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Competition matters: uniform vs. indication-based pricing of pharmaceuticals*

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Abstract

Pharmaceutical expenditures are rising rapidly, driven in part by the innovation of highly effective but very expensive drug therapies that treat multiple diseases. While these drugs offer substantial health benefits, payers face a critical trade-off between cost containment and access to new medicines. A key policy question is whether producers should be restricted to uniform pricing or allowed to use indication-based pricing, where prices vary across patient groups. We analyse how this choice affects drug producers' incentives to invest in new indications, their pricing strategies, and the resulting surplus for health plans. In a monopoly setting, indication-based pricing yields higher profits and thus strengthens incentives to invest in new indications, while the payer prefers uniform pricing unless the fixed investment costs cannot be recouped. The novelty of our study lies in showing that monopoly-based insights may not hold under competition. Specifically, we identify a softening-of-competition effect, where a uniform pricing restriction serves as a credible commitment to raise prices in the competitive market. In this case, the health plan generally favours indication-based pricing to reduce costs. However, an exception arises, where both parties prefer uniform pricing, if the uniform price generates significant health gains through demand expansion in the original monopoly market. Our findings suggest that neither pricing scheme is universally optimal, underscoring the need for case-by-case assessments across drug classes.

Keywords: Pharmaceuticals; Innovation incentives; Payer pricing schemes

JEL Classification: I18; L13; L65; O31

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1 Introduction

New innovative drugs are being introduced at a rapid pace, significantly contributing to the rise in drug expenditures. According to the IQVIA Institute, global pharmaceutical spending increased from \$1.2 trillion in 2018 to \$1.6 trillion in 2023—a growth of more than 30% (IQVIA, 2024).¹ This growth in expenditure is driven not only by the large number of global launches of novel active substances, but also by the increasing approvals of drugs for multiple new indications.²

The top-selling drug Keytruda, developed by Merck, serves as an excellent example.³ First approved by the U.S. Food and Drug Administration (FDA) in September 2014 for the treatment of advanced or unresectable melanoma, Keytruda has since expanded its range of approved indications, including lung cancer, head and neck cancer, bladder cancer, among others. This year, the drug got its 40th FDA approval. From modest sales after its initial launch, Keytruda's global sales peaked at \$25 billion globally in 2023, with forecasts projecting it to reach \$30 billion by 2025.⁴

Many of the new medicines, such as Keytruda, are highly effective in treating a range of serious illnesses, including various cancers. These drugs prolong life expectancy, improve quality of life, and provide significant health gains to both patients and the society. However, the rapid pace of new, innovative drugs also poses challenges to payers due to high prices and escalating treatment costs. Thus, health plans face a critical trade-off: on the one hand, ensuring their patients access to new, effective drug therapies; and on the other, controlling prices and managing drug expenditures.

A key issue at the forefront of recent policy discussions is whether drug producers should be permitted to set different prices of a medication based on its effectiveness for various indications or medical conditions—a practice known as indication-based pricing.⁵ Proponents argue that allowing producers to price discriminate across patient groups aligns drug prices more closely

¹These estimates exclude COVID-19 vaccines and therapeutics.

²Once a new drug is approved for its primary indication, pharmaceutical companies often continue investing in clinical trials to gather evidence of its efficacy for additional medical conditions. In some cases, promising treatment effects for new indications are discovered by chance. In others, the decision to explore new indications is guided by existing knowledge about the drug (Berndt et al., 2006).

³According to IQVIA (2023, p. 36), of the 89 solid tumor cancer drugs launched in the United States since 2013, 22 have received approval for multiple indications.

⁴See Merck's 4th quarter and full-year financial results published February 1, 2024.

⁵See, for instance, the article "AstraZeneca calls on UK to change rules on innovative drug pricing" in the Financial Times on 25 July 2024 or the recent report by Woods et al. (2024) that estimates the population health effects of uniform and indication-based pricing for the UK NHS.

with their therapeutic value, potentially improving access to new medicines and encouraging innovation.⁶

However, health plans typically require uniform pricing of drugs, which prevents drug producers from price discriminating across indications, even when there are substantial differences in therapeutic benefits. Furthermore, once a drug is approved for a primary medical condition, health plans often restrict drug producers from increasing the (uniform) price of the first approved indication. This practice effectively imposes a *de facto* price cap for subsequent indication approvals, limiting the drug producers' flexibility to adjust prices based on variations in demand and health benefits across patient groups.

The primary rationale for health plans to adopt uniform pricing policies is to contain costs.⁷ However, prior studies have pointed out that this practice may have adverse effects on patients.⁸ First, it can lead to reduced coverage for low-value indications, as the uniform price may be too high for these treatments to be considered cost-effective. Second, it can discourage drug producers from investing in approvals for new indications, as the inability to adjust prices might result in insufficient demand and profits to recoup fixed investment costs.

In this paper, we explore the trade-off between cost containment and access to new medicines by analysing how the choice of pricing scheme affects the drug producers' incentives to invest in approvals for additional indications, their strategic pricing of the drugs, and the resulting surplus to the health plan and its patients. While a small but growing body of literature already exists on indication-based and uniform pricing of pharmaceuticals, a key assumption in this literature is that the drug producer operates as a monopolist.⁹ However, in reality it is rarely the case that multi-indication drugs are completely shielded from therapeutic competition. For many indications, multiple drug therapies are typically available. For example, the top-selling drug Keytruda, as mentioned above, faces competition from alternative therapies for several cancer indications.¹⁰

The key contribution of our paper is to incorporate *competition* into the analysis of the effects of uniform and indication-based pricing schemes. Building on the two-market (two-indication)

⁶See, for instance, the systematic review by Preckler and Espin (2022) or the recent report by Woods et al. (2024).

⁷Low administrative burdens and simplicity of implementation are also mentioned as arguments in favour of uniform pricing as opposed to indication-based pricing (see, e.g., Woods et al., 2024).

⁸See, for instance, Preckler and Espin (2022).

⁹See, for instance, Adida (2023) and references therein. We relate our paper to the existing literature in the next section.

¹⁰The main competitors are Opdivo (by Bristol-Myers Squibb), Tecentriq (by Roche) and Imfinzi (by AstraZeneca), which are approved for a subset of the same indications as Keytruda (by Merck).

framework developed by Adida (2023) for the monopoly case, we introduce competition in two distinct ways, based on the observation that multi-indication drug producers often face competition for some indications while having monopoly power for others. First, we analyse the scenario where a drug producer faces competition in the original market and decides whether to invest in approval for a second indication, where it would operate as a monopolist. Second, we examine the reverse scenario, where the drug producer is a monopolist in the original market and considers investing in approval for a new indication that already has a therapeutic alternative. We contrast these two competitive scenarios with a benchmark case in which a monopolist drug producer decides whether to invest in approval for a new indication that currently lacks any treatment alternatives, as examined by Adida (2023). This approach enables us to evaluate the extent to which insights from the monopoly benchmark remain applicable in the presence of competition, whether in the original market or the market for a new indication.

Using a standard duopoly model, where the therapeutic effects of available drug therapies can vary both vertically and horizontally across patients and indications, we derive the equilibrium outcomes for three different pricing schemes: (i) indication-based pricing, where the drug producer sets prices separately in each market; (ii) unrestricted uniform pricing, where the drug producer must set the same price across indications but is allowed to adjust the uniform price upward if profitable after investing in approval for a new indication; and (iii) restricted uniform pricing, where the price of the originally approved indication acts as a price cap for subsequent indications.

Starting with the monopoly case, our results align with the findings of Adida (2023). The drug producer achieves higher profits with indication-based pricing and is more likely to invest in approval for a new indication compared to either unrestricted or restricted uniform pricing. The health plan is generally better off with uniform pricing unless the producer’s profits from the new indication are insufficient to cover the fixed investment costs of approval. In cases where launching the drug for a new indication is not profitable for the producer, the health plan and its patients may benefit more from indication-based pricing, as it increases access to the drug for a broader group of patients. These findings highlight the trade-off health plans face between containing costs and ensuring access to new medicines.

However, with competition (in either the original or the new market), the insights from the monopoly case may no longer hold. Specifically, we identify a *softening-of-competition* effect due to uniform pricing, where the drug producer can actually earn higher profits than with

indication-based pricing. This effect occurs when the price in the monopoly market is higher than the price in the competitive market under indication-based pricing.¹¹ In this case, the uniform pricing restriction serves as a credible commitment for the drug producer to set a higher price in the competitive market than what would be possible under indication-based pricing.

We show that the profit gain of a higher price in the competitive market can outweigh the profit loss in the monopoly market, where the uniform price is lower than the monopoly price. Uniform pricing is more likely to be profitable for the producer when the rival drug is a relatively close substitute, which means that price competition will be fierce in the competitive market with indication-based pricing. In this case, uniform pricing would make the drug producer less price aggressive when launching the drug for a new indication. Since prices are strategic complements, the rival drug producer responds by also being less price aggressive, which in turn results in higher prices and larger profit margins in the competitive market.

The softening-of-competition effect occurs regardless of whether competition takes place in the original or in the new market.¹² However, if the health plan does not permit upward adjustments of the uniform price (i.e., restricted uniform pricing), this effect is eliminated for the scenario with competition in the original market. In this scenario, the drug producer has an incentive to increase the uniform price when entering the new (monopoly) market but is constrained by the health plan's restriction. As a result, the drug producer would prefer indication-based pricing, as it allows for monopoly pricing in the new market. In the opposite scenario, where competition occurs in the new market, the drug producer has an incentive to lower the uniform price set for the original indication upon launching the drug for the new indication. In this case, the implicit price cap imposed by the restriction on upward price adjustments no longer constrains the drug producer. Therefore, the potential for a softening-of-competition effect from uniform pricing is greater when competition occurs in the new market and/or upward price adjustments are permitted.

While uniform pricing can lead to a softening-of-competition effect that increases profits for the multi-indication drug producer, the health plan and its patients are generally worse off in this scenario and prefer indication-based pricing to reduce drug expenditures. However, we

¹¹In the opposite case, where the price in the competitive market is higher than the price in the monopoly market, uniform pricing intensifies (instead of softens) competition. In this case, the drug producer always prefers indication-based pricing, and the results are qualitatively similar to the monopoly case.

¹²The necessary condition is, as mentioned above, that the price in the monopoly market is higher than the price in the competitive market under indication-based pricing.

also identify an exception where both the drug producer and the health plan are better off with uniform pricing. This exception occurs when competition takes place in the new market, leading to a reduction in the (uniform) price in the original (monopoly) market when the drug is launched for the new indication. In this scenario, uniform pricing expands demand in the original market, generating a health gain for patients that can outweigh the losses from higher prices in the new (competitive) market compared to indication-based pricing.

These findings have important implications for policymakers and health plans. Rather than applying a uniform pricing rule across all drugs within a class, it may be more effective to implement drug class-specific pricing policies that consider factors such as relative incidences, treatment effects, investment costs for approvals, and, importantly, the potential for competition within each indication. Certain drugs might be required to maintain uniform prices across indications, while others could be permitted to use indication-based pricing. By tailoring pricing policies to the characteristics of specific drug classes, policymakers and health plans can achieve a balance between ensuring patient access to treatments and containing costs, while accounting for the complexities and competitive dynamics within different indications.

The rest of the paper is organised as follows. In the next section we relate our study to the existing literature. Section 3 introduces the theoretical model. Section 4 derives the monopoly benchmark under indication-based pricing and both restricted and unrestricted uniform pricing. Section 5 examines the equilibrium outcomes when competition exists either in the original or the new market. Section 6 compares the effects of the three pricing schemes on the drug producer's incentives to invest in approval for a new indication and the health plan's surplus. Section 7 discusses policy implications and offers concluding remarks. Finally, Appendix A provides the equilibrium existence conditions, and Appendix B presents the proofs of the propositions.

2 Related literature

Our study makes contributions to several strands of the existing literature. The health policy and economics literature have extensively discussed indication-based pricing, using numerical examples of specific drugs to illustrate potential effects on prices and drug expenditure (see, for instance, Garrison and Veenstra, 2009; Bach, 2014; Yeung et al., 2017; Hui et al., 2017; Mestre-Ferrandiz et al., 2018; and Woods et al., 2024). These contributions generally support indication-based pricing by highlighting the improved alignment of prices with the value of the

drug across different uses. Value-based pricing allows manufacturers to sell the drug to patients with lower treatment value, without compromising profitability when selling the same drug to patients with more significant treatment effects. However, as noted by Chandra and Garthwaite (2017), indication-based pricing not only enables manufacturers to reduce prices for low-value indications but also to increase prices for high-value indications.

More recently, several authors have developed theoretical models to evaluate the performance of indication-based pricing. Levaggi and Pertile (2020) characterise the dynamic (innovation) and static (access) efficiency properties of different pricing rules when treatment effects vary across patients. Assuming price regulation, they consider a set up where the payer sets the drug price either equal to the treatment benefit for the marginal patient or equal to the average benefit of the treated population. They show that average value-based prices ensure both static and dynamic efficiency, but result in higher drug expenditures and lower consumer surplus compared to marginal value-based pricing.

