

External referencing and pharmaceutical price negotiation^{*}

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Abstract

External referencing (ER) imposes a price cap for pharmaceuticals based on prices of identical products in other countries. Suppose country A negotiates prices with a pharmaceutical firm while country B can either negotiate independently or implement ER based on A's price. We show that B always prefers ER if (i) B can condition ER on the drug being subsidized in A and (ii) copayments are higher in B than in A. B's preference is reinforced when the difference between country copayments is large and/or B's population is small. External referencing by B always harms A if (ii) holds, but less so if (i) holds.

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1. Introduction

This paper aims at analyzing the incentives for a country to engage in external referencing for pharmaceuticals as opposed to directly negotiating the drug's price with the firm. External referencing (ER) consists of a price cap for pharmaceuticals, based on prices of identical products in other countries.

With very few exceptions, most countries in the industrialized world have implemented ER at some point of time.¹ For instance, this policy came into force in the Netherlands and in Switzerland in 1996, under the Pharmaceutical Prices Act and the Health Insurance Law, respectively. In the Netherlands, the maximum price for a drug is established as an average of the prices of the drug in Germany, France, UK, and Belgium. Prior to 1996, the prices for pharmaceuticals in the Netherlands were not subject to any regulation, and they were high compared to the prices in those surrounding countries. As expected, the Pharmaceutical Prices Act resulted in considerably lower prices in general for the Netherlands (see Windmeijer et al., 2006). In Switzerland, the Health Insurance Law introduced a 'positive list' of reimbursed pharmaceuticals. For a drug to be included in this positive list, its price should not exceed the average of the prices in Germany, Denmark, the Netherlands and the UK.

Both the Dutch and the Swiss experiences raise the following questions: Why are these countries interested in engaging in external referencing rather than in any other type of cost-containment regulation? Namely, given that pharmaceutical prices are directly negotiated upon in the UK and Germany, why does the Dutch health authority rely on these foreign prices rather than on prices specifically negotiated for the Netherlands? What is the influence of the ER policy on the reference countries?

To tackle these questions, we use a model where a pharmaceutical firm sells a drug in two countries. To focus on the role of consumer copayments and also to gather whether there are any size effects we assume that countries differ both in size (i.e., the number of consumers) and in the level of copayments.

One of the countries (country A henceforth) negotiates the price with the firm. This country is unable to threaten the firm with not authorizing the drug for sale in case of

¹ See Section 2 for a detailed account of the European experience.

negotiation failure. The only threat available to A is that of not listing the drug for reimbursement, so that the firm can still sell the drug at its chosen price with no subsidy. The other country (country B henceforth) can either negotiate the price of the drug with the firm, or instead commit to imposing a price cap based upon the price in the reference country. We study B's decision under two scenarios: one where B, like A, is unable to threaten with not authorizing the drug, and one where B is able to do so. We say that the first scenario is one with "weak threats" and the other one with "tough threats". Our assumption is that whether tough threats are feasible or not is an exogenous feature in our model. For each scenario, we analyze how the commitment by country B to engage in ER affects negotiations in A and ultimately determines the firm's total profit.

We show that the effects of an ER policy crucially depend on its specific design. In this respect, we distinguish between non-conditional and conditional ER policies. In a non-conditional ER policy, the price in A is used as a price cap regardless of whether it was the result of successful negotiations in country A or chosen by the firm once negotiations had failed. In a conditional ER policy, the price in A is used as a price cap only if it is the result of successful negotiations, i.e., only if the drug is included in A's list of subsidized drugs.

The main results of the paper are the following. First, an unconditional ER policy harms both countries and should never be chosen. In this case, whether threats are weak or tough is irrelevant, since no threats are ever made.

Let us now consider a conditional ER. Here it becomes crucial whether we are in the weak-threats scenario or in the tough-threats scenario. In the former scenario, B's ER policy results in an increased negotiated price in country A. This harms A. We also prove that, for any given population size of A, B prefers a conditional ER to an independent price negotiation. However, it is true that B's preference for ER over independent negotiations diminishes as B's population size grows, although it never disappears.

Our results for the tough-threats scenario are somewhat different. First, the effect of conditional ER on the bargained price in A is negative, which benefits A. Second, a conditional ER should only be observed if the copayment in B is sufficiently larger

than A's and/or the negotiating power of the agency in country A is sufficiently strong. This is in contrast to the weak threats scenario. The idea is that the feasibility of tough threats improves B's payoff not only under conditional ER but also under independent negotiations. This explains why the results on the B's preference for ER are not so clear cut in the tough-threats scenario.

Let us offer some intuition for our results. For almost all situations, we find that the ER policy worsens the bargaining power of country A *vis à vis* the firm and increases the price in A. The mechanism is as follows. The firm's threat point in the bargaining with A improves when an ER policy is chosen. By how much it improves depends on the way B designs its ER policy. As an illustration, consider the extreme case where the ER is non-conditional. In other words, suppose that B promises to set the price in A as a price cap, even if this price is not the result of a successful negotiation in A. If demand is quite inelastic, B's promise can be exploited by the firm, who may not negotiate in A and set a very high price in order to maximize the profits in B. Our point is that under an unconditional ER the firm is able to extract higher rents from B. This "linked demand" effect is also present (although in a smaller scale) in the weak-threats scenario and under a conditional ER. Indeed, the only situation where the linked demand effect does not exist is in the tough-threats scenario. The reason is that in this scenario, a negotiation failure in A implies that the firm loses B's market. In order to draw comparisons, we study as a benchmark the case where the firm negotiates with each country independently.

Our results with independent negotiations are a direct corollary of Jelovac (2003), where she shows that with independent negotiations, prices are lower where subsidies are higher.² Since a more generous subsidy results in a smaller negotiated price, there is scope for a country to engage in ER if its copayments are sufficiently larger than the other's. Hence, our contribution is the characterization of the effect of ER in this setting.

Another contribution of our paper is that it enlightens the difference between external referencing and parallel imports. The closest paper to ours in this respect is Pecorino

² This may seem counterintuitive, since in markets that use the price mechanism as an allocation device high subsidies are associated with demand inelasticity and high prices. However, with bargaining, high subsidies increase the gains from negotiation to firms, who are then willing to go with lower prices.

(2002), who studies the effects of parallel imports from country A to country B on A's price negotiation. He obtains that, surprisingly, the presence of parallel imports in this context results in higher profits for the firm. It turns out that our model with unconditional ER yields the same results, as it constitutes a different version of Pecorino's one, namely one with subsidies (which he assumes away). Hence the statement made by Danzon *et al.* (1997) that external referencing is tantamount to a 100% parallel import is confirmed for the case of an unconditional ER policy. In contrast, if ER is conditional, Pecorino's result is reversed: the profits of the firm decrease due to a conditional ER policy.

Unfortunately, a limitation to our study is that there is very scarce information about the details of existing ER policies. For example, we do not know whether these policies are conditional or unconditional, or whether their details are far more sophisticated than the ones we have described before. After all, an ER policy is an *ex-ante* commitment and it could be made to depend on the complex flux of events it precedes. However, we believe that by focusing on the three examples that we have picked (unconditional ER, conditional ER with weak threats, and conditional ER with tough threats) we can gather the direction of the effects and demonstrate how important the design of the policy is.

