Paying for pharmaceuticals: uniform pricing versus two-part tariffs*

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Abstract

Two-part pricing (the Netflix model) has recently been proposed instead of uniform pricing for pharmaceuticals. Under two-part pricing the health plan pays a fixed fee for access to a drug at unit prices equal to marginal costs. Despite two-part pricing being socially efficient, we show that the health plan is worse off when the drug producer is a monopolist, as all surplus is extracted. This result is reversed with competition, as two-part pricing yields higher patient utility and lower drug costs for the health plan. However, if we allow for exclusive contracts, uniform pricing is preferred by the health plan.

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1 Introduction

Pharmaceutical firms need to make large, up-front investments in drug discovery and clinical trials before new drugs can be approved and launched in the market. To stimulate such investments, pharmaceutical firms are granted patent protection, which in many cases gives rise to market power. Although market power is deliberately granted, and intended to allow pharmaceutical firms to charge higher prices over a given period of time, controversies over excessive prices are common. New life-extending drugs for cancer treatment, orphan drugs that target rare but severe diseases, and new HIV drugs are examples of drugs that have come under scrutiny for very high prices.[1]

Inducing innovation by allowing firms to charge high prices for new drugs runs the risk of reducing access to new treatments in spite of relatively low variable costs of production. This illustrates the familiar trade-off between static and dynamic efficiency. Public health plans in different countries try to mitigate supply-side market power by employing various price control mechanisms, such as direct regulation of drug prices (price caps) or regulation of the reimbursement level (reference pricing). To what extent price controls curtail market power, though, depends on the availability of close substitutes and documented treatment effects. Drugs that offer substantial health improvements will often be able to charge higher prices within such regulatory frameworks.

Recently, new drug pricing mechanisms, referred to as the Netflix model applied to pharmaceuticals, have been proposed to decouple the utilisation of a new drug from payments that allow recoupment of the firm's development costs. Instead of paying a price per package, the health plan negotiates a fixed amount (access or subscription fee) in exchange for unlimited prescription volume. Australia has adopted this approach to providing antivirals (DAAs) to patients with hepatitis C virus. According to Moon and Erikson (2019), the Australian authority negotiated an agreement to spend approximately 1 billion Australian dollars over 5 years to get unlimited access to the drugs. Two states in the US, Louisiana and Washington, have recently adopted similar purchasing strategies for the same class of drugs.[2]

As a two-part tariff, the so-called Netflix model has the intuitive advantages of giving access to the individual customers at very low marginal cost for the health plan without preventing suppliers from profiting from valuable innovations. Translating these effects into pharmaceutical markets, however, requires attention to specific institutional characteristics, including decisions made by

[1] See Mailankody and Prasad (2016).

[2] See https://www.gov.louisiana.gov/index.cfm/newsroom/detail/2031 and https://www.hca.wa.gov/assets/program/hep-c-elimination-gov-directive-18-13-final.pdf

health plans and competition between suppliers of drugs that target the same group of patients. In this paper, we compare the performance of two-part tariffs and uniform prices, both from the health plan's and drug producers' point of view. We model a market for on-patent prescription drugs that is served either by a monopolist or by two different producers supplying therapeutically substitutable drugs. A drug producer can only gain access to the market if the health plan is willing to sign a contract with this producer, and these contractual decisions determine which drugs can be prescribed by physicians affiliated with the health plan.

Since the health plan can sign a contract with both drug suppliers, this is not a pure competition for the market. With both suppliers signed up, their market shares will depend on (unit) prices and the drugs' treatment effect (i.e., the drugs' vertical and horizontal characteristics). When the quality difference between the two drugs is sufficiently large, turning the high-quality supplier into a *de facto* monopolist, we confirm the well-known property of two-part tariffs: The price charged per prescription equals marginal costs and the fixed fee extracts the entire surplus of the health plan. Although two-part tariffs ensure efficient access to the drug, the health plan prefers uniform pricing if therapeutic competition is out of reach.

Once we introduce therapeutic competition between the two suppliers, there is a striking change in the health plan's preference ranking of the two payment schemes. The reason for this is two-fold. First, with therapeutic competition, the credible threat of excluding one of the drugs from the health plan protects the plan against the aggressive surplus extraction when the drug producer is a monopolist. Second, two-part tariffs eliminate an allocative inefficiency that is present under monopoly pricing. Although different patented drugs belong to the same therapeutic class, they are not perfect substitutes. Marginal cost pricing associated with two-part tariffs ensures that the individual patients are allocated to the best drug, taking into account both treatment effects and costs. With uniform pricing, the allocation of patients between the two drugs is distorted since the firm with highest quality can exploit its demand advantage by setting a higher price.

The two-part tariff scheme (so-called Netflix model) therefore improves access to high-quality drugs, in line with its advocacy among policymakers. The distribution of surplus, however, crucially depends on the competition regime. Drug suppliers tend to prefer uniform pricing under therapeutic competition, and two-part tariffs under monopoly, which is the exact opposite of the ranking of payment regimes by the health plan. Thus, if we consider a game in which the health plan is given the power to determine the type of payment scheme at the outset, the subgame perfect Nash equilibrium would have two-part tariffs only in the presence of (sufficiently strong) therapeutic competition. This conclusion relies on the assumption that the health plan will include all drugs that contributes to increasing its surplus. However, in an extension to the main analysis we show that if we include the possibility of exclusive contracts, where only one of the drugs is included in the health plan, then uniform pricing is always weakly preferred by the purchaser.

Our study builds on, and bridges, two different strands of literature. On the one side, we employ a standard theoretical framework applied to pharmaceutical markets for studying price competition and regulatory policies under imperfect competition. Due to heterogeneity among patients and differences in quality and the workings of different drugs, models combining horizontal and vertical differentiation have been useful in capturing important features of pharmaceutical markets, both demand-side and supply-side characteristics (see for example Brekke et al. (2007), Miraldo (2009), Bardey et al. (2010), Bardey et al. (2016), Brekke et al. (2016) and Gonzàles et al. (2016)). Among these, the general set-up in our paper relates most closely to the spatial formulation in Brekke et al. (2007) and Miraldo (2009).

The novel contribution of our paper in relation to this strand of literature is two-fold. First, we introduce two-part pricing into this framework, whereas previous studies focus solely on uniform pricing. As we will show, two-part pricing not only changes the drug producers' pricing decisions (including unit prices), but indeed also the intensity of competition among the producers. Second, we allow for the health plan to decide on market access of one or both of the drugs, implying that drug producers compete both for the market and on the market. Both elements implies a radical change in equilibrium outcomes compared to the standard models.

On the other side, our paper builds on the strand of literature that focuses on two-part tariffs. Since the seminal paper by Oi (1971), two-part pricing contracts are known for allowing a monopolist to sell goods at marginal cost, but to still extract consumer surplus in the form of an upfront payment. There is a large literature on price discrimination, including two-part tariffs, in oligopoly markets, with early contributions going back to Stole (1996), Armstrong and Vickers (2001), and Yin (2004). These models focus on two-part pricing at consumer level and do not deal with the specificities of pharmaceutical markets.[3] Lakdawalla and Sood (2009, 2013) consider two-part pricing in health care markets. Health insurance, both public and private, implies that consumers pay

[3]In a setting where different producers sell to a common retailer, potential pro-competitive effects of two-part tariffs have been identified by Gabrielsen and Sørgard (1998) and Cachon and Kök (2010). These effects are similar in nature to the ones identified in the present analysis, although the institutional setting is very different.

upfront premiums in exchange for lower unit prices (co-payments) in the event of illness. Assuming that insured consumers' demand for drugs is a function of the co-payments (in addition to their health status and income), they show that health insurance eliminates the deadweight loss from market power in health care provision, including pharmaceuticals. Our paper focuses on a different issue, namely two-part pricing at health plan level instead of consumer level. This topic is conceptually different, and allows us to study the game between drug producers and health plans in terms of market access and inclusion of drugs in the health plan. To the best of our knowledge, this represents the first attempt to derive properties of two-part tariffs, when applied by health plans in paying for pharmaceuticals. Our aim is to study the effect on two-part pricing on the health plan's access decision and the corresponding distribution of surpluses across drug producers and the health plan. This is a highly relevant issue both for public and private health plans.

The remainder of the paper is structured as follows. In Section 2 we present the model. In Section 3 we compare uniform pricing and two-part tariffs in the case where the market is served by a monopolist. Therapeutic competition is then introduced in Section 4, where we make the same comparison of pharmaceutical pricing schemes when the market is (potentially) served by the producers of two therapeutically substitutable drugs. In Section 5 we extend the analysis of therapeutic competition to include the possibility of exclusive contracting by the health plan. Finally, Section 6 provides a discussion and some concluding remarks.