Hlávka et al. (2021) examine a setting where the payer and a manufacturer engage in price negotiations for a drug. They consider a predefined set of indications with varying expected treatment outcomes, and the drug prices and access to different indications are jointly determined through Nash bargaining. Assuming symmetric information and no agency issues between the payer, patients, and providers, a uniform price across all indications achieves efficiency. However, by relaxing the assumptions regarding information and agency, they discuss situations in which indication-based pricing can improve efficiency.

Like Hlávka et al. (2021), Levaggi and Levaggi (2021) assume that the effectiveness of the drug differs both between and within indications. Instead of engaging in efficient bargaining, they assume that the manufacturer sets the drug price first, and subsequently the payer reacts by selecting the number of approved indications that maximises consumer surplus. In such a situation, the drug is approved for too few indications. Effectively, this outcome is similar to uniform monopoly pricing. Levaggi and Levaggi (2024) expand on this analysis by allowing the manufacturer to propose prices specific to each indication. This enables the payer to ensure efficient access to the drug by establishing a common cost-effectiveness threshold for all indications prior to the manufacturer submitting the indication-specific prices. Nevertheless, achieving the ideal level of access requires that the threshold is set at the social value of treatment, resulting in the manufacturer extracting the entire surplus.

These theoretical studies share the assumption that once a drug is approved as safe and effec-

tive by the authority, it becomes automatically available for reimbursement across all indications chosen by the payer. However, we deviate from this assumption by adopting the framework proposed by Adida (2023), which aligns with the growing field of healthcare operations management that explores new pricing models for drugs; see Adida (2021), Olsder et al. (2022), and Xu et al. (2022). Adida (2023) assumes that a drug is already approved for a primary indication and that the manufacturer can choose to invest in gaining approval for a supplementary indication. She finds that the manufacturer earns higher profits under indication-based pricing than under uniform pricing. Moreover, indication-based pricing improves incentives for the manufacturer to invest in a new indication and for the payer to cover the drug. If the fixed investment cost is high, indication-based pricing also benefits patients and the payer’s objective. Otherwise, the patient demand, patient utility and payer’s objective may be lower under indication-based pricing.

A common feature shared by both the health economics and operations management literature concerning the choice of pricing scheme is the absence of competition among drug manufacturers. Our novel contribution to both research streams stems from the introduction of therapeutic competition. We develop an extensive analysis of indication-based pricing by incorporating different market structures for both the primary and the supplementary indication. This allows us to capture a crucial aspect of pharmaceutical markets, as multiple manufacturers often seek approval for the same indication (see, for example, Gerriets et al., 2023). Previous studies demonstrate that the entry of therapeutic competitors indeed has an impact on the prices of existing drugs, even in markets for cancer therapies (see, e.g., Kanavos et al., 2007; Danzon and Epstein, 2012; Vokinger et al., 2022).¹³

We introduce therapeutic competition by drawing from a body of literature on pharmaceutical markets that utilises a spatial framework, incorporating both horizontal and vertical differentiation among drugs (see, for example Miraldo, 2009; Bala and Bhardwaj 2010; Bardey et al. 2010; Bardey et al. 2016; González et al. 2016; Brekke et al., 2022, 2023, and 2024). By adopting the spatial competition model to the multi-indication drug framework proposed by Adida (2023), we isolate the impact of competition on the efficacy of indication-based pricing. In the next section we present our modelling framework.

¹³Our focus on competition means that our paper also relates more broadly to the IO literature on third-degree price discrimination in oligopoly, where some early key contributions include Holmes (1989), Winter (1997) and Corts (1998). However, the particular institutional features and policy concerns related to pharmaceutical markets imply that the insights from the more general IO literature are not directly transferrable to an analysis of indication-based vs. uniform pricing of drugs.

3 Model

Consider a unit mass of patients who differ with respect to indication and their therapeutic response to drug treatment. A share $1 - \lambda$ of them have indication A and constitute the potential demand in what we refer to as Market A . The remaining share of patients have indication B and constitute the potential demand in Market B . Thus, we can interpret λ as the size of Market B relative to Market A . All patients are covered by a (monopoly) health plan, and each patient can be treated by one unit of any available drug that is included in the plan as treatment for the relevant indication.

An on-patent drug is currently used to treat indication A . However, it has recently been discovered that the same drug might also be used to treat indication B . This enables the producer to enter Market B with the same drug by applying for its inclusion in the health plan as treatment also for indication B . The therapeutic benefit of this drug for a patient with indication j is given by $v^j - t^j x$, where the therapeutic mismatch value x is a random draw from a uniform distribution on $[0, 1]$, and $j = A, B$. Thus, within each indication, some patients respond better to the drug treatment than others, and the parameter t^j measures the degree of patient heterogeneity in terms of therapeutic benefit of drug treatment for indication j .

In each market, the producer of the drug might face competition from another producer of a therapeutically substitutable drug. If so, the therapeutic benefit of the alternative drug treatment in Market j is $v^j - t^j (1 - x)$, implying that the therapeutic mismatch values for the two drugs are negatively correlated, such that each drug yields a higher therapeutic benefit than its alternative for half of the patients with indication j , and that the intensity of therapeutic competition in Market j is inversely measured by the parameter t^j . In case of therapeutic competition, which might occur either in Market A or in Market B , we will refer to the drug in question as drug 1 and the therapeutic alternative as drug 2.

Treatment choices are made by physicians who consider both therapeutic benefits and treatment costs when making their drug prescription decisions. More specifically, in case there is only one available drug in the market, we assume that one unit of this drug will be prescribed to those patients for whom the therapeutic benefit (measured in monetary terms) is at least as high as the price of the drug. In markets with therapeutic competition, each patient will be prescribed one unit of the drug that yields the higher net therapeutic benefit (i.e., therapeutic benefit minus the drug price), provided that this net benefit is non-negative. Thus, we can

think of prescription choices as being made by a physician who acts as a perfect agent for a health plan that maximises total treatment benefits net of purchasing costs.¹⁴

We will consider three different market structures regarding the degree of therapeutic competition in the two markets. As a benchmark, we use the case of monopoly in both markets. In this case, which we denote by MM , the drug in question is the only available treatment for indication A and there is no pre-existing treatment for indication B , implying that the drug's producer will be a monopolist in both markets if the drug is included in the health plan as treatment also for indication B . We will compare this benchmark with two different market structures that imply therapeutic competition for one of the two indications. First, we consider the case in which the producer already faces therapeutic competition in Market A but will become a monopolist in Market B if it enters this market. We will denote this market structure by CM . Second, we consider the opposite case, in which the drug in question is the only available treatment for indication A but there already exists another treatment for indication B , implying that the producer will face therapeutic competition in Market B if it enters. We will denote this market structure by MC .

Regardless of market structure, we assume that all drugs can be produced at a constant marginal cost which, without further loss of generality, is set equal to zero, and that all drug producers are profit maximisers. We also assume that drug prices are set by the producers (in a non-cooperative simultaneous-move game in case of therapeutic competition). However, the health plan might impose restrictions on this price setting.

More specifically, we assume that, in case the drug in question is approved by the health plan as treatment for both indications, the pricing decision is made under one of three possible price-setting schemes: (i) *indication-based pricing*, denoted by I , in which pricing is completely unrestricted and the producer can set different prices for the drug in the two markets; (ii) *unrestricted uniform pricing*, denoted by U , in which the producer is only restricted by the condition that the drug must have the same price in both markets; (iii) *restricted uniform pricing*, denoted by $\hat{U}$, in which the producer must set the same price in both markets and also faces the additional restriction that this price cannot be higher than the pre-existing price of the drug in Market A (i.e., upward price adjustments are not allowed).

In the subsequent sections we derive the equilibrium drug prices for each possible combi-

¹⁴In case of patient copayments, the total purchasing cost will be shared between the health plan and the patients. As long as the prescribing physician places equal weights on therapeutic benefits and treatment costs, it does not matter for prescription choices who pays these costs.

nation of market structure and pricing scheme. We restrict attention to equilibria in which Market j is fully covered under therapeutic competition (i.e., every patient with indication j is prescribed one of the available drugs) but only partially covered under monopoly (i.e., some of the patients with indication j are not prescribed the drug because the therapeutic benefit is too low compared to the treatment costs). This assumption has two seemingly attractive implications, since it allows us to focus on cases in which (i) demand for a drug is price elastic regardless of whether the producer of the drug faces therapeutic competition or not, and (ii) entry of a new therapeutic alternative for a particular indication implies an expansion of the market and not just ‘business stealing’ from the pre-existing drug. For each of the three market structures considered, we will define a parameter set in which such equilibria exist under all three pricing schemes.

Finally, in order to determine the drug producer’s entry decision, suppose that the costs associated with having the drug approved as a treatment for indication B are given by $f > 0$, and suppose that the health plan is able to commit to a certain pricing scheme before the entry decision is made. The producer’s entry decision is then assumed to be made at the second stage of the following three-stage game:

Stage 1 The health plan decides a pricing scheme $s \in S = \{I, U, \hat{U}\}$.

Stage 2 The producer decides whether or not to invest f in order to have its drug approved for indication B .

Stage 3 The producer chooses the price(s) of its drug.

Since we are focusing on the pricing and entry incentives of the producer of the drug that already exists in Market A and might enter Market B , we will intermittently refer to these two markets as the *original market* and the *new market*, respectively.

4 Benchmark: Monopoly in both markets

Suppose that there is only one drug that can treat patients with either indication A or indication B , and that both treatments (with the same drug) are included in the health plan. Let p^j be the price of this drug when prescribed as treatment for patients with indication j . If prescription choices are made according to the assumptions laid out in the previous section, demand for this

drug in Market A is given by

$$q^A = (1 - \lambda) \left(\frac{v^A - p^A}{t^A} \right), \quad (1)$$

whereas demand for the same drug in Market B is given by

$$q^B = \lambda \left(\frac{v^B - p^B}{t^B} \right). \quad (2)$$

The producer's profits from sales in Market j are then given by

$$\pi^j = p^j q^j, \quad j = A, B. \quad (3)$$

The health plan's surplus is the total health benefits minus total purchasing costs, which in Market A is given by

$$S^A = (1 - \lambda) \int_0^{\frac{v^A - p^A}{t^A}} (v^A - t^A x) dx - p^A q^A, \quad (4)$$

and in Market B is given by

$$S^B = \lambda \int_0^{\frac{v^B - p^B}{t^B}} (v^B - t^B x) dx - p^B q^B. \quad (5)$$

4.1 Indication-based pricing

Supposed that the producer is allowed to charge different prices in the two markets. In this case, the profit-maximising price in Market j is given by

$$p_{MM}^j(I) = \frac{v^j}{2}, \quad j = A, B, \quad (6)$$

which implies that the producer will set a higher price for the drug when prescribed to patients with an indication for which the drug has a higher therapeutic benefit (on average). The reason is simply that a higher therapeutic benefit increases demand and therefore makes it less price-elastic, all else being equal, which in turn implies that profits are maximised at a higher price level.

With prices given by (6), market-specific demand is given by

$$q_{MM}^A(I) = \frac{(1 - \lambda) v^A}{2t^A} \quad (7)$$

and

$$q_{MM}^B(I) = \frac{\lambda v^B}{2t^B}, \quad (8)$$

and market-specific profits by

$$\pi_{MM}^A(I) = \frac{(1-\lambda)(v^A)^2}{4t^A} \quad (9)$$

and

$$\pi_{MM}^B(I) = \frac{\lambda(v^B)^2}{4t^B}. \quad (10)$$

Total profits are then given by

$$\pi_{MM}(I) = \pi_{MM}^A(I) + \pi_{MM}^B(I) = \frac{(1-\lambda)t^B(v^A)^2 + \lambda t^A(v^B)^2}{4t^A t^B}, \quad (11)$$

whereas the total surplus for the health plan is given by

$$S_{MM}(I) = \frac{(1-\lambda)t^B(v^A)^2 + \lambda t^A(v^B)^2}{8t^A t^B}. \quad (12)$$

This equilibrium, with partial coverage in each market, exists if

$$v^j < 2t^j, \quad j = A, B, \quad (13)$$

which essentially implies that, in each market, the degree of patient heterogeneity in therapeutic benefits is sufficiently large, such that a monopolist will not find it profitable to set the price so low that all patients who might potentially benefit from drug treatment will be prescribed the drug.

4.2 Unrestricted uniform pricing

Suppose instead that the producer is not allowed to set different prices of the drug when used for patients with different indications, but is otherwise allowed to set any (uniform) price. The profit-maximising uniform price is given by

$$p_{MM}(U) = \frac{(1-\lambda)t^B v^A + \lambda t^A v^B}{2((1-\lambda)t^B + \lambda t^A)}. \quad (14)$$

Whereas the optimal indication-based prices depend on the price elasticity of demand in each market, the optimal uniform price is determined by the *weighted average price elasticity* of

demand across the two markets. It is therefore easily verified that the price given by (14) is a weighted average of the two prices given by (6), where the weights depend on relative market size. If a larger share of the firm's total sales occur in Market j , the optimal uniform price is closer to the price that maximises the profits from selling the drug to Market j alone.

