Public Hospitals - Incentives and Organization

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Abstract

This paper presents a novel way to analyze the organization of public hospitals by applying the property rights approach to organizations (PRA) to the problem. It is proposed that while PRA is suitable for the analysis of all hospitals it is especially so for public hospitals.The analysis explores issues concerning privatization and integration of public hospital services. The findings are generally supportive of integration as long as the public principal's human capital is essential for the production of hospital care.

Keywords: Public Hospitals, The Property Rights Approach to Organizations, Joint Production, Integration, Privatization
JEL Classifications: D23, I18

1 Introduction

Public hospitals are a central feature of public health care systems. Providing specialized care, they are at the centre of attention of citizens as well as politicians, and they represent the bulk of health care expenditure. Public hospitals are often perceived as overly complex and bureaucratic hierarchic organizations and the efficiency of these organizations is often questioned.

Hospital care, both in private and public settings, is the joint production of care by several different specialities. Obviously joint production requires cooperation and the better the cooperation the higher will the quality of hospital care be. Good cooperation entails that the cooperating parties make investments in their relationship e.g. learn about the other parties' needs and modify human capital and assets to suite these needs. Undoubtedly a hospital organization that supports good cooperation is a prerequisite, but not a guarantee, for efficient and qualitative hospital care.

Despite of hospitals being the centerpiece of most health care systems, their internal organization has rendered little research interest among economists - Harris (1977) being the most obvious exception. The organization of public

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hospitals is even less explored. This paper analyzes the organization of public hospitals by applying the property rights approach (PRA) to organizations developed in Grossman & Hart (1986), Hart & Moore (1990) and Hart (1995). The use of the PRA is conducive, as will be discussed below, to the analysis of public hospitals and new to hospital literature. With this approach a comparative study is performed yielding insights about privatization and integration of hospital services. This is done in two different scenarios: *privatization*, where an integrated structure serves as the starting point for the analysis and *construction*, where non-integration serves as the starting point. In the latter scenario it is envisioned that the hospital principal wants to construct a new treatment unit within a hospital or a new hospital, while the principal, in the first scenario, considers reorganizing an already integrated structure . The focus of the paper is on bilateral relationships within public hospital, e.g. between a surgery department and a radiology department, while relationships involving more than two parties are only briefly discussed.

The paper is organized as follows: next the fundamentals of hospital care and health care markets are introduced followed by a short introduction of the property rights approach and an illustrative example. Section 2 discusses the conduciveness of PRA to analyzing public hospital organization. Section 3 analyzes two different bilateral relationships within public hospitals, while section 4 takes a brief look at extensions to the analysis. Section 5 concludes.

Health Care Markets, Hospital Production and Organization When studying the organization of hospital care one must take into account the specific nature of health care markets. Typically they are markets characterized by decentralized decision-making, asymmetric information and irreducible uncertainty.[1] This implies that neither health care outcomes nor provider behavior can be contracted on in a contingent manner. These features of the health care market also apply to the internal organization of hospitals. It is not possible for hospital managers to write complete contracts, with the different parts of the hospital, that specify treatment outcomes, all input characteristics and individual efforts.

The health care market dealt with in this paper is a public health care system with some private initiatives (much like the Swedish health care system). Here health care is publicly funded and all hospital care is publicly provided whereas some specialist care may be privately provided. Each public hospital has a regional monopoly on hospital care and serve a specified part of the populace, thus demand issues are abstracted from in this paper. That is, the demand for hospital care will not change with the hospitals' organizational form.

[1] The characteristics of the health care markets have inspired ample research yielding three strands of literature: insurance literature dealing with the relation payer-patient (e.g. Arrow 1963, Pauly 1968, Zeckhauser 1970 and Nyman 1999), physician agency literature dealing with the relationship between patient and provider (e.g. Evans 1974, Dranove 1988, Choné & Ma 2005 and a nice overview in McGuire 2000), and reimbursement literature dealing with the payer-provider relation (e.g. Ellis & McGuire 1986, Ma 1994, Chalkley & Malcomson 1998 and Eggelston 2004).

In general a hospital consists of a wide variety of services and assets, all to some extent needed in the production of hospital care. The most evident services are of course the medical services such as surgery, cardiology, and oncology. Without these medical services there would be no production of hospital care. However the production of the final good, hospital care, requires a number of inputs from other services that are usually found in hospitals, foremost support services (e.g. radiology, pharmacy, blood-bank and laboratories) but also hotel services (cooking, laundry, cleaning, transports and so on).

The production of hospital care is the *joint production* of care carried out by a number of interdependent medical departments and support services (and hotel services) (Harris, 1977). In the joint production of hospital care every patient "receives customized attention"[2] consisting of inputs from different parts of the hospital - both from different medical departments and from different support services. The customized attention that each patient receives requires that decision making is decentralized. That is, that patient care decisions are made by the treating hospital departments because they have information about the patient that hospital management does not have - there is asymmetric information about the treatment needs of the patient.[3] Moreover, the irreducible uncertainty about treatment outcomes makes it difficult for the hospital management to assess the departments actions *ex post*.[4] This implies that the hospital management cannot contract, in an enforceable manner, the hospital departments to take certain actions e.g. to ensure qualitative cooperation in the joint production of hospital care. Instead the organization of the joint production in itself must be such that it ensures a high level of cooperation and coordination. The common organizational response, for public hospitals, to this challenge have been *integration* (c.f. Söderström & Lundbäck, 2002).The main benefit from integration is realization of scale economies, while the costs mainly stem from muted individual incentives and rising administrative costs.(see e.g. Robinson & Casalino, 1996; Posnett, 2002; Söderström & Lundbäck, 2002).

What are the alternatives to integration? Robinson & Casalino (1996) suggest *contractual networks*, not only for hospitals but as a broader solution for the entire health care sector, that has many of the benefits of integration but gives stronger performance incentives for the individual members of the network. Christopher E. Press (1999) puts forward a similar idea for hospitals, suggesting a model of *orchestration* for hospitals much like the organization of airports or shopping malls. The authors of both articles reject the idea that health care (hospital care) should be produced by a fragmented set of specialists (the market solution). Hence the organizational choice for hospitals stand between vertical integration and contractual networks. This notion is captured

[2] See Harris (1977).

[3] Physicians (medical departments) will, in most instances, have an informational advantage over both hospital managements and patients (see e.g. Arrow, 1963).

[4] Irreducible uncertainty is the absence of information about the consequences of health care treatment that is shared equally by the providers, patients and payers (c.f. McGuire, 2000). It essentially imply that recovery from disease is a random event. While health care influences this randomness it will never be a sure thing that a treatment always gives the same outcome or requiers the same inputs.

in the analysis in this paper where the transaction is either integrated or carried out in a contractual network.

The Property Rights Approach This theory focuses on the importance of asset ownership for the *relationship-specific investments* made in a transaction (trade relationship). In the model investments follow asset ownership and the distribution of assets determine the organizational form, e.g. under integration one party owns all assets used in the transaction. Relationship-specific investments are investments that are more valuable in the transaction than outside the transaction.[5] That is, the investments ensure that the trade relationship becomes more efficient and beneficial (e.g. through greater coordination and better cooperation) for the trading parties. The transaction is carried out in a world of incomplete contracting which creates a potential for hold-ups, i.e. by making the investment the investing party becomes vulnerable to withdrawal from trade by a party that does not invest or invests less.

In contrast to transaction cost theory[6] PRA suggests that integration does not automatically solve/reduce the hold-up problem. Instead PRA contends that opportunistic behavior may prevail within firms (c.f. Hart 1995). Heeding this possibility PRA provides a framework for understanding the boundaries of a firm. In PRA the optimal organizational structure is the structure that yields the greatest incentives for relationship-specific investments.

The relationship-specific investments can be interpreted in terms of effort for coordination and cooperation, thus PRA provides a good framework for analyzing the joint production of hospital care and its organization. The complete rationale for using PRA in the case of hospital care is presented and discussed in section 2.[7]

Cardiovascular Intensive Care - an Illustrative Example A hospital manager may face two types of organizational decisions: reorganization of old treatment units, or whole hospitals, and organization of new treatment units (construction). For public hospitals the former usually include privatization or, if you like, disintegration because public hospitals in most cases are vertically integrated structures. Thus two scenarios are discussed in this example: privatization and construction. With privatization the initial organization is vertical integration and with construction it is non-integration.

[5] Relationship-specific investments are investments by party A in the relationship with party B and vice versa that increase the mutual dependence and the coordination between the parties - ensuring a more rewarding cooperation between A and B i.e. increasing the value of the relationship.

[6] E.g. Klein *et al* 1978, Williamson 1985.

[7] There is some critique concerning the PRA that one should be aware of, in particular.:

i) Holmström (1999) suggests that the theory fails to explain the boundaries of the firm because it fails to explain how different activities are distributed across firms.

ii) Whinston (2003) concludes that little empirical work has been done on the theory and that empirical studies on transaction cost do not lend support, as often suggested, to property rights theory.