The three examples studied are somewhat more general than at first glance. For instance, it is interesting to note that if the firm is able to make transfers to the agency in the benchmark country in exchange for higher prices, and these transfers are unobservable to the referencing country, then the situation is equivalent to one of unconditional ER: the firm is able to induce a large price in both countries. The only difference with the unconditional ER situations is that the benchmark country is not forced now to delist the pharmaceutical drug. In contrast, if transfers are observable (and the referencing country has large incentives to monitor) the referencing country can delist the drug upon observation of such transfers. This would be consistent with what we assume to happen under the weak conditional ER when a break-up of negotiations is observed.

Again, we do not have information on how referencing countries do respond in reality to transfers of this kind. We do however observe them. For instance, Pfizer offered

disease management services to state residents in the state of Florida in order to avoid a low price (namely, a lower rebate) that would be a benchmark for other states.³

It is important to emphasize that our analysis is positive in nature, rather than normative. We do not analyze how and why copayments are chosen or why threats may be tough or weak –we only observe that in practice copayments and threats differ.⁴ Similarly, we do not seek to offer a complete explanation of why some countries are reference countries and others are referencing countries. The basis of our analysis is the fact that in the real world there are countries of either type. However, it is clear that if a country's objective is to reduce the costs of drugs, she will have an incentive to engage in ER if by doing this it can induce lower prices than by negotiating directly.

The paper is organized as follows. A description of the European experience with ER is provided in Section 2. A two-country model with fixed-charge copayments is described in Section 3. Section 4 provides the solution to the benchmark case in which each country negotiates the price with the pharmaceutical firm, independently of the other country. Section 5 introduces the possibility for one country to adopt a weak-threat ER policy, and analyzes its effects. Section 6 extends the analysis adding the possibility of transfers from the firm to the benchmark country to influence the benchmark price. Section 7 extends the analysis to the tough-threat case. Section 8 graphically summarizes our findings. Section 9 concludes. All the proofs are in the appendix.

³ Florida-Pfizer deal charts new territory in overall cost control, but can it work? *Formulary* September 1, 2001.

⁴ For example, one observes that in the Netherlands, failure of abiding by the price cap results in no sales authorization, whilst in Switzerland drugs are always allowed for sale, but they may not be subsidized.

2. The European Experience

Let us now overview the many instances of ER that one can find in Europe. We concentrate in this area because it is the most documented one.⁵ We concentrate on the issues that are most relevant to appraise the relevance of our model.

Countries using ER and benchmark countries

Many countries in Europe have implemented ER policies. However, not only the details differ from country to country, but are also changed often. For instance, in Denmark, foreign prices were used to determine the reimbursement price for groups of drugs (drugs with same ATC-code), but this policy has been discontinued recently, and has been replaced by non-price controls. In Sweden, external referencing was discontinued in 2002. Hence, the situation is, to say the least, volatile. Hence, the examples given below should be taken with caution, as they are only valid as of the time of writing this section.

The ER formula

As for inter-country differences, some administrations use the prices of other countries to construct an average reference price, whereas others take the minimum price. Among the first ones, some use a large list of referenced countries. Austria uses prices from Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain, Sweden, and the UK. Finland adds to the previous long list prices from Austria, Belgium, Ireland, and Norway. Also among countries using average prices, others use prices from just a handful of countries. This is what happens in the two examples presented in the beginning of the introduction: the Netherlands uses the prices observed in Belgium, France, Germany, and the UK while Switzerland uses the prices from Denmark, Germany, the Netherlands, and the UK. There are many other countries that take averages (from different lists): Austria, Belgium, Italy, Lithuania (average minus 5%), and Norway (average of the lowest 3).

⁵There are countries outside Europe that also have implemented ER: Brazil (lowest price); Canada (median price); Japan, Korea, and Taiwan (average price).

As mentioned earlier, some countries take the minimum instead of the average price. France uses the lowest price among Austria, Belgium, Denmark, Finland, Germany, Greece, Italy, the Netherlands, Portugal, Spain, Sweden, and the UK. Other countries using the same method (again with different reference countries) are: Bulgaria, Croatia, Czech Republic, Estonia, Greece, Hungary, Latvia, Poland, Portugal, Romania, ex-Serbia-Montenegro, Slovakia, and Slovenia.

In summary, out of all European Countries, only UK, Sweden, Germany, and Denmark do not currently have an ER policy.

Formal versus informal ER

Very importantly for our model, the ER policy may be implemented more or less formally. We assume that the referencing country commits to its policy at the outset. This is precisely why the ER impacts the negotiations carried out in the reference countries. In this respect, Spain uses ER only informally, and therefore it is less appropriate to apply our analysis to this particular case.

Weak versus tough threats

Also importantly for our model, there are reasons to believe that most of European experiences correspond to the weak threats scenario. The reason is simple. In Europe, authorization and price negotiation are separate processes carried out by separated agencies, based on different criteria, and with different time horizons. As Heuer et al. (2007) point out, “[W]ith the introduction of the European Medicines Evaluation Agency (EMA) in 1995, the EU Member States wanted to harmonize access to the pharmaceutical market” so that “[...] companies benefit from a larger market after authorization.” (p. 2). As for Switzerland, a non-EU state, Paris and Docteur (2007) report that “to be launched on the Swiss market, pharmaceutical products have to be approved by the Swissmedic [...] The institute grants a marketing authorization if the product meets the requirements of quality, safety and effectiveness. The clinical assessment is based on data provided by the pharmaceutical company. This authorization is valid for 5 years.” In contrast, “The Federal Office of Public Health (OFSP) regulates both inclusion in the positive list and pricing of reimbursed pharmaceuticals.”

Empirical measures of the effects of ER

Apart from the work by Windmeijer (2006) already mentioned in the introduction, there are several other empirical studies that analyze the impact of price regulation. Unfortunately, more than exploring the effects of ER in isolation, most empirical studies aim to determining the effect of price controls in general.⁶ An exception is Heuer et al (2007), who explore whether countries engaging in ER suffer from delays in the launch of pharmaceutical products. Although we do not address this phenomenon, we think that it is a good proxy for the importance of ER.

These authors explicitly distinguish ER from other direct price controls (which include the consideration of the therapeutic value of the drug, its cost-effectiveness, or its pharmaceutical contribution to the economy). The authors also consider the effect of reference pricing (that is, having the subsidy depend on the prices of similar drugs), which constitutes an indirect form of price control. It is suggestive that the only coefficient that is significant at the 5% level is that of the dummy variable for the presence of ER.⁷ In contrast, the coefficients for the presence of other direct controls and for reference pricing are not significant.

Relative market sizes

Our most important result for the European experience is that under conditional ER and under weak threats, the referencing country's preference for ER over independent negotiations diminishes as the benchmark country's population size grows, although it never disappears. In Table 2 we report total pharmaceutical sales in millions of US dollars in the year 2001. Recall that the Netherlands uses an average of the prices of the drug in Belgium, France, Germany, and UK. If we divide sales in the Netherlands by each of these countries', we obtain, respectively, 1.20, 0.18, 0.16, and 0.25. If we take the unweighted average of these numbers we obtain 0.45. If we performed the same calculation assuming that Germany was to use the same list of countries as benchmarks (adding the Netherlands and taking away Germany), we would obtain

⁶ On the effects of regulation on price see Danzon and Chao (2000a, 2000b) and Cabrales and Jimenez (2007). On the effects of regulation and price differentials on launch delays see Danzon, Wang and Wang (2005) and Kyle (forthcoming).

⁷ More specifically, they show that, all else equal, if a country abolished the use of ER then the chance of launch within eight months would rise by 50.9%.