With a uniform price given by (14), the demand for the drug in the two markets is given by

$$q_{MM}^A(U) = (1 - \lambda) \frac{[(1 - \lambda)t^B + 2\lambda t^A]v^A - \lambda t^A v^B}{2((1 - \lambda)t^B + \lambda t^A)t^A} \quad (15)$$

and

$$q_{MM}^B(U) = \lambda \frac{(1 - \lambda)(2v^B - v^A)t^B + \lambda t^A v^B}{2((1 - \lambda)t^B + \lambda t^A)t^B}, \quad (16)$$

respectively. The corresponding expressions for total profits of the producer and total surplus of health plan are given by

$$\pi_{MM}(U) = \frac{((1 - \lambda)t^B v^A + \lambda t^A v^B)^2}{4((1 - \lambda)t^B + \lambda t^A)t^A t^B} \quad (17)$$

and

$$S_{MM}(U) = \frac{\left[(1 - \lambda)((1 - \lambda)t^B + 4\lambda t^A)t^B(v^A)^2 + \lambda(4(1 - \lambda)t^B + \lambda t^A)t^A(v^B)^2 - 6\lambda(1 - \lambda)t^A t^B v^A v^B \right]}{8((1 - \lambda)t^B + \lambda t^A)t^A t^B}, \quad (18)$$

respectively.

This equilibrium exists for a parameter set given by

$$\underline{v}_{MM} < v^B < \bar{v}_{MM}. \quad (19)$$

If the therapeutic benefit of the drug for patients with indication B is sufficiently low, it is not profitable for the firm to enter Market B when it has to charge the same (low) price for the drug in Market A . On the other hand, if the therapeutic benefit of the drug is sufficiently high in Market B , the firm's most profitable option is to leave Market A and enter Market B with an even higher price than the one given by (14). Both of these possibilities are ruled out as equilibrium outcomes by the condition in (19).¹⁵

¹⁵See Appendix A for a formal proof of equilibrium existence, including explicit expressions for the lower and upper bounds on v^B .

4.3 Restricted uniform pricing

Finally, suppose that, if entering Market B with the same drug that is already used in Market A , the producer must charge a uniform price that cannot be higher than the pre-existing price of the drug in Market A , which is given by (6).¹⁶ Whether or not this additional restriction binds depends on whether the uniform price that maximises the profits of selling to both markets is higher or lower than the price that maximises the profits of selling to Market A only. From the previous analysis, it follows that the former price is lower (higher) than the latter price if $v^A > (<) v^B$. Thus, if $v^A > v^B$, the optimal price under restricted uniform pricing is still given by (14).

On the other hand, if $v^A < v^B$, the solution to the firm's constrained profit-maximisation problem is a corner solution with a uniform price given by (6). In other words, the producer will set a price

$$p_{MM}(\hat{U}) = p_{MM}^A(I) = \frac{v^A}{2}, \quad (20)$$

which yields the following demand in the two markets:

$$q_{MM}^A(\hat{U}) = q_{MM}^A(I) = \frac{(1-\lambda)v^A}{2t^A}, \quad (21)$$

$$q_{MM}^B(\hat{U}) = \frac{\lambda(2v^B - v^A)}{2t^B}. \quad (22)$$

The profits of the producer and the surplus of the health plan are given by, respectively,

$$\pi_{MM}(\hat{U}) = \left(\frac{(1-\lambda)t^B v^A + \lambda(2v^B - v^A)t^A}{4t^A t^B} \right) v^A \quad (23)$$

and

$$S_{MM}(\hat{U}) = \frac{((1-\lambda)t^B + \lambda t^A)(v^A)^2 + 4\lambda(v^B - v^A)t^A v^B}{8t^A t^B}. \quad (24)$$

This equilibrium exists under the parameter condition

$$v^A < v^B < \frac{v^A}{2} + t^B. \quad (25)$$

The lower bound in on v^B is required for the additional restriction on uniform pricing to bind, whereas the upper bound is required to have a partially covered market for indication A . It is

¹⁶This is a quite common restriction that many health plans impose, which essentially amounts to an implicit price cap on the drug pricing.

easily verified that the parameter set given by (25) is non-empty if $v^A < 2t^B$.

4.4 Uniform vs. indication-based pricing

Suppose that the parameters of the model are such that an interior-solution equilibrium exists under all three pricing schemes. This amounts to assuming that $(v^j, t^j, \lambda) \in \Omega_{MM}$, $j = A, B$, where the set Ω_{MM} is defined by (A19)-(A20) in Appendix A. The effects of different pricing schemes on the producer's profits and the health plan's surplus are then characterised as follows:

Proposition 1 *In the case of monopoly (no therapeutic competition), indication-based pricing always yields higher profits for the producer and lower surplus for the health plan than (restricted or unrestricted) uniform pricing. If the therapeutic benefit of the drug is higher in the new market than in the original market (i.e., $v^A > v^B$), restricted uniform pricing yields lower profits and higher health plan surplus than unrestricted uniform pricing.*

These results are not surprising and are in line with well-known results about third-degree price discrimination as a pricing strategy that allows a monopolist to extract a larger share of consumers' surplus than what is possible by uniform pricing. Intuitively, a binding constraint on the uniform price (as under pricing scheme $\widehat{U}$ when $v^A > v^B$) will further hamper the monopolist's ability to extract surplus and therefore benefit the health plan. Thus, in the absence of competition, the producer and the health plan have diametrically opposite interests with respect to the choice of pricing scheme.

The results in Proposition 1 are derived under the assumption that it is profitable for the producer to enter the new market under all three pricing regimes. However, this is not necessarily the case if the entry cost f is sufficiently large. In case of no entry, the health plan's choice of pricing scheme is irrelevant for the producer's pricing decision, which in any case is given by (6) for $j = A$, and the producer's profit (from sales in Market A) is given by (9). The entry decision therefore depends on whether or not the additional profits that can be achieved (in both markets) by selling the drug in the new market under pricing scheme s outweigh the investment cost f . These additional profits, which we denote by Δ_s , are formally given by

$$\Delta_s := \pi_{MM}(s) - \pi_{MM}^A(I), \quad s = I, U, \widehat{U}.$$

At the first stage of the game described in Section 3, the health plan chooses the pricing scheme that maximises the health plan's surplus. Notice that this surplus is always higher if the

producer chooses to enter the new market, regardless of which pricing scheme is in place.¹⁷ The subgame-perfect Nash equilibrium of the full game therefore follows directly from Proposition 1, and is characterised as follows:¹⁸

Proposition 2 *In the case of monopoly (no therapeutic competition), the equilibrium pricing scheme is restricted uniform pricing if $f \leq \Delta_{\widehat{U}}$, unrestricted uniform pricing if $\Delta_{\widehat{U}} < f \leq \Delta_U$, and indication-based pricing if $f > \Delta_U$.*

This proposition illustrates the fundamental trade-off between cost savings and patient access to drug treatments that determines the health plan’s optimal choice of pricing scheme. The health plan’s surplus is higher under uniform pricing when the drug is sold in both markets, but this pricing scheme might not give the producer sufficient incentives to enter the new market. Thus, if the entry costs are sufficiently high, concerns about drug access will induce the health plan to allow indication-based pricing. This is essentially the same trade-off that is identified by Adida (2023), and our results for the benchmark with no competition largely mirror the main results of her analysis. However, the pricing scheme preferences of both the producer and the health plan might significantly change in the face of therapeutic competition in one of the markets, as we will show in the subsequent sections.

5 Therapeutic competition

Suppose now that the drug producer faces therapeutic competition either in the original or in the new market. In the following we derive the Nash equilibrium for each of these two cases—under each of the three pricing schemes considered—starting with the former.

5.1 Therapeutic competition in the original market

If the drug in question faces therapeutic competition from another drug in the original market, under the assumptions about therapeutic benefits and prescription choices laid out in Section 3, demand for the two drugs in Market A is given by

$$q_i^A = (1 - \lambda) \left(\frac{1}{2} + \frac{p_k^A - p_i^A}{2t^A} \right), \quad i, k = 1, 2, \quad i \neq k, \quad (26)$$

¹⁷In case of entry, it follows from Proposition 1 that the health plan’s surplus is lowest under indication-based pricing, in which case the surplus is given by (12). Without entry, the health plan’s surplus comes only from the use of the drug in Market A , at the same price, and is therefore lower than (12).

¹⁸We assume that f is low enough for entry not to be blockaded.

where 1 and 2 denote the drug in question and its therapeutic alternative, respectively. In the absence of competition in Market B , drug demand in that market is still given by (2). The profits of the producer in question, with a drug sold in both markets, are now given by

$$\pi = p_1^A q_1^A + p^B q^B, \quad (27)$$

whereas the profits of the producer of the therapeutic alternative in Market A are given by

$$\pi_2^A = p_2^A q_2^A. \quad (28)$$

With therapeutic competition in Market A , the health plan's surplus in this market is now given by

$$S^A = (1 - \lambda) \left(\int_0^{\frac{1}{2} + \frac{p_2^A - p_1^A}{2t^A}} (v^A - t^A x) dx + \int_{\frac{1}{2} + \frac{p_2^A - p_1^A}{2t^A}}^1 (v^A - t^A (1 - x)) dx \right) - \sum_{i,j} p_i^j q_i^j, \quad (29)$$

where $i = 1, 2$ and $j = A, B$. The health plan's surplus in Market B is still given by (5).

5.1.1 Indication-based pricing

If the producer is able to charge different prices in the two markets, the Nash equilibrium prices in Market A are unaffected by demand in Market B and given by

$$p_{CM1}^A(I) = p_{CM2}^A(I) = t^A. \quad (30)$$

Notice that competition implies that drug prices are decoupled from overall therapeutic benefits and only depend on the degree of therapeutic substitutability, and thus the degree of competition, between the two drugs. In Market B , on the other hand, the profit-maximising price is unaffected by therapeutic competition in Market A and given by (6) for $j = B$. Equilibrium drug demand in Market B is therefore the same as in the benchmark case, given by (8), while demand for each of the two drugs in Market A is given by

$$q_{CM1}^A(I) = q_{CM2}^A(I) = \frac{1 - \lambda}{2}. \quad (31)$$

This yields market-specific profits of

$$\pi_{CM1}^A(I) = \frac{(1-\lambda)t^A}{2} \quad (32)$$

and

$$\pi_{CM}^B(I) = \frac{\lambda(v^B)^2}{4t^B}, \quad (33)$$

and total profits of¹⁹

$$\pi_{CM}(I) = \pi_{CM1}^A(I) + \pi_{CM}^B(I) = \frac{2(1-\lambda)t^A t^B + \lambda(v^B)^2}{4t^B}. \quad (34)$$

The total surplus of the health plan is

$$S_{CM}(I) = \frac{2(1-\lambda)(4v^A - 5t^A)t^B + \lambda(v^B)^2}{8t^B}. \quad (35)$$

This equilibrium, with full coverage in Market A and partial coverage in Market B , exists if

$$v^A > \frac{3}{2}t^A \quad (36)$$

and

$$v^B < 2t^B. \quad (37)$$

5.1.2 Unrestricted uniform pricing

If the producer cannot use indication-based pricing, but is allowed to set an unrestricted uniform price, this price is in equilibrium given by

$$p_{CM}(U) = \frac{3(1-\lambda)t^B + 4\lambda v^B}{3(1-\lambda)t^B + 8\lambda t^A} t^A, \quad (38)$$

whereas the equilibrium price of the therapeutic alternative in Market A is given by

$$p_{CM2}^A(U) = \frac{3(1-\lambda)t^B + 2\lambda(v^B + 2t^A)}{3(1-\lambda)t^B + 8\lambda t^A} t^A. \quad (39)$$

¹⁹The profits of the therapeutic competitor in Market A is not relevant for the analysis and is thus not reported (here or in the subsequent analysis).

A comparison of (30) and (38)-(39) reveals, unsurprisingly, that $p_{CM}(U) > p_{CM2}^A(U) > p_{CMi}^A(I)$ if $v^B > 2t^A$, while $p_{CM}(U) < p_{CM2}^A(U) < p_{CMi}^A(I)$ if $v^B < 2t^A$. If the monopoly price in Market B is higher (lower) than the equilibrium price in Market A under indication-based pricing (i.e., if $v^B > (<) 2t^A$), unrestricted uniform pricing leads to a price increase (reduction) in Market A and price reduction (increase) in Market B . Thus, (unrestricted) uniform pricing implies either a softening or a hardening of competition in the original market, depending on the monopoly price level in the new market. Notice that the price response of the therapeutic competitor in Market A goes in the same direction because of strategic complementarity.²⁰

With these prices, drug demand in the two markets is given by

$$q_{CM1}^A(U) = (1 - \lambda) \frac{3(1 - \lambda)t^B + 2\lambda(6t^A - v^B)}{2(3(1 - \lambda)t^B + 8\lambda t^A)}, \quad (40)$$

$$q_{CM2}^A(U) = (1 - \lambda) \frac{3(1 - \lambda)t^B + 2\lambda(2t^A + v^B)}{2(3(1 - \lambda)t^B + 8\lambda t^A)} \quad (41)$$

and

$$q_{CM}^B(U) = \lambda \frac{3(1 - \lambda)(v^B - t^A)t^B + 4\lambda t^A v^B}{(3(1 - \lambda)t^B + 8\lambda t^A)t^B}. \quad (42)$$

This yields total profits (from selling the drug in both markets) equal to

$$\pi_{CM}(U) = \frac{((1 - \lambda)t^B + 2\lambda t^A)(3(1 - \lambda)t^B + 4\lambda v^B)^2 t^A}{2t^B(3(1 - \lambda)t^B + 8\lambda t^A)^2} \quad (43)$$

and a total surplus for the health plan equal to

$$S_{CM}(U) = (1 - \lambda)v^A + \frac{2\lambda\Phi v^B - (1 - \lambda)\Psi t^A t^B}{4t^B(3(1 - \lambda)t^B + 8\lambda t^A)^2}, \quad (44)$$

where

$$\Phi := (9(1 - \lambda)t^B + 8\lambda t^A)((1 - \lambda)(v^B - 4t^A)t^B + 2\lambda t^A v^B) - 48\lambda(1 - \lambda)(t^A)^2 t^B \quad (45)$$

and

$$\Psi := 45(1 - \lambda)^2 (t^B)^2 + 150\lambda(1 - \lambda)t^A t^B + 112\lambda^2 (t^A)^2. \quad (46)$$

²⁰Prices are strategic complements because a unilateral price increase leads to higher demand, and thus less price-elastic demand, for the competing drug.