To keep things simple consider the hospital treatment of *acute myocardial infarction* (heart attack, AMI) by a cardiovascular intensive care unit, and assume that the public principal organizing the treatment also functions as the cardiology department. The cardiology department produces the final good, hospital care for AMI, using inputs from radiology and thoracic surgery. [8] The production of the final good is a combination of treatment at the cardiology department and decisions on what inputs to use. The cardiology department receives information from ultrasonography, supplied by the radiology department, to determine the size and severity of the thrombosis. Then they administer thrombolytic therapy but find that the treatment is ineffective and opt for bypass surgery. The bypass surgery is performed by a thoracic surgeon, using information from a *angiography (diagnostic cardiac catherization)* to locate the infarct.[9] Figure 1 gives a schematic depiction of the hospital treatment of AMI i.e. the involved departments, the inputs and the assets that each department use for the production of their input.

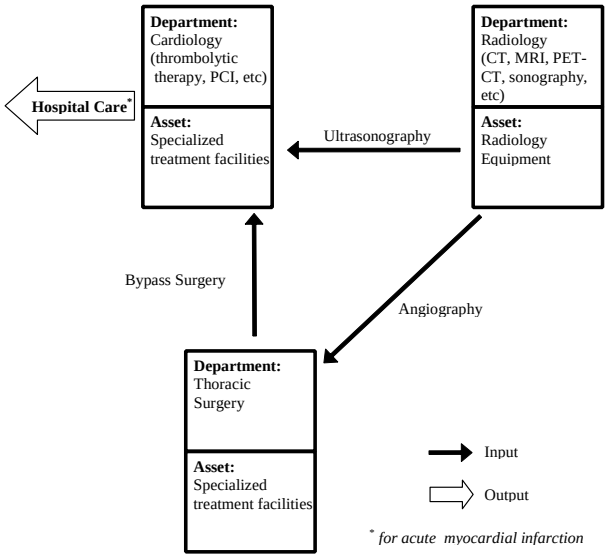

Figure 1: A possible scenario for the treatment of AMI

For this treatment sequence to function smoothly the three departments need to invest in their relationship e.g.: the cardiology department needs to invest in knowledge about thoracic surgery and interpretation of sonograms, the thoracic surgeon needs to be able to specify requirements on diagnostic

[8] Abstracting from e.g. first-responder care, anesthetics, post-operative care and rehabilitation.

[9] The cardiology department might also opt for angioplasty, in this case bypass surgery would have served as an emergency backup. Moreover the angiography results is supplied to the cardiology department in the case of PCI and possibly in this case as well.

technologies and know how thrombolytic therapy affects the bypass surgery, and the radiology department needs to invest in knowledge about ultrasonography and CT-scanners, MRI *etc.* and AMI. In this paper it is hypothesized that the more the parties invest in knowledge the better is the joint production of hospital care. The question that arises is: how should the cardiovascular intensive care unit be organized to foster the greatest investments?

The answer (as will be seen in the subsequent sections) will typically depend on the starting point (i.e. the initial organization), the characteristics of assets (independent or complementary) and the characteristics of human capital (essential or non-essential). Starting with the characteristics of assets it is obvious that the assets are complementary, i.e. it is hard to imagine that the treatment could be performed without all three parties' assets e.g. without a heart-lung machine (for the bypass surgery), a sonograph and facilities for thrombolytic therapy. Moreover, one might argue that the human capital of the cardiology department as well as the thoracic surgeon is essential for the treatment, while the radiology department's human capital may be important but not essential. How does these suggestion affect the organizational choice?

In the construction case, vertical integration (i.e. that the cardiology department owns all assets) should be opted for if the complementary of assets imply that the thoracic surgeon is indifferent between owning and not owning its facilities. In all other circumstances either integration between thoracic surgery and radiology or integration between cardiology and radiology, with the third party as an outside contractor, would be a better option.

Moreover, privatization of parts of an already existing, vertically integrated, treatment unit is only an improvement if both the radiology department's and the thoracic surgeon's human capital is essential while the cardiology department's human capital is relatively unimportant. Given the setup in this example this is an unlikely situation.

There are ample examples of treatments performed at public hospitals, besides the treatment of AMI, that could fit this picture. Any treatment involving two treating departments and one support service fits directly e.g. the treatment of breast cancer involving a radiology department (e.g. mammography), a surgeon (removal of the tumor) and an oncology department (e.g. chemotherapy). Furthermore, with proper adaptations examples of treatments using one treating department and one or two support services may be constructed e.g. hip arthroplasty involving an orthopedic surgeon, a radiology department (in evaluation stage) and an anesthesiologist (for anesthesia during the operation).

2 The Property Rights Approach and Hospital Organization

Some general features of PRA need to be clarified before discussing the PRA in relation to hospitals.

The basic PRA-model is a two-period model with two parties, one producing

the final product and the other an input to this production (Hart, 1995). Each party in this transaction have an *outside option* i.e. may choose not to trade with the other party, withdraw from this specific transaction, and sell respectively buy the input on the open market. There is no uncertainty about costs and benefits, and no asymmetric information in this model. Moreover, the parties can make correct calculations about expected return of any action. However, there is *ex ante* uncertainty about the quality of the input - its characteristics cannot be contracted on in contingent manner.

Figure 2 describes the timing of the model, notably assets are already allocated, i.e. the organizational structure for the transaction is decided, when the investments are made in period 0. In period 1 the parties trade with each other, the uncertainty about input quality is resolved, and the parties bargain over the division of surplus.[10] In the bargaining the outside options function as threat points.

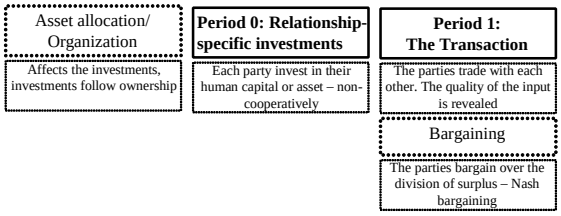

Figure 2: The timing of the PRA-model

In PRA the interaction between asset ownership and relationship-specific investments determines the organizational structure. All investments are beneficial for the investing party irrespective if she trades with the other party making or not. However, the benefit is greater if the investing parties trade with each other (c.f. Hart, 1995).[11] The investments are either made in human capital or in physical assets. Asset ownership gives the asset owner control over contingencies concerning assets not specified in the contract (residual control rights). Residual control rights are important given the uncertainty in the model, stemming from the presence of unforeseen contingencies (since it is an incomplete contracting model) and the *ex ante* uncertainty about input quality. In general asset ownership creates greater incentives for investments because the increased control makes the asset owner less vulnerable to a withdrawal from trade by the other party.

[10] The bargaining solution used is symmetric Nash bargaining with outside options. Notably, De Meza & Lockwood (1998) show that the predictions of the model are vulnerable to changes in bargaining assumptions.

[11] Investments make the use of assets more productive, especially in conjunction with the other party's asset if this party makes similar investments, but also if the investing parties do not trade with each other - albeit to a lesser extent.

As noted a *period* 0-*contract*, e.g. establishing the basic conditions for the transaction, cannot not specify the relevant characteristics (the quality) of the input in a verifiable manner.[12] If this was possible the parties could coordinate their investments to maximize the *ex post* surplus, but since this is not possible the choice of investments is made non-cooperatively.[13]

In the basic setup the incentives for investments crucially depend on asset allocation, but in certain circumstances asset ownership is inconsequential to the choice of investment (as will be seen in the analysis below) for some or all parties involved in the transaction. This enables a comparative analysis of the organizational structure. Two such circumstances would be that the parties' assets are complementary and/or that one or both parties' human capital is essential for the transaction. In the comparative analysis the best organizational structure is the structure that supports the greatest relationship-specific investments, and thus creates the greatest surplus.

Finally, two additional features of PRA deserve mentioning before moving on to specific issues about PRA and hospitals. First, any contract may be renegotiated in the model at any time (until the transaction is carried out) at zero cost implying that there is a lack of commitment in the model i.e no period 0-contract is binding. This is due to the uncertainty in the model. Second and importantly the model focuses on issues concerning organization and abstracts from demand (consumer side) issues that might affect the benefit of a certain organization. This is of course a short-coming of the model, but an inconsequential short-coming in the case of public hospitals. Theses issues will be returned to below.

PRA and Hospitals There are two fundamental circumstances that decide the optimal organization of hospital care, both in public and private settings: hospital care being joint production and complete contracting being impossible. The property rights approach to organizations captures both these aspects of hospital care. First, PRA is an incomplete contracting model where the quality of inputs cannot be contracted on and any contract may be renegotiated i.e. the parties cannot commit themselves to a contract - reflecting an irreducible uncertainty in the transaction. Second, and most profoundly, the emphasis on relationship-specific investments in PRA captures the essence of joint production: the coordination and mutual dependence between the different parties contributing to hospital care.

It is obvious that if the joint production does not work properly the hospital care will be of poor quality. Joint production requires coordination of efforts. The individual efforts are generally not verifiable implying that the quality each party's input to the production of hospital care cannot be contracted on. One way to coordinate the efforts of the parties is to make them mutually dependent

[12] E.g. it is difficult to *ex ante* describe all relevant characteristics of a specific X-ray image, e.g. in terms of precision, workload and interpretability - these might vary considerably from patient to patient.