2 Model

Consider a therapeutic market where either one or two on-patent prescription drugs are available for patients. If there is only one drug in the market, it is located at one of the endpoints of a unit line. If there are two drugs in the market, they are located at different endpoints of the same line; drug 1 at the left endpoint and drug 2 at the right endpoint. Patients are uniformly distributed on the line with total patient mass equal to one. We can interpret the unit line as a 'disease space' where a patient's therapeutic benefit of a particular drug is higher the closer the patient is located to the drug, all else equal. Thus, the distance between the location of a particular drug and the location of a particular patient reflects the degree of therapeutic mismatch between the two.

Each patient attends a physician who prescribes what is considered the most appropriate treatment for the patient, which is either one unit of a drug from the available choice set, or no drug treatment. When making this decision, the prescribing physician takes into account both the patient's health benefit and the price(s) of the drug(s). More specifically, let $v_i > 0$, $p_i > 0$ and $z_i \in \{0, 1\}$ denote the quality, price and therapeutic location, respectively, of drug i, where $i = 1, 2$. If one unit of this drug is prescribed to a patient located at $x \in [0, 1]$, the utility assigned to this choice by the prescribing physician is

$$u_i(x) = v_i - t|x - z_i| - \beta p_i. \quad (1)$$

For each patient, the physician will prescribe the drug that yields the highest utility, as specified by (1), but only if this utility is non-negative. Otherwise, no drug treatment is given.

The utility function given by (1) consists of two components. The first component is the patient's health benefit of being prescribed drug i, which is given by $v_i - t|x - z_i|$. The health benefit depends on the quality of the drug and the therapeutic match between the patient and the drug, where the relative importance of the latter is reflected by the mismatch cost parameter $t > 0$.[4] Notice that, in case of two available drugs in the prescription choice set, t also measures (inversely) the degree of therapeutic substitutability, and thus the intensity of therapeutic competition, between the two drugs.

The second component in the utility function reflects the cost of drug treatment. The parameter $\beta \in \left(\frac{1}{2}, 1\right]$ measures how sensitive the physician's prescription decision is to drug prices. In the special case of $\beta = 1$, the physician takes drug prices fully into account and acts as a perfect agent for a third-party purchaser (i.e., the health plan) that maximises total health benefits net of purchasing costs. However, in the more general case of $\beta < 1$, health benefits are more important than drug prices for the prescribing physician. In order to ensure equilibrium existence throughout our analysis, we impose a lower bound on β equal to one half. Notice that our interpretation of β is sufficiently general to incorporate patient copayments, where a higher copayment rate implies a higher value of β.[5]

Each drug is produced by a profit-maximising firm. The payment for drug i includes the per-unit price p_i and potentially also a fixed fee f_i, depending on the type of payment contracts used.

[4] The mismatch cost can be interpreted as the subjective effectiveness of the drug therapy for a given patient, including also possible side-effects of the drug that are specific to the patient.

[5] Consider a patient located at x who is prescribed drug i and pays σp_i, where $\sigma \in (0, 1)$ is the copayment rate. The utility associated with this prescription choice is $v_i - \sigma p_i - t|x - z_i|$ from a patient perspective and $v_i - p_i - t|x - z_i|$ from a third-party purchaser perspective. If the prescribing physician maximises a weighted average of patient utility and purchaser utility, with a weight α given to the latter, the resulting physician payoff function is identical to (1) for $\beta := \alpha(1 - \sigma) + \sigma$, implying that β is increasing in the copayment rate (σ) and in the weight given to purchaser utility (α). If the prescribing physician places equal weights on patient and purchaser utility, i.e., $\alpha = \frac{1}{2}$, then $\beta = \frac{1}{2}(1 + \sigma) \in \left(\frac{1}{2}, 1\right)$.

Assuming a constant marginal cost c of drug production, equal for both drugs, the profit of producer i is given by

$$\pi_i = (p_i - c)\, y_i + f_i, \tag{2}$$

where y_i is the demand for drug i, which is derived from drug prescription decisions that maximise (1) for each patient.

The available number of drugs in the market is determined by a monopoly purchaser (health plan) who decides whether to include one or both of the drugs in its health plan. The objective of the health plan is to maximise its surplus, defined as total health benefits to patients net of drug expenditures. If only drug i is included in the plan, the surplus is given by

$$S_i = H_i - p_i y_i - f_i, \tag{3}$$

where

$$H_i = \int_0^{y_i} (v_i - tx)\, dx = \left(v_i - \frac{ty_i}{2}\right) y_i \tag{4}$$

is the total health benefit of drug i, and where the market is partially (fully) covered if $y_i < (=)\, 1$. If both drugs are included, and there is viable competition between them, implying that the market is fully covered, the surplus is

$$S_{12} = H_{12} - p_1 y_1 - p_2 (1 - y_1) - f_1 - f_2, \tag{5}$$

where

$$H_{12} = \int_0^{y_1} (v_1 - tx)\, dx + \int_{y_1}^{1} (v_2 - t(1 - x))\, dx = v_1 y_1 + v_2 (1 - y_1) - \frac{t}{2}(1 - 2(1 - y_1)\, y_1) \tag{6}$$

is the total health benefit of including both drugs in the health plan.

Finally, we impose two parameter restrictions:

A1 $\min\{v_1, v_2\} > c + t$.

A2 $|v_1 - v_2| < 3t$

The first assumption states that the net health benefit (health benefit minus production cost) of each drug is positive for all patients in the market. This implies that the socially efficient outcome is a fully covered market, where each patient is given drug treatment, regardless of whether the prescription choice set consists of one or two drugs. Another implication of this assumption is that there is a monotonic relationship between total health benefit and total welfare, defined as total health benefit net of production costs. The second assumption applies to the case of therapeutic competition analysed in Section 4, ensuring that the quality difference between the two drugs is sufficiently low to ensure equilibrium existence under both payment schemes considered, when both drugs are included in the health plan. Given the above assumptions, we consider the following game:

1. The drug producers simultaneously and non-cooperatively submit bids (p_i, f_i).
2. The purchaser decides whether to include one or both of the drugs in the health plan (or none of the drugs if a positive surplus cannot be achieved).
3. Each patient is prescribed a drug from the available choice set (or no prescription if drug treatment does not yield a positive utility).

We will consider two different versions of this game, where the payment scheme is either based on uniform pricing ($f_i = 0$) or two-part tariffs ($f_i > 0$). As usual, the game is solved by backwards induction to find the subgame perfect Nash equilibrium.

3 Monopoly

We start out by considering the case of a monopoly market, where only one drug exists. Alternatively, we can interpret this case as the quality difference between the two drugs being so large that therapeutic competition is infeasible, effectively turning the market into monopoly for the high-quality drug. Given that the existing (high-quality) drug is located at one of the endpoints of the unit line, and assuming that the drug is prescribed to all patients for which the utility given by (1) is non-negative, total demand for the drug is given by[6]

$$y = \min \left\{ \frac{v - \beta p}{t}, 1 \right\}. \tag{7}$$

The monopoly version of the game described towards the end of the last section is simply that the producer makes a take-it-or-leave-it offer which the purchaser can either accept or reject. Thus,

[6] To ease notation, we drop the subscript i in the monopoly case.

the monopoly producer's problem is to maximise profits under the constraint that the purchaser's surplus, which in this case is given by (3), is non-negative. In the following we will solve this maximisation problem under two different assumptions about the price offer, namely that (i) the producer offers a uniform price (p), or (ii) the producer offers a two-part tariff (p, f).

3.1 Uniform pricing

Given that the drug is included in the health plan, the profit-maximising price is either an interior solution where $y < 1$, or a corner solution where the price is set such that the prescribing physician is indifferent between prescribing or not the drug to the patient with the lowest health benefit; i.e., $u(1) = 0$. The producer's choice of whether to implement an interior solution or not depends generally on the quality of the drug and on the price sensitivity of the prescription decision. However, inclusion in the health plan is not guaranteed at any price. The producer is therefore also constrained by the condition that the offered price must give the health plan a non-negative surplus. If this condition binds, the profit-maximising price is implicitly given by $S = 0$, where S is defined by (3) for $f = 0$.