4.09. The fact that Germany does not engage in ER while the Netherlands does is not incompatible with our results. In Table 1 we repeat the same analysis using Gross Domestic Product at current prices, in Millions of Euro for the EU-15 (2nd quarter of 2006, the most recent quarter for which we have a complete set of data). We obtain 0.63 (instead of 0.45) and 3.58 (instead of 4.09).

Table 1: GDP (Year 2006, 2nd quarter)

Country	GDP
Germany	578.800,00
UK	467.969,40
France	447.496,80
Italy	368.254,50
Spain	243.136,00
The Netherlands	132.936,00
Belgium	78.041,00
Norway	68.450,60
Poland	66.028,30
Austria	64.059,80
Denmark	55.300,50
Greece	47.581,00
Ireland	42.518,60
Finland	41.356,00
Portugal	38.627,60
Czeck Republic	27.990,30
Hungary	22.063,20
Slovakia	10.721,00
Luxembourg	8.383,00
Slovenia	7.414,90
Lithuania	5.835,90
Latvia	3.901,90
Cyprus	3.615,30
Estonia	3.228,60
Malta	1.245,90

Source: Eurostat

Table 2: Pharmaceutical sales

Country		Relative size of referencing country		Benchmarks	
		Hypothetical: Germany	the Netherlands	the Netherlands	Germany's hypothetical benchmarks
Belgium	2544	7,47	1,20	1,20	7,47
Czech Republic	1163	16,35	2,63		
Denmark	1485	12,80	2,06		
Finland	1123	16,93	2,72		
France	16968	1,12	0,18	0,18	1,12
Germany	19014	1,00	0,16	0,16	
Greece	2799	6,79	1,09		
Hungary	959	19,83	3,18		
Iceland	134	141,90	22,79		
Italy	15328	1,24	0,20		
Luxembourg	117	162,51	26,10		
Netherlands	3054	6,23	1,00		6,23
Norway	1400	13,58	2,18		
Portugal	1484	12,81	2,06		
Slovak Republic	344	55,27	8,88		
Sweden	2434	7,81	1,25		
Switzerland	3124	6,09	0,98		
Turkey	1977	9,62	1,54		
United Kingdom	12348	1,54	0,25	0,25	1,54
Averages				0,45	4,09

Source OECD HEALTH DATA 2007, July 07

3. The Model

The players in this game are a pharmaceutical firm and the health authorities of two countries, A and B. We refer to these players as the firm and the agencies. The firm sells a drug in both countries. It holds a patent for the drug in both countries and produces at no variable cost.⁸

Both agencies operate a positive list of reimbursed pharmaceuticals. If the drug is listed for reimbursement in country i , patients pay a fixed and exogenous copayment C_i , and the difference between the price and the copayment, $P_i - C_i$ is reimbursed by

⁸ The assumption that variable costs are negligible can be sustained empirically. Moreover, our analysis can be extended to situations with constant returns to scale. Having a positive marginal cost would only involve more complicated calculations, while in essence the results would be the same.

the agency to the firm. If the drug is not listed for reimbursement, then the patients pay the full price of the drug, P_i .

We assume that aggregate demand in country A is given by $D(Z_A)$, with $D'(Z_A) < 0$, $D''(Z_A) < 0$ and Z_A is the out-of-pocket payment. Country B is a K -replica of country A, with $K > 0$ but not necessarily larger than one.⁹ We just say that country B has size K while country A has size 1. Aggregate demand in country B is $KD(Z_B)$.

Note that by assuming that copayments are fixed, demand is fixed and independent of the price as long as the price is above the copayment. If the price is below the copayment we assume that the out-of-pocket payment Z_i , $i = A, B$, is the price itself (no taxes). Formally,

$$Z_i = \text{Min}\{C_i, P_i\}, \quad i = A, B.$$

The following assumption is a fundamental assumption throughout our analysis. As we will see, B would never implement an ER if it fails to hold.

Assumption 1 *Patients pay less in country A than in country B, that is, $C_A < C_B$.*

Notice that A and B have different aggregate demand for two reasons. One is country size, as explained above. The other is that, even if an individual in A has the same demand function as another in B and even if prices are the same in the two countries, the latter individual will demand less due to the higher copayment.

The pharmaceutical firm aims at maximizing its joint profit from both countries, with $P_A D(Z_A)$ being profit in country A and $P_B K D(Z_B)$ being profit in country B.

We assume that, in each country i , copayments are exogenously set beforehand by some outside player (say the Government or The Parliament of this country i). Hence we do not aim at studying what the optimal copayment C_i should be. This depends on the outside players' preferences, whether the firm is owned by nationals or foreigners, equity and insurance considerations, consumption externalities, etc. The agency only

⁹ Suppose that, as for the individual demand function for the drug, there are T different types of individuals in country A, $t = 1, 2, \dots, T$. We are assuming that if there are n_t agents of type t in country A then there are Kn_t agents of exactly that same type in country B, for all t .

bargains for low prices with firms in return for a “fixed gain”, the granting of reimbursement rights. We believe this encompasses most real world cases.¹⁰

We assume that the agency is given the following mandate by the outside player: She should negotiate prices with the firm in order to maximize net consumer surplus minus the public costs of provision. Hence, the agency’s objective function does not include the profits of the firm. We believe this assumption also to be in accordance with reality. A motivation is that the outside player finds it beneficial to delegate the bargaining over price to a more aggressive negotiator.

Now, in a market of size K we define the net consumer surplus as:

$$K \cdot CS(Z_i) = K \left[\int_0^{D(Z_i)} D^{-1}(q) dq - C_i \cdot D(Z_i) \right].^{11}$$

The objective function of the agency of a country of size K and copayment C_i is:

$$K \cdot CS(Z_i) - K \cdot (P_i - Z_i) \cdot D(Z_i).^{12}$$

We model the negotiation process as a Nash bargaining game. We first develop our weak-threats scenario.¹³ Namely, we assume that if negotiations fail in a country, the drug is not listed for reimbursement and the firm markets the product in that country at the monopoly price, P^M , with $P^M > C_B > C_A$ (otherwise, the drug subsidization system would vanish). Notice that this price is independent of country size due to our

¹⁰ Some countries rely on the so-called “tiered pricing” whereby lower prices result in the drug enjoying a higher subsidy. Our model amounts to a very simple tiered pricing mechanism. As it will be explained below, negotiation failure results in the drug not being listed for subsidization. Hence, only two tiers are present: a subsidy $P - C_i$ or no subsidy at all.

¹¹ We consider the consumer surplus as a measure of health benefits as it is linked to the willingness to pay for the drug.

¹² Note that, for all $C < P$, the objective function of the agency is decreasing in C . Although, as explained above, we take copayments as exogenously set beforehand, it is useful to understand why this is so. Suppose that one increases the copayment so that demand is reduced by one unit. This has a negative effect on gross consumer surplus equal to the original copayment, as the unit that is no longer sold was enjoyed by the marginal consumer. However, it also has a positive effect, as total expenditures (consumer plus government’s) are reduced by the price. Since our premise was that copayment was below price, the assumed objective function increases. In consequence, if the agency was in charge of setting copayments, drug consumption would not be subsidized. However, also as explained above, the outside player’s preferences may be quite different from those of the agency.

¹³ In the extensions section we discuss the tough-threats scenario, where B (but not A) is able to threaten the firm with not authorizing the drug for sale in country B.

assumption of zero variable costs (and in general due to constant returns to scale gross of sunk costs). In such case, there are no public expenses associated with subsidizing the drug and the objective function of the government reduces to $CS(P^M)$, the value of the net consumer surplus at the monopoly price.

