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DRGs: the link between investment in technologies and appropriateness

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Abstract

In this paper we investigate the relationship between the DRG system for hospital reimbursement and investment in technologies. We use a simple economic model where the reimbursement policy for treatments whose provision requires a sunk investment cost has an impact on both the decision *whether to adopt* the technology and *many patients to treat with it*. The optimal pricing policy involves a two-part tariff: a price equal to the marginal cost of the patient whose benefit of treatment equals the cost of provision, and a separate payment for the partial reimbursement of capital costs. Departures from this scheme, which are frequent in DRG tariff systems designed around the world, lead to a trade-off between the objective of making effective technologies available to patients and the need to ensure appropriateness in use.

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1 Introduction

Although there is agreement that the diffusion of new health care technology led to substantial improvement in patient outcomes (Cutler and McClellan, 2001), the sustainability of its impact on health care expenditure is often questioned (Dybczak and Przywara, 2010; Chandra and Skinner, 2011). For the US, Smith et al. (2009) estimate that medical technology diffusion is responsible for 27-48% of growth in total expenditure. It is often argued that at least part of this increase is due to inappropriateness in use (OECD, 2010). There are at least two separate stages at which efficient decisions are essential to ensure that the incremental cost of new technologies is good value for money: adoption and use. In the quest to improve value for money of technological diffusion regulators have employed a wide range of instruments, both direct - *ex-ante* assessments by HTA national agencies, *Certificates of Need* as those employed in several U.S. states - and indirect - price regulation in (quasi-)competitive markets. The impact of these policies on adoption and use of the technologies has been widely investigated, within two largely independent strands of literature.¹ Adoption is studied regardless of use, whereas appropriateness is studied conditional on an adoption decision. In this paper we argue that if the adoption requires an investment cost, the regulatory issues concerning the decisions on whether to adopt the new technology and to whom the treatment should be provided should be studied together. The most obvious example of technology requiring an investment cost is equipment. However, from the technical point of view, our results are equally relevant to any other situation where a fixed cost (e.g. training) must be

¹The literature related to technology diffusion is mainly empirical. For example, the impact of the introduction of “managed care” in the U.S. on technology adoption has been widely studied (Dranove and White, 1994; Bresnahan and Reiss, 1991; Melnick, 1992; Gruber, 1994). Schreyögg et al. (2009) provide an overview of regulatory measures in use in some European countries for medical devices and discuss their implications with respect to the balance between adoption and affordability. Theoretical analyses of the impact of regulation on investments that enhance the quality of the treatment can be found in Bös and De Fraja (2002), Levaggi and Moretto (2008) and Levaggi et al. (2012). Most of the empirical analyses of appropriateness are specific to one technology (recent examples include Roudsari et al. (2012), Cristofaro et al. (2012), Las Hayas et al. (2010) and Hendee et al. (2010)). A more general analysis of appropriateness can be found in Buetow et al. (1997). The impact of regulation on the efficient selection of treatments is theoretically studied in Hafsteinsdottir and Siciliani (2010), Siciliani (2006) and Liu and Ma (2012).

paid before some kind of treatment is provided to patients.

We study indirect regulation, through prices. There may exist a specific tariff for the reimbursement of treatments involving one technology (e.g. diagnostics for outpatient care) or it can be part of the DRG price. Our analysis applies to both situations, as long as at least part of the DRG price is meant to reimburse the treatment provided with the technology of interest.

The efficiency of purely prospective prices has been thoroughly investigated. The literature has shown that it is typically optimal to add a cost sharing component to the contract if the provider has better information about costs than the purchaser (Laffont and Tirole 1993, Allen and Gentler 1991, Ellis and McGuire 1986, 1990). The presence of a sunk cost as a condition for the provision of the treatment is in principle another specific economic condition of interest, which seems to have been overlooked in the literature so far.