[13] However, the investments are observable to both parties, but not verfiable to outsiders (not enforceable). The same holds for the cost and value of the investments (c.f. Hart 1995).

of each other. Relationship-specific investments have the potential to ensure a mutual dependence between different parts of the hospital and thus ensure coordination of efforts. This even if the investments are made non-cooperatively, i.e. even if they are chosen to maximize individual benefit. The relationship-specific investment are in this setting modifications of human capital and/or assets to meet the special demands of a specific transaction.
A radiology department, for example, has to supply the surgical department with specific diagnostic information and, to be able to do this, they have to make investments in human capital - learn the special requirements of the surgeon - or in the asset - buy equipment that produces the type of images that the surgery requires. The surgeon, on the other hand, must invest in the interpretation of the diagnostic information (sometimes the interpretation of the actual images).
These investments ensure that the joint production of hospital care runs smoothly and are therefore of great importance.

How does this relate to hospital organization? The link between relationship-specific investments and organization goes through the adaptation to changing circumstances, realtionship-specific investments make the parties, since contracts are incomplete, vulnerable to changing circumstances (unforeseen contingencies).
If the radiology equipment needs to be modified, e.g. through the purchase of new appliances, to fit a special surgical procedure in a way that is not specified in the contract (between them and the surgical department), then the radiology department will have the ability to do so if they own the equipment. The surgical department, however, is dependent on the radiology department's willingness to make this alteration. Since the surgical department has made relationship-specific investments in the relation with this specific radiology department they, now, may be held up for some of the cost for the modification. The threat of being held-up by the radiology department reduces the surgical department's incentives to make investment in this specific relation.
Thus the ability to change and the cost of changing follow ownership, and it is apparent that ownership also affects the relationship-specific investments. It is likely that the surgical department would have greater incentives to invest if they owned the radiology equipment, they would then have control over the adaptation needed in the new circumstances (residual control rights). Now, since relationship-specific investments are, or at least seem to be, beneficial for the joint production of hospital care the hospital should be organized in a way that promotes these investments. This fits well with the conclusion of PRA that the organizational structure that supports the greatest relationship-specific investments is the optimal way the organize a certain transaction.

Moreover PRA provides a framework for capturing salient features of hospital care such as: the medical departments' human capital, in most cases, being essential for the treatment outcome and that the different departments' assets are likely to be complementary in the treatment. An example of the latter could be the radiology equipment used for mammography and cytologist's equipment used to examine the cells, these two assets are complementary in the diagnosis and treatment of breast cancer.

PRA and Public Hospitals This paper contends that PRA is especially suitable for analyzing public hospitals. Public hospitals, like many other public agencies, are characterized by politically set goals, public funding and ownership, and lack of competition.[14] The public funding of hospital care is, at least in Sweden, in most case based on a fixed budget principle. When it comes to the internal funding of the departments' services the pattern is similar, i.e. the funding is given in terms of a budget. This total cost may be based on historical as well as predicted treatment costs given the internal prices for the different service need for a treatment. In this system there is room for disagreements and negotiations over the actual cost, i.e. resources used, for a treatment and over the quality of a service given the price. PRA, in a sense, capture these negotiations since it entails bargaining over the reimbursement for a service - this bargaining may be interpreted both in terms of negotiations over price for a given quality and quality for a given price.

The fact that contracts may be renegotiated without cost, in the model, captures another important public feature namely that public agencies often have the political power breach and renew agreements at any time.

Lack of competition between hospitals is a significant feature of public health care systems, e.g. the Swedish health care system where the public hospital serves a regulated part of the population. Thus demand does not discipline hospital behavior and affect hospital organization as it potentially does in a private health care system. PRA's focus on organizational issues and the lack of demand side fits well with analyzing public hospitals. Just as it would be natural to include demand issues in an analysis of private hospitals (e.g. Ma, 1994) it is natural to abstract from demand issues in the analysis of public hospitals.[15]

The choice of PRA is also justified by its ability to address relevant issues such as privatization and restrictions on ownership. In the political debate a major issue concerning public hospitals is whether certain activities could, and should, be privatized or, put in other words, disintegrated. This in an political environment where the need for political control spurs a preference for hierarchic public organizations, mainly because this limits the autonomy of the organization (c.f. Williamson 1999). The PRA may be used evaluate the benefits from disintegration by using integration as the starting point for the analysis. A related issue is politically assigned restrictions on ownership. A common characteristic of public ownership, from a historical point of view, is that public asset are seldom for sale. Obviously, some public assets are never or seldom sold to private interests, e.g. military defense facilities, and, at least in the Swedish case, hospital facilities.[16] This characteristic is easily captured

[14] See Dixit (2002) for a general discussion of characteristics of public agencies.

[15] Demand issues are sometimes abstracted from, maybe unjustly, in models of private health care, as well, for ease of exposition (e.g. Ellis & McGuire, 1986).

[16] To my knowledge there are only three private hospitals in Sweden - St Göran, Lundby and Simrishamn - where the latter two are minor hospitals. They are private in the sense that the provision of care is made by a private entrepreneur, however they are publicly funded and the infrastructure/buildings, as I understand it, are still publicly owned.

in PRA by assuming some restrictions on ownership. This kind of assumption will be used in the analysis below.

Applying PRA to the organization of public hospitals is novel and potentially rewarding (given the discussion above). In next section PRA is applied most basic transaction within a public hospital namely a *bilateral transaction* where two departments cooperate to produce hospital care.

3 Bilateral Transactions in Public Hospitals

As discussed and exemplified in previous sections hospital care is the joint production between medical services, support services and hotel services. In its most basic form the joint production involves two parties, i.e. it is a *bilateral transaction*, e.g. a medical department and a support service or a medical department and a hotel service. There are many examples of bilateral transactions of this kind within public hospitals e.g. the treatment of a simple leg or arm fracture (orthopedic department and radiology department) or a treatment requiring a special diet (medical department and hospital kitchen) and so on.[17] The plenitude of potential bilateral transactions within a hospital makes the organization of these transaction both important for hospital performance and interesting to analyze.

In the analysis below one may think of the bilateral transaction either as the simplest incarnation of a hospital or as a treatment unit within a larger hospital, both interpretations are valid. Below are two, somewhat different, bilateral transactions are considered. First, a transaction with one medical department and one support service, where both parties make investments in human capital, is analyzed. Second, a transaction involving a medical department and a hotel services is considered. In both case the medical department produces the final good and also functions as the public principal. In the latter transaction one party invests in its physical asset while the other party invests in its human capital. The basic features of PRA, discussed in section 2, apply in both cases and in both cases the comparative analysis is performed *vis-a-vis* two different starting points: integration (to analyze the privatization of hospital services) and non-integration (to analyze the construction of treatment units). Concerning the analysis, the setup for the first transaction is similar to the setup used by Hart (1995), while the analysis of the second transaction contains a number of novel features.

3.1 Medical Department plus Support Service

Consider a setting with one support service (e.g. radiology department) and one medical department (e.g. surgery department). Denote the support service S. Hence S supplies an input to M's production of the final good, which in this transaction is the hospital care. The support service uses one asset, p_S, to produce the input and the medical department uses one asset, p_M, and the input

[17] The example in section 1, of course, deals with a more complex situation.

to finalize the hospital care. Figure 3 gives a visualization of the production process, the assets used for the production and introduces the relationship-specific investments (μ_S and σ_M).

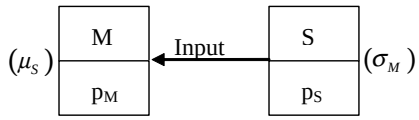

Figure 3: "The M & S Transaction"

S's investment enables them to produce an input suitable for M's production of hospital care. Moreover, M's investment allows them to make efficient use of the input. These investments are, by construction, investments in human capital; M's investment is μ_S and S's investment is σ_M. The assumption that these investments are made in the respective parties' human capital is important and implies that these investments cannot be transferred form one party to the other. That is S cannot make M's investment and vice versa - irrespective of ownership structure. Assume that these investments reflect both the level and the cost of the investment.

3.1.1 The Model

If both parties decide to enter this particular transaction (*trade*), where S supplies the input and M uses the input to produce hospital care, their payoffs are the following:

$$U_M = T(\mu_S) - v \quad (1)$$
$$U_S = v - C(\sigma_M) \quad (2)$$

where $T(\mu_S)$ is the treatment outcome and v is the reimbursement paid to the support department for the input. Assume that the treatment outcome can be interpreted in monetary units. $T(\mu_S)$ is the treatment outcome when S human capital is available to M i.e. when the parties trade with each other. $C(\sigma_M)$ is the support department's production cost for the input. The treatment outcome is improved when M invests more (i.e. μ_S increases) and S's production cost falls with greater σ_M. That is, the more the parties invest in their relationship the greater is the surplus from trade (i.e. treatment outcome minus cost). This reflects the benefits of increased coordination in the joint production of hospital care.