When considering both types of potential corner solutions, stemming from the prescription decisions and from the participation constraint of the purchaser, it can be shown (see Appendix A for details) that the optimal price is given by[7]

$$p^M = \begin{cases} \frac{v+\beta c}{2\beta} & if \quad v \leq 2t + \beta c \text{ and } \beta > \beta^*, \\ \frac{v}{2-\beta} & if \quad v \leq 2t + \beta c \text{ and } \beta^{**} < \beta \leq \beta^*, \\ \frac{v-t}{\beta} & if \quad v > 2t + \beta c \text{ and } \beta > \beta^{**}, \\ v - \frac{t}{2} & if \quad \beta \leq \beta^{**}, \end{cases} \tag{8}$$

where $\frac{1}{2} < \beta^{**} < \beta^* < 1$. The corresponding demand for the drug is given by

$$y^M = \begin{cases} \frac{v-\beta c}{2t} & if \quad v \leq 2t + \beta c \text{ and } \beta > \beta^*, \\ \frac{2(1-\beta)v}{(2-\beta)t} & if \quad v \leq 2t + \beta c \text{ and } \beta^{**} < \beta \leq \beta^*, \\ 1 & if \quad v > 2t + \beta c \text{ or } \beta \leq \beta^{**}. \end{cases} \tag{9}$$

Given that the drug is included in the health plan, the profit-maximising price is an interior solution, in which not all patients are prescribed the drug, if the drug quality is sufficiently low

[7] We use superscript M to denote equilibrium values under monopoly.

($v < 2t + \beta c$). Intuitively, the scope for such an interior solution is larger if drug demand is more price sensitive or if mismatch costs are larger. However, unless demand is sufficiently price sensitive, the unconstrained price will be too high to yield a non-negative surplus for the health plan. In this case, which occurs if $\beta \leq \beta^*$, the optimal price must be adjusted downwards in order to satisfy the participation constraint of the purchaser. Such a corner solution can imply either partial or full market coverage, with full coverage occurring if β is sufficiently low ($\beta \leq \beta^{**}$). Thus, the monopoly solution under uniform pricing implies full market coverage if (i) the quality of the drug is sufficiently high ($v > 2t + \beta c$), *or* if (ii) the price sensitivity of demand is sufficiently low ($\beta \leq \beta^{**}$). If neither of these two conditions are met, the monopoly solution implies partial market coverage.

The producer profits and health plan surplus in the monopoly solution are given by, respectively,

$$\pi^M = \begin{cases} \frac{(v-\beta c)^2}{4t\beta} & if \quad v \leq 2t + \beta c \text{ and } \beta > \beta^* \\ \frac{2v(1-\beta)(v-(2-\beta)c)}{t(2-\beta)^2} & if \quad v \leq 2t + \beta c \text{ and } \beta^{**} < \beta \leq \beta^* \\ \frac{v-t}{\beta} - c & if \quad v > 2t + \beta c \text{ and } \beta > \beta^{**} \\ v - \frac{t}{2} - c & if \quad \beta \leq \beta^{**} \end{cases} \tag{10}$$

and

$$S^M = \begin{cases} \frac{(v(3\beta-2)-(2-\beta)\beta c)(v-\beta c)}{8t\beta} & if \quad v \leq 2t + \beta c \text{ and } \beta > \beta^* \\ 0 & if \quad v \leq 2t + \beta c \text{ and } \beta^{**} < \beta \leq \beta^* \\ \frac{(2-\beta)t-2(1-\beta)v}{2\beta} & if \quad v > 2t + \beta c \text{ and } \beta > \beta^{**} \\ 0 & if \quad \beta \leq \beta^{**} \end{cases}. \tag{11}$$

Consistent with the above discussion of the producer's optimal pricing incentives, we see that the monopoly solution leaves the health plan with zero surplus if the price sensitivity of drug demand is sufficiently low, such that the participation constraint of the purchaser binds (this case includes two regimes, where the market is either partially or fully covered). Thus, complete surplus extraction through uniform pricing might happen only if the health plan's cost of purchasing the drug is not fully internalised by the prescribing physician (i.e., if $\beta < 1$), making drug demand less price elastic. On the other hand, if the purchasing cost is fully internalised ($\beta = 1$), we obtain the standard result that the monopolist's profits are maximised at a price that leaves the purchaser with a positive surplus, regardless of whether this price yields an interior solution ($y^M < 1$) or not ($y^M = 1$).[8]

[8] Notice that full market coverage ($y^M = 1$) does not necessarily imply full surplus extraction ($S^M = 0$), nor does

We summarise the above analysis as follows:

Proposition 1 *Under monopoly with uniform pricing, (i) the market is fully covered if the quality of the drug is sufficiently high or if the price sensitivity of demand is sufficiently low. Otherwise, the market is partially covered. (ii) If the price sensitivity of drug demand is sufficiently low, the health plan is left with zero surplus.*

3.2 Two-part tariffs

With two-part tariffs, the producer can extract the purchaser's entire surplus through the fixed fee f. From (3), this implies that, for any unit price p, the optimal fixed fee is given by

$$f = \left(v - p - \frac{ty}{2}\right) y. \tag{12}$$

The producer's profits can therefore be expressed as

$$\pi = (p - c)\, y + \left(v - p - \frac{ty}{2}\right) y = \left(v - c - \frac{ty}{2}\right) y. \tag{13}$$

For a given demand, a reduction in the unit price increases the health plan's surplus by the same amount as it reduces the firm's profits, implying that the profit loss of a unit price reduction can be fully recaptured by increasing the fixed fee. Thus, with two-part tariffs, the unit price affects profits only to the extent that it affects total demand, and it is optimally set to induce the level of demand that maximises the health plan's surplus. This demand level is clearly $y = 1$, given the assumption that the health benefits net of production costs are positive for all patients, i.e., $v > c + t$. Thus, the maximum profit under two-part tariffs is therefore

$$\widehat{\pi}^M = v - c - \frac{t}{2}, \tag{14}$$

which is independent of the unit price p as long as this price is low enough to induce a fully covered market. The characterisation of the optimal two-part tariff follows straightforwardly:

Proposition 2 *Under monopoly with two-part tariffs, there is a continuum of payoff-equivalent contracts characterised by*

$$\widehat{p}^M \leq \frac{v - t}{\beta} \tag{15}$$

partial market coverage ($y^M < 1$) necessarily imply that the purchaser is left with a positive surplus ($S^M > 0$).

and

$$\widehat{f}^M = v - \widehat{p}^M - \frac{t}{2}. \tag{16}$$

For any of these contracts, the producer's profits are given by (14) and the purchaser's surplus is zero.

Let us now compare the outcomes under the two different payment schemes. Whereas a socially efficient outcome (i.e., $y = 1$) is always guaranteed with a two-part tariff, uniform pricing produces an efficient outcome only if the drug quality is sufficiently high or if the price responsiveness of drug demand is sufficiently low. However, from the viewpoint of the purchaser, uniform pricing is strictly preferred to a two-part tariff if β is sufficiently high. Even if uniform pricing yields a worse health outcome, in the sense that some patients are not given the drug treatment because of an excessively high unit price, the additional health benefits obtained by the use of a two-part tariff are lower than the corresponding increase in total drug payments.

The producer, on the other hand, is obviously at least as well off with a two-part tariff, since this type of payment contract provides an additional instrument to extract surplus from the purchaser. However, if the price responsiveness of drug demand is sufficiently low, $\beta < \beta^{**}$, both the producer and the purchaser are indifferent between the two payment schemes.

The gains and losses from the two payment schemes under monopoly can be characterised as follows:

Proposition 3 *In case of monopoly, two-part tariffs yield weakly higher producer profits, health benefits and total welfare, but a weakly lower surplus for the health plan, than uniform pricing.*

4 Therapeutic competition

Consider now the case where two therapeutically substitutable drugs exist (or, alternatively, that the quality difference between the two drugs is sufficiently low to make therapeutic competition feasible). If both drugs are included in the health plan, and if prescription choices are made to maximise (1) for every patient, demand for drug i is given by

$$y_i = \frac{1}{2} + \frac{\Delta v - \beta \Delta p}{2t}, \tag{17}$$

$i,j=1,2,\ i\neq j$, where $\Delta v:=v_i-v_j$ is the quality difference and $\Delta p:=p_i-p_j$ is the price difference between drug i and drug j. An interior solution with positive demand for both drugs requires that $\Delta v<\beta\Delta p+t$.

In the following we will once more consider the two cases of uniform pricing and two-part tariffs, now solving the full game outlined in Section 2 with price competition between the two drug producers at the first stage of the game. Throughout the analysis we assume that the drug qualities are sufficiently high to make therapeutic competition viable, implying that the market is fully covered in equilibrium.