This equilibrium exists if

$$\underline{v}_{CM} < v^B < \bar{v}_{CM} \quad (47)$$

and

$$v^A > \frac{3t^A (3(1-\lambda)t^B + 4\lambda t^A + 2\lambda v^B)}{2(3(1-\lambda)t^B + 8\lambda t^A)}. \quad (48)$$

As in the benchmark case under unrestricted uniform pricing, equilibrium existence requires that the therapeutic benefit in Market B is sufficiently high to make it profitable to enter this market, but also sufficiently low to make it profitable to stay in Market A . Both these conditions are satisfied for the parameter set defined by (47). Additionally, the condition in (48) ensures that Market A is fully covered in equilibrium (i.e., that the therapeutic benefit of the prescribed drug is higher than the treatment cost for all patients with indication A).²¹

5.1.3 Restricted uniform pricing

Finally, if the producer is restricted to set a uniform price that does not exceed the pre-existing price in Market A , the equilibrium outcome is the same as under unrestricted uniform pricing if $v^B \leq 2t^A$. Otherwise, if $v^B > 2t^A$, the equilibrium prices in both markets are given by

$$p_{CM1}^A(\hat{U}) = p_{CM2}^A(\hat{U}) = p_{CM}^B(\hat{U}) = t^A. \quad (49)$$

This yields the same drug demand in Market A as under indication-based pricing, given by (31), whereas demand in Market B is given by

$$q_{CM}^B(\hat{U}) = \frac{\lambda(v^B - t^A)}{t^B}. \quad (50)$$

In this equilibrium, total profits for the producer in question are given by

$$\pi_{CM}(\hat{U}) = \left(\frac{(1-\lambda)t^B + 2\lambda(v^B - t^A)}{2t^B} \right) t^A, \quad (51)$$

whereas total surplus for the health plan is given by

$$S_{CM}(\hat{U}) = (1-\lambda)v^A + \frac{2\lambda v^B(v^B - 2t^A) - (5(1-\lambda)t^B - 2\lambda t^A)t^A}{4t^B}. \quad (52)$$

²¹See Appendix A for a full derivation of the equilibrium conditions, including explicit expressions for the upper and lower bounds on v^B .

This equilibrium exists under the parameter condition

$$2t^A < v^B < t^A + t^B, \quad (53)$$

in addition to the condition in (36) which ensures full coverage in Market A . It follows directly from (53) that this parameter set is non-empty if $t^B > t^A$.

5.2 Therapeutic competition in the new market

Suppose instead that the drug producer is a monopolist in the original market but faces therapeutic competition in the new market. In this case, market demand, profits and health plan surplus are equivalent to the previously considered case (CM) and found by replacing A with B and λ with $1 - \lambda$, and *vice versa*, in (26)-(29).

The Nash equilibrium drug prices under indication-based pricing and unrestricted uniform pricing are also mirror images of the corresponding prices reported in Section 5.1.2, with competition in the original market. Thus, with therapeutic competition in the new market, equilibrium prices under *indication-based pricing* are given by

$$p_{MC}^A(I) = \frac{v^A}{2}, \quad (54)$$

$$p_{MC1}^B(I) = p_{MC2}^B(I) = t^B, \quad (55)$$

whereas, under *unrestricted uniform pricing*, equilibrium prices are given by

$$p_{MC}(U) = \left(\frac{3\lambda t^A + 4(1 - \lambda)v^A}{3\lambda t^A + 8(1 - \lambda)t^B} \right) t^B \quad (56)$$

and

$$p_{MC2}^B(U) = \left(\frac{3\lambda t^A + 2(1 - \lambda)(v^A + 2t^B)}{3\lambda t^A + 8(1 - \lambda)t^B} \right) t^B. \quad (57)$$

Under both of these pricing schemes, equilibrium demand, profits and health plan surplus are found by replacing A with B and λ with $1 - \lambda$, and *vice versa*, in the relevant expressions in Section 5.1.2. Similarly, the parameter restrictions supporting these two equilibria are mirror images of (36)-(37) and (47)-(48), respectively.²²

However, under *restricted uniform pricing*, the Nash equilibria in market structures CM

²²See Appendix A for a complete characterisation of these parameter restrictions.

and MC are *not* mirror images of each other if the restriction on the uniform price binds. In this case, the equilibrium uniform price of the producer in question is given by the pre-existing equilibrium price in the original market, which is a market with therapeutic competition in market structure CM but not in market structure MC . In the Nash equilibrium of the latter market structure, if $v^A < 2t^B$, the producer selling its drug in both markets sets the price

$$p_{MC}(\widehat{U}) = p_{MC}^A(I) = \frac{v^A}{2}, \quad (58)$$

while the producer of the therapeutic alternative in Market B sets the price

$$p_{MC2}^B(\widehat{U}) = \frac{v^A}{4} + \frac{t^B}{2}. \quad (59)$$

The corresponding drug demand in the two markets is then given by

$$q_{MC}^A(\widehat{U}) = (1 - \lambda) \frac{v^A}{2t^A}, \quad (60)$$

$$q_{MC1}^B(\widehat{U}) = \frac{\lambda(6t^B - v^A)}{8t^B} \quad (61)$$

and

$$q_{MC2}^B(\widehat{U}) = \frac{\lambda(2t^B + v^A)}{8t^B}, \quad (62)$$

while the profits of the producer and the surplus of the health plan are given by

$$\pi_{MC}(\widehat{U}) = \left(\frac{4(1 - \lambda)t^B v^A + \lambda t^A(6t^B - v^A)}{16t^A t^B} \right) v^A \quad (63)$$

and

$$S_{MC}(\widehat{U}) = \lambda v^B + \frac{8(1 - \lambda)t^B + \lambda t^A}{64t^A t^B} (v^A)^2 - \frac{7}{16} \lambda (v^A + t^B), \quad (64)$$

respectively.

This equilibrium exists for a set of parameters characterised by

$$v^A < 2t^B \quad (65)$$

and

$$v^B > \frac{3}{8}v^A + \frac{3}{4}t^B. \quad (66)$$

The parameter condition in (65) ensures that the restriction on the uniform price binds for the producer that enters Market B with the same drug that is already sold in Market A , whereas the condition in (66) ensures that Market B is fully covered in equilibrium (i.e., that the therapeutic benefit of the drug prescribed to each patient is higher than the cost of treatment).

6 Uniform vs. indication-based pricing under therapeutic competition

In this section we characterise the producer's and the health plan's preferences for the different pricing schemes, focusing on how these preferences are changed by the presence of therapeutic competition, compared with the benchmark case analysed in Section 4. As in the previous section, we will contrast the cases of competition in the original market versus competition in the new market.

6.1 Therapeutic competition in the original market

Suppose that the parameters of the model are such that an interior-solution equilibrium exists under all three pricing schemes. This amounts to assuming that $(v^j, t^j, \lambda) \in \Omega_{CM}$, $j = A, B$, where the set Ω_{CM} is defined by (A42)-(A44) in Appendix A. The producer's and the health plan's preferences over the different pricing schemes are then characterised as follows:

Proposition 3 *If there is therapeutic competition in the original market and $v^B > 2t^A$, there exist two non-empty parameter sets $\bar{\Omega}_{CM} \subset \Omega_{CM}$ and $\hat{\Omega}_{CM} \subset \Omega_{CM}$, where $\hat{\Omega}_{CM} \subset \bar{\Omega}_{CM}$.*

(i) *If $(v^j, t^j, \lambda) \in \bar{\Omega}_{CM}$, the producer prefers unrestricted uniform pricing over indication-based pricing. Otherwise, if $(v^j, t^j, \lambda) \notin \bar{\Omega}_{CM}$, the producer's preferences are similar to the benchmark case (Proposition 1).*

(ii) *If $(v^j, t^j, \lambda) \in \hat{\Omega}_{CM}$, the health plan prefers indication-based pricing over unrestricted uniform pricing. Otherwise, if $(v^j, t^j, \lambda) \notin \hat{\Omega}_{CM}$, the health plan's preferences are similar to the benchmark case (Proposition 1).*

(iii) *For all $(v^j, t^j, \lambda) \in \Omega_{CM}$, the producer's profit is minimised, and the health plan's surplus is maximised, under restricted uniform pricing.*

Compared with the benchmark case, therapeutic competition in the original market might alter the preferences for indication-based versus unrestricted uniform pricing, both for the pro-

ducer and for the health plan. These departures from the benchmark results are identified in parts (i)-(ii) of Proposition 3. Notice, however, that the preference rankings might be different from the benchmark only if the equilibrium price is higher in the new market than in the original market under indication-based pricing (i.e., if $v^B > 2t^A$), implying that unrestricted uniform pricing leads to a price increase in the original market.

The first part of Proposition 3 identifies a parameter set in which the producer is better off with unrestricted uniform pricing than with indication-based pricing. The former pricing scheme implies a higher price in the original market and a lower price in the new market, compared with the latter scheme. Uniform pricing therefore yields a profit loss in the new market, where the uniform price is below the price that maximises the profits from drug sales in Market B . In Market A , on the other hand, a higher price yields a profit gain because of a positive strategic price response by the competing producer. Since prices are strategic complements, uniform pricing will lead to higher prices of *both drugs* in Market A , compared with indication-based pricing. And for parameters belonging to $\bar{\Omega}_{CM}$, it turns out that the profit gain in Market A outweighs the profit loss in Market B , thus leading to higher total profits under unrestricted uniform pricing than under indication-based pricing. In other words, if $v^B > 2t^A$, a uniform pricing scheme serves as a commitment device that allows the producer to credibly commit to a higher price in the original market, thus creating a *softening-of-competition effect* in this market that might increase the producer's total profits.

The second part of Proposition 2 identifies a parameter set in which the health plan's preferences are also partly reversed compared to the benchmark case, and where the health plan's surplus is higher under indication-based pricing than under unrestricted uniform pricing. This occurs for parameters belonging to $\hat{\Omega}_{CM}$, which is a subset of $\bar{\Omega}_{CM}$. Thus, the health plan prefers I over U only if the producer has opposite preferences. There are two different factors contributing to a higher health plan surplus under indication-based pricing. First, and most importantly, therapeutic competition in the original market means that unrestricted uniform pricing leads to a higher price for both drugs, as explained above. This softening-of-competition effect creates an additional cost of uniform pricing that is not present in the benchmark case. Second, uniform pricing implies that the equilibrium prices of the two therapeutically substitutable drugs in Market A are different from each other.²³ This creates an allocational inefficiency in the original market, where too many patients are prescribed the cheaper therapeutic alternative,

²³It follows from (38)-(39) that $p_{CM}(U) > p_{CM2}^A(U)$ if $v^B > 2t^A$.

thus leading to an overall reduction in health benefits, all else being equal.

It is worth repeating, though, that the departures from the benchmark results might only occur in cases where the profit-maximising price is higher in the new market than in the original market under indication-based pricing. In the opposite case (i.e., if $v^B < 2t^A$), uniform pricing would lead to a lower price in the original market compared with indication-based pricing, thus *reinforcing* the competition in this market due to strategic complementarity of prices. This would make the producer more strongly prefer indication-based pricing, and the health plan more strongly prefer uniform pricing, than in the benchmark case of no competition. Thus, the above described softening-of-competition effect only occurs if entry into the new market yields a price increase in the original market under a uniform pricing scheme, and therefore requires that uniform pricing is *unrestricted*.

Under restricted uniform pricing, on the other hand, there are by definition no price changes in the original market, which effectively eliminates the softening-of-competition effect, and this pricing scheme will therefore always minimise the profits of the producer and maximise the surplus of the health plan, as in the benchmark case. Thus, if we let the pricing scheme be determined as the SPNE of the entry game specified in Section 3, the equilibrium pricing scheme would still be restricted uniform pricing for sufficiently low values of f .