This paper presents some of the fundamental policy implications previously derived in a fully stochastic and dynamic framework by Levaggi et al. (2012), using a very simple and intuitive model. We show that when the cost to invest in a technology is sunk the optimal pricing policy involves a two-part tariff: a price equal to the marginal cost of the patient whose benefit of treatment equals the cost of provision, and a separate payment for the partial reimbursement of capital costs. Departures from this scheme, which are frequent in real world health care systems, lead to a trade-off between the objective of providing patients with effective technologies and the need to ensure appropriateness in use. In particular, wider diffusion can only be achieved at the price of reduced appropriateness in use. However, a two-part tariff is not *per se* sufficient to achieve efficiency, because the levels of the two parts should also be efficiently set. Failures to do so may lead to under- or over-provision of equipment with costly duplications, as well as under- or over-provision of treatments. The variability of tariffs that can be observed, sometimes even within the same health care system, suggests that this may be a further area of regulatory failure.

In the following section we describe the regulatory solutions adopted in a number of countries for the reimbursement of treatments provided with technologies that have the characteristics of interest. Section 3 presents the simple model and shows the characteristics of an optimal reimbursement policy. Section 4 links the theoretical results of Section 3 to the real world reimbursement policies introduced in Section 2 and discusses the implications of departing from the optimal rule. Section 5 concludes.

Country	Capital cost financed through DRG	Capital cost financed outside
Austria	Yes	No
England	Yes	No
Estonia	Yes	No
Finland	Yes	No
France	Yes	Yes
Germany	No	Yes
Ireland	No	Yes
Italy	Yes	Yes
Netherlands	Yes	No
Norway	No	Yes
Poland	Yes	Yes
Portugal	No	Yes
Spain	No	Yes
Sweden	Yes	No

Table 1: Capital cost reimbursement across Europe.

2 Capital cost reimbursement around the world

The recent completion of the Euro-DRG project² has shed light on the implementation of the DRG system across several European countries along a number of dimensions (Busse et al., 2011)³. Table 1 integrates a similar table reported in the appendix to Scheller-Kreinsen et al. (2011) with additional sources (HOPE, 2006; Lorenzoni and Pearson, 2011), to compare capital cost reimbursement policies. It should be noticed that the table is meant to reflect the main tendency of national systems. Some of the classifications may be ambiguous, especially for countries with a largely decentralized system.⁴ The first observation that can be made is that no clear prevalence of one scheme emerges. Six countries fund capital costs exclusively through the DRG system (Austria, UK, Estonia, Finland, Netherlands, Switzerland and Sweden). Five use only separate payments (Catalonia / Spain, Germany, Ireland, Portugal). Finally, three use both (France, Italy and Poland). It

²See also <http://www.eurodrgeu>.

³Health Economics has devoted a full supplement to the presentation of the results of the project. See also <http://onlinelibrary.wiley.com/doi/10.1002/hec.v21.S2/issuetoc>

⁴This is the case, for instance, for Austria and Italy.

is also interesting to note that some health care system (Spain, Portugal) are not using a fully local system because they import from other countries either the weight system or the cost base. In this case, although the capital cost is formally reimbursed separately, it may well be that a part of the DRG tariff is available for the reimbursement of capital cost.⁵

Outside Europe, a first look at the policies adopted by two big countries suggests that a similar variability might be a worldwide characteristic: within the U.S. Medicare programme, capital costs are reimbursed within the DRG system (MEDPAC, 2012); Australia, on the other hand, is about to implement a system where they are separately reimbursed (IPHA, 2012), and the price for outpatient services aims to reflect the marginal cost.

The system of some countries cannot be satisfactorily described using only the two dimensions of Table 1 (payment within DRGs or separate). For example, in Belgium important medical equipment and installations are in most cases financed by surgeons and hospital. Although Table 1 provides a very rough characterization of reimbursement systems for treatments involving some capital expenditure, it perfectly fits our research question. The simple model presented in the following section will enable to show the effects on efficiency of the alternative between funding of capital costs within or outside the DRG system.