4.1 Uniform pricing

Suppose that the payment contracts are linear, such that $f_i=0,\ i=1,2$. Consider first the decision made by the purchaser at the second stage of the game. Suppose that p_i and p_j are such that $S_i\geq S_j\geq 0$, implying that it is always optimal to include at least drug i in the health plan. In this case, by substituting (17) into (3)-(5) and setting $f_i=0$ for $i=1,2$, we find that both drugs will be included if

$$S_{12}-S_i=\frac{\left(\left(2-\beta\right)\Delta p+t-\Delta v\right)\left(\beta\Delta p+t-\Delta v\right)}{4t}\geq 0, \tag{18}$$

which is true for $\Delta v<\beta\Delta p+t$. Thus, if p_i and p_j are such that both drugs have positive demand if they belong to the available prescription choice set, including the second drug will always increase the surplus of the health plan, since utility is increased for the patients who are prescribed the second drug.

We now turn to the first stage of the game, where each producer sets a uniform price under the anticipation that both drugs will be included in the health plan. By substituting (17) into (2) and maximising with respect to p_i, we derive the best-response function of producer i, which is given by[9]

$$p_i\left(p_j\right)=\frac{1}{2}\left(c+p_j+\frac{t+\Delta v}{\beta}\right). \tag{19}$$

As expected, the prices are strategic complements. A higher price set by producer j shifts demand

[9] The second-order conditions of the profit-maximisation problems are satisfied, since

$$\frac{\partial^2\pi_i}{\partial p_i^2}=-\frac{\beta}{t}<0.$$

towards drug i, which consequently makes the demand for drug i less price elastic, and producer i optimally responds by increasing the price.

The Nash equilibrium at the price bidding stage is given by[10,11]

$$p_i^D = c + \frac{t}{\beta} + \frac{\Delta v}{3\beta}, \tag{20}$$

which implies

$$\Delta p^D = \frac{2\Delta v}{3\beta} \tag{21}$$

and

$$y_i^D = \frac{1}{2} + \frac{\Delta v}{6t}. \tag{22}$$

We see that Assumption A2 ensures $y_i > 0$ for $i = 1, 2$. The remaining properties of this equilibrium are straightforward and intuitive. The price level of each drug is increasing in the marginal production cost and in the quality of the drug, while decreasing in the degree of therapeutic substitutability and in the price responsiveness of demand. Furthermore, the producer of the high-quality drug charges the higher price.

The above derived equilibrium outcome ensures that the condition in (18) is satisfied, which implies that either both or no drugs will be included in the health plan. If both drugs are included, the profits of the drug producers are

$$\pi_i^D = \frac{(3t + \Delta v)^2}{18t\beta}, \tag{23}$$

implying $\pi_i^D > \pi_j^D$ if $\Delta v > 0$. The total health benefit in this equilibrium is given by

$$H_{12}^D = \overline{v} - \frac{t}{4} + \frac{5\,(\Delta v)^2}{36t}, \tag{24}$$

and the total surplus of the health plan is

$$S_{12}^D = \overline{v} - c - \frac{(4+\beta)\,t}{4\beta} - \frac{(4-5\beta)\,(\Delta v)^2}{36t\beta}, \tag{25}$$

[10] The Nash equillibrium is (locally) stable, since

$$\frac{\partial^2 \pi_1}{\partial p_1^2}\frac{\partial^2 \pi_2}{\partial p_2^2} - \frac{\partial \pi_1}{\partial p_1 \partial p_2}\frac{\partial \pi_2}{\partial p_1 \partial p_2} = \frac{3\beta^2}{4t^2} > 0.$$

[11] We use superscript D (for duopoly) to denote equilibrium values under therapeutic competition.

where $\overline{v} := (v_1 + v_2)/2$ is the average drug quality. The final condition needed for both drugs to be included in the health plan is that $S_{12}^D \geq 0$, which requires that the quality of each drug is sufficiently high (see Appendix B for a derivation of a specific sufficient condition for $S_{12}^D \geq 0$). We assume that this condition is satisfied.

4.2 Two-part tariffs

Suppose now that each of the drug producers bids a unit price p_i and a fixed fee f_i at the first stage of the game. Similarly to the monopoly case, this means that, for each producer, the additional surplus created by making drug i available at price p_i can be captured by the fixed fee f_i. However, this surplus extraction is conditional on the drug being included in the health plan. As we will show below, there are two different competition regimes arising under two-part tariffs, one in which both drugs are included in the plan, leading to *de facto therapeutic competition*, and one in which only one of the drugs is included, leading to a situation of *potential therapeutic competition*, where the non-included drug places a competitive pressure on the included one. The third possible outcome, where therapeutic competition is blockaded in the sense that it is not profitable for a rival with a therapeutic substitute to submit a bid (due to large quality differences), is captured by the monopoly case in the previous section.

4.2.1 *De facto* therapeutic competition

Suppose that drug j is included in the health plan. In this case, drug i will also be included if $S_{12} \geq S_j$. By substituting (17) into (3)-(5), the inclusion criterion for drug i is given by

$$\overline{v} - \overline{p} - \frac{t}{4} + \frac{(\Delta v - \beta \Delta p)(\Delta v - (2-\beta)\Delta p)}{4t} - f_i - f_j \geq v_j - p_j - \frac{t}{2} - f_j, \tag{26}$$

where $\overline{p} := (p_1 + p_2)/2$ is the average unit price. This condition can be re-formulated as

$$f_i \leq \widehat{f}_i := \frac{(t + \Delta v - (2-\beta)\Delta p)(t + \Delta v - \beta \Delta p)}{4t}. \tag{27}$$

Since a higher f_i implies a non-distortionary transfer from the buyer to the seller, the inequality in (27) will bind in equilibrium. Thus, given that drug j is included in the health plan, the producer of drug i can extract the additional surplus created by its inclusion through the fixed fee.

Setting $f_i = \widehat{f}_i$ in the profit function of producer i and maximising (2) with respect to the unit price p_i yields the following first-order condition for an interior solution:[12]

$$\frac{\partial \pi_i}{\partial p_i} = -\frac{\beta}{2t}\left(\beta p_i + (1-\beta)\, p_j - c\right) = 0. \tag{28}$$

The best-response functions are therefore given by

$$p_i\left(p_j\right) = \frac{c}{\beta} - \left(\frac{1-\beta}{\beta}\right) p_j, \quad i, j = 1, 2, \quad i \neq j. \tag{29}$$

There are two important observations that can be made here. First, we see that the nature of strategic interaction is fundamentally changed when the producers set two-part tariffs. Contrary to the case of uniform pricing, with two-part tariffs the unit prices are *strategic substitutes* at the price bidding stage (i.e., $\partial p_i / \partial p_j < 0$). In order to grasp the intuition behind this result, it is instructive to write the first-order condition (28) on a more general form, as

$$\frac{\partial \pi_i}{\partial p_i} = \frac{\partial\left(\left(p_i - c\right) y_i\right)}{\partial p_i} + \frac{\partial \widehat{f}_i}{\partial p_i} = 0. \tag{30}$$

Under two-part tariffs, a price increase affects variable profits ($\left(p_i - c\right) y_i$), as it does under uniform pricing, but it also affects the fixed fee that the firm can charge. More precisely, a higher price for drug i reduces the additional surplus generated by inclusion of the drug in the health plan, thus implying that the producer has to reduce the fixed fee in order to ensure inclusion. How do these marginal profit effects depend on the price level of the competing drug j? An increase in p_j shifts demand from drug j to drug i, which implies that the demand for drug i becomes less price elastic. All else equal, this increases the first term in (30) and gives producer i an incentive to set a higher price. This is the only strategic effect under uniform pricing, leading to strategic complementarity between the prices. However, under two-part tariffs, the price of drug j also affects the magnitude of the second term in (30), which can be written as

$$\frac{\partial \widehat{f}_i}{\partial p_i} = \left(2ty_i - (1-\beta)\,\Delta p\right) \frac{\partial y_i}{\partial p_i} - (1-\beta)\, y_i < 0. \tag{31}$$

Consider again an increase in p_j , which leads to higher demand for drug i (i.e., $\partial y_i / \partial p_j > 0$). This

[12] The second-order conditions of the profit-maximisation problems are satisfied, since

$$\frac{\partial^2 \pi_i}{\partial p_i^2} = -\frac{\beta^2}{2t} < 0.$$

demand increase implies that a marginal price increase for drug i will now affect a larger number of patients and therefore lead to a larger reduction in the additional surplus created by the inclusion of drug i in the health plan, leading in turn to a larger drop in the maximum fixed fee that producer i can charge. All else equal, this gives producer i an incentive to *reduce* the unit price. It turns out that the negative effect of p_j on the second term in (30) outweighs the positive effect on the first term, leading to strategic substitutability between the unit prices set by the two producers.