6.2 Therapeutic competition in the new market

Suppose again that the parameters of the model are such that an interior-solution equilibrium exists under all three pricing schemes. This amounts to assuming that $(v^j, t^j, \lambda) \in \Omega_{MC}$, $j = A, B$, where the set Ω_{MC} is defined by (A54)-(A55) in Appendix A. In this case, we identify the following departures from the benchmark results stated in Proposition 1:

Proposition 4 *If there is therapeutic competition in the new market, there exist three parameter sets $\bar{\Omega}_{MC} \subset \Omega_{MC}$, $\hat{\Omega}_{MC} \subset \Omega_{MC}$ and $\tilde{\Omega}_{MC} \subset \Omega_{MC}$, where $\bar{\Omega}_{MC} = \hat{\Omega}_{MC} \cup \tilde{\Omega}_{MC}$. The sets $\bar{\Omega}_{MC}$ and $\hat{\Omega}_{MC}$ are non-empty if $v^A > 2t^B$, and $\tilde{\Omega}_{MC}$ is non-empty if additionally $t^A > t^B$.*

(i) *If $(v^j, t^j, \lambda) \in \bar{\Omega}_{MC}$, the producer's profit is maximised under (restricted or unrestricted) uniform pricing. Otherwise, if $(v^j, t^j, \lambda) \notin \bar{\Omega}_{MC}$, the producer's preferences are similar to the benchmark case (Proposition 1)*

(ii) *If $(v^j, t^j, \lambda) \in \hat{\Omega}_{MC}$, the health plan's surplus is maximised under indication-based pricing. Otherwise, if $(v^j, t^j, \lambda) \notin \hat{\Omega}_{MC}$, the health plan's preferences are similar to the benchmark case (Proposition 1)*

(iii) If $(v^j, t^j, \lambda) \in \tilde{\Omega}_{MC}$, both the producer's profit and the health plan's surplus are maximised under (restricted or unrestricted) uniform pricing.

Contrary to the previous cases considered, competition in the new market creates a scope for indication-based pricing to *minimise* the producer's profit. This might occur if the equilibrium price is higher in the original market than in the new market under indication-based pricing (i.e., if $v^A > 2t^B$), which implies that entry into Market B under uniform pricing leads to a price reduction in Market A . This is therefore a case in which restricted and unrestricted uniform pricing are equivalent, because the restriction does not bind under the former pricing scheme. In this case, the producer's profits are higher under uniform pricing than under indication-based pricing for parameter configurations belonging to the set $\hat{\Omega}_{MC}$, and the reason is once more that uniform pricing has a *softening-of-competition* effect, this time in the new market.

A uniform pricing scheme (restricted or unrestricted) serves as a commitment device that allows the producer to set a higher price in the new market than it would have done under indication-based pricing. Due to strategic complementarity of prices, the competing producer in the new market will also set a higher price than under indication-based pricing. In other words, the softening-of-competition effect means that entry into Market B leads to a smaller price reduction in this market under uniform pricing than under indication-based pricing. For the producer in question, this creates a profit gain in the new market market that outweighs the profit loss in the original market if $(v^j, t^j, \lambda) \in \bar{\Omega}_{MC}$.

Competition in the new market also creates a scope for indication-based pricing to *maximise* the surplus of the health plan, which is not possible under any of the previously considered market structures. This occurs for parameters belong to a subset $\hat{\Omega}_{MC} \subset \bar{\Omega}_{MC}$. Thus, a necessary (but not sufficient) condition for indication-based pricing to maximise the health plan's surplus is that the same pricing scheme minimises the producer's profits. Similarly to the case identified in the second part of Proposition 3, indication-based pricing yields a higher health plan surplus than uniform pricing because of lower drug expenditures in the new market (with lower prices for both drugs under indication-based pricing) and also larger health gains in this market (since uniform pricing creates an allocational inefficiency).

Finally, and again in contrast to the previous cases considered, there might even be perfect agreement between the producer and the health plan about the preferred choice of pricing scheme when there is competition in the new market. This occurs for parameter configurations belonging to the set $\tilde{\Omega}_{MC} = \bar{\Omega}_{MC} \setminus \hat{\Omega}_{MC}$, in which the producer's profits and the health plan's

surplus are both maximised under (restricted or unrestricted) uniform pricing.

The different parameter sets identified in Proposition 4 are illustrated in (λ, v^A) space in Figure 1 for a particular numerical example where $t^A > t^B$, which implies that $\tilde{\Omega}_{MC}$ is a non-empty set. The set Ω_{MC} , in which an interior-solution equilibrium exists under all three pricing regimes, is given by the area between the upper and lower curves in the figure, and the case of $v^A > (<) 2t^B$ is given by the area above (below) the horizontal line. In this example, the set $\hat{\Omega}_{MC}$, in which the health plan prefers indication-based pricing and the producer prefers uniform pricing, covers a sizeable part of the parameter space in which uniform pricing leads to a lower price in the original market (i.e., when $v^A > 2t^B$). In opposite case (i.e., below the horizontal line in Figure 1, where $v^A < 2t^B$), the preference rankings of the producer and the health plan are similar to their preference rankings in the benchmark, as given by Proposition 1.

[Figure 1 here]

The preferences of the producer and the health plan are perfectly aligned for parameters in the set $\tilde{\Omega}_{MC}$, which is characterised by a relatively high value of v^A and a relatively low value of λ . In other words, both the producer and the health plan prefer uniform pricing if the original market is relatively large, compared with the new market, and the drug has relatively large therapeutic benefit for patients in this market. These properties of the set $\tilde{\Omega}_{MC}$ can be explained as follows.

If the producer's profits are higher under uniform pricing, this necessarily means that the health plan's drug expenditures are also higher.²⁴ For the health plan to prefer uniform pricing, these higher expenditures must therefore be more than compensated by larger health gains. If $v^A > 2t^B$, uniform pricing implies a health gain in the original market and a health loss in the new market, relative to indication-based pricing. The health gain in Market *A* results from the fact that more patients will be prescribed the drug when the price is lower (i.e., demand expansion), while the health loss in Market *B* results from the aforementioned allocational inefficiency due to a price difference between the two therapeutic alternatives under uniform pricing (i.e., misallocation cost).

²⁴Notice that, when $v^A > 2t^B$, uniform pricing leads to higher prices of both drugs in the new market, compared with indication-based pricing, which implies that the profits of the competing producer in the new market are always higher under uniform pricing than under indication-based pricing.

If a larger share of the patients have indication A (and thus fewer patients have indication B), this will obviously increase the health gain and reduce the health loss. Furthermore, since the equilibrium uniform price is set according to a weighted average of the price elasticities of demand in the two markets, a higher therapeutic benefit of the drug for indication A (which makes demand less price-elastic in Market A) implies a larger price reduction in the original market, all else being equal, when the producer uses uniform instead of indication-based pricing. This effect reinforces the health gain in Market A induced by uniform pricing. For these reasons, there exists a parameter set, given by $\tilde{\Omega}_{MC}$, in which the health gain in the original market not only outweighs the health loss in the new market, but where the net health gain outweighs the increase in total expenditures for the health plan, implying that uniform pricing is not only preferable for the producer, but is also the pricing scheme that maximises the health plan's surplus.

The pricing scheme preferences described in Proposition 4 might significantly alter the equilibrium pricing scheme, compared with the benchmark (Proposition 2). If we consider the three-stage entry game specified in Section 3, the results in Proposition 4 allow us to derive the following implications regarding the equilibrium pricing scheme:

Proposition 5 *If there is therapeutic competition in the new market and $v^A > 2t^B$, the equilibrium pricing scheme is (i) indication-based pricing if $(v^j, t^j, \lambda) \in \hat{\Omega}_{MC}$ and f is sufficiently small, and (ii) uniform pricing if $(v^j, t^j, \lambda) \in \tilde{\Omega}_{MC}$ for all f (as long as entry is not blockaded).*

The proposition identifies two significant departures from our previously derived results. First, indication-based pricing can be the equilibrium pricing scheme even in the absence of entry costs, since there exists a parameter set in which this pricing scheme maximises the health plan's surplus. Thus, for sufficiently low entry costs, the presence of therapeutic competition in the new market significantly increases the scope for indication-based pricing to be an equilibrium outcome. However, there also exists a parameter set in which uniform pricing is the equilibrium pricing scheme for any value of f (as long as entry costs are not so high that entry is blockaded), since uniform pricing maximises the surplus of both the producer and the health plan within this parameter set.

Thus, whereas the preference rankings of pricing schemes are very clear in the benchmark case of no competition, implying that the equilibrium pricing scheme depends only on the magnitude of the entry costs, the presence of therapeutic competition implies that the health

plan’s optimal policy to a much larger extent must be based on a case-by-case assessment. For a given level of entry costs, the equilibrium pricing scheme could in this case be either uniform or indication-based pricing, depending on the therapeutic benefits and relative incidence of the two indications in the patient population.

7 Discussion and concluding remarks

In this paper we have studied the effects of allowing indication-based pricing instead of uniform pricing for multi-indication drugs. The rapid growth in drug expenditures—driven in part by the innovation of highly effective but very expensive drug therapies that treat a range of indications—poses a key challenge to payers in balancing cost containment and ensuring access to new medicines. When evaluating the relative performance of these pricing schemes, we have focused on how they affect the drug producer’s incentives to invest in approvals for additional indications, their pricing strategies, and the resulting surplus for health plans and their patients. While a small but growing body of literature examines these effects, a common feature is the assumption of a monopolist drug producer.

The key contribution of our study is to introduce competition among drug producers. Based on the observation that multi-indication drug producers typically face therapeutic competition for at least some indications, we consider a two-market (two-indication) model in which a drug producer faces competition either in the original market or in the new market. Using a standard duopoly model, where the available drug therapies differ in their therapeutic effects both vertically and horizontally across patients and indications, we derive the equilibrium outcomes under indication-based pricing and both restricted and unrestricted uniform pricing.

Our main finding is that monopoly-based insights may not hold in the presence of competition. Specifically, we identify a softening-of-competition effect where uniform pricing can serve as a credible commitment for the multi-indication drug producer to set higher prices in the competitive market than what would be possible under indication-based pricing. Unlike in monopoly settings, uniform pricing can result in higher profits for the drug producer and stronger incentives to invest in new indications. However, the softening-of-competition effect only arises when the monopoly price is higher than the competitive price under indication-based pricing. Furthermore, it requires that upward price adjustments are allowed when competition occurs in the original market. Otherwise, the results resemble those of a monopoly scenario.

What are the policy implications of our findings? The health plan and the drug producer generally have opposing preferences for pricing schemes, provided that the producer can recoup the fixed investment costs of launching a drug for a new indication. However, alignment of preferences can occur in two specific cases:

1. *When profits from the new indication are insufficient to cover fixed investment costs:* In

this scenario, the health plan may benefit from adopting a pricing scheme that generates higher profits for the drug producer, as this ensures patients have access to the new medicine.

2. *When there is a softening-of-competition effect and competition occurs in the new market:*

In this scenario, uniform pricing leads to a reduction in the monopoly price and a demand expansion in the original market, which can result in a health gain that exceeds the losses from higher prices in the competitive market. In this case, both the health plan and the multi-indication drug producer can be better off with uniform pricing.

Our findings suggest that neither pricing scheme is universally optimal. Instead, a case-by-case assessment across drug classes is more appropriate. Specifically, the choice of pricing scheme should account for: (i) the incentives for drug producers to invest in new indications; (ii) the drug producers' pricing strategies; (iii) the health benefits to patients from gaining access to new medicines; (iv) the increase in drug expenditures; and (v) the potential for therapeutic competition across markets.

It is worth noting that our analysis is based on scenarios in which the producer in question faces competition in only one of the two markets that we consider. If the producer instead faces competition in both markets, this would not introduce any additional effects to the ones already identified in our analysis. However, such a scenario would imply that uniform (as opposed to indication-based) pricing has a softening-of-competition effect in one of the markets while simultaneously yielding a hardening-of-competition effect in the other. In our framework, it turns out that the latter effect always dominates, implying that the results in this case would be qualitatively more similar to the monopoly benchmark case.²⁵ This might suggest that the presence of therapeutic competition is more likely to significantly affect the desirability of different pricing schemes when such competition occurs in some but not all markets.

²⁵Detailed calculations are available upon request.

Our analysis also relies on the assumption that the drug’s ability to treat indication B is discovered only after the producer has entered Market A . This assumption seems to fit the observed pattern of indication approvals over time for many drugs, as discussed in the Introduction. However, in some cases a producer might know at the outset that its drug is effective in treating multiple indications. In our model, suppose that the producer is not already established in Market A , but instead makes the entry decision for both markets simultaneously. How would this affect the producer’s optimal pricing? Under indication-based pricing, this alternative assumption would not affect our analysis at all, since there is no cross-market externality in pricing. Under uniform pricing, however, simultaneous entry in both markets would effectively eliminate *restricted uniform pricing* as a relevant pricing scheme. This implies in turn that the main gist of Propositions 4 and 5 holds regardless of whether the producer faces therapeutic competition in Market A or in Market B . In either case, there exists a parameter set in which the producer prefers uniform pricing and the health plan prefers indication-based pricing, and there exists another parameter set in which both parties prefer uniform pricing. In this sense, a relaxation of the assumption that the producer is already established in one of the markets would increase the scope for the presence of therapeutic competition to qualitatively change the results of the benchmark monopoly case.

Finally, we would like to highlight a couple of limitations of our analysis. First, the approval process for new drug indications involves clinical testing and inherent uncertainty of success. We have modelled this as a deterministic process, where the drug producer incurs a fixed sunk cost for approval and proceeds if the net profit gain is positive. This net profit gain depends on pricing schemes, the degree of competition, and demand characteristics for the drug. We believe these factors are the most critical determinants of multi-indication drug producers’ entry decisions. Since the drug is already discovered, the primary uncertainty typically relates to molecule innovation rather than the exploration of new indications. Introducing uncertainty in the approval process would not significantly enrich our analysis unless the focus shifts to modelling an innovation race, which lies beyond the scope of our study.