3 A simple regulatory model

Let μ be the incremental effectiveness of the new technology. The total monetary benefit to treat x patients with it is $\mu b(x)$, with $b(\cdot)$ increasing and concave, i.e. the marginal benefit is decreasing in the number of patients treated. The sunk cost for the adoption of the technology is I . A fraction of this cost, γI , may be reimbursed by the regulator, who sets the parameter γ ($0 \leq \gamma \leq 1$). Notice that $\gamma > 0$ corresponds to a 'Yes' in the last column of Table 1.

Running costs are defined by the convex function $c(x)$, implying that the marginal cost is increasing in the number of patients. Those who are not treated with the new technology receive the base treatment, or no treatment at all. For simplicity, and without loss of generality, we assume zero benefits

⁵If the variable cost in that country is lower than in the one where the cost has been estimated.

and costs for these patients.

The flow of benefits and costs spans over a number of years in real life. For the sake of simplicity, the time-independent functions $b(x)$ and $c(x)$ already incorporate the discounted value of the stream of costs and benefits. This allows us to discuss the key policy implications in a very simple framework.⁶ If the technology is adopted, the provider receives a payment p for each patient treated. In order to capture the main differences across regulatory solutions observed in different countries it is convenient to separate the price into two components:

$$p = c'(x^s) + \eta f(I) \quad (1)$$

The first component is the marginal cost for an efficient number of treatments x^s , which will be characterized in the following subsection. The price always includes this component. $f(I)$ is a generic function of the capital cost that the regulator may include in the price. In particular, this component will enter, to some extent, the price whenever $\eta > 0$. η is the second parameter that the regulator sets, together with γ . A 'Yes' in the first column of Table 1 implies $\eta > 0$.

We assume that the total number of patients in need of treatment, either with the new or the existing technology, is fixed. Our focus is on the link between the reimbursement mechanism and the following two provider's decisions, which bear fundamental policy implications:

1. *whether to adopt the new technology*, given its effectiveness *and*
2. *how many patients* to treat with it.

3.1 The societal optimum

In this section, we characterize the two decisions of interest consistently with the objective of maximizing social welfare, i.e. the difference between total benefits and costs. This allows to set a benchmark respectively in terms of *efficiency in adoption* and *appropriateness* in use of the new technology. The adoption of the new technology is efficient if its effectiveness is such that that the benefits received by patients who receive the treatment, net of the costs of providing those treatments, exceed the investment cost. An appropriate

⁶For the analysis of the dynamic implications, see Levaggi et al. (2012).

use of the technology requires that only patients for whom the benefit of the treatment provided with the new technology exceeds the cost of its provision receive it.

Although adoption is a condition for the provision of treatment, it is convenient to study the decisions in reversed order.

3.1.1 Appropriateness

The previous definition of appropriateness may be formally translated into the following condition:

$$\mu b'(x^s) = c'(x^s) \quad (2)$$

where primes denote derivatives. Eq. (2) is a standard marginal benefit equal to marginal cost result. This condition defines x^s as the optimal number of treatments from the societal perspective. This number is increasing in the level of effectiveness, μ .

3.1.2 Adoption

Given the intensity of use of the technology defined in the previous subsection, efficiency in adoption requires that:

$$\mu b(x^s) > c(x^s) + I \quad (3)$$

i.e. that total benefits exceed total costs. Hence, we can define a threshold value μ^* , such that from the societal perspective it is optimal to adopt the new technology if and only if effectiveness exceeds that level:

$$\mu_s^* = \frac{I + c(x^s)}{b(x^s)}. \quad (4)$$

3.2 Optimal two-part tariff

This section investigates whether the societal optimum can be implemented in a system where, as actually happens in most health care systems, the decisions concerning adoption and the number of patients to treat are left to the provider, whereas the regulator defines the policy parameters η and γ . For simplicity, we assume that the provider maximizes the difference between revenues and costs. Although this may not reflect the complexity of

real world providers' objectives, it does not affect the quality of our results as long as budget considerations matter (Danzon, 1982; Dranove and White, 1994). We follow the same steps as in Section 3.1, starting from the decision on how many patients to treat, and moving then to the decision on whether to adopt the technology, given the previously defined use strategy.