Finally, the agencies of both countries have the same bargaining power, denoted by β . The bargaining power of the firm in either country is $1 - \beta$.

Throughout the text we will denote $CS^M = CS(P^M)$ and $\pi^M = P^M D(P^M)$. We will also denote $W(C_i) = CS(C_i) + C_i D(C_i)$ for $i = A, B$.

4. Independent Price Negotiations

Here we present our main benchmark case in which each country carries a price negotiation with the pharmaceutical firm, independently from the other country.¹⁴ We consider a situation where a failed negotiation results in the drug losing its subsidy but still being authorized for sale. Letting $K \cdot CS^M$ and $K \cdot \pi^M$ constitute the disagreement payoffs of the agency and the firm, respectively, the Nash bargaining problem for a country of size K is:

$$\begin{aligned} & \text{Maximize}_{\{P \in [C, P^M]\}} \\ & NB_1 = \beta \ln \left\{ K \left[CS(C) - (P - C) \cdot D(C) - CS^M \right] \right\} + (1 - \beta) \ln \left\{ K \left[P \cdot D(C) - \pi^M \right] \right\} \\ & = \ln[K] + \beta \ln[CS(C) - (P - C) \cdot D(C) - CS^M] + (1 - \beta) \ln[P \cdot D(C) - \pi^M] \quad (1) \end{aligned}$$

It is worth noting that in the bargaining problem of any country, we assume that the agency places no value on the consumer surplus or the public expenses of the other country. Note also that the size of the country, K , only constitutes a level effect in the independent bargaining problem, and in consequence will not affect the final price. By solving (1) we obtain the following lemmata.

¹⁴ This analysis heavily draws from Jelovac (2003).

Lemma 1. *When both countries independently negotiate the price with the firm, then*
(i) the resulting price in each country i , $i = A, B$ is:

$$P_i^* = (1 - \beta) \cdot C_i + (1 - \beta) \frac{[CS(C_i) - CS^M]}{D(C_i)} + \beta \frac{\pi^M}{D(C_i)}, \quad (2)$$

and

(ii) this price is increasing in the level of copayment, C_i .

Lemma 2. $P_i^* > C_i$ *for all $i = A, B$.*

Note that in this bargaining solution the profits per capita in country i , $\pi_i^* = P_i^* D(C_i)$ decrease in C_i , since

$$\pi_i^* = (1 - \beta) \cdot C_i D(C_i) + (1 - \beta)[CS(C_i) - CS^M] + \beta \pi^M$$

and

$$\partial \pi_i^* / \partial C_i = (1 - \beta) C_i D'(C_i) < 0.$$

This implies that, profits per capita are larger in country A.

The intuition for Lemma 1 is given after we further characterize the solution to (1). Lemma 1 implies the following equality:

$$(1 - \beta)[CS(C_i) - CS^M - (P^* - C_i)D(C_i)] = \beta[P^* D(C_i) - \pi^M]. \quad (3)$$

This equality illustrates that the total surplus generated by the negotiation above the disagreement point is split between the agency and the firm in the proportion β to $1 - \beta$, as it is usual in this type of problem.

In the bargaining problem, the disagreement positions of the agency and the firm do not depend on the copayment C_i . Hence, the effect of the copayment on the

negotiated price is only due to its effect on the surplus generated by the negotiation above the disagreement point. Let $S(C_i)$ denote this surplus, with

$$S(C_i) = CS(C_i) + C_i \cdot D(C_i) - CS^M - \pi^M. \quad (4)$$

Note that $S(C_i)$ is decreasing in C_i :

$$S'(C_i) = CS'(C_i) + D(C_i) + C_i \cdot D'(C_i) = C_i \cdot D'(C_i) < 0.$$

As the copayment increases, there is less to be split between the two parties and the negotiated solution converges to the monopoly solution. The public costs of the subsidy for an agency decrease, and the agency can afford higher negotiated prices. At the same time, as the copayment increases, there is less for the firm to gain by negotiating and hence it requires a larger price. This explains lemma 1. The next is a direct corollary.

Corollary 3. *For any K and with independent negotiations, the negotiated price in the country with a large copayment exceeds the negotiated price in the country with a small copayment: $P_A^* < P_B^*$.*

Hence, henceforth we consider the situation where Country A is the reference country for Country B.

5. The types of external referencing in the weak-threats scenario

In this section we consider the effects of an ER policy by B based on the price of country A. Our aim is to explain how B's ER affects the bargaining outcome in country A and to investigate whether it is in the interest of B to implement this regulation. As explained in the introduction, an ER policy may take many different forms, in particular what is defined as a price cap must be settled first. Is it any price in country A? Or is it the price in A as long as it results from successful negotiations?

In the first case we say that the ER policy is *unconditional*, in the second case we say that the ER policy is *conditional*. If ER is conditional, we must specify what happens in the case of failed negotiations in A. As we are under the weak-threat scenario, we assume that if negotiations in country A fail, B ceases to reimburse the drug but still allows the firm to sell the drug at a full price chosen by the firm.

5.1 The effects of an unconditional ER policy

An unconditional ER requires the least information on the part of B. It is the only feasible policy if B is unable to verify whether the negotiation in A has been successful (or, equivalently, whether the drug is on A's positive list). In this case, if negotiations fail in country A, the firm is allowed to set a price P that maximizes the following expression: $P(\text{Max}\{D(P), 0\} + KD(C_B))$. Note that this problem is unbounded, as the demand in country B is fixed. Hence, there is no surplus associated to the bargaining problem. In consequence, negotiations fail.¹⁵ This illustrates, in a very extreme way, what the problem with external referencing is, in general: It increases the disagreement payoff of the firm as compared to the disagreement payoff under independent negotiations (π^M). In this case the increase is in fact unbounded.

In conclusion, an unconditional price cap with fixed copayments is non-optimal, resulting in really adverse results for all countries, both referencing and referenced. In fact, one may say that this negative result motivates our research, as it is telling us that ER must have more to it than the mere “copying” of other countries’ prices. Either more sophisticated policies should be in place (normative approach) or are in place despite not being actually observed as negotiations succeed (positive approach). For this reason we turn our attention to conditional ER.

¹⁵ If an exogenous bound exists on the payments that country B can make, then we have to qualify our previous statement on negotiation failure. It only holds if the exogenous bound is large enough. If it is not, we would run into some convoluted casuistics that lie beyond the point we want to make, the extreme adverse effects of an unconditional ER on bargaining.

5.2 The effects of a conditional ER policy

Letting CS^M and $(1+K)\pi^M$ constitute the disagreement payoffs of A's agency and the firm,¹⁶ the Nash bargaining solution in country A is the solution to the following program:

$$\begin{aligned} & \text{Maximize}_{\{P \in [C_A, P^M]\}} \\ & \beta \ln\{CS(C_A) - (P - C_A)D(C_A) - CS^M\} + (1 - \beta) \ln\{P\{D(C_A) + KD(C_B)\} - (1 + K)\pi^M\}. \end{aligned} \quad (5)$$

To guarantee that P is strictly larger than C_B , we make the following assumption.

Assumption 2. $C_B D(C_A) < \pi^M$.

By solving (5) we obtain the following lemma.

