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Strategic Factor Markets, Scale Free Resources, and Economic Performance: The Impact of Product Market Rivalry

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STRATEGIC FACTOR MARKETS, SCALE-FREE RESOURCES, AND ECONOMIC PERFORMANCE: THE IMPACT OF PRODUCT MARKET RIVALRY

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ABSTRACT

This paper analyzes how scale-free resources, which can be acquired by multiple firms simultaneously and deployed against one another in product market competition, will be priced in strategic factor markets, and what the consequences are for the acquiring firms' performance. Based on a game-theoretic model, it shows how the impact of strategic factor markets on economic profits is influenced by product market rivalry, pre-existing competitive (dis)advantages, and the interaction of acquired resources with those pre-existing asymmetries. New insights include the result that resource suppliers will aim at (and largely succeed in) setting resource prices so that the acquiring firms earn *negative* strategic factor market profits—sacrificing some of their pre-existing market power rents—by acquiring resources which they know to be overpriced.

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INTRODUCTION

Scholars of the resource-based view (RBV) have been occupied with strategic factor markets (SFMs) since the publication of Barney's seminal article in 1986 (Adegbesan, 2009; Barney, 1986; 1989; Chatain, 2013; Dierickx and Cool, 1989; Makadok, 2001; Makadok and Barney, 2001). A key theme in this literature is that SFMs, while seemingly attractive to strategizing firms, ultimately serve as elusive paths to competitive advantage and superior performance if resource-acquiring firms have to pay the full economic value of the labor, technology, brands, firms, and physical assets that they purchase (Barney, 1986, 1988; Coff, 1999). This insight has led scholars to embark on an ongoing quest to map the conditions under which resources will be priced at their economic value and the conditions under which SFM imperfections offer potential gateways to rents (Dierickx and Cool, 1989; Makadok and Barney, 2001; Adegbesan, 2009).

With the recent exception of Chatain (2013), however, extant SFM models have simplified the *product market* conditions of the resource-acquiring firms. At the same time, one important class of resources remains virtually untouched in the SFM literature: resources that are 'scale-free' (Levinthal and Wu, 2010) so that more than one firm can potentially acquire them and use them at the same time, as is the case for many resources often associated with competitive advantage (e.g., technologies and brands). These two research gaps are related since, as shown in this paper, product market rivalry gives rise to distinct SFM outcomes when resources are scale-free. Accordingly, this paper aims to explore the impact of such rivalry on the pricing of scale-free resources and on the performance of the firms that acquire them. To shed light on these issues, it presents a formal model based on non-cooperative game theory.

The key insight emerging from this exercise is that firms will often be predictably harmed by the external availability of valuable resources—an idea that is counterintuitive, but, as argued in this paper, realistic and meaningful once the strategic interaction between them (and the behavior of the resource seller) is taken into account. In particular, the profits of resource-acquiring firms hinge on the resource seller's SFM strategies, which, in turn, are determined by the characteristics of the resource, product market, and firms. For example, when rivalry is soft and the firms are not too heterogeneous, the resource seller will price the resource so that they play a 'Prisoners' Dilemma' game for it and in the process *lose* economic profits. Conversely, if rivalry is strong or one firm already has a strong competitive advantage, the price will be such that only one firm acquires the resource and pays no more or less than the value of it. Finally, if the resource has a strong potential to upset the competitive balance in the product market, the resource seller may strategically restrict its capacity in order to increase the willingness-to-pay of the market leader, who will end up sacrificing profits by acquiring an overpriced resource.

The next section of the paper revisits the literatures on SFMs and product market rivalry and discusses how the current paper fits into these literatures. The subsequent section presents the assumptions of the model, followed by analyses of two types of product market rivalry (Bertrand and Cournot) and an extension capturing endogenous resource scarcity. Finally, I discuss the implications for scholars and managers and conclude.