3.2.1 Appropriateness

In order to maximize profits, the provider treats a number of patients x^p such that the following condition is satisfied:

$$p = c'(x^p), \quad (5)$$

that can be rewritten as:

$$c'(x^s) + \eta f(I) = c'(x^p) \quad (6)$$

If $\eta = 0$, then $x^p = x^s$. Hence, the regulator can ensure that the number of patients treated is consistent with the societal optimum by paying a price per patient including only the marginal cost (based on x^s patients) of the treatment.

3.2.2 Adoption

The provider will invest if revenues exceed costs, including both the sunk (net of the γI allowance) and the running component:

$$px^p - c(x^p) - (1 - \gamma)I \geq 0 \quad (7)$$

Following the same steps as in Section 3.1 we can move to the derivation of the minimum value of μ that triggers the investment. Recalling that the price paid to the provider always includes a component reflecting the marginal cost of treating the efficient number of patients ($c'(x^s)$) and that in x^s marginal costs equal marginal benefits, eq. (7) can be rewritten as:

$$x^p [\mu b'(x^s) + \eta f(I)] - c(x^p) - (1 - \gamma)I \geq 0 \quad (8)$$

so that the new threshold value for adoption is

$$\mu_p^* = \frac{I(1 - \gamma) + c(x^p) - x^p \eta f(I)}{b'(x^s) x^p} \quad (9)$$

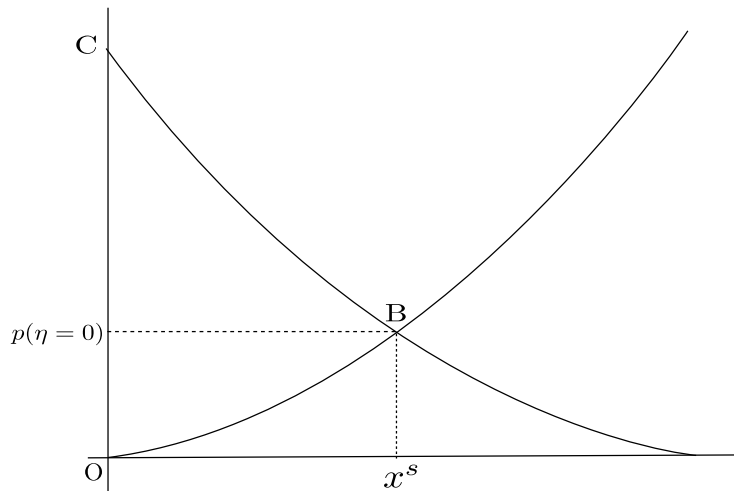


Figure 1: Efficient use of the technology with $\eta = 0$

The regulator should set the pricing parameters so that the adoption decision by the provider is consistent with the societal optimum defined by eq. (4), while preserving appropriateness in use. The latter requires $\eta = 0$. Assuming that η is set in this way, the following equation defines the value of γ such that eq. (9) coincides with eq. (4), i.e. the adoption decision is consistent with the societal optimum:

$$\gamma^* = \frac{I + c(x^s)}{I} \left(1 - \frac{b'(x^s) x^s}{b(x^s)} \right) \quad (10)$$

Figure 1 provides a graphical illustration. By setting the price equal to the marginal cost ($\eta = 0$), the regulator ensures that the number of treatments provided is efficient ($x^p = x^s$). However, benefits from the societal perspective are greater than those enjoyed by the provider. The former equal the area CBx^sO whereas the latter are only a portion of this, pBx^sO . This implies that if the provider is not compensated for this the investment in the new technology will be sub-optimal. Formally, this corresponds to $\mu_p^* > \mu_s^*$: patients do not have access to some technologies (those for which $\mu_s^* \leq \mu \leq \mu_p^*$) whose adoption would be efficient from the societal perspective. However, the regulator can use γ as a further instrument. By setting γ according to eq. (10) the regulator provides the right incentive for the provider to make an adoption decision consistent with the societal optimum

($\mu_p^* \equiv \mu_s^*$). The size of the separate payment γ^*I equals exactly the size of area cpB .