Second, we have not conducted a comprehensive welfare analysis of the pricing schemes. Instead, we have concentrated on how different pricing schemes affect the drug producer’s incentives to invest in approvals for new indications. A full welfare analysis would require considering fixed approval costs and potentially the design of the approval process. Our focus has been on the interaction between drug producers and health plans and the resulting equilibrium

outcomes under various pricing schemes. Indication-based pricing likely improves allocative efficiency by moving closer to the first-best outcome, as it enables drug producers to capture consumer surplus and enhances access to new medicines, akin to third-degree price discrimination. However, in a second-best setting, trade-offs between access and cost containment persist, as analysed in the paper.

Appendix A: Equilibrium existence conditions

This appendix contains a complete characterisation of the parameter sets in which an interior-solution equilibrium exists for all three pricing schemes, under each of the three market structures considered. For each market structure (MM , CM and MC), we start out by characterising the conditions for equilibrium existence under each of the three pricing schemes (I , U and $\hat{U}$), before defining the intersection of these three parameter sets and verifying that this intersection is a non-empty set.

Monopoly in both markets

(i) Under *indication-based pricing*, from (7)-(8) it is straightforward to verify that $q_{MM}^A(I) \in (0, 1 - \lambda)$ and $q^B \in (0, \lambda)$ if the parameter condition in (13) holds.

(ii) Under *unrestricted uniform pricing*, it follows from (15) that $q_{MM}^A(U) \in (0, 1 - \lambda)$ if $v_1 < v^B < v_2$, where

$$v_1 := \frac{(1 - \lambda)(v^A - 2t^A)t^B + 2\lambda(v^A - t^A)t^A}{\lambda t^A} \quad (\text{A1})$$

and

$$v_2 := \frac{((1 - \lambda)t^B + 2\lambda t^A)v^A}{\lambda t^A}. \quad (\text{A2})$$

Similarly, it follows from (16) that $q_{MM}^B(U) \in (0, \lambda)$ if $v_3 < v^B < v_4$, where

$$v_3 := \frac{(1 - \lambda)v^A t^B}{\lambda t^A + 2(1 - \lambda)t^B} \quad (\text{A3})$$

and

$$v_4 := \frac{((1 - \lambda)(v^A + 2t^B) + 2\lambda t^A)t^B}{\lambda t^A + 2(1 - \lambda)t^B}. \quad (\text{A4})$$

In addition, equilibrium existence requires that the firm has no incentive to leave either of

the markets. By leaving (or not entering) Market B , the firm can achieve a profit of $\pi_{MM}^A(I)$, given by (9). Thus, the firm will stay in Market B only if

$$\pi_{MM}(U) - \pi_{MM}^A(I) = \frac{(2(1-\lambda)t^B v^A + \lambda t^A v^B) v^B - (1-\lambda)t^B (v^A)^2}{4\lambda^{-1}((1-\lambda)t^B + \lambda t^A)t^B} > 0, \quad (\text{A5})$$

which is true if $v^B > v_5$, where

$$v_5 := \left(\frac{\sqrt{(1-\lambda)((1-\lambda)t^B + \lambda t^A)t^B} - (1-\lambda)t^B}{\lambda t^A} \right) v^A. \quad (\text{A6})$$

Furthermore, by leaving Market A (and staying in Market B), the firm can achieve a profit of $\pi_{MM}^B(I)$, given by (10). Thus, the firm will stay in Market A only if

$$\pi_{MM}(U) - \pi_{MM}^A(I) = \frac{(1-\lambda)t^B (v^A)^2 - \lambda(v^B - 2v^A)t^A v^B}{4(1-\lambda)^{-1}((1-\lambda)t^B + \lambda t^A)t^A} > 0, \quad (\text{A7})$$

which is true if $v^B < v_6$, where

$$v_6 := \left(1 + \frac{\sqrt{\lambda((1-\lambda)t^B + \lambda t^A)t^A}}{\lambda t^A} \right) v^A. \quad (\text{A8})$$

A comparison of (A3) and (A6) shows that $v_5 > v_3$ if

$$\sqrt{(1-\lambda)((1-\lambda)t^B + \lambda t^A)t^B} > \frac{(1-\lambda)v^A t^B \lambda t^A}{(\lambda t^A + 2(1-\lambda)t^B)v^A} + (1-\lambda)t^B \quad (\text{A9})$$

$\Leftrightarrow$

$$(1-\lambda)((1-\lambda)t^B + \lambda t^A)t^B > \left(\frac{(1-\lambda)v^A t^B \lambda t^A}{(\lambda t^A + 2(1-\lambda)t^B)v^A} + (1-\lambda)t^B \right)^2 \quad (\text{A10})$$

$\Leftrightarrow$

$$\frac{((1-\lambda)t^B + \lambda t^A)\lambda^2(1-\lambda)t^B(t^A)^2}{(2(1-\lambda)t^B + \lambda t^A)^2} > 0, \quad (\text{A11})$$

which is always true. Similarly, a comparison of (A2) and (A8) shows that $v_6 < v_2$ if

$$\sqrt{\lambda((1-\lambda)t^B + \lambda t^A)t^A} < \left(\frac{((1-\lambda)t^B + 2\lambda t^A)v^A}{\lambda t^A v^A} - 1 \right) \lambda t^A \quad (\text{A12})$$

$\Leftrightarrow$

$$\lambda((1-\lambda)t^B + \lambda t^A)t^A < \left(\left(\frac{((1-\lambda)t^B + 2\lambda t^A)v^A}{\lambda t^A v^A} - 1 \right) \lambda t^A \right)^2 \quad (\text{A13})$$

$\Leftrightarrow$

$$-(1-\lambda) \left((1-\lambda) t^B + \lambda t^A \right) t^B < 0, \quad (\text{A14})$$

which is always true. Thus, we conclude that $v_5 > v_3$ and $v_6 < v_2$, implying that the parameter conditions $v^B > v_3$ and $v^B < v_2$ are redundant. This implies in turn that equilibrium existence under unrestricted uniform pricing is guaranteed for a parameter set given by (19), where

$$\underline{v}_{MM} := \max \{v_1, v_5\} \quad (\text{A15})$$

and

$$\bar{v}_{MM} := \min \{v_4, v_6\}. \quad (\text{A16})$$

(iii) Under *restricted uniform pricing*, it follows from (22) that $q_{MM}^B(\hat{U}) \in (0, \lambda)$ if $v^B < v_7$, where

$$v_7 := \frac{v^A}{2} + t^B. \quad (\text{A17})$$

Furthermore, since the uniform price given by (20) is optimal only for $v^B > v^A$, it follows from the condition $v^B < v_7$ that equilibrium existence additionally requires $v^A < 2t^B$.

(iv) An interior-solution equilibrium exists under all three payment schemes for parameters belonging to the intersection of the three parameter sets derived in (i)-(iii) above. Notice that a comparison of (A4) and (A17) yields

$$v_4 - v_7 = \frac{\lambda (2t^B - v^A) t^A}{2(2(1-\lambda)t^B + \lambda t^A)} > 0 \text{ if } v^A < 2t^B, \quad (\text{A18})$$

which implies that the condition $v^B < v_4$ is redundant. Thus, the intersection of the parameter sets derived in (i)-(iii) is a set defined by

$$\underline{v}_{MM} < v^B < \min \{v_6, v_7, 2t^B\} \quad (\text{A19})$$

and

$$v^A < \min \{2t^A, 2t^B\}. \quad (\text{A20})$$

It is easily verified that this parameter set is non-empty. For example, if $v^A = 1.5$, $t^A = t^B = 1$ and $\lambda = 0.5$, an interior-solution equilibrium exists under all payment schemes for all $v^B \in (0.62, 1.75)$.

Therapeutic competition in the original market

(i) Under *indication-based pricing*, equilibrium drug prices are equal in Market A , which implies that the patient with the lowest therapeutic benefit has a benefit of $v^A - (t^A/2)$. It is easily confirmed that this benefit is higher than the treatment cost, given by (30), if the condition in (36) holds. The drug price in Market B is the same as in the benchmark case and $q_{CM}^B \in (0, \lambda)$ if (37) holds, as before.

(ii) Under *unrestricted uniform pricing*, it follows from (40)-(41) that $q_{CMi}^A(U) \in (0, 1 - \lambda)$, $i = 1, 2$, if $v^B < v_8$, where

$$v_8 := \frac{12\lambda t^A + 3(1 - \lambda)t^B}{2\lambda}. \quad (\text{A21})$$

Furthermore, it follows from (42) that $q_{CM}^B(U) \in (0, \lambda)$ if $v_9 < v^B < v_{10}$, where

$$v_9 := \frac{3(1 - \lambda)t^A t^B}{4\lambda t^A + 3(1 - \lambda)t^B} \quad (\text{A22})$$

and

$$v_{10} := \frac{(3(1 - \lambda)t^B + (3 + 5\lambda)t^A)t^B}{4\lambda t^A + 3(1 - \lambda)t^B}. \quad (\text{A23})$$

Additionally, a fully covered Market A requires that the therapeutic benefit is higher than the treatment costs for all patients with indication A . With drug prices given by (38)-(39), the patients who receive the lowest net therapeutic benefit of drug treatment (therapeutic benefit minus treatment cost) in Market A have a mismatch value given by

$$x_{CM}^A(U) = \frac{1}{2} + \frac{2\lambda(2t^A - v^B)}{2(3(1 - \lambda)t^B + 8\lambda t^A)}. \quad (\text{A24})$$

These patients have therefore a net therapeutic benefit equal to

$$v^A - t^A x_{CM}^A(U) - p_{CM1}^A(U) = v^A - t^A \left(\frac{3(3(1 - \lambda)t^B + 4\lambda t^A) + 6\lambda v^B}{2(3(1 - \lambda)t^B + 8\lambda t^A)} \right). \quad (\text{A25})$$

It is easily confirmed that this net benefit is non-negative under the parameter condition given by (48).

Equilibrium existence also requires that it is profitable for the producer to enter Market B ,

which requires that

$$\pi_{CM}(U) - \pi_{CM1}^A(I) = \frac{\left[4((1-\lambda)t^B + 2\lambda t^A)(3(1-\lambda)t^B + 2\lambda v^B)v^B - (1-\lambda)(15(1-\lambda)t^B + 32\lambda t^A)t^A t^B \right]}{\lambda^{-1}(t^A)^{-1}t^B(3(1-\lambda)t^B + 8\lambda t^A)^2} > 0, \quad (\text{A26})$$

which is true if $v^B > v_{11}$, where

$$v_{11} := \frac{(3(1-\lambda)t^B + 8\lambda t^A)\sqrt{t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)} - 3t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)}{4\lambda((1-\lambda)t^B + 2\lambda t^A)}. \quad (\text{A27})$$

In a similar vein, it must be profitable for the producer to remain in Market A , which requires that

$$\pi_{CM}(U) - \pi_{CM1}^B(I) = \frac{\left[18(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)t^A t^B - \lambda(v^B(9(1-\lambda)t^B + 16\lambda t^A) - 48t^A((1-\lambda)t^B + 2\lambda t^A))v^B \right]}{4(1-\lambda)^{-1}(3(1-\lambda)t^B + 8\lambda t^A)^2} > 0, \quad (\text{A28})$$

which is true if $v^B < v_{12}$, where

$$v_{12} := \frac{24\lambda t^A((1-\lambda)t^B + 2\lambda t^A) + 9\sqrt{2}((1-\lambda)t^B + \frac{8}{3}\lambda t^A)\sqrt{\lambda t^A((1-\lambda)t^B + 2\lambda t^A)}}{\lambda(9(1-\lambda)t^B + 16\lambda t^A)}. \quad (\text{A29})$$

A comparison of (A22) and (A27) shows that

$$v_{11} - v_9 = \frac{\left[\sqrt{t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)}(3(1-\lambda)t^B + 4\lambda t^A) - 3t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A) \right]}{4\lambda((1-\lambda)t^B + 2\lambda t^A)(3(1-\lambda)t^B + 4\lambda t^A)(3(1-\lambda)t^B + 8\lambda t^A)^{-1}}. \quad (\text{A30})$$

This expression is positive if

$$\sqrt{t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)} > \frac{3t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)}{3(1-\lambda)t^B + 4\lambda t^A} \quad (\text{A31})$$

$\Leftrightarrow$

$$t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A) > \left(\frac{3t^B(1-\lambda)((1-\lambda)t^B + 2\lambda t^A)}{3(1-\lambda)t^B + 4\lambda t^A} \right)^2 \quad (\text{A32})$$

$\Leftrightarrow$

$$\frac{2\lambda(1-\lambda)(3(1-\lambda)t^B + 8\lambda t^A)((1-\lambda)t^B + 2\lambda t^A)t^A t^B}{(3(1-\lambda)t^B + 4\lambda t^A)^2} > 0, \quad (\text{A33})$$

which is always true. Furthermore, a comparison of (A21) and (A29) yields

$$v_8 - v_{12} = \frac{(3(1-\lambda)t^B + 4\lambda t^A) - 2\sqrt{2\lambda t^A((1-\lambda)t^B + 2\lambda t^A)}}{6\lambda((1-\lambda)t + \frac{16}{9}\lambda t^A)(3(1-\lambda)t^B + 8\lambda t^A)^{-1}}. \quad (\text{A34})$$

This expression is positive if

$$\frac{3(1-\lambda)t^B + 4\lambda t^A}{2} > \sqrt{2\lambda t^A((1-\lambda)t^B + 2\lambda t^A)} \quad (\text{A35})$$

$\Leftrightarrow$

$$\left(\frac{3(1-\lambda)t^B + 4\lambda t^A}{2}\right)^2 > 2\lambda t^A((1-\lambda)t^B + 2\lambda t^A) \quad (\text{A36})$$

$\Leftrightarrow$

$$\frac{1}{4}t^B(1-\lambda)(9(1-\lambda)t^B + 16\lambda t^A) > 0, \quad (\text{A37})$$

which is always true. Thus, we conclude that $v_{11} > v_9$ and $v_{12} < v_8$, implying that parameter restrictions $v^B > v_9$ and $v^B < v_8$ are redundant. This means that an interior equilibrium exists under unrestricted uniform pricing for a parameter set given by (47) and (48), where

$$\underline{v}_{CM} := v_{11} \quad (\text{A38})$$

and

$$\bar{v}_{CM} := \min\{v_{10}, v_{12}\}. \quad (\text{A39})$$

(iii) Under *restricted uniform pricing*, it follows from (50) that $q_{CM}^B(\hat{U}) \in (0, \lambda)$ if $v^B < v_{13}$, where

$$v_{13} := t^A + t^B. \quad (\text{A40})$$

Furthermore, since the uniform price given by (49) is optimal only for $v^B > 2t^A$, it follows from the condition $v^B < v_{13}$ that equilibrium existence additionally requires $t^B > t^A$. Moreover, since the equilibrium prices in Market *A* in this case are identical to the equilibrium prices under indication-based pricing, the parameter condition in (37) is needed also in this case.