BACKGROUND

Early SFM studies emphasized information asymmetry as a precursor to SFM rents, which may accrue to firms with superior private information about the resources in such markets (e.g. Barney, 1986; 1988; Makadok, 2001; Makadok and Barney, 2001). More recently, focus has shifted towards the way in which the economic value of each SFM resource varies across potential buyers (Makadok, 2001; Makadok and Barney, 2001; Adegbesan, 2009) and how such heterogeneity may enable firms to earn SFM rents. In all these studies, however, the mechanism by which each resource creates value is exogenous. Hence, *product market* rivalry is a determinant that has been touched upon in the broader RBV debate but has not yet been fully developed in the extant SFM literature.

Barney (1986; 1991) originally argued that resources are valuable because they facilitate certain product market strategies. By implication, the value of a resource is not independent of the product market environment (Priem and Butler, 2001). An emerging stream of research is now taking important steps towards explicitly incorporating this idea into the RBV (MacDonald and Ryall, 2004; Adner and Zemsky, 2006; Costa, Cool, and Dierickx, 2013). For example, recent papers by Makadok (2010) and Chatain and Zemsky (2011) imply that the benefits of having a resource-based competitive advantage are greater given strong product market rivalry. However, as these papers do not extend their models to SFMs *per se*, they do not say much about the impact of product market rivalry when resources are not developed, but bought in markets at an endogenously determined price. This question is particularly pertinent in light of recent work suggesting that firms can harm their product market rivals when they interact in factor markets (Capron and Chatain, 2008; Markman, Gianiodis, and Buchholtz, 2009). In particular, as demonstrated formally by Chatain (2013), when *ex ante* identical product market rivals bid for a non-scale free (unique) resource, they submit bids which are above the value-in-use of that resource, because each firm is willing to pay a price premium in order to preempt the resource from being acquired by its rival and used against itself in the product market.

Despite these recent advances, two questions still remain unanswered. First, what happens when an SFM resource is not unique but *scale-free* (Levinthal and Wu, 2010) and can potentially be acquired by multiple rivals at the same time? Consider markets for technology: British chip designer ARM Holdings has sold its technology to 191 companies, many of whom use it to compete directly against one another (e.g. Apple and Samsung, both of whom used 32-bit ARMv7 processors in their smartphone offerings in 2012-2013). Similar dynamics take place in markets for brands, such as in the toy industry where Disney's Lucasfilm subsidiary has licensed its Star Wars intellectual property to both Hasbro and LEGO (each of whom produces, for example, its own version of Obi-Wan Kenobi and other Star Wars characters). Clearly, then, scale-free resources can be, and often are, acquired by product market rivals who deploy them directly against one another in varying instances of competition. We need to know more about how the markets for such resources work and what the implications are for firm performance.

Second, when multiple product market rivals can acquire the same resource, what will happen to pre-existing competitive asymmetries? Industrial Organization (IO) scholars have asked related questions, focusing either on the timing of technology adoption (e.g. Scherer, 1967; Fudenberg and Tirole, 1985; Reinganum, 1981) or on the persistence of monopoly (e.g. Arrow, 1962; Gilbert and Newbery, 1982; Reinganum, 1983). In the latter literature, the 'replacement effect' posits that an entrant will have a stronger incentive than an incumbent to adopt an innovation, because the incumbent realizes that the new technology cannibalizes its own existing technological strength. The 'efficiency effect', on the other hand, suggests that the incumbent will have a stronger incentive to patent an innovation than the entrant. In particular, because a monopolist makes more profits than two duopolists do, its gain from preemptively patenting the new technology and thereby remaining a monopolist is larger than the entrant's gain from patenting the technology and becoming a duopolist. Yet these models predate the RBV and as such do not explicitly model resource interactions, and they assume exogenously priced resources. Consequently, we know relatively little about the extent to which SFMs give rise to replacement and efficiency effects and the implications of this for competitive (dis)advantage and performance. This paper aims to draw out those implications with a model that bridges the IO and SFM literatures.