On the other hand the parties may also decide not to enter the transaction (*no-trade*) i.e. they have an outside-option. In the outside option M buys a generic input and S sells a generic input on the open market; the market price is denoted $\bar{v}$. Here generic means that the input is not adjusted to fit the transaction between M and S. The production cost for a generic input is $c(\sigma_M; P_S)$ and P_S are the asset owned by S in the outside option. Notably, S makes the same relationship-specific investment also in this case.[18] Given this investment S has to incur a cost to make the input generic, i.e. although the investment always is beneficial it creates an extra cost in no-trade. It is assumed that $c(\sigma_M; P_S) > C(\sigma_M)$ since it is costly to make the input generic. In the outside option M produces the final good using a generic input and in the absences of S's human capital. The treatment outcome in this cases is $t(\mu_S; P_M)$, where P_M are the assets owned by M. Given the need for coordination in the joint production of health care it is assumed that $t(\mu_S; P_M) < T(\mu_S)$.

Notably asset ownership affects the treatment outcome and the cost in the outside option. Asset ownership matters in the outside option because the parties do not have access to the other party's asset unless they own them - in the trade case both parties have access to all assets, and human capital, but not do necessarily own them. Here P_M may equal $\{p_M\}$ or $\{p_M, p_S\}$ while P_S may equal $\varnothing$ or $\{p_S\}$. That is, it is assumed that S may never own M's assets, because public assets are infrequently for sale, reflecting inertia or a political preference for public ownership.[19] This assumption is called *restricted ownership.* The payoffs in the outside option are given by u_M and u_S.

$$u_M = t(\mu_S; P_M) - \bar{v} \tag{3}$$
$$u_S = \bar{v} - c(\sigma_M; P_S) \tag{4}$$

As already been hinted it is assumed that $T(\mu_S)$ is strictly concave in μ_S and that $C(\sigma_M)$ is strictly convex in σ_M. Moreover, assume that $t(\mu_S; P_M)$ is concave in μ_S and that $c(\sigma_M; P_S)$ is convex in σ_M.[20]

Relationship-specific investments are beneficial in any industry and maybe especially so for the hospital industry, given the joint production and the complementaries between different services in hospital care. This is reflected by the assumption that the surplus from trade is greater than the surplus from no-trade:

$$T(\mu_S) - C(\sigma_M) > t(\mu_S; P_M) - c(\sigma_M; P_S) \tag{5}$$
$$\text{for } \forall\ P_M, P_S \text{ where } P_M \cap P_S = \varnothing, P_M \cup P_S = \{p_M, p_S\}$$

[18] As already noted, investments, for both parties, have a higher value in the transaction than in the outside option, but the investments are also valuable in the outside option. That is, making the investment is beneficial in both cases but to different degrees.

[19] The analysis below deals with the non-integration case when M owns p_M and S owns p_S and the full integration case when M owns both $p_M$and p_S. It abstracts from the case where S owns both p_M and p_S, which is called *type 2 integration* by Hart (1995)

[20] That is, $T'(\mu_S) > 0, T''(\mu_S) < 0$, $C'(\sigma_M) < 0, C''(\sigma_M) > 0$ and $t'(\mu_S) \geq 0, t''(\mu_S) \leq 0$, $c'(\sigma_M) \leq 0, c''(\sigma_M) \geq 0$.

In Hart (1995) it is also assumed that the marginal benefit from an increased investment is greater, or at least as great, the more assets the party making the investment has access to. The ranking of the first derivatives with respect to investments, hereafter called the *marginal conditions*, are the following:

$$\begin{array}{ccccccc} \dfrac{\partial T(\mu_S)}{\partial \mu_S} & > & \dfrac{\partial t(\mu_S; p_M, p_S)}{\partial \mu_S} & \geq & \dfrac{\partial t(\mu_S; p_M)}{\partial \mu_S} & \geq & \dfrac{\partial t(\mu_S; \varnothing)}{\partial \mu_S} \\ \dfrac{\partial C(\sigma_M)}{\partial \sigma_M} & < & \dfrac{\partial c(\sigma_M; p_M, p_S)}{\partial \sigma_M} & \leq & \dfrac{\partial c(\sigma_M; p_S)}{\partial \sigma_M} & \leq & \dfrac{\partial c(\sigma_M; \varnothing)}{\partial \sigma_M} \end{array} \tag{6}$$

The strict inequalities in (6) imply that M's investment is at least partly specific to S's human capital and that S's investment is at least partly specific to M's human capital. For example, if the medical department is a specialist on neuro surgery and the radiology department invests in increased knowledge about brain tomography then the latter's investment is at least specific to the medical department's human capital. The weak inequalities mean that the investments may or may not be specific to the assets p_M and p_S respectively. In the example, the knowledge in brain tomography might be specific to the radiology equipment, p_S, but not to the surgical equipment, p_M or in terms of (6): $\frac{\partial c(\sigma_M; p_M, p_S)}{\partial \sigma_M} = \frac{\partial c(\sigma_M; p_S)}{\partial \sigma_M} < \frac{\partial c(\sigma_M; \varnothing)}{\partial \sigma_M}$.

In equilibrium the parties will trade with each other and not use their outside option. As already stated, trade creates a surplus compared to no-trade, the division of this surplus is decided by negotiation and following Hart (1995) symmetric Nash bargaining with outside options is applied. This negotiation decides the reimbursement from M to S for the input that S supplies, in this case the reimbursement is:[21]

$$v = \bar{v} - \frac{T(\mu_S) - t(\mu_S; P_M) + C(\sigma_M) - c(\sigma_M; P_S)}{2} \tag{7}$$

That is, the parties each get half the surplus from trade relative the outside options. The individual *ex post* benefits from trade are equal to the payoff from trade, after inserting the reimbursement v, minus the investment cost i.e.:

$$\begin{aligned} T(\mu_S) - \bar{v} - \frac{T(\mu_S) - t(\mu_S; P_M) + C(\sigma_M) - c(\sigma_M; P_S)}{2} - \mu_S = \\ = \frac{T(\mu_S) + t(\mu_S; P_M) - C(\sigma_M) + c(\sigma_M; P_S)}{2} - \bar{v} - \mu_S \end{aligned} \tag{8}$$

$$\begin{aligned} \bar{v} - \frac{T(\mu_S) - t(\mu_S; P_M) + C(\sigma_M) - c(\sigma_M; P_S)}{2} - C(\sigma_M) - \sigma_M = \\ = \frac{T(\mu_S) - t(\mu_S; P_M) - C(\sigma_M) - c(\sigma_M; P_S)}{2} + \bar{v} - \sigma_M \end{aligned} \tag{9}$$

In the *second-best world* of incomplete contracting M and S choose investments non-cooperatively at date 0 to maximize (8)and (9) respectively. Hart

[21] Calculated by maximizing the Nash Bargaining product:
$NBP = [(T(\cdot) - v) - (t(\cdot) - \bar{v})] \times [(v - C(\cdot)) - (\bar{v} - c(\cdot))]$

(1995) shows that the non-cooperative choice of investments leads to under-investments, for any ownership structure, compared to the *first-best*. In the first-best the investments are chosen cooperatively in period 0 to maximize total surplus from trade. The second-best first order conditions are:

$$\frac{1}{2}\frac{\partial T(\mu_S)}{\partial \mu_S} + \frac{1}{2}\frac{\partial t(\mu_S; P_M)}{\partial \mu_S} - 1 = 0 \quad (10)$$

$$-\frac{1}{2}\frac{\partial C(\sigma_M)}{\partial \sigma_M} - \frac{1}{2}\frac{\partial c(\sigma_M; P_S)}{\partial \sigma_M} - 1 = 0 \quad (11)$$

In this model ownership, organization, matters because it affects marginal benefit of no-trade. The marginal benefit of an investment is greater or at least as great, depending on the nature of the assets and investments, if the investing party owns more assets, see (6). The intuition is that the investing party will invest more if the reduction in benefit in no-trade, compared to trade is low, and this is generally the case when it owns more of the assets.

3.1.2 Organizational Choice

The aim of the analysis is to decide the optimal organization for the bilateral transaction under certain circumstances. These circumstances are typically characteristics of assets and human capital, but the characteristics of investments may also be a factor. Definition 1 and 2 define the effects of two important characteristics for the production of hospital care.[22]

Definition 1 *Asset p_M and p_S are strictly complementary if either $t'(\mu_S; p_M) \equiv t'(\mu_S; \varnothing)$ or $c'(\sigma_M; p_S) \equiv c'(\sigma_M; \varnothing)$*

Definition 2 *M's human capital (S's human capital) is essential if $c'(\sigma_M; p_M, p_S) \equiv c'(\sigma_M; \varnothing)$ ($t'(\mu_S; p_M, p_S) \equiv t'(\mu_S; \varnothing)$)*

Strict complementarity implies that incentive for investment, for one of the parties, in the outside option (i.e. where ownership matters) is unaffected by ownership unless the party owns both assets. That is, owning only one of the assets does not increase the marginal return of investments. Essential human capital, on the other hand, implies that the investment incentive for the non-essential party is equalized over ownership structures.