(iv) An interior-solution equilibrium exists under all three payment schemes for parameters belonging to the intersection of the three parameter sets derived in (i)-(iii) above. Notice first

that a comparison of (A23) and (A40) yields

$$v_{10} - v_{13} = \frac{4\lambda (t^B - t^A) t^A}{3(1-\lambda)t^B + 4\lambda t^A} > 0 \text{ if } t^B > t^A, \quad (\text{A41})$$

implying that the condition $v^B < v_{10}$ is redundant. Additionally, the condition $v_B < v_{13}$ makes the condition $v^B < 2t^B$ redundant for $t^B > t^A$. Thus, the intersection of the parameter sets derived in (i)-(iii) is a set defined by

$$\underline{v}_{CM} < v^B < \min\{v_{12}, v_{13}\}, \quad (\text{A42})$$

$$v^A > \max\left\{\frac{3(3(1-\lambda)t^B + 4\lambda t^A + 2\lambda v^B)t^A}{2(3(1-\lambda)t^B + 8\lambda t^A)}, \frac{3}{2}t^A\right\} \quad (\text{A43})$$

and

$$t^B > t^A. \quad (\text{A44})$$

It is easily verified that this parameter set is non-empty. For example, if $v^B = 2$, $t^A = 1$, $t^B = 2$ and $\lambda = 0.5$, an interior-solution equilibrium exists under all payment schemes for $v^A \geq 1.5$.

Therapeutic competition in the new market

(i) Under *indication-based pricing*, the equilibria in CM and MC are mirror images of each other, and so are the parameter conditions for equilibrium existence. Thus, the relevant parameter conditions are

$$v^A < 2t^A \quad (\text{A45})$$

and

$$v^B > \frac{3}{2}t^B. \quad (\text{A46})$$

(ii) Under *unrestricted uniform pricing*, CM and MC are also equivalent, implying that the relevant parameter conditions are

$$\underline{v}_{MC} < v^A < \bar{v}_{MC} \quad (\text{A47})$$

and

$$v^B > \frac{3t^B(3\lambda t^A + 4(1-\lambda)t^B + 2(1-\lambda)v^A)}{2(3\lambda t^A + 8(1-\lambda)t^B)}, \quad (\text{A48})$$

where

$$\underline{v}_{MC} := \frac{(3\lambda t^A + 8(1-\lambda)t^B) \sqrt{t^A \lambda (\lambda t^A + 2(1-\lambda)t^B)} - 3\lambda t^A (\lambda t^A + 2(1-\lambda)t^B)}{4(1-\lambda)(\lambda t^A + 2(1-\lambda)t^B)}, \quad (\text{A49})$$

$$\bar{v}_{MC} := \min \left\{ \frac{(3(1-\lambda)t^B + (3+5\lambda)t^A)t^B}{4\lambda t^A + 3(1-\lambda)t^B}, v_{14} \right\} \quad (\text{A50})$$

and

$$v_{14} := \frac{\left[\begin{aligned} &24(1-\lambda)t^B(\lambda t^A + 2(1-\lambda)t^B) \\ &+ 9(\lambda t^A + \frac{8}{3}(1-\lambda)t^B) \sqrt{2(1-\lambda)t^B(\lambda t^A + 2(1-\lambda)t^B)} \end{aligned} \right]}{(1-\lambda)(9\lambda t^A + 16(1-\lambda)t^B)}. \quad (\text{A51})$$

(iii) Under *restricted uniform pricing*, it straightforward to verify that the equilibrium given by (58)-(59) is relevant only if $v^A < 2t^B$, which implies that the equilibrium price is higher in Market B than in Market A under indication-based pricing. Furthermore, a fully covered Market B requires that the therapeutic benefit is higher than the treatment costs for all patients with indication B . With drug prices given by (58)-(59), the patients who receive the lowest net therapeutic benefit of drug treatment (therapeutic benefit minus treatment cost) in Market B have a mismatch value given by

$$x_{MC}^A(\hat{U}) = \frac{3}{4} - \frac{v^A}{8t^B}. \quad (\text{A52})$$

These patients have therefore a net therapeutic benefit equal to

$$v^B - t^B x_{MC}^A(\hat{U}) - p_{MC}(\hat{U}) = v^B - \frac{3}{8}v^A - \frac{3}{4}t^B. \quad (\text{A53})$$

It is easily confirmed that this net benefit is non-negative under the parameter condition given by (66).

(iv) An interior-solution equilibrium exists under all three payment schemes for parameters belonging to the intersection of the three parameter sets derived in (i)-(iii) above, which is a set defined by

$$\underline{v}_{MC} < v^A < \min \{ \bar{v}_{MC}, 2t^A \}, \quad (\text{A54})$$

and

$$v^B > \max \left\{ \frac{3}{2}t^B, \frac{3}{8}v^A + \frac{3}{4}t^B, \frac{3t^B(3\lambda t^A + 4(1-\lambda)t^B + 2(1-\lambda)v^A)}{2(3\lambda t^A + 8(1-\lambda)t^B)} \right\}. \quad (\text{A55})$$

It is easily verified that this parameter set is non-empty. For example, if $v^A = 1.5$, $t^A = t^B = 1$ and $\lambda = 0.5$, an interior-solution equilibrium exists under all payment schemes for $v^B \geq 1.5$.

Appendix B: Proofs

In this appendix we present formal proofs of Propositions 1, 3 and 4. As for the remaining two propositions in the paper, it is easily confirmed that Proposition 2 and Proposition 5 follow straightforwardly from Proposition 1 and Proposition 4, respectively.

Proof of Proposition 1

A comparison of (11), (17) and (23) yields

$$\pi_{MM}(I) - \pi_{MM}(U) = \frac{(1-\lambda)\lambda(v^A - v^B)^2}{4((1-\lambda)t^B + \lambda t^A)} > 0, \quad (\text{B1})$$

and

$$\pi_{MM}(U) - \pi_{MM}(\hat{U}) = \frac{(v^B - v^A)^2 \lambda^2 t^A}{4((1-\lambda)t^B + \lambda t^A)t^B} > 0. \quad (\text{B2})$$

A comparison of (12), (18) and (24) yields:

$$S_{MM}(I) - S_{MM}(U) = -\frac{3(1-\lambda)\lambda(v^A - v^B)^2}{8((1-\lambda)t^B + \lambda t^A)} < 0 \quad (\text{B3})$$

and

$$S_{MM}(\hat{U}) - S_{MM}(U) = \frac{2(1-\lambda)t^B v^A + \lambda t^A(3v^B - v^A)}{8\lambda^{-1}(v^B - v^A)^{-1}((1-\lambda)t^B + \lambda t^A)t^B} > 0 \quad \text{for } v^B > v^A. \quad (\text{B4})$$

(Recall that $U = \hat{U}$ for $v^B \leq v^A$).

Proof of Proposition 3

(i) A comparison of (34) and (43) yields

$$\pi_{CM}(U) - \pi_{CM}(I) = \frac{\lambda(1-\lambda)(2t^A - v^B)\mu}{4(3(1-\lambda)t^B + 8\lambda t^A)^2}, \quad (\text{B5})$$

where

$$\mu := 2(15(1-\lambda)t^B + 32\lambda t^A)t^A - (9(1-\lambda)t^B + 16\lambda t^A)v^B. \quad (\text{B6})$$

It follows from (B5) that $\pi_{CM}(U) > \pi_{CM}(I)$ if $(2t^A - v^B)$ and μ have the same sign, and it follows from (B6) that

$$\mu > (<) 0 \text{ if } v^B > (<) v_{15}, \quad (\text{B7})$$

where

$$v_{15} := \frac{2(15(1-\lambda)t^B + 32\lambda t^A)}{9(1-\lambda)t^B + 16\lambda t^A} t^A. \quad (\text{B8})$$

From (B8) we can easily verify that $v_{15} > 2t^A$, which implies that $\pi_{CM}(U) > \pi_{CM}(I)$ if $v^B \in (2t^A, v_{15})$ and that $\pi_{CM}(U) < \pi_{CM}(I)$ otherwise. The set $\bar{\Omega}_{CM}$ is then defined by

$$2t^A < v^B < \min\{v_{12}, v_{13}, v_{15}\} \quad (\text{B9})$$

together with (A43)-(A44). It is straightforward to verify that the set given by (B9) is non-empty, which implies that $\bar{\Omega}_{CM}$ is also non-empty and is a subset of Ω_{CM} .

(ii) A comparison of (35) and (44) yields

$$S_{CM}(U) - S_{CM}(I) = \frac{\lambda(1-\lambda)(v^B - 2t^A)\theta}{8(3(1-\lambda)t^B + 8\lambda t^A)^2}, \quad (\text{B10})$$

where

$$\theta := 2(45(1-\lambda)t^B + 104\lambda t^A)t^A - (27(1-\lambda)t^B + 56\lambda t^A)v^B. \quad (\text{B11})$$

It follows from (B10) that $S_{CM}(I) > S_{CM}(U)$ if $(v^B - 2t^A)$ and θ have the same sign, and it follows from (B11) that

$$\theta > (<) 0 \text{ if } v^B < (>) v_{16}, \quad (\text{B12})$$

where

$$v_{16} := \frac{2(45(1-\lambda)t^B + 104\lambda t^A)}{27(1-\lambda)t^B + 56\lambda t^A} t^A. \quad (\text{B13})$$

From (B13) we can easily verify that $v_{16} > 2t^A$, which implies that $S_{CM}(I) > S_{CM}(U)$ if $v^B \in (2t^A, v_{16})$ and that $S_{CM}(I) < S_{CM}(U)$ otherwise. The set $\hat{\Omega}_{CM}$ is then defined by

$$2t^A < v^B < \min\{v_{12}, v_{13}, v_{16}\} \quad (\text{B14})$$

together with (A43)-(A44). It is straightforward to verify that the set given by (B14) is non-empty, which implies that $\hat{\Omega}_{CM}$ is also non-empty and is a subset of Ω_{CM} . Furthermore, a

comparison of (B8) and (B13) yields

$$v_{15} - v_{16} = \frac{32\lambda (3(1-\lambda)t^B + 8\lambda t^A) (t^A)^2}{(27(1-\lambda)t^B + 56\lambda t^A)(9(1-\lambda)t^B + 16\lambda t^A)} > 0, \quad (\text{B15})$$

which implies that $\widehat{\Omega}_{CM}$ is also a subset of $\overline{\Omega}_{CM}$.

(iii) A comparison of (34), (43) and (51) yields

$$\pi_{CM}(I) - \pi_{CM}(\widehat{U}) = \frac{\lambda (v^B - 2t^A)^2}{4t} > 0 \quad (\text{B16})$$

and

$$\pi_{CM}(U) - \pi_{CM}(\widehat{U}) = \frac{3(t^B)^2(1-\lambda)^2 + 8\lambda [v^B((1-\lambda)t^B + 2\lambda t^A) - ((1-\lambda)t^B + 4\lambda t^A)t^A]}{\lambda^{-1}(t^A)^{-1}(v^B - 2t^A)^{-1}t^B(3(1-\lambda)t^B + 8\lambda t^A)^2}, \quad (\text{B17})$$

which is positive for the relevant case of $v^B > 2t^A$ (i.e., the case in which the restriction on uniform pricing binds). It follows from part (i) of the proof that

$$\pi_{CM}(I) > \pi_{CM}(U) = \pi_{CM}(\widehat{U}) \quad (\text{B18})$$

for the remaining case of $v^B < 2t^A$. Furthermore, a comparison of (35), (44) and (52) yields

$$S_{CM}(\widehat{U}) - S_{CM}(U) = \frac{9(t^B)^2(1-\lambda)^2 + 8\lambda^2 t^A (3v^B - 2t^A) + \lambda(1-\lambda)(11v^B + 14t^A)t^B}{\lambda^{-1}(t^A)^{-1}(v^B - 2t^A)^{-1}t^B(3(1-\lambda)t^B + 8\lambda t^A)^2} \quad (\text{B19})$$

and

$$S_{CM}(\widehat{U}) - S_{CM}(I) = \frac{\lambda (v^B - 2t^A) (3v^B - 2t^A)}{16t^B}, \quad (\text{B20})$$

both of which are positive for the relevant case of $v^B > 2t^A$. It follows from part (ii) of the proof that

$$S_{CM}(\widehat{U}) = S_{CM}(U) > S_{CM}(I) \quad (\text{B21})$$

for the remaining case of $v^B < 2t^A$.