The second important observation we can make from the set of best-response functions, (29), is that they are completely symmetric and thus not dependent on the quality difference between the two drugs. This implies that the Nash equilibrium is also symmetric in terms of unit prices (but not in terms of fixed fees), and given by marginal cost pricing for both producers:[13]

$$\widehat{p}_i^D = c, \quad i = 1, 2. \tag{32}$$

The intuition follows from the explanation for strategic substitutability, as outlined above. For any pair of unit prices higher than marginal cost, an increase in variable profits due to a higher price is more than offset by a reduction in the fixed fee, regardless of the quality differences between the drugs, thus implying that neither of the drug producers have any incentives to set their unit prices above marginal cost. This means that profits are fully extracted through the fixed fees. Equilibrium profits (and fixed fees) are therefore given by

$$\widehat{\pi}_i^D = \widehat{f}_i^D = \frac{(t + \Delta v)^2}{4t}, \quad i, j = 1, 2, \quad i \neq j, \tag{33}$$

implying that the high-quality producer charges a higher fee and consequently earns a higher profit in equilibrium.

With marginal cost pricing, equilibrium demand is given by

$$\widehat{y}_i^D = \frac{1}{2} + \frac{\Delta v}{2t}, \quad i, j = 1, 2, \quad i \neq j. \tag{34}$$

An interior solution therefore requires that the drug quality difference is sufficiently low: $\Delta v < t$.

[13] The condition for (local) stability of the Nash equilibrium is

$$\frac{\partial^2 \pi_1}{\partial p_1^2} \frac{\partial^2 \pi_2}{\partial p_2^2} - \frac{\partial^2 \pi_1}{\partial p_1 \partial p_2} \frac{\partial^2 \pi_2}{\partial p_1 \partial p_2} = \frac{\beta^2 (2\beta - 1)}{4t^2} > 0,$$

which holds for $\beta > 1/2$.

Notice that this is *not* guaranteed for all parameter configurations covered by Assumption A2. Under the condition that $\Delta v < t$, both drugs will be included in the health plan, and the total health benefits are

$$\widehat{H}_{12}^{D} = \overline{v} - \frac{t}{4} + \frac{(\Delta v)^2}{4t}, \tag{35}$$

whereas the total surplus of the health plan is

$$\widehat{S}_{12}^{D} = \overline{v} - c - \frac{3t}{4} - \frac{(\Delta v)^2}{4t}. \tag{36}$$

It is easily confirmed that $\widehat{S}_{12}^{D} > 0$ for all parameter values satisfying Assumption A1.

4.2.2 Potential therapeutic competition

Consider now the case of $t < \Delta v < 3t$, for which *de facto* therapeutic competition is not feasible, since the quality difference is too large for the low-quality drug to obtain positive demand, given the contract offered by the high-quality producer in the candidate equilibrium. However, this does not allow the high-quality producer to extract all surplus with a two-part tariff, as in the monopoly case, because the purchaser can credibly threaten to replace the high-quality drug with the low-quality drug in the health plan. Thus, if drug i is the high-quality drug, the bid submitted by producer i is constrained by the condition that the health plan's surplus obtained by including only drug i must be at least as high as the surplus obtained if drug i is replaced by drug j in the health plan. Under the assumption of full market coverage, this condition is given by

$$v_i - p_i - \frac{t}{2} - f_i \geq v_j - p_j - \frac{t}{2} - f_j, \tag{37}$$

which, using our previously defined notation, can be re-written as

$$f_i \leq \Delta v - \Delta p + f_j. \tag{38}$$

All else equal, the most profitable contract offer for each producer is a contract that maximises total surplus and extracts profits only through the fixed fee, which implies that the unit price is set equal to marginal cost. This implies that the optimal contract offer by producer i is a contract given by $p_i = c$ and f_i, where f_i is just low enough to make the condition in (37) hold for all weakly profitable contract offers by producer j. In the latter set of contracts, the one that maximises the surplus of the health plan is a contract with $p_j = c$ and $f_j = 0$. Based on (38), this implies that the optimal contract offer by producer i has $f_i = \Delta v$.

Thus, for $t < \Delta v < 3t$, only the high-quality drug is included in the health plan, and the equilibrium two-part tariff is given by[14]

$$\widehat{p}_i^d = c \text{ and } \widehat{f}_i^d = \Delta v. \tag{39}$$

Equilibrium profits, total health benefit and total surplus for the health plan are given by, respectively,

$$\widehat{\pi}_i^d = \Delta v, \tag{40}$$

$$\widehat{H}_i^d = v_i - \frac{t}{2} \tag{41}$$

and

$$\widehat{S}_i^d = v_i - c - \frac{t}{2} - \Delta v = v_j - c - \frac{t}{2} > 0. \tag{42}$$

Thus, the equilibrium profits of the high-quality producer are given by the quality difference between the two drugs, whereas the equilibrium surplus of the health plan is given by the maximum value of the purchaser's outside option, i.e., the maximum surplus that can be obtained by replacing drug i by drug j in the health plan.

The next proposition summarises some of the main insights from the analysis in this section.

Proposition 4 *Suppose there are two therapeutically substitutable drugs that are candidates for inclusion in the health plan. (i) Under uniform pricing, both drugs are included for all $\Delta v < 3t$. (ii) Under two-part tariffs, both drugs are included if the drug quality difference is sufficiently low, $\Delta v < t$, whereas only the high-quality drug is included if $t \leq \Delta v < 3t$. Whether one or both drugs are included in the health plan, the equilibrium two-part tariffs have unit prices equal to marginal cost.*

4.3 Comparison of payment contracts under therapeutic competition

We conclude this section by comparing the equilibrium outcomes under the two different payment contracts. Who gains and who loses from the use of two-part tariffs instead of uniform pricing? The answer to this question is summarised in the following proposition (see Appendix C for a proof):

[14] We use superscript d to denote equilibrium values under potential therapeutic competition.

Proposition 5 *(i) Under de facto therapeutic competition ($\Delta v < t$), the surplus of the health plan is always higher with two-part tariffs than with uniform pricing. The same is true under potential therapeutic competition ($t \leq \Delta v < 3t$), unless the drug quality difference and the price sensitivity of demand are both sufficiently high.*

(ii) The profit of the low-quality producer is always higher with uniform pricing than with two-part tariffs, regardless of whether there is de facto or potential competition. The same is true for the profit of the high-quality producer, if the price sensitivity of demand is sufficiently low. On the other hand, if demand is sufficiently price sensitive, the profit of the high-quality producer is higher with two-part tariffs under de facto competition if the quality difference is sufficiently large, and it is always higher with two-part tariffs under potential competition.

(iii) The total health benefit (and thus total welfare) is always higher with two-part tariffs, regardless of whether there is de facto or potential competition.

The impact of therapeutic competition on the purchaser's preference ranking of the two payment schemes is quite striking. In complete contrast to the monopoly case, in which the monopoly supplier is able to extract all surplus by using a two-part tariff, the health plan obtains a higher surplus under therapeutic competition if the drug payments are based on two-part tariffs instead of uniform pricing. The only exception is the case in which the quality difference is high and drug demand is sensitive to price changes.

There are two different reasons why two-part tariffs are generally preferable to uniform pricing from the viewpoint of the purchaser. First, with therapeutic competition between drug suppliers, each supplier is only able to extract the additional surplus created by the inclusion of its drug in the health plan. The purchaser's credible threat of excluding one of the drugs from the health plan implies that the producers' surplus extraction is lower than in the case of a monopoly producer. Thus, *competition for access* between the two producers ensures that a larger share of the surplus is captured by the purchaser. The second reason is that the use of two-part tariffs eliminates an allocational inefficiency that is present under uniform pricing, thereby creating a larger surplus. If the two producers compete by setting uniform prices, the high-quality producer exploits its demand advantage by setting a higher price than the low-quality producer. This creates an allocative inefficiency where some patients would have been better off being treated with the high-quality drug, but are instead being prescribed the low-quality drug because it is less expensive. In other words, too few patients are being prescribed the high-quality drug under uniform pricing. This inefficiency is eliminated under two-part tariffs, because of the producers' incentives to set unit prices equal to marginal cost, regardless of drug quality differences.