In the analysis below two organizational forms are considered: *non-integration* and *integration.* Non-integration is in this model equivalent to contractual network. Notably, the incentives for investments are given by the first order conditions in the different organizational structures:

Under non-integration (N) the first-order conditions become:

$$\frac{1}{2}\frac{\partial T\left(\mu_S^N\right)}{\partial \mu_S^N} + \frac{1}{2}\frac{\partial t\left(\mu_S^N; p_M\right)}{\partial \mu_S^N} = 1 \quad (12)$$

$$-\frac{1}{2}\frac{\partial C\left(\sigma_M^N\right)}{\partial \sigma_M^N} - \frac{1}{2}\frac{\partial c\left(\sigma_M^N; p_S\right)}{\partial \sigma_M^N} = 1 \quad (13)$$

[22] Definition 4 and 5 in Hart (1995) with appropriate adaptations to the current model.

Under full integration (F) the first-order conditions become:

$$\frac{1}{2}\frac{\partial T\left(\mu_S^F\right)}{\partial \mu_S^F}+\frac{1}{2}\frac{\partial t\left(\mu_S^F;p_M,p_S\right)}{\partial \mu_S^F} = 1 \quad (14)$$

$$-\frac{1}{2}\frac{\partial C\left(\sigma_M^F\right)}{\partial \sigma_M^F}-\frac{1}{2}\frac{\partial c\left(\sigma_M^F;\varnothing\right)}{\partial \sigma_M^F} = 1 \quad (15)$$

(6) state that M will invest at least as much under integration as under non-integration, while it is the other way around for S. That is: $\mu_S^F \geq \mu_S^N$ and $\sigma_M^F \leq \sigma_M^N$. To determine which ownership structure that is best for the public hospital one needs to find the structure supports the greatest investments and hence creates the greatest total surplus. Notably, any ownership structure change that increases investments by one party, and does not decrease the other party's investment is beneficial for the transaction. This because of the inherent under-investments in the second-best, i.e. a change in ownership structure with the described effect on investments will imply that the economy comes closer to the first-best. A change of this kind is thus a Pareto improvement relative the starting point for the analysis.

Two Starting Points for the Analysis It is important to establish the starting point for the analysis, especially when there are rigidities in the allocation of asset e.g. a political opinion for public ownership or organizational inertia in public hospitals.[23] The assumption of restricted ownership could reflect a rigidity in the allocation of assets. When thinking about public hospitals it is natural to think of them as large integrated entities, possibly inefficient and in need of disintegration i.e. privatization of certain activities. Thus one natural starting point is full integration. One could also think of a public principal wanting to construct a new *hospital division* or *treatment unit* consisting of support services and medical services. In this case non-integration is the natural starting point. The two starting points yield two different strands of analysis labeled, as above, *privatization and construction*. Next both views are exemplified using definition 1 and 2.

Strict Complementarity In the production of hospital care it is reasonable to assume that the assets are complementary and thus that either $t'\left(\mu_S;p_M\right) = t'\left(\mu_S;\varnothing\right)$ or $c'\left(\sigma_M;p_S\right) = c'\left(\sigma_M;\varnothing\right)$. That is, the complementarity of assets either implies that M is indifferent between owning p_M and not owning p_M, or that S is indifferent indifferent between owning p_S and not owning p_S. The reason for this is that p_M is useless without p_S, and *vice versa*, when the assets are strictly complementary. Complementarity implies that some form of integration is optimal (Hart, 1995). Given the assumption about restricted

[23] If there are no such rigidities and assets are easily allocated and reallocated the starting point could be less important and *relative productivity of investments* more important for the organizational choice. See Rehn (2007) for a more detailed discussion of these issues, and section 4 for brief discussion of relative productivity.

ownership the case when $t'(\mu_S; p_M) = t'(\mu_S; \varnothing)$ becomes irrelevant. Thus if the assets are complementary then the complementarity implies that $c'(\sigma_M; p_S) = c'(\sigma_M; \varnothing)$ i.e. that S is indifferent. The intuition is that S as a support service is dependent on access to the other party's (the party S is supporting) asset to be able to realize a higher marginal benefit of the investment when the assets are complementary. M, on the other hand, that produces the final product might be able to realize a greater marginal benefit, compared to the case when M does not own any assets, by only owning p_M in the outside option, especially given the restricted ownership assumption, even if assets are complementary.

Construction Here the starting point for the analysis is non-integration. Obviously strict complementarity, that makes S indifferent in the sense described above, implies that (13) and (15) are the same, which in turn implies that $\sigma_M^F = \sigma_M^N$. That is, S invests as much under integration as under non-integration. M, on the other hand, invests weakly more under integration ($\mu_S^F \geq \mu_S^N$) thus integration entails a weak Pareto improvement over non-integration.

Privatization Does disintegration increase the total relationship-specific investments, i.e. the joint production/ coordination, compared to full integration when assets are strictly complementary? The answer is no. As in the construction case strict complementarity implies that S makes the same investment under both non-integration and full integration while M will invest weakly less under non-integration than under full integration. Thus privatization does not constitute a Pareto improvement in this setting.

Essential Human Capital One or both parties human capital may be essential for the production of hospital care, e.g. the doctors and nurses at the medical department. The question is how this affects the choice of organization. Definition 2 formalizes the idea of essential human capital, it says that if one party's human capital is essential then ownership does not matter for the other party in its outside option. That is. if e.g. M's human capital is essential for the production of hospital care, then S's marginal (no-trade) benefit of investments is independent of ownership i.e. $c'(\sigma_M; p_M, p_S) = c'(\sigma_M; p_S) = c'(\sigma_M; \varnothing)$. In short the absence of M's human capital makes asset ownership irrelevant.

Construction Starting from non-integration and assuming that M's human capital is essential gives that integration is a Pareto improvement. To see this note that the solutions to (13) and (15) are the same (asset ownership has no effect on S's investment incentive), while $\mu_S^F \geq \mu_S^N$ still holds. Notably, if M's human capital is essential this effect overrides any effect from the relation between assets, that is integration is optimal irrespective of assets being complements or independent when M's human capital is pivotal for the production of hospital care. This begs the question whether M's human capital is essential. Given that M is a medical department and medical care is the primary output

from a hospital it is natural that M's human capital is essential. What about S's human capital? It is of course important in the joint production of hospital care but in most cases not essential.[24] However, even if S's human capital is essential as well, i.e. if both parties human capital is essential, this does not alter the conclusion that integration is optimal, in the sense that it is still in the set of optimal organizational forms, because organizational form does not matter in this case - "... neither party's investment will pay off in the absence of agreement with the other" (Hart, 1995:48).

Privatization Clearly, disintegration or privatization does not constitute a Pareto improvement over full integration when M's human capital is essential. That is, S will make the same investment but M will invest less if the asset p_S is reallocated from M to S. If both M and S human capital is essential then privatization is an option. However all other organizational forms are equally good because the incentives for investments are the same in all ownership structures for both parties. Thus if privatization is opted for in this case it can be made without cost, in terms of the model, but it is not an improvement as such.

3.1.3 Conclusion M & S

The analysis provides a strong case for integration given that assets are strictly complementary in the way described and that the medical department's human capital is essential for the production of hospital care. Both assumptions are likely to hold for many treatments performed in hospitals. Interestingly privatization of the support service is weakly Pareto dominated by keeping the vertical structure in all instances. Furthermore, also when constructing new treatment units integration should be opted.[25]

3.2 Medical Department plus Hotel Service

Now consider a different setup, in this new setup the transaction involves a hotel service, H, and a medical department/public principal, M. M owns one asset p_B and H owns one asset p_H. H's asset is for example a kitchen (kitchen equipment) where the patients' food is produced. M uses this input in the production of hospital care, e.g. during *pre-* and *post*-operative care. The medical department pays H a reimbursement h for the input. Furthermore, M makes an investment in its physical asset while H invests in human capital. Thus this section deals with another and as will be seen somewhat different, bilateral transaction needed in the production of hospital care. First, the case

[24] One might argue (concerning essential human capital) that a surgeon should be able to produce usable diagnosis and/or X-ray images if she has the equipment needed (assets), while a X-ray engineer would most likely fail at performing surgery even if she had the equipment.

[25] This might be interpreted in terms of *lean production* where complementary assets and competencies should be close to each other. This to enable a quick and comprehensive treatment of patients. (see e.g. Kollberg et al (2006) for a discussion of lean thinking and health care)

when M makes generic investment is looked at, followed by the case when M makes a specific investment. In both cases M's physical asset may be thought of as a building or some asset not directly used in the production of hospital care. Thus the public principal might be less restricted in disposing of this asset than other assets used directly in the production of health care. One might actually think of M having two assets p_M and p_B. Hence the assumption of restricted ownership is relaxed for p_B in the two scenarios below.