THE MAIN ASSUMPTIONS OF THE MODEL

Suppose that we have an SFM in which a resource seller faces two potential buyers (henceforth referred to simply as the 'firms' or the 'rivals') operating in the same product market, where they are assumed to be either Bertrand or Cournot competitors. While the distinction between Bertrand and Cournot also indicates deeper differences in industry structure (Costa et al., 2013), it has been used in earlier research in combination with homogenous products and cost-reducing resources as a simple but powerful instrument for contrasting high and low rivalry (e.g. Makadok, 2010). The SFM resource is scale-free and can therefore be sold to one or both of the product market rivals[1] at marginal cost 0 to the resource seller. The seller may have incurred fixed costs to develop the resource, but these are sunk and thus have no impact on the outcome of the game.

*** Figure 1 about here ***

Figure 1 illustrates the timeline of the model. There are three stages: (1) A pricing stage in which the resource seller chooses the price p of the resource, (2) a simultaneous-move SFM stage in which each product market rival decides whether or not to acquire one unit of the resource, and (3) a product market stage in which the rivals face an output demand curve normalized to $P = 1 - Q$, where P denotes the product market price and Q denotes product market quantity.

[1] Even if a resource is scale-free, a resource supplier may in some cases be able to commit to selling the resource to only one firm. The base model, presented in the following, assumes that such a commitment is not possible, but in a subsequent extension that assumption is relaxed.

This is a sequential game, with a pure-strategy subgame perfect Nash Equilibrium which can be found by backwards induction, following the arrows in the figure: the firms' purchasing patterns in the second stage will depend on their expectation of the product market rivalry in the third stage, and the resource seller's pricing strategy in the first stage will depend on its expectation of the firms' purchasing patterns in the second stage. For simplicity, the time value of money is assumed away (including this would merely deflate the second stage SFM prices by a discount factor, leaving all other results and the propositions unchanged). It is assumed without loss of generality that the two firms, denoted 1 and 2, have constant marginal cost $MC_1 = \frac{1}{2} - a$ and $MC_2 = \frac{1}{2}$, respectively, so that it is meaningful to refer to firm 1 as the 'strong firm', firm 2 as the 'weak firm', and *a* as the magnitude of the competitive advantage of the strong firm.

Resource Synergies. Following Adegbesan (2009), Makadok (2001), and Makadok and Barney (2001), I assume that the synergy with the SFM resource may differ among acquiring firms. Formally, this resource synergy can be captured by a firm-specific parameter c_i describing the extent to which the resource can create value in combination with the assets of firm *i*. In particular, following Makadok (2010), suppose that the resource from the SFM lowers the marginal costs of firm *i* by c_i if that firm acquires it.[2] Of course, whether the value created by this cost reduction will ultimately be appropriated by the firm itself (MacDonald and Ryall, 2004; Grahovac and Miller, 2009; Brandenburger and Stuart, 1996) is a question that can only be determined when the resource-armed firm is ultimately tested by some yet to-be-specified product market competition. Hence, product market rivalry determines to what extent such an apparently 'valuable' resource will generate rents for the firm.

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[2] Alternatively, one could assume that the resource increases the quality of the firm's products rather than lowering its costs, but this would not substantially change the insights resulting from the model.

The Interaction of Resource Synergies with Competitive Advantage. When two firms—one with a pre-existing competitive advantage over the other—get access to an SFM such as the one described above, which of these firms would benefit the most? *A priori* one could argue for different outcomes, based on the different types of *interactions* between resources and competitive advantage that have been suggested in the literature. For example, innovation scholars have extended the notion of radical innovation (Arrow, 1962) and described types of technologies that unsettle market leaders by virtue of being incompatible with their pre-existing technological architecture (Henderson and Clark, 1990). Cognitive psychologists have been interested in the extent to which new knowledge is *supplantive*, i.e. replaces pre-existing knowledge (Atherton, 1999). Similarly, RBV scholars have called resources 'suppressive' or 'substitute' if they replace firms' pre-existing core competences rather than add to them (see e.g. Jeffers, Muhanna and Nault, 2008; Poppo and Zenger, 2002; Siggelkow, 2002; Black and Boal, 1994). The counter-points to these examples are incremental innovations, which tend to sustain the pre-existing competitive advantages of the market leaders (Gilbert and Newbery, 1982), and *additive* knowledge which stacks on top of firms' pre-existing knowledge bases (Atherton, 1999) without cannibalizing them. In a setup without pre-existing competitive advantages, Chatain (2013) calls two resources 'additive' if a firm can use both of them at the same time and 'exclusive' if it can only use one of them. Building on these ideas, the models presented in this paper will contrast two important classes of resources, as defined by restrictions on c_i:

Additive Resources. A resource for which the two firms' resource synergies are equally strong $\left(c_1 = c_2\right)$ can be called *additive* to the strong firm's competitive advantage because its effect is independent of that advantage. Presumably, such a resource acts on a part of the organization or strategy which is distinct from the part where the pre-existing competitive advantage resides. Because the additive resource has a symmetric impact on the firms, we can denote its ‘strength’ without a subscript, i.e. setting $c \equiv c_1 = c_2$.

Supplantive Resources. If the resources behind the strong firm’s competitive advantage cease to be useful after the SFM resource is deployed, we can say that this resource is *supplantive* of the strong firm’s competitive advantage rather than additive to it. Such a resource has a stronger effect on the weak firm than on the strong firm as it more than fully compensates for its pre-existing competitive disadvantage $\left(c_2 = a + c_1\right)$. This can be conceptualized as the situation in which the SFM resource is a substitute for the resources underpinning the strong firm’s competitive advantage, which it will therefore replace if the strong firm acquires it. With the symmetry in outcomes, we can again remove the subscript and characterize the strength of a supplantive resource by $c \equiv c_1 = c_2 - a$, which gives both resource-acquiring firms identical marginal costs $MC = \frac{1}{2} - a - c$.

A simple way to express the distinction between additive and supplantive resources is to say that an additive resource lowers the marginal cost of the firm that deploys it *by* a certain amount (c), whereas a supplantive resource lowers it *to* a certain level ($\frac{1}{2} - a - c$, irrespective of the buyer’s previous cost level). For both types of resources, it is assumed in the following that $a + c < \frac{1}{2}$, a restriction that ensures positive marginal costs, a limit pricing Nash Equilibrium (NE) in the Bertrand model, and an interior solution to the Cournot model.

The main variable of interest in this paper—henceforth called ‘SFM rents’ or ‘SFM profits’—is denoted π_S and defined as the additional profits a resource-acquiring firm earns as a consequence of the existence of the SFM. The profits it would have earned in its absence are called ‘pre-SFM profits’ and denoted π_M. SFM profits can be further split into two components: the additional product market profits earned as a result of resource possession (denoted π_R), and the price paid to the resource supplier (denoted *p*). Hence, if π denotes a firm's total profit in the presence of the SFM ('post-SFM profits') and π_S is the part of that profit which can be ascribed to the existence of the SFM,

$$\pi \equiv \pi_M + \pi_S = \pi_M + \left(\pi_R - p\right) \Leftrightarrow \pi_S = \pi_R - p = \pi - \pi_M \ . \qquad (1)$$

This implies that the economic impact of the SFM on the resource-acquiring firm (π_S) can be evaluated by a comparison of its profits in the (hypothetical) situation in which that SFM did not exist (π_M), and its profits in the situation where it does exist (π). I will show that there is a complex relationship between π_S and the underlying competitive outcomes of the SFM. As shown in Figure 2, these outcomes can take four forms: *divergence* when only the strong firm buys a resource so that the marginal costs levels of the two firms diverge even further; *leapfrogging* when only the weak firm buys a supplantive resource so that it can leapfrog the marginal cost level of the strong firm; *maintenance* when both firms buy an additive resource and thereby maintain the difference in their marginal cost levels; and *convergence* when both firms buy a supplantive resource and converge at the same (lower) marginal cost level. Figure 2 shows the contingencies and proposition numbers that are linked to these outcomes in the models below.