The allocative inefficiency caused by uniform pricing explains why the total health benefits are always higher under two-part tariffs. This is also true under *potential* therapeutic competition, even if the use of two-part tariffs instead of uniform pricing in this case implies a reduction in the prescription choice set from two to one drugs. However, remember that this case arises for $\Delta v > t$, which implies that all patients in the market obtains a higher health benefit if they are treated by the high-quality drug. This illustrates again the allocative inefficiency related to uniform pricing. For $\Delta v \in (t, 3t)$, some patients are treated with the therapeutically less appropriate drug under uniform pricing because of the price difference caused by this payment scheme.

Since the purchaser generally prefers two-part tariffs under therapeutic competition, the producers tend to prefer uniform pricing, again in contrast to the monopoly case. However, while this is always the case for the low-quality producer, the high-quality producer might also prefer two-part tariffs if demand is sufficiently price sensitive and if the quality difference is sufficiently large. The partially aligned interests of the purchaser and the high-quality producer can be explained by the above mentioned efficiency gain from using two-part tariffs, which increases in the quality difference between the drugs.

Overall, our analysis shows how the presence (or not) of therapeutic competition is of crucial importance for identifying the winners and losers from the two different payment schemes under consideration. Although the use of two-part tariffs always maximises the total surplus, and therefore also maximises total health benefits, the distribution of this surplus depends crucially on the competition regime. Under monopoly, a switch from uniform pricing to two-part tariffs generally benefits drug producers at the expense of drug purchasers. In the presence of therapeutic competition, the opposite tends to be the case.

5 Exclusive contracting

In this section we extend our analysis of therapeutic competition by considering an alternative version of the game, where the two producers compete for an *exclusive contract* with the health plan. This implies a modification of the rules at stage two of the game outlined in Section 2, where we now assume that the purchaser only includes the drug that yields the highest surplus for the health plan. Thus, drug i will obtain exclusivity if $S_i \geq S_j$. Clearly, this condition holds in equilibrium only if drug i is the high-quality drug, i.e., if $v_i \geq v_j$. In this case, the producer of drug i can obtain exclusivity by making a bid that outperforms all profitable bids by the producer of drug j. The unique Nash equilibrium is then that producer j makes a bid that yields zero profits if the bid is accepted, while producer i makes a bid that is marginally more favourable for the health plan. Assuming a tie-breaking rule where producer i wins the contest if both bids yield equal surplus for the health plan, the equilibrium bid by producer i is implicitly given by

$$S_i = S_j|_{\pi_j=0}\,. \tag{43}$$

If the two producers compete for exclusivity by using *two-part tariffs*, the game is identical to the one described under *potential therapeutic competition* in Section 4.2.2, and the winning bid is therefore given by (39), which gives the health plan a surplus given by (42). On the other hand, if the producers compete in *uniform prices*, the bid that gives zero profits for producer j is $p_j = c$. Using (3)-(4), and assuming that v_i is large enough to ensure full market coverage in equilibrium, the equilibrium condition (43) under uniform pricing then becomes

$$v_i - p_i - \frac{t}{2} = v_j - c - \frac{t}{2}, \tag{44}$$

which implies that the winning bid is given by

$$p_i = c + \Delta v. \tag{45}$$

Since total demand is one, this gives producer i a profit of Δv, which is exactly the same as under competition for exclusivity in two-part tariffs. The surplus of the health plan is therefore also the same, and given by (42). Thus:

Proposition 6 *If the health plan offers an exclusive contract, the equilibrium outcome is the same regardless of whether the producers compete for the contract by uniform or two-part pricing. In both cases, the high-quality producer wins the contract and obtains a profit equivalent to the quality difference between the drugs, while the health plan obtains a surplus equal to the maximum value of its outside option.*

Would the health plan benefit from offering an exclusive contract? And would such a contract lead to a better or worse health outcome for patients? The answers to these questions are not *a priori* obvious, because exclusive contracting will generally affect both the purchasing costs, through changes in the degree of competition between the producers, and the total health gain, through changes in mismatch costs. By making the relevant comparisons of health gains and purchaser surplus with and without contract exclusivity, we arrive at the following conclusions (proof in Appendix C):

Proposition 7 *(i) If drug payment is based on two-part tariffs, and if $\Delta v < t$, offering an exclusive contract always yields a lower total health benefit but a higher surplus for the health plan. For $\Delta v \in [t, 3t)$, exclusive contracting has no implications for the equilibrium outcome under two-part pricing.*

(ii) If drug payment is instead based on uniform pricing, non-exclusivity yields a higher surplus for the health plan if demand is sufficiently price sensitive and the drug quality difference is sufficiently large. Otherwise, the health plan would be better off by offering an exclusive contract. The total health benefit is higher (lower) with exclusive contracting if the drug quality difference is sufficiently large (small).

With two-part pricing, there are two counteracting effects. On the one hand, since competition on the market yields marginal cost pricing and therefore no allocative inefficiencies, exclusive contracting always leads to higher mismatch costs and therefore lower total health gains, because patients lose access to a valuable therapeutic substitute. On the other hand, letting the producers compete for an exclusive contract always intensifies the competition between them (as long as *de facto* therapeutic competition would ensue if both drugs are included in the plan) and therefore allows the health plan to reduce its purchasing costs. Perhaps surprisingly, the pro-competitive effect of exclusive contracting dominates for the entire (relevant) range of parameters. Although exclusivity leads to a worse health outcome, this is more than outweighed by a reduction in purchasing costs. In order to understand this result, notice that what increases the health loss of exclusive contracting also increases the amount of purchasing costs that can be saved by letting the producers compete for exclusivity. Consider an increase in the mismatch cost parameter t. This increases the health loss of excluding one of the drugs from the market, all else equal. However, a higher t also reduces competition between the producers on the market if both drugs are included in the health plan. Since the exclusive contract equilibrium does not depend on t, higher mismatch costs therefore increase the pro-competitive effect of contract exclusivity.

With *uniform pricing*, the effects are more complicated. In this case, exclusive contracting can lead to either higher or lower health gains, and also higher or lower purchasing costs. The direction of both effects depends crucially on the quality difference between the two drugs. Consider first the effect on health gains. Since a larger quality difference increases the share of patients who are better off with the high-quality drug, the additional health benefit of having access to a second (lower-quality) drug is reduced. Furthermore, and in contrast to the case of two-part pricing, the allocative inefficiency created by uniform pricing (as discussed in Section 4.3) implies that, if the quality difference is sufficiently large, the total health gain is higher if only the high-quality drug is included in the health plan. Thus, exclusive contracting leads to an overall *increase* in health benefits for a sufficiently large quality difference between the drugs.[15] Consider next the effect of exclusive contracting on total purchasing costs. Once more, this effect depends crucially on the drug quality difference. Although a higher quality difference dampens the degree of competition on the market if both drugs are included, it leads to an even stronger reduction in the competition for an exclusive contract and, importantly, this difference is larger the more price sensitive drug demand is.[16] In fact, for sufficiently price sensitive demand *and* a sufficiently large quality difference, the purchasing costs are *higher* with exclusive contracting than under non-exclusivity. Overall, it turns out that, for sufficiently low quality differences, the negative health effect of exclusive contracting is more than outweighed by the reduction in purchasing costs, leading to an increase in the health plan's surplus. However, for sufficiently high quality differences, and if in addition demand is sufficiently price sensitive, the *positive* health effect of exclusive contracting is more than outweighed by the *increase* in purchasing costs, leading to a *reduction* in the surplus of the health plan.[17]

The possibility of offering exclusive contracts has interesting implications for the relative merits of uniform versus two-part pricing from the health plan's point of view. From Proposition 7 we know that the health plan always (weakly) prefers contract exclusivity under two-part pricing, but

[15] An increase in patients' health benefits as a result of exclusive contracting occurs if $\Delta v > \frac{3}{5}t$. This implies that there exists a parameter set, given by $\Delta v \in \left(\frac{3}{5}t, t\right)$, in which having access to only the high-quality drug yields higher health benefits than having access to both drugs at distorted prices, even if the total health benefits would be maximised with a strictly positive share of patients being prescribed the low-quality drug. In other words, since too many patients are prescribed the low-quality drug under non-exclusivity with uniform pricing, total health benefits would increase by removing access to the low-quality drug.

[16] Notice that while more price sensitive demand (i.e., a higher β) intensifies price competition in the market duopoly, the exclusive contract equilibrium is unaffected by the price sensitivity of demand.