Lemma 4. *Under Assumption 2, when the conditional ER is adopted in country B, the negotiated price in country A is:*

$$P^{WC} = (1 - \beta)C_A + (1 - \beta) \frac{CS(C_A) - CS^M}{D(C_A)} + \beta \frac{(1 + K)\pi^M}{D(C_A) + KD(C_B)}, \quad (6)$$

which is increasing in both C_A and C_B as well as in K .

Lemma 4 allows us to write the following equality:

$$\begin{aligned} & (1 - \beta) \frac{D(C_A) + KD(C_B)}{D(C_A)} \{CS(C_A) - (P^{WC} - C_A)D(C_A) - CS^M\} \\ & = \beta \{P^{WC} \{D(C_A) + KD(C_B)\} - (1 + K)\pi^M\}. \end{aligned} \quad (7)$$

¹⁶ If the negotiations with country A fail the firm will sell the drug with no subsidy in both countries.

This equality illustrates that the total surplus generated by the negotiation above the disagreement point is split between country A and the firm in the ratio:

$$\beta \text{ to } (1 - \beta) \frac{D(C_A) + KD(C_B)}{D(C_A)} > (1 - \beta).$$

This shows that the implicit negotiation power of the firm is higher when country B engages in a conditional ER as compared to independent negotiations.

It is also interesting to analyze how changes in K change the outcome of the negotiation in A on the face of an ER. A raise in K affects the bargaining between A and the firm in two ways. First, the pie to be shared between both parties is larger; hence there is an outwards shift in the frontier of the problem. Second, the firm has a stronger disagreement payoff whilst A's disagreement payoff remains the same. The next proposition tells us the outcome of these two effects.

Proposition 5. *Suppose that Assumptions 1 and 2 hold. Then:*

- (i) $P^{WC} - P_A^* > 0$ and this difference increases in K .
- (ii) $P^{WC} - P_B^* < 0$, this difference decreases in K and it converges to an asymptote as K tends to infinity. This asymptote decreases in the difference $C_B - C_A$. Therefore, the difference between P^{WC} and P_B^* decreases monotonically as C_A tends to C_B .

The proposition is illustrated in Figure 1. It implies that B always prefers to commit to a conditional ER policy than to engage in independent price negotiations with the firm. It also implies that this preference diminishes as the size of country B increases and as copayments become more homogeneous, but is always positive. However, as a direct result of the adoption of the ER in country B, the price negotiated in country A raises. This is explained by the change in the differences between failure and success payoffs of A and the firm. Moreover, as K increases the negotiated price in country A

raises, but never to be so high that B loses out by choosing the ER policy rather than independently negotiating with the firm. Public expenses as well as the firm's profit in country B are lower. The opposite holds in country A.

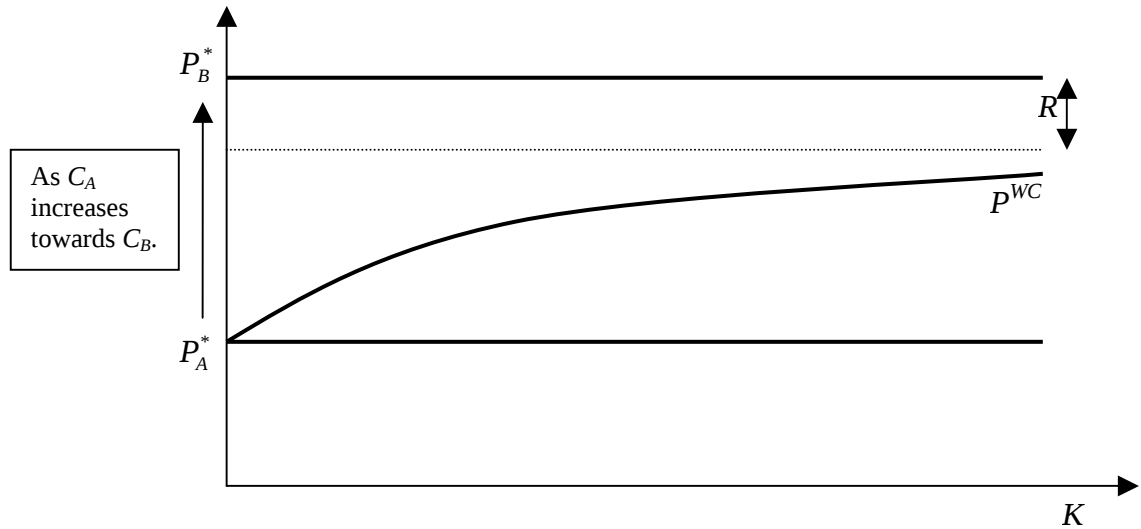


Figure 1. Comparing independent price negotiations to weak conditional ER as country B's size (K) increases relative to country A's. The value of R is derived in the Appendix (proof of Proposition 5). It decreases as C_A increases.

Finally notice that consumers in either country are not affected by the ER policy since they pay a fixed copayment. The next proposition states that the total profits of the firm decrease because of the adoption of such an ER policy.

Proposition 6. *Under Assumptions 1 and 2, the total profits of the firm are lower when country B engages in ER, that is,*

$$P^{WC} \{D(C_A) + KD(C_B)\} < P_A^* D(C_A) + P_B^* KD(C_B).$$

Consequently, the sum of public expenses in both countries also decreases, implying that the decrease in B's expenses compensates for the extra expenses in country A. This means that if country B wanted to fully compensate A for her "free riding", she could do so and still achieve higher welfare than under independent negotiations.

6. Extension to feasible transfers from the firm to the benchmark country

Assume that, similarly to what occurs when a break up of negotiations is observed, B delists the drug if a transfer is observed from the firm to country A. In this case the negotiations in A will be based on both the price P and the transfer T . The Nash Bargaining Problem becomes:

$$\text{Maximize}_{\{P \in [C_A, P^M], T > 0\}}$$

$$\beta \ln \{CS(C_A) - (P - C_A)D(C_A) + T - CS^M\} + (1 - \beta) \ln \{PD(C_A) - T + K\pi^M - (1 + K)\pi^M\}$$

By letting $\tau = PD(C_A) - T$ and cancelling terms, this is equivalent to:

$$\text{Maximize}_{\{\tau > \pi^M\}}$$

$$\beta \ln \{CS(C_A) - \tau + C_A D(C_A) - CS^M\} + (1 - \beta) \ln \{\tau - \pi^M\}$$

Let us compare this problem with the independent negotiations problem (1) for country A (that is, for $K = 1$ and $C = C_A$). Notice that choosing P in (1) is tantamount to choosing τ here, since both $D(C_A)$ and T are constants. Therefore, the two problems are equivalent. Hence, by accepting transfers, the agency in the benchmark country is able to revert to an independent negotiations process. This is a preferred situation by A, by Proposition 5. The next question is whether the firm also finds it beneficial to engaging in such transfers. The answer is no. First, using transfers decreases firm's profit in country A up to the value obtained under independent negotiations, which is lower than that under ER (also by Proposition 5). Second, using transfers implies that the drug will be delisted in country B, leading to profits $\pi^M < \pi^{WC}$. Therefore, no transfers should be observed in this case.

In contrast, it is interesting to note that if the firm is able to make transfers to the agency in the benchmark country in exchange for higher prices, and that these transfers are unobservable to the referencing country, the situation is equivalent to one of unconditional ER: the firm is able to induce a large price in both countries. The

only difference with the unconditional ER situations is that the benchmark country is not forced now to delist the pharmaceutical drug.