3.2.1 A Generic Investment by M

Here H makes a relationship-specific investment δ in period 0, this investment is an investment in human capital e.g. educating the kitchen personnel about suitable food for different diseases and/or the hospitals special requirements about nutrition values and cooking procedures. The hospital management (the medicine department) makes a generic investment β in the physical asset p_B, e.g. a building where the kitchen may be placed, in period 0. The investment is generic in the sense that it is not specific to H's asset, i.e. any kitchen equipment may be placed in this building. This investment increases the value of the asset in the transaction, but also in all other uses - the increase in value is independent of both H and M's participation in the transaction once the investment is made (c.f. Hart, 1995). The payoffs from trade are the following:

$$U_M = Z(\beta) - h \tag{16}$$

$$U_H = h - L(\delta) \tag{17}$$

Where $Z(\beta)$ is the treatment outcome when H's human capital is available and $L(\delta)$ is the cost of producing hotel services when the investment β (in practice a part of p_B) and M's human capital are available to H. If the two parties do not trade with each other they have to buy and sell the hotel service on the open market. $\bar{h}$ is market price for a generic hotel service. The payoffs in the outside option are the following:

$$u_M = z(\beta; P_B) - \bar{h} \tag{18}$$

$$u_H = \bar{h} - l(\delta; P_H) \tag{19}$$

$z(\beta; P_B)$ is the treatment outcome in the absence of H's human capital and $l(\delta; P_H)$ is the production cost in the absence of M's human capital. P_B denotes the assets available to M in the outside option, and $P_B = \varnothing$, $P_B = \{p_B\}$ or $P_B = \{p_B, p_H\}$. Similarly, P_H is the assets available to the supplier of hotel services if the parties do not trade with each other, and $P_H = \{p_B, p_H\}$, $P_H = \{p_H\}$ or $P_H = \varnothing$. The marginal conditions are in this case:

$$\frac{\partial Z(\beta)}{\partial \beta} = \frac{\partial z(\beta; p_B, p_H)}{\partial \beta} = \frac{\partial z(\beta; p_B)}{\partial \beta} > \frac{\partial z(\beta; \varnothing)}{\partial \beta} = 0 \tag{20}$$

$$\frac{\partial L(\delta)}{\partial \delta} < \frac{\partial l(\delta; p_B, p_H)}{\partial \delta} \leq \frac{\partial l(\delta; p_H)}{\partial \delta} \leq \frac{\partial l(\delta; \varnothing)}{\partial \delta} \tag{21}$$

The derivative $\frac{\partial z(\beta;\varnothing)}{\partial \beta}$ equals zero because an investment in p_B is of no value to M, in the outside option, when M does not own p_B . Furthermore, the equalities in (20) are explained by the assumption that β is an generic investment in the physical asset (p_B) - thus the presence of H's human capital and physical asset has no effect on the marginal benefit of this investment. However the presence of H's human capital has a positive effect on the treatment outcome in an absolute sense, there is therefore a surplus from trade i.e.: $Z(\beta) - L(\delta) > z(\beta; P_B) - l(\delta; P_H)$ for all ownership structures. This surplus is divided through negotiations and once again the Nash bargaining solution is applied to find the reimbursement h, which in this case is:

$$h = \bar{h} + \frac{Z(\beta) - z(\beta; P_B) + L(\delta) - l(\delta; P_H)}{2} \tag{22}$$

Inserting this h in the payoffs from trade and subtracting the investment cost produces the *ex post* benefits from trade. The first order conditions are given by maximizing these benefits with respect to the investments. In this setting three organizational forms are considered M-integration, H-integration and non-integration. Skipping the first order conditions in the general case, the first order conditions under non-integration (N), M-integration (M) and H-integration (H) are:

$$\frac{1}{2}\frac{\partial Z\left(\beta^N\right)}{\partial \beta^N} + \frac{1}{2}\frac{\partial z\left(\beta^N; p_B\right)}{\partial \beta^N} = 1 \tag{23}$$

$$-\frac{1}{2}\frac{\partial L\left(\delta^N\right)}{\partial \delta^N} - \frac{1}{2}\frac{\partial l\left(\delta^N; p_H\right)}{\partial \delta^N} = 1 \tag{24}$$

$$\frac{1}{2}\frac{\partial Z\left(\beta^M\right)}{\partial \beta^M} + \frac{1}{2}\frac{\partial z\left(\beta^M; p_B, p_H\right)}{\partial \beta^M} = 1 \tag{25}$$

$$-\frac{1}{2}\frac{\partial L\left(\delta^M\right)}{\partial \delta^M} - \frac{1}{2}\frac{\partial l\left(\delta^M; \varnothing\right)}{\partial \delta^M} = 1 \tag{26}$$

$$\frac{1}{2}\frac{\partial Z\left(\beta^H\right)}{\partial \beta^H} + \frac{1}{2}\frac{\partial z\left(\beta^H; \varnothing\right)}{\partial \beta^H} = \frac{1}{2}\frac{\partial Z\left(\beta^H\right)}{\partial \beta^H} = 1 \tag{27}$$

$$-\frac{1}{2}\frac{\partial L\left(\delta^H\right)}{\partial \delta^H} - \frac{1}{2}\frac{\partial l\left(\delta^H; p_B, p_H\right)}{\partial \delta^H} = 1 \tag{28}$$

Organizational Choice Since M owns p_B both under non-integration and M-integration and the investment β increases the value of this asset irrespective of the ownership structure they will make the same investments in both cases

i.e. $\beta^N = \beta^M$. The same reasoning gives that M will invest less under H-integration. When M owns p_B H does not get a part of the increase in value from the investment, i.e. the asset owner receives the full increase in value (c.f. Hart 1995). H, the other hand, will invest weakly more the more assets H owns hence $\delta^H \geq \delta^N \geq \delta^M$ (see (21)). Under H-integration M will invest strictly less and H will invest weakly more than under both M-integration and non-integration, thus H-integration is not a Pareto improvement irrespective of the starting point. Non-integration, however, implies that H will invest weakly more than under M-integration while M will make the same investment, hence non-integration is an Pareto improvement over M-integration. This reasoning also gives that non-integration cannot be improved on if this is the starting point.

It is obvious that the best organizational choice this transaction is non-integration with each party owning its own asset. This is in line with casual observation of modern public hospitals suggesting that hotel services like laundry, cleaning and cooking often are outsourced i.e. not integrated in the hospital organization.

3.2.2 A Specific Investment by M

Once again H makes the relationship-specific investment δ in period 0, but this scenario M's investment β in the asset p_B is specific to H's asset p_H. Imagine for example that M invests in adapting a building such that it fits the specific type of kitchen inventory that H works with better than most competitors' equipment - i.e. there is some significant difference between H's equipment and generic equipment. The more M invests in making p_B suitable for p_H the costlier will it be not to trade with H (as long as H owns p_H) . That is, the cost of making p_B generic again increases with the investment. Call this cost b (the *readjustment cost*). Let b be an increasing function in the investment β such that $\frac{db(\beta)}{d\beta} \geq 0$ and $\frac{d^2b(\beta)}{d^2\beta} \geq 0$. This cost affects the M's payoff from no-trade (the payoff from trade is unaffected):

$$z\left(\beta, b\left(\beta\right); P_B\right) - \bar{h} \tag{29}$$

Obviously the cost lowers the benefit from no-trade compared to the case when investments do not have a readjustment cost. Moreover, the cost b has a negative effect on M's payoff in the outside option:

$$\frac{\partial z\left(\beta, b; P_B\right)}{\partial b} \leq 0 \text{ for a given } \beta$$

This implies that the investment β is more valuable (less costly) when M and H trade with each other. However, since β is an investment in p_B that is specific to p_H (H's physical capital) the increase in value is independent of both H and M's participation in the transaction, but will depend on the access to both

assets. Specifically, assume that the negative effect of the readjustment cost on M's no-trade benefit is zero when M owns both asset, i.e.:

$$0 = \frac{\partial z\left(\beta, b; p_B, p_H\right)}{\partial b} \geq \frac{\partial z\left(\beta, b; p_B\right)}{\partial b} \text{ for a given } \beta \tag{30}$$

Now assume that the inequality in (30) is strict, implying that effect of the readjustment cost is strictly negative when M only owns p_B.

The total effect on M's benefit from the investment under no-trade is a composite of a benefit and a cost effect:[26]

$$\frac{dz\left(\beta, b\left(\beta\right); P_B\right)}{d\beta} = \frac{\partial z\left(\beta, b\left(\beta\right); P_B\right)}{\partial \beta} + \frac{\partial z\left(\beta, b\left(\beta\right); P_B\right)}{\partial b}\frac{db(\beta)}{d\beta} \tag{31}$$

where $\frac{\partial z(\beta, b(\beta); P_B)}{\partial \beta} \geq 0$[27] is the benefit effect and it is already assumed that $\frac{db(\beta)}{d\beta} \geq 0$, i.e. the negative effect is multiplied by the impact of increased investments on the readjustment cost. The total effect of the investment also depends on the assets owned by M. The total effect on benefit (given the assumptions above) is strictly greater when M owns both p_B and p_H, unless the readjustment cost does not rise with investment i.e. unless $\frac{db(\beta)}{d\beta} = 0$. To make things interesting assume that the readjustment cost is strictly increasing in the investment β. In this case the marginal conditions are (note that marginal cost structure for H is unchanged and still given by relation (21)):

$$\begin{gathered}\frac{\partial Z\left(\beta\right)}{\partial \beta} = \frac{dz\left(\beta, b\left(\beta\right); p_B, p_H\right)}{d\beta} > \frac{dz\left(\beta, b\left(\beta\right); p_B\right)}{d\beta} \geq \frac{dz\left(\beta, b\left(\beta\right); \varnothing\right)}{d\beta} = 0 \\ \frac{\partial L\left(\delta\right)}{\partial \delta} < \frac{\partial l\left(\delta; p_B, p_H\right)}{\partial \delta} \leq \frac{\partial l\left(\delta; p_H\right)}{\partial \delta} \leq \frac{\partial l\left(\delta; \varnothing\right)}{\partial \delta}\end{gathered} \tag{32}$$