[17] The parameter space for which contract exclusivity leads to a lower surplus for the health plan under uniform pricing coincides with the parameter space in which the purchaser, under non-exclusivity, prefers uniform over two-part pricing. From Proposition 5 we know that this parameter space is a subset of $\Delta v \in (t, 3t)$.

from Proposition 6 we know that, under contract exclusivity, the health plan is indifferent between uniform pricing and two-part tariffs. In other words, any benefit from exclusive contracting for the health plan can just as well be obtained using uniform pricing, which has the following immediate implication:

Corollary 1 *If offering exclusive contracts is a possibility, the health plan will always weakly prefer uniform pricing over two-part tariffs.*

6 Concluding remarks

In this paper we have studied the effects of adopting a new payment scheme (the Netflix model) for pharmaceuticals in a setup where drug producers submit bids to a purchaser for being included in the health plan. In particular, we have analysed distributional effects (who gains and who loses) of switching from a traditional system with uniform pricing to a new payment scheme with two-part pricing, where the health plan pays an access (subscription) fee in addition to a low unit price (equal to marginal costs). A key insight from our analysis is that the effects of two-part pricing crucially depend on whether or not there is competition in the relevant therapeutic market. If a drug producer is a monopolist (i.e., there exists no viable therapeutic alternatives), two-part pricing is beneficial for the drug producer but not for the health plan, because it enables the monopolist to extract all of the surplus from the health plan. However, this result is reversed if there is competition among drug producers in the therapeutic market. In this case, the drug producers compete more aggressively under two-part pricing than uniform pricing for being included in the health plan. Two-part pricing benefits the health plan in two ways; it improves allocative efficiency (unit prices equal to marginal costs) and lowers drug expenditures (intensified competition). This conclusion relies, however, on the assumption of non-exclusivity, meaning that health plan will include all drugs that contributes positively to the health plan's surplus. If we also open up for the possibility of exclusive contracting, where only one drug is included in the plan, then uniform pricing is always weakly preferred by drug purchaser.

While the paper employs a duopoly Hotelling model to study the effects of two-part pricing, the results hold more generally. Allowing for more (than two) drug companies will make competition more intense and thus reduce the distortions in consumption under uniform prices due to prices above marginal costs. However, this generalisation will not change our results in qualitative terms;

neither the comparison of monopoly versus competition nor the comparison of uniform versus two-part pricing under competition. The same is true for a more general demand structure under standard assumptions. The key results depend on whether the health plan has an outside option when deciding on the inclusion, and to what extent two-part pricing results in marginal cost pricing.

By way of conclusion, we would like to point at some limitations of our study. First, our analysis has not accounted for possible externalities across markets of adopting two-part pricing. In the presence of parallel trade, drug producers may be reluctant to offer unit prices at marginal costs, as this may result in parallel export to countries with higher, uniform prices. A similar type of spillover may occur across health plans. If prices are public information, then drug producers may be reluctant to offer unit prices equal to marginal costs under two-part pricing, as this may have a negative impact on the price-setting to other health plans (using uniform pricing). Such cross-market externalities can reduce the scope for two-part pricing.

Second, our analysis has not considered how drug producers' innovation incentives are affected by the choice of payment scheme, but can shed some light on this question. On the one hand, two-part pricing results in lower profits to the drug producers due to intensified competition, especially when the quality difference between the therapeutic alternatives are not too large. This result points in the direction of lower patent rent due to two-part pricing. On the other hand, drug producers obtain higher profits under two-part pricing in the case of a monopoly position in the therapeutic market. This result points in the direction of higher patent rent if the drug producer has developed a significantly better product than its rivals. Thus, two-part pricing may stimulate drug producers to spend less resources on marginal (me-too) innovations and more resources on radical (disruptive) innovations.

Third, we model physicians' prescription choices in a highly reduced form. In practice, physicians' prescription choices are likely to be affected by many factors, including their contract with the health plan, remuneration schemes, the competitive environment, marketing by drug companies, etc. We have reduced these circumstances to a single parameter (β), measuring the weight that the physician puts on patients' health benefits relative to the price of the drug. While we believe this is a key element of physicians' prescription choices, a more careful analysis of physician behaviour is needed to fully understand the effects of different payment schemes. However, this is beyond the scope of the current paper, and we leave this issue, as well as innovation incentives and cross-market spillovers, to future research.

Appendix

A. Optimal uniform pricing under monopoly

Suppose that the drug is included in the health plan (i.e., that the participation constraint of the purchaser holds). Substituting the demand function, (7), into the profit function, (2), and maximising with respect to the unit price p, the optimal (unconstrained) solution is

$$p = \begin{cases} \frac{v+\beta c}{2\beta} & if \quad v \leq 2t + \beta c \\ \frac{v-t}{\beta} & if \quad v > 2t + \beta c \end{cases}, \tag{A1}$$

where $y < (=)\, 1$ if $v < (\geq)\, 2t + \beta c$.

The next step is to check what is required for the purchaser's participation constraint to hold. From (3), under uniform pricing, this constraint is given by

$$S = \left(v - p - \frac{ty}{2} \right) y \geq 0. \tag{A2}$$

Consider first the case of $v < 2t + \beta c$, for which unconstrained monopoly pricing yields $p = (v + \beta c)/2\beta$ and $y = (v - \beta c)/2t$, so (A2) becomes

$$S = (v\,(3\beta - 2) - (2 - \beta)\,\beta c)\, \frac{(v - \beta c)}{8t\beta} \geq 0. \tag{A3}$$

It follows that $S \geq 0$ if $\beta \geq \beta^*$, where

$$\beta^* := 1 - \left(\frac{3v - \sqrt{9v^2 - 4c\,(v - c)}}{2c} \right). \tag{A4}$$

If β is below this threshold level, the drug producer's price setting is constrained by the condition that the health plan's surplus must be non-negative. In this case, the optimal (constrained) price solves

$$\left(v - p - \frac{ty}{2} \right) y = 0, \tag{A5}$$

where y is either an interior solution given by $y = (v - \beta p)/t$, or a corner solution given by $y = 1$. The optimal (constrained) price that implements an interior solution is therefore given by

$$p = \frac{v}{2 - \beta}, \tag{A6}$$

whereas the price that implements a corner solution is

$$p = v - \frac{t}{2}. \tag{A7}$$

By a simple comparison of profits, we find that the optimal price is given by (A6) if $\beta > \beta^{**}$ and by (A7) if $\beta < \beta^{**}$, where

$$\beta^{**} := \frac{2(v-t)}{2v-t}. \tag{A8}$$

Consider now the case of $v > 2t + \beta c$, which implies a fully covered market in the profit-maximising solution. Setting $p = (v-t)/\beta$ and $y = 1$ in (A2), the purchaser's participation constraint is given by

$$S = \frac{t(2-\beta) - 2(1-\beta)v}{2\beta} \geq 0. \tag{A9}$$

This constraint holds if $\beta \geq \beta^{**}$. On the contrary, if $\beta < \beta^{**}$, the producer must offer the purchaser a lower price. In this case, we have already found that the highest price that the purchaser is willing to accept is the price given by (A7). This completes all the relevant regimes and the monopoly solution under uniform pricing is fully characterised by (8).

B. Equilibrium existence under therapeutic competition with uniform pricing

The Nash equilibrium given by (20) exists if the surplus of the health plan, S_{12}^D, is non-negative. To confirm this, assume without loss of generality that $v_i \geq v_j$, implying $\Delta v \geq 0$. From (25) we derive

$$\frac{\partial S_{12}^D}{\partial v_i} = \frac{1}{2} + \frac{(5\beta - 4)\Delta v}{18t\beta} > 0 \text{ for } \Delta v < 3t. \tag{B1}$$

Thus, for a given value of v_j, S_{12}^D is monotonically increasing in v_i, which implies that the scope for $S_{12}^D \geq 0$ is minimised for $v_i = v_j$. Evaluating S_{12}^D at $v_i = v_j$ yields

$$S_{12}^D\big|_{v_i=v_j} = v_i - c - \frac{4+\beta}{4\beta}t. \tag{B2}$$

It follows that a sufficient (but not necessary) condition for $S_{12}^D \geq 0$ is

$$\min\{v_i, v_j\} \geq c + \frac{4+\beta}{4\beta}t. \tag{B3}$$

C. Proofs

Proof of Proposition 5

Let drug i be the high-quality drug and drug j the low-quality drug, implying $\Delta v > 0$.