4 Payment rules in practice

The previous section has shown that in the presence of sunk capital costs a two-part tariff can be designed to provide appropriate incentives towards both adoption and use of a technology. With reference to Table 1, this scheme would imply a 'no' in the first column and a 'yes' in the second. The table shows that, among the countries considered, a similar scheme is adopted in only five countries.⁷ Its efficiency also depends on how the parameter γ is fixed and on how well the price per patient reflects the cost of the (efficiently identified) marginal patient, but it has the potential to be so. It is not our objective here to investigate why several countries depart from this scheme. However, it is worth stressing that financial constraints that the purchaser may face are not sufficient to justify a departure. In the model of Section 3 the separate capital cost component is designed as a lump sum payment of γI made to the provider that decides to adopt the technology. The key economic feature of this payment is not that it is made up-front, but that it is independent of the number of patients treated. Therefore, for a piece of equipment that will be in use for a number of years, a scheme may be optimal even if it involves a separate payment of a fraction of γI (appropriately adjusted for discounting) for each year in which the equipment will be in use, provided that: (i) the size of the separate payment is efficiently set, and (ii) its amount is independent of the number of patients treated.

What are the consequences of departing from an optimal scheme? Figure 2 illustrates the trade-off implied by the decision not to reimburse capital costs separately ($\gamma = 0$; 'no' in the second column of Table 1). Appropriateness may only be ensured by setting $\eta = 0$. According to eq. (9) $\eta = 0$ and $\gamma = 0$ implies $\mu_p^* > \mu_s^*$, i.e. under-provision of cost-effective technologies to patients. Referring to Figure 1, this is due to the fact that the provider internalizes only part (area pBO) of the societal net benefits of adopting the technology (area CBO) and this is not compensated by any separate payment of capital costs. Not surprisingly, Table 1 shows that no country

⁷Sometimes experts advise against this decision. See, for example, <http://ihpa.gov.au/internet/ihpa/publishing.nsf/content/future-payment-reform>.