The equality in (32) stems for H's human capital being unimportant, in a marginal sense, as long as M has access to the asset p_H. The inequality in (32) is strict since it is assumed that $\frac{db(\beta)}{d\beta} > 0$, and once again the incentives for M to make the investment in p_B, in the outside option, is zero if M does not own this asset. However, as in the previous setup trade is beneficial for both parties. That is, the presence of H's human capital is beneficial (given H's investments in human capital) for M and the other way around. This creates a surplus from trade. To divide the surplus Nash bargaining applies also in this case yielding similar *ex post* benefits, to the generic setup, and thus similar first

[26] Assume that $\frac{dz(\beta, b(\beta); P_B)}{d\beta} \geq 0$, i.e. the total effect of making investments is positive, so that it is worthwhile making the investment. Furthermore note that $\frac{d^2 z(\beta, b(\beta); P_B)}{d\beta^2} \leq 0$ if $\frac{\partial z(\beta, b(\beta); P_B)}{\partial \beta \partial b} \leq 0$ and $\frac{\partial^2 z(\beta, b(\beta); P_B)}{\partial b^2} \leq 0$ - assume that this is the case, implying that the marginal benefit of the investment β is decreasing.

[27] Assume $\frac{\partial^2 T(\beta, b(\beta); P_M)}{\partial^2 \beta} \leq 0$, i.e. that benefit is decreasing in β.

order conditions (identical for H).The first order conditions for non-integration, M-integration and H-integration respectively become:

$$\frac{1}{2}\frac{\partial Z\left(\beta^N\right)}{\partial \beta^N}+\frac{1}{2}\frac{dz\left(\beta^N,b\left(\beta^N\right);p_B\right)}{d\beta^N}=1 \tag{33}$$

$$-\frac{1}{2}\frac{\partial L\left(\delta^N\right)}{\partial \delta^N}-\frac{1}{2}\frac{\partial l\left(\delta^N;p_H\right)}{\partial \delta^N}=1 \tag{34}$$

$$\frac{1}{2}\frac{\partial Z\left(\beta^M\right)}{\partial \beta^M}+\frac{1}{2}\frac{dz\left(\beta^M,b\left(\beta^M\right);p_B,p_H\right)}{d\beta^M}=1 \tag{35}$$

$$-\frac{1}{2}\frac{\partial L\left(\delta^M\right)}{\partial \delta^M}-\frac{1}{2}\frac{\partial l\left(\delta^M;\varnothing\right)}{\partial \delta^M}=1 \tag{36}$$

$$\frac{1}{2}\frac{\partial Z\left(\beta^H\right)}{\partial \beta^H}+\frac{1}{2}\frac{dz\left(\beta^H,b\left(\beta^H\right);\varnothing\right)}{d\beta^H}=\frac{1}{2}\frac{\partial Z\left(\beta^H\right)}{\partial \beta^H}=1 \tag{37}$$

$$-\frac{1}{2}\frac{\partial L\left(\delta^H\right)}{\partial \delta^H}-\frac{1}{2}\frac{\partial l\left(\delta;p_B,p_H\right)}{\partial \delta^H}=1 \tag{38}$$

Organizational Choice It is obvious from (32) that $\beta^M>\beta^N\geq\beta^H$ - given that the benefit of investments is concave in β. Moreover, the investment β is an adjustment of p_B to make it complementary (specific) to p_H. Now, assume that the investment β ensures strict complementarity between the assets, i.e. that if this investments is made then p_B and p_H are strictly complementary. Definition 1 says that if the assets are strictly complementary then either 1) $\frac{\partial l(\delta;p_H)}{\partial \delta}\equiv\frac{\partial l(\delta;\varnothing)}{\partial \delta}$ or 2) $\frac{dz(\beta,b(\beta);p_B)}{d\beta}\equiv\frac{dz(\beta,b(\beta);\varnothing)}{d\beta}$.

If 1) holds then H is indifferent between owning and not owning p_H and M will obviously have greater incentives for investments if it owns all assets. Thus a move from non-integration between M and H to M-integration would entail a Pareto improvement. By the same token a move from M-integration to non-integration with H owning its asset (privatization) is not an Pareto improvement - H will make the same investment and M will invest less. Obviously H-integration does not constitute a Pareto improvement either, since then would M invest less (strictly or weakly) than under both M-integration and non-integration.

If 2) applies then M, in anticipation of this, will not make the investment unless owning both assets. This since the marginal value of an investment in a physical asset only accrues to the owner of the asset and therefore will the party not owning the asset make a zero investment (c.f. Hart, 1995). In this

case the marginal value of the investment when owning the asset, p_B, is equal to the marginal value when not owning the asset, hence no investment is made unless M owns both assets. It is a radical conclusion that M will only invest in the their own asset if they also own p_H, and it implies that M-integration gives M incentive to make the investment, but not non-integration. But M-integration is not a Pareto improvement over non-integration, this since H will invest weakly more if they own p_H than if they do not, i.e. $\delta^M \leq \delta^N$. However, H-integration would be an improvement, albeit with no investment from M, over non-integration since H invests more. Obviously would a move from M-integration a disintegrated structure (or H-integration) not constitute a Pareto improvement since M would then not make the investment.

Thus if 2) applies then H-integration is an Pareto improvement in the construction scenario (i.e. with non-integration as the starting point), if zero investments by M are acceptable. Furthermore if the starting point is M-integration then privatization (non-integration or H-integration) is not a Pareto improvement. Thus depending on the starting point the optimal organizational structure is one of the extreme i.e. either H-integration or M-integration.

Complementary Investments It seems somewhat strange that the optimal organizational structure involves zero investments from M as it does in the construction scenario in 2). This especially since M's investment is an investment specific to H's asset that should be valuable to both parties if its made. One way to make the investment valuable to both parties is to assume that the parties investments are complementary. For example, an investment in educating the kitchen personnel about hygiene would be more valuable to H if M at the same time made an investment in the special equipment needed to put this knowledge into use e.g. disinfection equipment.[28]

If the benefit of H's investment is closely linked to the investment made by M then a zero investment by M is a rather unsatisfactory solution. Unsatisfactory in the sense that benefit from trade for H would be higher if M made some investment. This kind of complementarity is implicitly assumed in the statement that $L(\delta)$ is the production cost when M's human capital and β is available to H (see the previous subsection). Thus, it is in line with the rest of the model to assume that:

$$L(\delta : \beta) < L(\delta : 0) \tag{39}$$

where $L(\delta : \beta)$ is the production cost when some investment β is made, and $L(\delta : 0)$ is the production cost when no investment is made.[29] However this realization by itself does not give M any incentives to make investments, but if it is coupled with the some ownership of p_H it might.

Joint ownership of the asset p_H could be a way to ensure positive investments from M and at the same time maintain H's level of investments. If the parties

[28] Admittedly not a very specific investment, but for the sake of argument assume that it is specific to the kitchen equipment used by H.

[29] The intuition is straightforward, if M does not make the necessary adjustments of the building H either has to make them themselves or experience a greater production cost because the building is ill-fitting for their production.

decide on joint ownership of p_H and both parties have *veto* power or the use of the asset any increase in surplus, from the investment, will be shared $50:50$ under Nash bargaining (see Hart, 1995). Here the increase in surplus is $Z(\beta) - Z(0) - z(\beta, b(\beta); \{p_B, p_H\}) + z(0; p_B) + L(\delta:0) - L(\delta:\beta)$. Where 0 indicates that M do not make any investment when they only own p_B. Thus M will get $\frac{1}{2}[Z(\beta) - Z(0) - z(\beta, b(\beta); \{p_B, p_H\}) + z(0; p_B) + L(\delta:0) - L(\delta:\beta)]$ if they make the investment, and they will make the investment if and only if this covers the cost of investment, i.e:

$$\beta > 0 \text{ iff } \frac{1}{2}\left[\begin{array}{c} Z(\beta) - Z(0) - z(\beta, b(\beta); \{p_B, p_H\}) + \\ +z(0; p_B) + L(\delta:0) - L(\delta:\beta) \end{array}\right] \geq \beta \tag{40}$$

When (40) applies then joint ownership of H's asset is an improvement over non-integration, i.e. it increases M's investment without lowering H's investment.[30]

Is joint ownership an improvement over M-integration? Given that M has *veto* power over the use of assets its incentive for investments is unaltered by the move from M-integration to non-integration, this while H's investment increases. Thus joint ownership as a Pareto improvement irrespective of the starting point if the investments δ and β are complementary in the sense described here.