(i) Consider first the case of *de facto* therapeutic competition, which requires $\Delta v < t$. From (25) and (36), a comparison of the *health plan surplus* under uniform pricing and two-part tariffs yields

$$S_{12}^{D} - \widehat{S}_{12}^{D} = \frac{(7\beta - 2)(\Delta v)^2 - (2 - \beta) 9t^2}{18t\beta}. \tag{C1}$$

The sign of (C1) depends on the sign of the numerator, which is monotonically increasing in Δv. Setting Δv at the upper bound, $\Delta v = t$, the numerator reduces to $-4t^2(5 - 4\beta) < 0$. Thus, $S_{12}^{D} < \widehat{S}_{12}^{D}$ for all $\Delta v < t$.

Consider next the case of *potential* therapeutic competition, which requires $\Delta v \in (t, 3t)$. From (25) and (42), a similar *health plan surplus* comparison yields

$$S_{12}^{D} - \widehat{S}_{i}^{d} = \frac{9t((2\Delta v + t)\beta - 4t) + (5\beta - 4)(\Delta v)^2}{36t\beta}. \tag{C2}$$

The sign of (C2) depends on the sign of the numerator, which we define as A, where

$$\frac{\partial A}{\partial \beta} = (3t + \Delta v)(3t + 5\Delta v) > 0, \tag{C3}$$

implying that the numerator is monotonically increasing in β. Evaluating A at the lower bound of β yields

$$A|_{\beta=\frac{1}{2}} = -\frac{3}{2}\left(3t(7t - 2\Delta v) + (\Delta v)^2\right) < 0 \text{ for } \Delta v \in (t, 3t). \tag{C4}$$

Evaluating A at the upper bound of β yields

$$A|_{\beta=1} = 9t(2\Delta v - 3t) + (\Delta v)^2, \tag{C5}$$

which is monotonically increasing in Δv. It is easily verified that $A|_{\beta=1} < 0$ for $\Delta v = t$ and $A|_{\beta=1} > 0$ for $\Delta v = 3t$. Thus, $A > 0$, implying $S_{12}^{D} > \widehat{S}_{i}^{d}$ if both β and Δv are sufficiently high. Otherwise, $S_{12}^{D} < \widehat{S}_{i}^{d}$.

(ii) Consider first the case of *de facto* therapeutic competition, which requires $\Delta v < t$. From (23) and (33), a comparison of profits under uniform pricing and two-part tariffs for the *high-quality* *producer* yields

$$\pi_i^D - \widehat{\pi}_i^D = \frac{9t^2\,(2-\beta) - \Delta v\,((9\beta - 2)\,\Delta v - 6t\,(2-3\beta))}{36t\beta}. \tag{C6}$$

The sign of (C6) is given by the sign of the numerator, which we define as B, where

$$\frac{\partial B}{\partial \beta} = -9\,(t + \Delta v)^2 < 0, \tag{C7}$$

implying that the numerator is monotonically decreasing in β. Evaluating B at the lower bound of β yields

$$B|_{\beta=\frac{1}{2}} = \frac{1}{2}\,(3t - \Delta v)\,(9t + 5\Delta v) > 0 \text{ for } \Delta v < t. \tag{C8}$$

Evaluating B at the upper bound of β yields

$$B|_{\beta=1} = 3t\,(3t - 2\Delta v) - 7\,(\Delta v)^2\,. \tag{C9}$$

It is easily verified that $B|_{\beta=1} > 0$ if Δv is sufficiently close to zero, and $B|_{\beta=1} < 0$ if Δv is sufficiently close to t. Thus, $\pi_i^D < \widehat{\pi}_i^D$ if β and Δv are both sufficiently high. Otherwise, $\pi_i^D > \widehat{\pi}_i^D$. A similar profit comparison for the *low-quality producer* yields

$$\pi_j^D - \widehat{\pi}_j^D = \frac{9t^2\,(2-\beta) - \Delta v\,((9\beta - 2)\,\Delta v + 6t\,(2-3\beta))}{36t\beta}. \tag{C10}$$

The sign of (C10) depends on the sign of the numerator, which we define as C, where

$$\frac{\partial C}{\partial \beta} = -9\,(t - \Delta v)^2 < 0, \tag{C11}$$

implying that the numerator is monotonically decreasing in β. Evaluating C at the upper bound of β yields

$$C|_{\beta=1} = \Delta v\,(6t - 7\Delta v) + 9t^2 > 0 \text{ for } \Delta v < t. \tag{C12}$$

Thus, $C > 0$, implying $\pi_j^D > \widehat{\pi}_j^D$ for all $\beta \in \left(\frac{1}{2}, 1\right]$ and $\Delta v < t$.

Consider next the case of *potential* therapeutic competition, which requires $\Delta v \in (t, 3t)$. In this regime, the *low-quality producer* is included in the health plan under uniform pricing and excluded from the health plan under two-part tariffs, which obviously means that the profits are higher in the former case. From (23) and (40), a profit comparison for the *high-quality producer* yields

$$\pi_i^D - \widehat{\pi}_i^d = \frac{3t\left(3t - 2\Delta v\left(3\beta - 1\right)\right) + \left(\Delta v\right)^2}{18t\beta}. \tag{C13}$$

The sign of (C13) depends on the sign of the numerator, which we define as E, where

$$\frac{\partial E}{\partial \beta} = -\frac{\left(3t + \Delta v\right)^2}{18t\beta^2} < 0, \tag{C14}$$

implying that the numerator is monotonically decreasing in β. Evaluating E at the lower bound of β yields

$$E|_{\beta=\frac{1}{2}} = \frac{3t\left(3t - \Delta v\right) + \left(\Delta v\right)^2}{9t} > 0 \text{ for } \Delta v \in \left(t, 3t\right), \tag{C15}$$

while evaluating E at the upper bound of β yields

$$E|_{\beta=1} = \frac{\left(\Delta v\right)^2 - 3t\left(4\Delta v - 3t\right)}{18t} < 0 \text{ for } \Delta v \in \left(t, 3t\right). \tag{C16}$$

Thus, $\pi_i^D > (<)\, \widehat{\pi}_i^d$ if β is sufficiently low (high).

(iii) Consider first the case of *de facto* therapeutic competition, which requires $\Delta v < t$. From (24) and (35), a comparison of the *total health benefit* under uniform pricing and two-part tariffs yields

$$H_i^D - \widehat{H}_i^D = -\frac{\left(\Delta v\right)^2}{9t} < 0. \tag{C17}$$

For the case of *potential* competition, which requires $\Delta v \in (t, 3t)$, a similar comparison yields

$$H_i^D - \widehat{H}_i^d = \frac{\left(3t - 5\Delta v\right)\left(3t - \Delta v\right)}{36t} < 0 \text{ for } \Delta v \in \left(t, 3t\right). \tag{C18}$$

Proof of Proposition 7

(i) For $\Delta v < t$, the health benefit of exclusive contracting when the producers use two-part tariffs, denoted by ΔH, is given by a comparison of (41) and (35), yielding

$$\Delta H = v_i - \frac{t}{2} - \left(\overline{v} - \frac{t}{4} + \frac{\left(\Delta v\right)^2}{4t}\right) = -\frac{\left(t - \Delta v\right)^2}{4t} < 0. \tag{C19}$$

The effect of exclusive contracting on the surplus of the health plan, denoted by ΔS, is given by a comparison of (42) and (36), yielding

$$\Delta S = v_j - c - \frac{t}{2} - \left(\overline{v} - c - \frac{3t}{4} - \frac{(\Delta v)^2}{4t} \right) = \frac{(t - \Delta v)^2}{4t} > 0. \tag{C20}$$

For $\Delta v \in [t, 3t)$, the Nash equilibrium under exclusive contracting is identical to the Nash equilibrium under non-exclusivity (which is characterised by *potential therapeutic competition*). Contract exclusivity is therefore irrelevant in this parameter range.

(ii) Under uniform pricing, the health benefit of non-exclusivity (instead of exclusive contracting) is given by (C18) in the proof of Proposition 5, where in this case the relevant parameter range is $\Delta v < 3t$. It is straightforward to verify that this expression is positive (negative) if $\Delta v < (>) \frac{3}{5}t$. Similarly, the effect of non-exclusivity on the health plan's surplus is given by (C2) in the proof of Proposition 5, once more with the relevant parameter range being $\Delta v < 3t$. It is easily verified that the condition for a positive (resp. negative) sign of this expression, which in the proof of Proposition 5 is derived for $\Delta v \in [t, 3t)$, also extends to $\Delta v < t$. Thus, (C2) is positive if both β and Δv are sufficiently high, and negative otherwise.

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