7. Extension to tough-threats

In this subsection we assume that B, but not A,¹⁷ is able to make tough threats in the following sense. Suppose first that negotiations are independent. If negotiation in country B fails, B does not authorize the drug for sale. Suppose now that B implements a conditional ER policy. Then, if negotiations in country A fail, again B does not authorize the drug for sale. This changes the *status quo* of both the Nash bargaining problem in B under independent negotiations and the Nash bargaining problem in A when B engages in ER. A full description of these problems and their solutions can be found in Appendix B, where we show that, first, under independent price negotiations, the negotiated price in country B is independent of B's relative size. This result was also obtained under weak threats, and the intuition provided there is valid for this case as well. Second, we also show that the negotiated price in A under a conditional ER by B, denoted by P^{TC} , is increasing in both C_A and C_B and decreasing in the relative size of country B. Intuitively, under tough threats the *status quo* of both the firm and A are independent of K . An increase in K only affects the bargaining problem by shifting the firm's losses due to negotiation failure upwards, not A's. This results in smaller negotiated prices. Third, we also show that P^{TC} is lower than the independently negotiated price in A. Hence, in contrast to the weak-threats case, A is benefited by B's ER. One cannot say that Country B free rides on Country A. Rather, now it is country A who free rides on B's tough position.

Finally, and most importantly, we show that an open set of parameters exists where B finds it beneficial to engage in ER. More specifically, ER is more likely to be implemented (a) the larger the difference between copayments and/or (b) the smaller the agencies' negotiation power β . That B finds it beneficial to engage in ER is quite surprising because, by engaging in ER, B seems to be "copying" the price of a country that is unable to make tough threats. The intuition behind (a) is that under independent

¹⁷ This is consistent with the assumption that A is unable to engage in ER due to an overall weak position *vis à vis* the firm.

negotiations (our point of comparison), B's position is weakened (even under tough threats) if country B's copayment is high. This in turn is explained by the fact that when copayments are high, the firm does not gain so much from a successful negotiation. The intuition behind (b) is that the firm's tough threat is transmitted into the price negotiation in A through B's ER policy. This turns out to be more effective the weaker the agencies' negotiation power is. In contrast, if the agencies' negotiation power is large and/or copayments are close enough then B may prefer to stick to independent negotiations with the firm. We show this in Appendix B by means a numerical example.

8. Graphical analysis

In Figure 2 we illustrate our results by depicting the Nash Bargaining problem in the classical form, i.e., as a maximization under constraints.

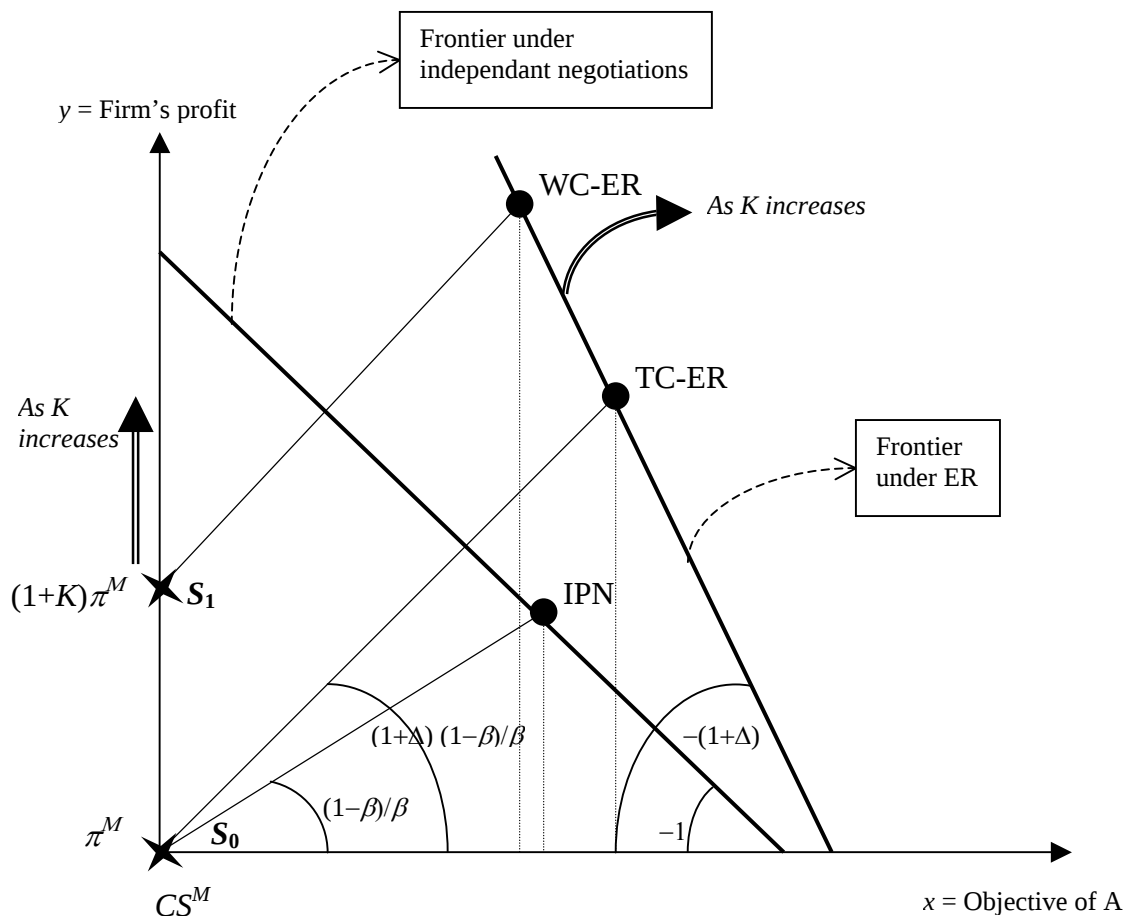


Figure 2. The Nash bargaining solution (NBS) in country A (i) under a weak conditional ER (WC-

ER), (ii) under a tough conditional ER (TC-ER), and (iii) under independent negotiations (IPN). The crosses denote *statu quo* points. The dots represent the NBS in each case. The final and total profits of the firm can be read out of the vertical axis except for independent price negotiations.

8.1 Construction of Figure 2

Formally, let $x = X(P)$ and $y = Y(P)$ be agency A's and firm's payoff when price is P , and let x_0 and y_0 be these player's disagreement payoffs. Then we can express the NBS (Nash bargaining solution) as the solution to

$$\begin{aligned} \text{Max}_{(x,y) \in \mathfrak{R}_+^2} \quad & \beta \log(x - x_0) + (1 - \beta) \log(y - y_0) \\ \text{subject to} \quad & x = X(P) \\ & y = Y(P) \end{aligned}$$

Then the frontier $y = \phi(x)$ is found by solving $x = X(P)$ for P and substituting the solution into $y = Y(P)$. Let us refer to the objective function of the previous problem simply as OF . The NBS is found at the tangency point between the frontier and the isoquants of OF , which have to be shifted as if the axes have origin in the disagreement point (x_0, y_0) . Formally, it is the solution to:

$$\begin{cases} y = \phi(x) \\ \phi'(x) = -\frac{\beta}{1-\beta} \frac{y - y_0}{x - x_0}, \end{cases}$$

where the right-hand side term of the second equation is the slope of OF 's isoquants. Equivalently, the solution lies at the intersection between the frontier $y = \phi(x)$ with slope $\phi'(x)$, and the ray obtained by rearranging the second tangency equation:

$$\frac{y - y_0}{x - x_0} = -\frac{1-\beta}{\beta} \phi',$$

with slope:

$$-\frac{1-\beta}{\beta} \phi'.$$

When A conducts independent price negotiations, we have that

$$X(P) = CS(C_A) - (P - C_A)D(C_A) \text{ and } Y(P) = PD(C_A).$$

The slope of the frontier is -1, as can be readily checked. The disagreement payoff is given by $S_0 = (CS^M, \pi^M)$, where both the agency and the firm's payoffs correspond to the monopolistic solution. It is also important to draw the corresponding ray through S_0 , with slope:

$$-\frac{1-\beta}{\beta}.$$

The NBS is found at the intersection of the frontier and that ray, denoted by IPN.

