main text has shown that, when the demand shock affects linearly the reservation price for health-care services, the government expected payoff under bureaucratic consolidation is

$$E(\hat{M}G^{11}) = 2R + \frac{(\alpha - c)^2}{4(\beta + 2\gamma)} + \frac{s^2}{4(\beta + 2\gamma)}$$

Thus, the government expected payoff is increasing in the variance of the shock, other things being equal. It is useful to decompose the stochastic component as follows

$$\frac{s^2}{4(\beta + 2\gamma)} = \underbrace{\frac{2s^2}{4(\beta + 2\gamma)}}_{\text{stochastic gains from rents}} - \underbrace{\frac{s^2}{4(\beta + 2\gamma)}}_{\text{stochastic loss from production}} . \quad \text{(A.1)}$$

(A.1) shows that the stochastic shock alters the government trade-off between utility from political rents and utility from the outputs. The economic intuition for this result is as follows. The government expected compliance level in the stochastic case, $E\hat{g}^{11} = \frac{\alpha^2 - c^2 - s^2}{4R(\beta + 2\gamma)}$ (using equation 6 in the main text), is less than the level it would choose in the deterministic case, $\hat{g}^{11} = \frac{\alpha^2 - c^2}{4R(\beta + 2\gamma)}$ (see Fedeli and Santoni, 2006: 65). This implies that the government expected political rents are higher in the stochastic than in the deterministic case. However, although it can be shown that the equilibrium level of health-care services is the same in both cases, $E\left(\frac{\hat{g}^{11}\hat{h}^{11}R}{c}\right) = E\left(\frac{\alpha + \varepsilon - c}{2(\beta + 2\gamma)}\right) = \frac{\alpha - c}{2(\beta + 2\gamma)}$, the government expected indirect utility from the outputs is lower in the stochastic than in the deterministic case, as long as $E\left[\left(\frac{\hat{g}^{11}\hat{h}^{11}R}{c}\right)^2\right] = \left[\frac{(\alpha - c)^2 + s^2}{4(\beta + 2\gamma)^2}\right] > \left[E\left(\frac{\hat{g}^{11}\hat{h}^{11}R}{c}\right)\right]^2 = \left(\frac{\alpha - c}{2(\beta + 2\gamma)}\right)^2$ by Jensen's inequality. Considering both effects together, and given that the government payoff is concave in outputs, in the stochastic case, relatively to the deterministic case, the increase in the expected political rents more than compensate the reduction in the expected gains from the outputs. As a result, the government expected payoff becomes an increasing function in the variance of the shock.

APPENDIX 2 Bureaucratic consolidation with random shocks to the demand slopes

Following Klempere and Meyer (1986), assume that the random shock influences the slopes of the demands for health-care services as follows:

$$V_i^M = \alpha - \frac{\beta}{\varepsilon} Q_i - \frac{2\gamma}{\varepsilon} Q_j \quad \text{(A2.1)}$$

with=1, 2 and i≠j and $E(\varepsilon) = 1, E(1/\varepsilon) > 1, E(\varepsilon^2) = s^2 > 1$. Note that the random shock leaves the degree of substitutability between products unaffected. Solving the model in the usual way, it turns out that the players' compliance levels at a symmetric Nash equilibrium when the government deals with one consolidated bureau are

$$\breve{g}_1^{\,11} = \breve{g}_2^{\,11} = \frac{(\alpha - \text{c})[2\alpha - (\alpha - \text{c})\varepsilon]\varepsilon}{4\text{R}(\beta + 2\gamma)}$$
$$\breve{h}_1^{\,11} = \breve{h}_2^{\,11} = \frac{2c}{2\alpha - (\alpha - \text{c})\varepsilon} \tag{A2.2}$$

Thus, at stage one, the government's expected payoff is

$$E(MG^{11}) = \underbrace{2R}_{\text{deterministic payoff}} + \underbrace{\frac{2s^2(\alpha - c)^2}{4(\beta + 2\gamma)}}_{\text{stochastic gain in terms of rents}} - \underbrace{\frac{s^2(\alpha - c)^2}{4(\beta + 2\gamma)}}_{\text{stochastic loss in terms of output evaluation}} \tag{A2.3}$$

Similarly, the symmetric Nash equilibrium compliance levels when the government deals with two independent bureaus are

$$g_1^{12} = g_2^{12} = \frac{(\alpha - \text{c})[2\alpha(\beta + \gamma) - (\alpha - \text{c})(\beta + 2\gamma)\varepsilon]\varepsilon}{4\text{R}(\beta + \gamma)^2}$$
$$h_1^{11} = h_2^{11} = \frac{2c(\beta + \gamma)}{2\alpha(\beta + \gamma) - (\alpha - \text{c})(\beta + 2\gamma)\varepsilon} \tag{A2.4}$$

from which follows the government's expected payoff

$$E(MG^{12}) = \underbrace{2R}_{\text{deterministic payoff}} + \underbrace{\frac{2s^2(\alpha - c)^2(\beta + 2\gamma)}{4(\beta + \gamma)^2}}_{\text{stochastic gain in terms of rents}} - \underbrace{\frac{s^2(\alpha - c)^2(\beta + 2\gamma)}{4(\beta + \gamma)^2}}_{\text{stochastic loss in terms of output evaluation}} \tag{A2.5}$$