Proof of Proposition 4

(i) Suppose that $v^A > 2t^B$. In this case, the restriction does not bind under restricted uniform pricing, so that $\pi_{MC}(U) = \pi_{MC}(\widehat{U})$. Furthermore, a comparison of equilibrium profits under

indication-based and uniform pricing yields

$$\pi_{MC}(I) - \pi_{MC}(U) = \frac{\lambda(1-\lambda)(v^A - 2t^B)\gamma}{4(8(1-\lambda)t^B + 3\lambda t^A)^2}, \quad (\text{B22})$$

where

$$\gamma := (16(1-\lambda)t^B + 9\lambda t^A)v^A - (32(1-\lambda)t^B + 15\lambda t^A)2t^B. \quad (\text{B23})$$

For $v^A > 2t^B$, the sign of (B22) is given by the sign of γ , which is positive (negative) if $v^A > (<) v_{17}$, where

$$v_{17} := \frac{2(15\lambda t^A + 32(1-\lambda)t^B)}{(9\lambda t^A + 16(1-\lambda)t^B)}t^B. \quad (\text{B24})$$

From (B24) we can easily verify that $v_{17} > 2t^B$, which means that $\pi_{MC}(U) > \pi_{MC}(I)$ if $v^A \in (2t^B, v_{17})$. The set $\bar{\Omega}_{MC}$ is then defined by

$$2t^B < v^A < \min\{\bar{v}_{MC}, 2t^A, v_{17}\}, \quad (\text{B25})$$

in addition to (A55) and $t^A > t^B$, which is a necessary and sufficient condition for (B25) to be a non-empty set, implying that $\bar{\Omega}_{MC}$ is a subset of Ω_{MC} .

(ii) Suppose again that $v^A > 2t^B$, which implies that $S_{MC}(U) = S_{MC}(\hat{U})$. A comparison of the health plan's surplus under indication-based and uniform pricing yields

$$S_{MC}(I) - S_{MC}(U) = \frac{\lambda(1-\lambda)(v^A - 2t^B)\eta}{8(8(1-\lambda)t^B + 3\lambda t^A)^2}, \quad (\text{B26})$$

where

$$\eta := 2(104(1-\lambda)t^B + 45\lambda t^A)t^B - (56(1-\lambda)t^B + 27\lambda t^A)v^A. \quad (\text{B27})$$

For $v^A > 2t^B$, the sign of (B26) is given by the sign of η , which is positive (negative) if $v^A < (>) v_{18}$, where

$$v_{18} := \frac{2(104(1-\lambda)t^B + 45\lambda t^A)}{(56(1-\lambda)t^B + 27\lambda t^A)}t^B. \quad (\text{B28})$$

From (B28) we can easily verify that $v_{18} > 2t^B$, implying that $S_{MC}(I) > S_{MC}(U)$ if $v^A \in (2t^B, v_{18})$. The set $\hat{\Omega}_{MC}$ is therefore defined by

$$2t^B < v^A < \min\{\bar{v}_{MC}, 2t^A, v_{18}\}, \quad (\text{B29})$$

in addition to (A55) and $t^A > t^B$, which is a necessary and sufficient condition for (B29) to be a non-empty set, implying that $\widehat{\Omega}_{MC}$ is a subset of Ω_{MC} . Furthermore, a comparison of (B24) and (B28) yields

$$v_{17} - v_{18} = \frac{32(1-\lambda)(8(1-\lambda)t^B + 3\lambda t^A)(t^B)^2}{(16(1-\lambda)t^B + 9\lambda t^A)(56(1-\lambda)t^B + 27\lambda t^A)} > 0, \quad (\text{B30})$$

which implies that $\widehat{\Omega}_{MC}$ is also a subset of $\overline{\Omega}_{MC}$.

(iii) Since $v_{17} > v_{18}$, it follows from the analysis in (i)-(ii) that $\pi_{MC}(U) > \pi_{MC}(I)$ and $S_{MC}(U) > S_{MC}(I)$ if $v_{18} < v^A < v_{17}$. For this set to be non-empty, we need to make sure that $v_{18} < \min\{\bar{v}_{MC}, 2t^A\}$. Using (A50) and (B28), a comparison of v_{18} with each of the three relevant upper bounds yields

$$2t^A - v_{18} = \frac{2 \left[56t^A t^B - 104(1-\lambda)(t^B)^2 - \lambda(101^B - 27t^A)t^A \right]}{56(1-\lambda)t^B + 27\lambda t^A}, \quad (\text{B31})$$

$$\frac{(3(1-\lambda)t^B + (3+5\lambda)t^A)t^B}{4\lambda t^A + 3(1-\lambda)t^B} - v_{18} = \frac{(8(1-\lambda)t^B + 3\lambda t^A)\kappa}{(56(1-\lambda)t^B + 27\lambda t^A)(4(1-\lambda)t^B + 3\lambda t^A)} \quad (\text{B32})$$

and

$$v_{14} - v_{18} = \frac{5((1-\lambda)t^B + \frac{3}{8}\lambda t^A)\rho}{70(1-\lambda)((1-\lambda)t^B + \frac{27}{56}\lambda t^A)((1-\lambda)t^B + \frac{9}{16}\lambda t^A)}, \quad (\text{B33})$$

where

$$\kappa := 7(8-17\lambda)t^A t^B + 27\lambda(t^A)^2 - (1-\lambda)104(t^B)^2 \quad (\text{B34})$$

and

$$\begin{aligned} \rho &:= 21\sqrt{2(1-\lambda)t^B(\lambda t^A + 2(1-\lambda)t^B)} \left((1-\lambda)t^B + \frac{27}{56}\lambda t^A \right) \\ &\quad - \frac{1}{4}(1-\lambda)(40(1-\lambda)t^B + 27\lambda t^A)t^B. \end{aligned} \quad (\text{B35})$$

We need to define a parameter set for which (B31)-(B33) are all positive. The sign of (B33) is given by the sign of ρ , which is positive if

$$\begin{aligned} &21\sqrt{2(1-\lambda)t^B(\lambda t^A + 2(1-\lambda)t^B)} \left((1-\lambda)t^B + \frac{27}{56}\lambda t^A \right) \\ &> \frac{1}{4}t^B(1-\lambda)(40(1-\lambda)t^B + 27\lambda t^A) \end{aligned} \quad (\text{B36})$$

$\Leftrightarrow$

$$\sqrt{2(1-\lambda)t^B(\lambda t^A + 2(1-\lambda)t^B)} > \frac{t^B(1-\lambda)(40(1-\lambda)t^B + 27\lambda t^A)}{84((1-\lambda)t^B + \frac{27}{56}\lambda t^A)} \quad (\text{B37})$$

$\Leftrightarrow$

$$2(1-\lambda)t^B(\lambda t^A + 2(1-\lambda)t^B) - \left(\frac{t^B(1-\lambda)(40(1-\lambda)t^B + 27\lambda t^A)}{84((1-\lambda)t^B + \frac{27}{56}\lambda t^A)} \right)^2 > 0 \quad (\text{B38})$$

$\Leftrightarrow$

$$\frac{(3328(1-\lambda(2-\lambda))(t^B)^2 + 729(\lambda t^A)^2 + 3024\lambda(1-\lambda)t^A t^B)t^B}{9(1-\lambda)^{-1}(16(1-\lambda)t^B + 9\lambda t^A)^{-1}(56(1-\lambda)t^B + 27\lambda t^A)^2} > 0, \quad (\text{B39})$$

which is always true. Furthermore, it is fairly straightforward to verify that (B31) is positive for all $\lambda \in (0, 1)$ if $t^A > \frac{13}{7}t^B$. Finally, the sign of (B32) is given by the sign of κ , which is positive if

$$t^A > \left(\frac{119\lambda - 56 + \sqrt{3136 + (2929\lambda - 2096)\lambda}}{54\lambda} \right) t^B. \quad (\text{B40})$$

It is easily verified that the condition $t^A > \frac{13}{7}t^B$ always holds if (B40) holds. Thus, (B31)-(B33) are all positive if the condition in (B40) holds.

Using the analysis in (i)-(ii), the parameter set $\tilde{\Omega}_{MC}$ is then defined by

$$v_{18} < v^A < \min\{\bar{v}_{MC}, 2t^A, v_{17}\}, \quad (\text{B41})$$

together with (A55) and (B40). Notice that these parameter restrictions imply $t^A > t^B$ and $v^A > 2t^B$. It also follows from the definitions of $\bar{\Omega}_{MC}$, $\hat{\Omega}_{MC}$ and $\tilde{\Omega}_{MC}$ that $\bar{\Omega}_{MC} = \hat{\Omega}_{MC} \cup \tilde{\Omega}_{MC}$.

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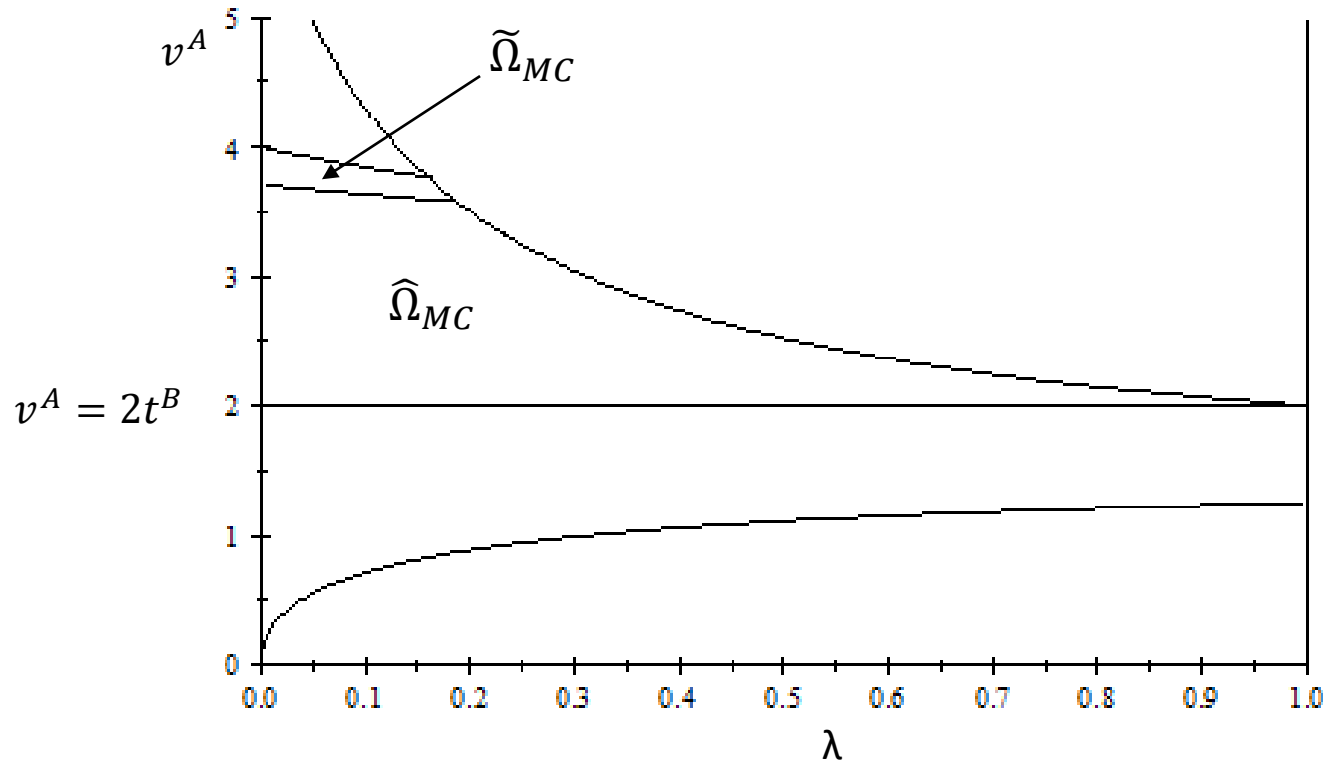


Figure 1. Pricing scheme preferences with therapeutic competition in the new market. In $\hat{\Omega}_{MC}$, the health plan prefers indication-based pricing while the producer prefers uniform pricing. In $\tilde{\Omega}_{MC}$, both the health plan and the producer prefer uniform pricing. Other parameter values: $v^B = 3$, $t^A = 5$ and $t^B = 1$.

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