3.2.3 Conclusion M & H

The optimal way to organization the transaction between a medical department/public principal and a hotel service depends on the characteristics of investments. In this section it is assumed that the hotel service makes an investment in its human capital and that the medical department invests in its physical asset. If the medical department's investment is generic then non-integration is optimal. If the investment is specific to the hotel service's asset then the transaction may be organized in three ways depending on the starting point, and the complementarity of investments and assets.

When the assets are strictly complementary, such that H is indifferent between owning and not owning p_H, then M-integration is the best organizational structure irrespective of the starting point. If the strict complementarity implies that M's indifferent over owning or not owning p_B, then H-integration is an improvement over non-integration and M-integration cannot be improved on if it is the starting point. This if zero investments by M are acceptable. However, if M's investment matters to H, i.e. the two parties investments are complementary, then joint ownership of p_H is the best option irrespective of the starting point.

[30] H's inventive for investments is unaltered since they have *veto* power over the use of the asset.

4 Extensions to the Analysis

This paper has so far analyzed two different bilateral transactions, but as already been mentioned the joint production of hospital care in many instances involve more than two parties. In this section the effects of an extension to a trilateral transaction is discussed, and thereafter is another extension, the inclusion of relative productivity of investments in the analysis, briefly touched upon.

4.1 Trilateral Transactions in Public Hospitals

In general a hospital consists of many different medical departments, support departments and hotel services. These services and departments are all involved, to different degrees, in the joint production of hospital care. Many of the factions of the hospital are not only involved in bilateral transactions but also in multilateral transactions. Medical departments, for example, supply inputs to each other using inputs from support services and hotel services in a complex pattern of internal demand and internal supply. Thus a natural extension to the bilateral model is to analyze the organization of a more complex transaction e.g. a trilateral transaction. Rehn (2007) extends the property rights approach to encompass trilateral transactions of the type described in figure 4.

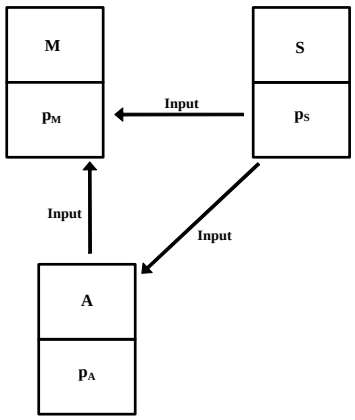

Figure 4: The trilateral transaction

Now, assume that A (in figure 4) is a medical department (e.g. a cardiology department). M is, as above, a medical department (e.g. surgeon) and the public principal and S is a support service (e.g. radiology department). Issues concerning hotel services are abstracted from in this section, this done for two reasons: first, trilateral transactions involving two medical departments and one support service seem commonplace and important in hospitals (see section 1); and second, hotel services are further from the core activities of hospitals

than medical departments and thus less interesting to include in the trilateral transaction.

As above M produces the final good but now it uses inputs both from S and A. Moreover A uses an input produced by S in its production. Thus S produces inputs to both M and A and the two inputs are not the same product. The three parties make relationship-specific investments in their human capital and use one asset each for their production (see figure 4). In these aspects and in all other aspects, but one, the model replicates Rehn (2007). The exception is that here restricted ownership is assumed i.e. that M will always own the asset p_M. This limits the number of possible organizational forms to six (instead of ten), but besides this the results presented here stem directly from Rehn (2007).

In a trilateral model it is possible to create large number of examples of organizational choices by varying starting points, characteristics of assets, human capital and investments, but here the focus is on two questions: *When is privatization optimal?* and *When should full integration be opted for?*

When is Privatization Optimal? Here the starting point is M-integration i.e. that the public principal owns all assets (p_M, p_A and p_S). Thus, privatization/disintegration entails that some of M's assets are reallocated to the other parties and because investments increase with asset ownership, as in the bilateral model, something special is required to make privatization optimal. In fact privatization is only a Pareto improvement if both A and S's human capital is essential. If this is the case then any other form of organization than M-integration is a Pareto improvement i.e. increases the level of investments by at least one party without changing the other parties' investments. In all other cases M-integration cannot be improved on.

When Should Full Integration be Opted For? Full integration is in this setting equivalent with M-integration since ownership of p_M is restricted. Full integration is interesting because medical services and support services often are vertically integrated in public hospitals. This provides rationale for using full integration as the starting point of the analysis, as above, but also investigating under which circumstances full integration should be used creating a new hospital division or treatment unit involving a trilateral transaction. There are two cases where M-integration constitutes a Pareto improvement over non-integration: 1) if both M and A's human capital are essential and p_M and p_A are strictly complementary such that A is indifferent over ownership that does not include p_M. 2) if p_M and p_S are strictly complementary and p_M and p_A are strictly complementary in a way that makes A and S indifferent. Apparently M-integration is only an improvement under special combinations of characteristics, implying that choosing full integration without information about all characteristics might be suboptimal. Thus the public principal constructing the new division needs information about the characteristics of both human capital and assets before deciding to go for full integration of these activities.

For most other combinations of characteristics the optimal organization is

either some form of partial integration (e.g. M owning S's asset and A owning its own asset) or non-integration (see Rehn, 2007).

4.2 Relative Productivity of Investments

The relative productivity of investments is measured by the different investments relative contribution to total surplus from trade. In the analysis above relative productivity of investments was mentioned, in passing, when discussing the different starting points. In the search for clear-cut Pareto improvements the relative productivity of investments does not matter. This since a Pareto improvement implies greater investments from at least one party and unchanged investments from the others. Could an analysis of public hospitals gain from an introduction of relative productivity?

First it must be noted that an analysis using relative productivity is more demanding, in terms of information and in terms of flexibility in the asset allocation, than an Pareto analysis like the one performed here. Moreover, the relative productivity of investments matters when an organizational change makes the investment level for different parties go in opposite direction. Notably it would be important when discussing privatization since this necessarily implies lower investments by the public principal (M) and, as can be seen in Rehn (2007), it is generally more relevant in the trilateral model than in the bilateral model. Relevant in the sense that investments more often go in opposite directions when the organization changes. Is this more demanding analysis suitable for public hospitals?

The conjecture is that *it could be* for certain transaction e.g. the transaction between M and H in this paper. In this case one might be able to say something about the relative contribution of the investments to total surplus, e.g. that M's investment in the building contributes less to total surplus than H's investment in educating its personnel. But even this is not a clear-cut example and the general idea here is that it is difficult incorporate relative productivity in the analysis. Contributing to this is the assumption of restricted ownership, that may be interpreted as a rigidity in the allocation of assets. This makes it difficult to reap the benefits of relatively productive. In rigid asset market it might be costly, e.g. in this case politically unappealing, to reallocate assets and this together with lower investments by one party may outweigh the relative gain of greater investments by other parties. If the change in asset allocation entailed a clear-cut Pareto improvement this cost would be insignificant since the total level of investments is increased implying a move towards first-best.

Even if there are no rigidities in the allocation of assets the relative productivity of investment might be difficult act on due lack of information. In the hospital setting it is difficult for the parties to assess the relative productivity of an investment e.g. does an investment in the surgeon's knowledge contribute more to the total surplus from hospital care than an investment in the cardiologist's knowledge? This kind question seems hard to answer in a straightforward manner.

5 Concluding Remarks

By studying a straightforward model of the joint production of hospital care this paper produces a number of results. Most interestingly it is found, when studying the transaction involving a medical department (public principal) and a support service, that integration should be opted for both when constructing new treatment units as well as when considering privatization of the support service. Both results are foremost driven by the realization that the medical department's human capital is essential for production of hospital care. This is intuitively appealing, and somewhat trivial, without the cooperation with medical departments most support services would experience difficulties in giving patients suitable treatment. Furthermore, this proposes that public ownership of all assets in the transaction is the best option as long as the public principal's human capital is essential.[31]

Hospitals also consist of hotel services that contribute to the joint production e.g. by producing food and doing laundry. The analysis of the transaction between the medical department and the hotel service reveal that the organization of the transaction depends on the characteristics of investments. In certain circumstances integration should be opted for, in other circumstances the best option is non-integration and in yet other circumstances joint ownership could be the solution. The fundamental lesson concerning this transaction is that being dependent on access to the other party's assets and/or investment lowers the incentive for investments unless some residual control rights over assets can be granted - either through integration or joint ownership. Specific investments in physical capital and complementary investments create such dependence.

If the analysis is extended to trilateral transactions it is found that privatization, i.e. disintegrating an integrated structure, is a Pareto improvement only in very special circumstances. However, it is also found that when constructing new treatment units then full integration, in most instances, is not an improvement over non-integration or partial integration. Thus trilateral transactions that are already integrated should remain integrated and new treatment units should either be non-integrated or partially integrated.

The results in this paper depend on the assumptions about characteristics of investments, human capital and assets. These assumptions need to be scrutinized and compared to the actual characteristics of investments, human capital and assets in public hospitals to enable a conclusion applicable to a specific hospital. This research lies in the future. This paper, however, provides a basic framework for thinking about public hospital organization from a new perspective, that seems useful, this by applying the property rights approach to organizations to the problem.

[31] Obviously, if the public principal were not also a medical department, as assumed here, it would be more questionable that its human capital is essential for hospital care and this would change the conclusion made here.

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