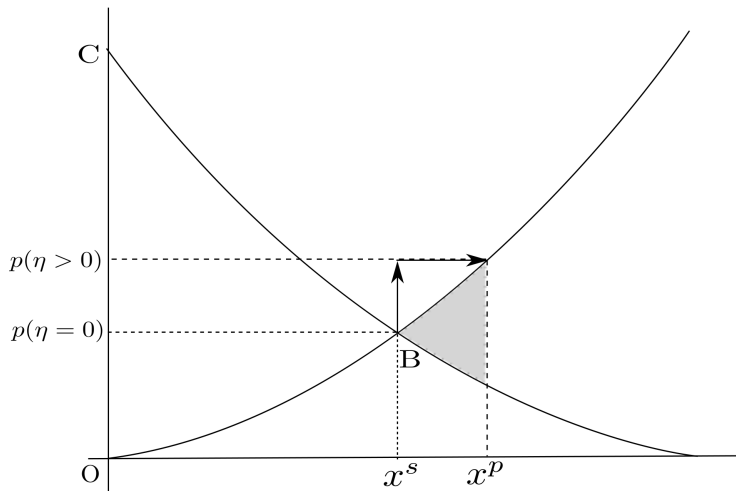


Figure 2: Implications for efficiency in use of setting $\eta > 0$

follows such an extreme policy favoring appropriateness at the price of limited diffusion of technologies, which would imply a 'no' in both columns. Strengthening the incentive to adoption without paying capital costs separately requires increasing the fee per patient ($\eta > 0$; 'yes' in the first column and 'no' in the second). Figure 2 illustrates the trade-off faced by countries following this policy. An increase in p aimed at promoting the diffusion of the technology leads the provider to adjust the number of patients treated from x^s to a larger value in order to satisfy the optimality condition of eq. (5). This enhances the incentive to adopt, but the resulting inappropriateness has a cost in terms of efficiency corresponding to the shaded area. The size of that area and the corresponding efficiency loss expands as the marginal cost and marginal benefit curves get respectively flatter and steeper. The policy implication is that incorporating capital costs into DRGs is particularly inefficient for targeted technologies that can be provided to patients at roughly constant marginal costs.

As a straightforward application of the economic theory of second best, if we interpret $\gamma = 0$ as a constraint, it will be second-best optimal to set the price (through η) so that there is some inappropriateness and some under-provision of the technology. However, if the price is set above the second-best optimum there can be even more inappropriateness and over-provision of the technology with inefficient duplication of fixed costs.

Table 1 shows that there are also countries (France, Italy, Poland) that reim-

burse capital costs both within the DRG and separately ($\eta > 0$ and $\gamma > 0$). Since $\eta > 0$, these schemes are also sub-optimal. However, the fact that part of the incentive to adopt technologies is provided through a separate payment allows to mitigate the trade-off in comparison to the situation where no separate payment is made.

5 Conclusions

The diffusion of large scale medical equipment may have substantial impacts on health care expenditure. It is then essential to grant rapid access to patients who can benefit from the technology, while avoiding costly duplications and inappropriateness in use. The economic implications of the decision for the provider are different from those related to the adoption of technologies involving no investment costs (e.g. devices). The present paper studies how regulation should account for these differences in designing reimbursement policies.

Our focus is on regulation through reimbursement, which can coexist with direct regulation of adoption (e.g. through *Certificates of Need*). We show that the optimal reimbursement policy involves a two-part tariff: a price equal to the marginal cost of the patient whose benefit of treatment equals the cost of provision, and a separate payment for the partial reimbursement of capital costs. Several countries depart from this scheme by including capital costs into the price per patient. This leads to a trade-off between the objective of providing patients with effective technologies and the need to ensure appropriateness in use.

The fact that some countries have implemented two-part reimbursement schemes (e.g. Germany, Ireland, Norway, Portugal, Spain) proves that it is qualitatively feasible. It is important to note that the separate payment need not be made at the time of adoption, which may raise the issue of financial constraints for the purchaser; what is essential is that its size is independent of the number of patients treated. Setting policy parameters efficiently may be difficult for regulators, because this also requires knowledge of technology-specific benefit and cost functions as well as providers' objective functions. However, the issue of the relationship between efficient prices, no matter whether first- or second-best, and technology characteristics is not specific to a two-part tariff. This seems to be often overlooked, as

witnessed by the large variability in tariffs that can be observed both across and within countries. Using a single- rather than a two-part tariff, as several countries do, introduces a relevant distortion related to the quality of the reimbursement scheme, without simplifying in any way the problem of defining second-best efficient prices.

References

- D. Bös and G. De Fraja. Quality and outside capacity in the provision of health services. *Journal of Public Economics*, 84:199–218, 2002.
- T.F. Bresnahan and P. Reiss. Entry and competition in concentrated markets. *Journal of Political Economy*, 99:977–1009, 1991.
- S. A. Buetow, B. Sibbald, J. A. Cantrill, and S. Halliwell. Appropriateness in health care: Application to prescribing. *Social Science & Medicine*, 45 (2):261–271, 1997.
- R. Busse, Q Geisler, A. and Wilm, and M. Wiley, editors. *Diagnosis-Related Groups in Europe*. European Observatory on Health Systems and Policies. Open University Press-McGraw-Hill, 2011.
- A. Chandra and J.S Skinner. Technology growth and expenditure growth in health care. NBER Working Papers 16953, National Bureau of Economic Research, Inc, 2011.
- M. Cristofaro, E. Busi Rizzi, V. Schinina, D. Chiappetta, C. Angeletti, and C. Bibbolino. Appropriateness: analysis of outpatient radiology requests. *Radiologia Medica*, 117(2):322–332, 2012.
- D.M. Cutler and M. McClellan. Is technological change in medicine worth it? *Health Affairs*, 20(5):11–29, 2001.
- D. Dranove and W.D. White. Recent theory and evidence on competition in hospital markets. *Journal of Economics and Management Strategy*, 3: 169–209, 1994.
- J. Dybczak and B. Przywara. The role of technology in health care expenditure in the eu. European Economy - Economic Papers 400, Directorate General Economic and Monetary Affairs, European Commission, 2010.