This exercise can be repeated for the case where B engages in conditional ER with weak threats. There, $X(P) = CS(C_A) - (P - C_A)D(C_A)$ (as before) whereas $Y(P) = P\{D(C_A) + KD(C_B)\}$. The frontier rotates outwards and the slope becomes

$$-(1 + \Delta), \text{ with } \Delta = K \frac{D(C_B)}{D(C_A)}.$$

The frontier is thus steeper than before, and more so the larger K is. The disagreement point now becomes $S_1 = (CS^M, (1 + K)\pi^M)$, just above the one with independent negotiations. Accordingly, we draw through S_1 a ray with slope:

$$-\frac{1-\beta}{\beta}(1 + \Delta).$$

The NBS in this case is denoted WC-ER in Figure 2.

Finally, if B engages in ER but is able to make tough threats, the frontier stays the same as that with weak threats. However, the disagreement point is now the same as under independent price negotiations, S_0 . Therefore, we now draw the relevant ray through S_0 , with the same slope as under ER with weak threats. The solution lies on the point TC-ER in Figure 2.

8.2 Interpretation of Figure 2

The diagram clearly shows that the frontier of the problem shifts clockwise with ER, and it also indicates the higher position of the firm's disagreement payoff when bargaining under weak threats. This explains the ranking of the values of A's objective function, where the maximum is achieved with tough ER, then independent negotiations and then external referencing with weak threats.¹⁸ We have also depicted the effects of size of the referencing country (K). On the one hand, the increase in K affects the frontier under ER, causing a positive effect on A's payoff. This is irrespective of whether threats are weak or tough. On the other hand, the increase in K affects the threat point only under a conditional ER with weak threats, causing a negative effect on A's payoff. This explains why under tough threats A's payoff can only increase, whereas under weak threats we have both a positive and a negative effect. It turns out that the latter dominates.

9. Conclusions

Using a model where two countries differ only in their population size and reimbursement policies, our most general result is that a country has an incentive to engage in ER if its copayment levels are high as compared to the other country's. This preference dwindles as the relative size of the country engaging in ER increases. We have analyzed how external referencing affects the negotiations in the country of reference, A, proving that the design of the policy makes a substantial difference. One of the reasons for these differences is the fact that changing the design of the ER policy results in changes in the disagreement point in A's bargaining problem. Instead, an ER policy always increases the surplus to be shared between country A and the firm no matter its design. The idea is that the profits obtained by the firm in country B become part of the pie.

We have also examined which is the best policy for B. Clearly B should never adopt unconditional ER. That is, "foreign" prices should only be used as price caps if these drugs are included in the foreign positive list. A tough ER is better than a weak ER as

¹⁸ In the case of an unconditional ER the firm's status quo grows to the point where the firm captures all the rents from both countries. Such policy should never be observed.

it is based on harsher threats in the case that negotiations in A fail. However, if tough threats are feasible under ER, they will also be under independent negotiations in country B. The right comparison is between the conditional ER with harsh threats and independent price negotiations also with harsh threats. This leads to the weaker results given in Subsection 4.2.

Of course, one would like to know whether and why some countries use harsh threats and others do not. This may depend on institutional features that we have not modelled and that lie beyond the scope of our paper. We content ourselves by looking at the two cases in a way that seems to us to be the most consistent one.

Finally, for the case with weak threats, we can provide a clear empirical prediction that hinges on the relative size of the referencing country. Perhaps surprisingly, it turns out that the relative size of the referencing country is irrelevant as to *the sign* of the advantage of ER over independent negotiations. It is always positive. Only the size of the advantage is affected. In other words, should ER have some external and fixed cost that we have not taken into account,¹⁹ then ER will only be implemented if the size of the referencing country is not too large. In a nut shell, “only small countries should be observed to engage in ER and/or ER should be based on large countries.” Our analysis yields an analogous prediction if one substitutes “large country” by “small copayment country” and *vice versa*.

¹⁹ For instance, some political cost.

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Appendix A

Proof of Lemma 1

For convenience we eliminate the sub-indices in this proof. The first-order condition associated to the Nash bargaining program (1) can be written as:

$$\left. \frac{\partial NB_1}{\partial P} \right|_{P^*} = -\beta \frac{D(C)}{CS(C) - (P^* - C)D(C) - CS^M} + (1 - \beta) \frac{D(C)}{P^*D(C) - \pi^M} = 0.$$

Rearranging this expression, equation (2) in *Lemma 1* is obtained. This is the solution to (1) since (1) is concave in P :

$$\frac{\partial^2 NB_1}{\partial P^2} = -\beta \left[\frac{D(C)}{CS(C) - (P - C)D(C) - CS^M} \right]^2 - (1 - \beta) \left[\frac{D(C)}{P \cdot D(C) - \pi^M} \right]^2 < 0.$$

To check that P^* is increasing in C , rewrite the first-order condition associated to (1) as:

$$(1 - \beta) [CS(C) - (P^* - C)D(C) - CS^M] - \beta [P^*D(C) - \pi^M] = 0.$$

Applying the implicit function theorem to this expression, we obtain:

$$\begin{aligned} \frac{\partial P^*}{\partial C} &= - \frac{(1 - \beta) [CS'(C) + D(C) - (P^* - C)D'(C)] - \beta P^* D'(C)}{- (1 - \beta) D(C) - \beta \cdot D(C)} \\ &= - \frac{D'(C)}{D(C)} [P^* - (1 - \beta)C] > 0. \end{aligned}$$

This is positive, as equation (2) implies $P^* > (1 - \beta)C$.

Proof of Lemma 2

By definition, $\pi^M > P \cdot D(P)$, $\forall P \neq P^M$. Therefore, $C_i < P^M \Rightarrow \frac{\pi^M}{D(C_i)} > C_i$.

Moreover, $C_i < P^M \Rightarrow CS(C_i) > CS^M$. Therefore, $P_i^* > C_i$, $\forall i = A, B$.

Proof of Corollary 3

By Lemma 1 part (ii) and $C_A < C_B$.