Equations (A2.3) and (A2.5) show that the government's expected payoff in either case increases with the variance of the shock. Using (A2.3) and (A2.5), yields

$$E(MG^{11}) - E(MG^{12}) = -\gamma\left[(\alpha - \text{c})^2 s^2\right]\left[\frac{2\beta + 3\gamma}{4(\beta + 2\gamma)(\beta + \gamma)^2}\right] > 0 \tag{A2.6}$$

Uncertainty on the slope of demand does not change the government's incentives to choose bureaucratic consolidation (separation) with complements (substitutes), or $\gamma<0$ ($\gamma>0$). However, uncertainty reinforces such an incentive, other things being equal. This is the same qualitative result as for the case of an additive random shock explicitly considered in section 2.2 of the main text.

APPENDIX 3 Bureaucratic consolidation with random shocks to the degree of substitutability

With a uniformly distributed random shock $\varepsilon \sim U(\varepsilon_L,\ \varepsilon_H)$, $\varepsilon_L < 0$ and $\varepsilon_\text{H} > 0$, the government's expected payoff from bureaucratic consolidation is from equation (12)

$$\begin{aligned} E(\widetilde{M}G^{11}) &= 2R + \frac{(\alpha \text{ - c})^2(\beta + 2\gamma)}{4} E\left[\frac{1}{(\beta + 2\gamma + 2\varepsilon)^2}\right] = \\ &= 2R + \frac{(\alpha \text{ - c})^2(\beta + 2\gamma)}{4}\int_{\varepsilon_L}^{\varepsilon_H} \frac{1}{(\beta + 2\gamma + 2\varepsilon)^2}\frac{d\varepsilon}{\varepsilon_\text{H} - \varepsilon_\text{L}} = \\ &= 2R + \frac{(\alpha \text{ - c})^2(\beta + 2\gamma)}{4(\beta + 2\gamma + 2\varepsilon_H)(\beta + 2\gamma + 2\varepsilon_L)} \end{aligned} \tag{A3.1}$$

Similarly, the government's expected payoff under bureaucratic separation is from equation (14)

$$E(MG^{12}) = 2R + \frac{(\alpha - c)^2(\beta + 2\gamma)}{4} E\left[\frac{1}{(\beta + \gamma + \varepsilon)^2}\right] =$$

$$= 2R + \frac{(\alpha - c)^2(\beta + 2\gamma)}{4} \int_{\varepsilon_L}^{\varepsilon_H} \frac{1}{(\beta + \gamma + \varepsilon)^2} \frac{d\varepsilon}{\varepsilon_H - \varepsilon_L} = \tag{A3.2}$$

$$= 2R + \frac{(\alpha - c)^2(\beta + 2\gamma)}{4(\beta + \gamma + \varepsilon_H)(\beta + \gamma + \varepsilon_L)}$$

The government chooses bureaucratic merging if its expected payoff (A3.1) is larger than (A3.2), which is the condition (15) given in the main text.

APPENDIX 4 Robustness checks

This Appendix presents estimates of the model based on alternative definitions of the degree of centralisation as indicated in Table 1 of the text. The results, reported from Table 4 to Table 7 below, confirm the basic results of the model.