- J. Gruber. The effect of price shopping in medical markets: hospital responses to PPOs in California. *Journal of Health Economics*, XXXVIII:183–212, 1994.
- E. J. G. Hafsteinsdottir and L. Siciliani. Drg prospective payment systems: refine or not refine? *Health Economics*, 19(10):1226–1239, 2010.
- W. R. Hendee, G. J. Becker, J. P. Borgstede, J. Bosma, W. J. Casarella, B. A. Erickson, C. D. Maynard, J. H. Thrall, and P. E. Wallner. Addressing Overutilization in Medical Imaging. *Radiology*, 257(1):240–245, 2010.
- HOPE. Drg as a financing tool. Technical report, HOPE-European Hospital and Healthcare Federation, 2006.
- IPHA. National pricing model technical specification 2012-2013. Technical report, IPHA, 2012.
- C. Las Hayas, N. Gonzalez, U. Aguirre, J. A. Blasco, B. Elizalde, E. Perea, A. Escobar, G. Navarro, X. Castells, and J. M. Quintana. Can an appropriateness evaluation tool be used to prioritize patients on a waiting list for cataract extraction? *Health Policy*, 95(2-3):194–203, 2010.
- R. Levaggi and M. Moretto. Investment in hospital care technology under different purchasing rules: A real option approach. *Bulletin of Economic Research*, 60(2):159–181, 2008.
- R. Levaggi, M. Moretto, and P. Pertile. Static and dynamic efficiency of irreversible health care investments under alternative payment rules. *Journal of Health Economics*, 31(1):169–179, 2012.
- Ting Liu and Ching-to Albert Ma. Health insurance, treatment plan, and delegation to altruistic physician. Department of Economics Working Papers 12-08, Stony Brook University, Department of Economics, 2012.
- L. Lorenzoni and M. Pearson. Description of alternative approaches to measure and place a value on hospital products in seven oecd countries. Health Working Papers 56, OECD Publishing, 2011.
- MEDPAC. Hospital acute inpatient services payment basics payment system. Technical report, MEDPAC, 2012.

- G. et al. Melnick. The effects of market structure and bargaining position on hospital prices. *Journal of Health Economics*, XI:217–34, 1992.
- OECD. *Value for money in Health Spending*. Health Policy Studies. OECD Publishing, 2010.
- B. Roudsari, K. J. Psoter, G. C. Fine, and J. G. Jarvik. Falls, Older Adults, and the Trend in Utilization of CT in a Level I Trauma Center. *American Journal of Roentgenology*, 198(5):985–991, 2012.
- D. Scheller-Kreinsen, W. Quentin, and R. Busse. Drg-based hospital payment systems and technological innovation in 12 european countries. *Value Health*, forthcoming, 2011.
- J. Schreyögg, M. Bäumlner, and R. Busse. Balancing adoption and affordability of medical devices in europe. *Health Policy*, 92(2-3):218–224, 2009.
- L. Siciliani. Selection of treatment under prospective payment systems in the hospital sector. *Journal of Health Economics*, 25(3):479–499, 2006.
- S. Smith, J. P. Newhouse, and M. S. Freeland. Income, insurance, and technology: Why does health spending outpace economic growth? *Health Affairs*, 28(5):1276–1284, 2009.