Proof of Lemma 4

The first-order condition associated to the Nash bargaining program (5) can be written as:

$$\begin{aligned} \frac{\partial NB_2}{\partial P} \Big|_{P^{**}} &= -\beta \frac{D(C_A)}{CS(C_A) - (P^{WC} - C_A)D(C_A) - CS^M} + \\ &+ (1 - \beta) \frac{D(C_A) + KD(C_B)}{P^{WC} \{D(C_A) + KD(C_B)\} - (1 + K)\pi^M} = 0. \end{aligned}$$

Rearranging this expression, equation (6) in Lemma 2 is obtained. This is the solution to (5) since (5) is concave in P :

$$\begin{aligned} \frac{\partial^2 NB_2}{\partial P^2} &= -\beta \left[\frac{D(C_A)}{CS(C_A) - (P - C_A)D(C_A) - CS^M} \right]^2 - \\ &- (1 - \beta) \left[\frac{D(C_A) + KD(C_B)}{P \{D(C_A) + KD(C_B)\} - (1 + K)\pi^M} \right]^2 < 0. \end{aligned}$$

Differentiating P^{WC} with respect to C_A and C_B , we obtain, respectively:

$$\frac{\partial P^{WC}}{\partial C_A} = (1 - \beta) \left[1 + \frac{CS'(C_A)D(C_A) - D'(C_A)[CS(C_A) - CS^M]}{[D(C_A)]^2} \right] - \beta D'(C_A) \frac{(1 + K)\pi^M}{[D(C_A) + KD(C_B)]^2}.$$

Using the fact that $CS'(C_A) = -D(C_A)$ we can simplify the expression to:

$$\frac{\partial P^{WC}}{\partial C_A} = -D'(C_A) \left[(1-\beta) \frac{CS(C_A) - CS^M}{[D(C_A)]^2} + \beta \frac{(1+K)\pi^M}{[D(C_A) + KD(C_B)]^2} \right] > 0,$$

and

$$\frac{\partial P^{WC}}{\partial C_B} = -KD'(C_B) \beta \frac{(1+K)\pi^M}{[D(C_A) + KD(C_B)]^2} > 0$$

Finally note that:

$$\frac{\partial P^{WC}}{\partial K} = \frac{\beta \pi^M (D(C_A) - D(C_B))}{(D(C_A) + KD(C_B))^2} > 0$$

Proof of Proposition 5

Part (i).

Using Lemma 1 (for $i = A$) and Lemma 4, we can write

$$P^{WC} = P_A^* + \beta K \pi^M \left[\frac{D(C_A) - D(C_B)}{D(C_A)[D(C_A) + KD(C_B)]} \right] > P_A^*, \text{ and}$$

$$\frac{\partial P^{WC} - P_A^*}{\partial K} = \beta \pi^M \left[\frac{D(C_A) - D(C_B)}{D(C_A) + KD(C_B)} \right] > 0.$$

Part (ii).

As K tends to infinity, P^{WC} tends to:

$$P_{\lim}^{WC} = (1-\beta)C_A + (1-\beta) \frac{CS(C_A) - CS^M}{D(C_A)} + \beta \frac{\pi^M}{D(C_B)}.$$

To compare $P_{\lim}^{WC}$ with P_B^* as defined in Lemma 1, it is enough to notice that the auxiliary function $f(Z)$ is increasing in Z , where:

$$f(z) = z + \frac{CS(z) - CS^M}{D(z)}.$$

Using $CS'(Z) = -D(Z)$ and assuming that $Z < P^M$, we have that:

$$f'(z) = -\frac{D'(z)[CS(z) - CS^M]}{[D(z)]^2} > 0.$$

This implies $P_{\lim}^{WC} < P_B^*$, since $C_A < C_B$. Given that P^{WC} is increasing in K (see Lemma 4), $P^{WC} - P_B^* < 0$, $\forall K$.

The fact that $f'(Z) > 0$ also implies that the difference $R = P_B^* - P_{\lim}^{WC}$ decreases as C_A tends to C_B . Therefore, the difference between P^{WC} and P_B^* decreases monotonically as C_A tends to C_B .

Proof of Proposition 6

Define $\Delta(C_A, C_B, K) = P_A^* D(C_A) + P_B^* K D(C_B) - P^{WC} \{D(C_A) + K D(C_B)\}$. We need to prove that $\Delta(C_A, C_B, K) > 0$. Suppose first that $K = 0$. In this case $P_A^* = P^{WC}$ and therefore $\Delta(C_A, C_B, 0) = (P_A^* - P^{WC}) D(C_A) = 0$. Hence it suffices to prove that $\frac{\partial \Delta}{\partial K} > 0$.

That is, we need:

$$\begin{aligned} \frac{\partial \Delta}{\partial K} &= P_B^* D(C_B) - (D(C_A) + K D(C_B)) \frac{\partial P^{WC}}{\partial K} - P^{WC} D(C_B) = \\ &= (P_B^* - P^{WC}) D(C_B) - (D(C_A) + K D(C_B)) \frac{\partial P^{WC}}{\partial K} > 0. \end{aligned}$$

Substituting P^{WC} from Lemma 4, P_B^* from Lemma 1, and the formula of $\frac{\partial P^{WC}}{\partial K}$

derived in the proof of Lemma 4 in the expression we obtain:

$$\begin{aligned} \frac{\partial \Delta}{\partial K} &= [f(C_B) - f(C_A)](1 - \beta) D(C_B) \\ &+ \beta \pi^M \left[1 - \frac{(1 + K) D(C_B)}{D(C_A) + K D(C_B)} - \frac{(D(C_A) - D(C_B))}{D(C_A) + K D(C_B)} \right], \end{aligned}$$

with the function $f(Z)$ defined within the proof of Proposition 5. Notice that the second term is zero. The expression in brackets in the first term is positive since $f'(Z) > 0$ is proven for Proposition 5.

Appendix B

Independent negotiations with tough threats for country B

The Nash bargaining program is the following:

$$\begin{aligned} & \text{Maximize}_{\{P \in [C_B, P^M]\}} \\ & \ln\{K\} + \beta \ln\{CS(C_B) - (P - C_B)D(C_B)\} + (1 - \beta) \ln\{P\{D(C_B)\}\}. \end{aligned}$$

The Nash bargaining solution, when interior, is the following:

$$P^{*T} = (1 - \beta)C_B + (1 - \beta) \frac{CS(C_B)}{D(C_B)}.$$

This solution price is decreasing in C_B :

$$\frac{\partial P^{*T}}{\partial C_B} = -(1 - \beta) \frac{CS(C_B)D'(C_B)}{[D(C_B)]^2} > 0,$$

and it is decreasing in β .

Conditional ER with tough threats

The Nash bargaining program is the following:

$$\begin{aligned} & \text{Maximize}_{\{P \in [C_A, P^M]\}} \\ & \beta \ln\{CS(C_A) - (P - C_A)D(C_A) - CS^M\} + (1 - \beta) \ln\{P\{D(C_A) + KPD(C_B) - \Pi^M\}\}. \end{aligned}$$

The Nash bargaining solution, when interior, is the following:

$$P^{TC} = (1 - \beta)C_A + (1 - \beta)\frac{CS(C_A) - CS^M}{D(C_A)} + \beta\frac{\pi^M}{D(C_A) + KD(C_B)}.$$

This solution price is increasing in both C_A (see the proof of Proposition 5, which is similar) and C_B , and it is decreasing in K . It is also lower than P_A^* defined in Lemma 1.

Numerical example

Let us provide a numerical example where B engages in a conditional ER policy when agencies' negotiation power β is weak while B prefers to stick to independent negotiations when β is higher. Suppose demand is linear and given by $D(P) = 120 - 3P$. Unsubsidized monopoly price is $P^M = 20$ and monopoly profits are $\pi^M = 1200$. Copayments in country A and country B are given, respectively, by $C_A = 5$ and $C_B = 6$. Suppose also that countries have the same size ($K = 1$). Suppose first that $\beta = 0.5$. Then independent price negotiations in country B lead to a price $P^{*T} = 11.5$ while a conditional ER policy by B leads to a price $P^{TC} = 11.2914 < 11.5$. Hence B prefers to engage in ER. Suppose now that $\beta = 0.6$. Then $P^{*T} = 9.2$ while $P^{TC} = 10.1925 > 9.2$. Hence B prefers not to engage in ER.