Table 4. Robustness check. Random effects probit regression for centralisation:dependent variable Hosp_bin_G

```
Group variable: cod_reg                         Number of groups   =        20
Random effects u_i ~ Gaussian                   Obs per group: min =        24
                                                               avg =      24.0
                                                               max =        24
                                                LR chi2(9)         =    177.16
Log likelihood  = -54.770835                    Prob > chi2        =    0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sana_2002	1.961361	.9624952	2.04	0.042	.0749045	3.847817
sinis_gov	1.480486	.7589365	1.95	0.051	-.0070026	2.967974
t_mort	.274067	.495682	0.55	0.580	-.6974519	1.245586
t_mort_inf	-.7302298	.2641333	-2.76	0.006	-1.247922	-.2125381
log_GDP_PC	-1.365314	.7692514	-1.77	0.076	-2.873019	.1423911
elez	-.1363653	.4196484	-0.32	0.745	-.958861	.6861304
me_Hosp_letti	-111.7168	36.9912	-3.02	0.003	-184.2182	-39.21542
me_gen_letti	279.2075	84.30489	3.31	0.001	113.973	444.4421
ratio_med	-63.40908	22.58673	-2.81	0.005	-107.6783	-19.1399
_cons	31.93236	15.25161	2.09	0.036	2.039755	61.82497
/lnsig2u	2.783324	.6503214			1.508718	4.057931
sigma_u	4.021529	1.307643			2.126248	7.606213
rho	.941768	.0356643			.8188711	.9830089

Likelihood-ratio test of rho=0: chibar2(01) = 121.09 Prob >= chibar2 = 0.000

.

Table 5. Robustness check. Random effects probit regression for centralisation:dependent variable Hosp_bin_H

Random-effects probit regression — Number of obs = 480
Group variable: cod_reg — Number of groups = 20
Random effects u_i ~ Gaussian — Obs per group: min = 24; avg = 24.0; max = 24
LR chi2(9) = 165.94
Log likelihood = -43.268537 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sana_2002	5.375237	1.955144	2.75	0.006	1.543226	9.207248
sinis_gov	7.682678	1.54962	4.96	0.000	4.645479	10.71988
t_mort	.307081	.9474698	0.32	0.746	-1.549926	2.164088
t_mort_inf	-1.625163	.5316519	-3.06	0.002	-2.667181	-.5831439
log_GDP_PC	-6.409332	1.472184	-4.35	0.000	-9.29476	-3.523904
elez	-.1431731	.8573449	-0.17	0.867	-1.823538	1.537192
me_Hosp_letti	-207.9461	63.05882	-3.30	0.001	-331.5391	-84.35305
me_gen_letti	565.214	140.2766	4.03	0.000	290.2769	840.151
ratio_med	-129.5871	38.59994	-3.36	0.001	-205.2416	-53.9326
_cons	88.68243	32.66773	2.71	0.007	24.65487	152.71
/lnsig2u	5.081557	.4726023			4.155273	6.00784
sigma_u	12.68954	2.998554			7.985574	20.16443
rho	.9938281	.0028989			.9845606	.9975466

Likelihood-ratio test of rho=0: chibar2(01) = 142.84 Prob >= chibar2 = 0.000

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Table 6. Robustness check. Random effects probit regression for centralisation:dependent variable Hosp_bin_I

Random-effects probit regression — Number of obs = 480
Group variable: cod_reg — Number of groups = 20
Random effects u_i ~ Gaussian — Obs per group: min = 24; avg = 24.0; max = 24
LR chi2(9) = 86.35
Log likelihood = -49.586982 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sana_2002	.4988122	.8434162	0.59	0.554	-1.154253	2.151878
sinis_gov	.4974437	.5968948	0.83	0.405	-.6724486	1.667336
t_mort	.6221544	.4066687	1.53	0.126	-.1749017	1.41921
t_mort_inf	-.7588529	.2252979	-3.37	0.001	-1.200429	-.3172771
log_GDP_PC	-2.817274	.759423	-3.71	0.000	-4.305715	-1.328832
elez	-.1461276	.3897528	-0.37	0.708	-.9100291	.6177739
me_Hosp_letti	-61.8657	19.82289	-3.12	0.002	-100.7178	-23.01355
me_gen_letti	166.5269	45.28284	3.68	0.000	77.77422	255.2797
ratio_med	-37.93757	11.95948	-3.17	0.002	-61.37772	-14.49742
_cons	31.51518	10.16243	3.10	0.002	11.59719	51.43316
/lnsig2u	2.505749	.5947187			1.340121	3.671376
sigma_u	3.50039	1.040874			1.954356	6.269445
rho	.9245438	.0414891			.7925099	.9751898

Likelihood-ratio test of rho=0: chibar2(01) = 121.21 Prob >= chibar2 = 0.000

.

Table 7. Robustness check. Random effects probit regression for centralisation:dependent variable Hosp_bin_L

```
Group variable: cod_reg                         Number of groups   =        20
Random effects u_i ~ Gaussian                   Obs per group: min =        24
                                                               avg =      24.0
                                                               max =        24
                                                LR chi2(9)         =     60.20
Log likelihood  = -22.411073                    Prob > chi2        =    0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sana_2002	4.734813	1.705468	2.78	0.005	1.392156	8.077469
sinis_gov	1.664277	1.254786	1.33	0.185	-.7950595	4.123613
t_mort	.5370312	.8450437	0.64	0.525	-1.119224	2.193286
t_mort_inf	-1.951522	.5819589	-3.35	0.001	-3.092141	-.8109038
log_GDP_PC	-8.559473	1.316199	-6.50	0.000	-11.13918	-5.97977
elez	1.155499	.8563101	1.35	0.177	-.5228382	2.833836
me_Hosp_letti	-161.1076	40.05207	-4.02	0.000	-239.6082	-82.60697
me_gen_letti	381.7956	77.54364	4.92	0.000	229.8129	533.7783
ratio_med	-100.9094	21.79928	-4.63	0.000	-143.6352	-58.18362
_cons	109.0421	20.58078	5.30	0.000	68.70448	149.3797
/lnsig2u	4.785678	.5232669			3.760094	5.811263
sigma_u	10.94452	2.863454			6.553813	18.27678
rho	.9917207	.0042964			.9772481	.9970153

Likelihood-ratio test of rho=0: chibar2(01) =   141.97 Prob >= chibar2 = 0.000