*** Figure 2 about here ***

Product market monopoly: A benchmark

Before we look at the determination of SFM profits under product market rivalry, it is useful to establish, as a benchmark, how these profits are determined *in the absence of* product market rivalry. Hence, suppose that the two firms are potential buyers in the same SFM but sell their output in two perfectly isolated product markets where each firm enjoys a monopoly position. For example, these could be national telecommunications firms having monopolies in their local markets while sourcing technological resources in the same global SFM. Faced with these two potential buyers, what price should the resource seller charge? Generally, the profit functions of the two firms will differ because they face different demand functions and have different cost structures, and, accordingly, so will their reservation prices for the resource. Recall that firm *i* will earn π_{Mi} if it does not acquire the resource and $\pi_i = \pi_{Mi} + \pi_{Ri} - p$ if it does, and assume without loss of generality that $\pi_{R1} > \pi_{R2}$. Endowed with a scale-free resource, the resource seller can pursue two pricing strategies: it can price the resource just below π_{R1} and sell one unit of the resource at this high price (henceforth, a 'high-price' strategy), or lower the price of the resource to just below π_{R2} and sell two units (a 'low-price' strategy). It will choose the latter only if the potential buyers are sufficiently similar, as captured by $\frac{1}{2}\pi_{R1} < \pi_{R2} < \pi_{R1}$.

This choice, in turn, has strong performance implications for the two firms. With the high-price strategy, only firm 1 will buy the resource, paying the full value of it in the SFM, and no one will earn SFM rents. With the low-price strategy, on the other hand, both firms will buy the resource, and firm 1 will earn SFM rents proportional to the difference between the two reservation prices. Hence, the price of the resource responds to the demand for it but does not rise all the way up to the highest willingness-to-pay. This result is similar to the one shown by Adegbesan (2010), in which SFM rents also arose as a result of firm heterogeneity. However, the mechanism is different as, in the present model, it is the scale-free nature of the resource and the presence of the less willing-to-pay rival that lowers the optimal price of the resource supplier. In that way, heterogeneous product market monopolists may earn rents on an SFM in a way that resembles how heterogeneous consumers earn consumer surplus in a textbook competitive market: the least-willing-to-pay buyers contribute to lowering the market price below the reservation price of the most-willing-to-pay buyers.

THE IMPACT OF PRODUCT MARKET RIVALRY

The above analysis raises the question of whether SFM rents are also possible when the acquiring firms are product market rivals that may deploy the SFM resource against one another. We therefore now introduce product market rivalry into the model. This creates a possibility that some or all of the value of a resource can be appropriated by consumers, rather than by the resource-acquiring firms. Since we have defined two types of resources—additive and supplantive—and want to distinguish between strong and weak rivalry (as captured by the Bertrand and Cournot models, respectively), there are four cases to consider, each of which will be examined in a dedicated section below. Proofs of all propositions and results can be found in the online Appendix to the paper.

Bertrand rivalry and additive resources

Following the Bertrand (1883) model, assume that both firms compete for the same consumers, who care only about the price in the product market and will therefore buy from the least expensive firm (or randomize if both firms charge the same price). This means that demand for firm 1 will be $Q_1 = (1 - P_1)$ if $P_1 < P_2$, $Q_1 = 0$ if $P_1 > P_2$, and $Q_1 = \frac{1}{2}(1 - P_1)$ if $P_1 = P_2$ (and vice versa for firm 2). Each firm is assumed to have sufficient capacity to serve the entire consumer market on its own at no cost penalty, should it choose to underbid its rival. What will be the price of the SFM resource with these assumptions? The calculation of the firms' reservation prices is not as straightforward as in the monopoly case, because the price that they are willing to pay for the resource in the SFM will depend on how much of its value they expect to appropriate in the product market, while the expected value appropriation in the product market depends on the preceding resource acquisition strategy of the competitor in the SFM.

This interdependency between the resource acquisition strategies of the two firms means that game theory is needed to identify the firms' reservation prices.

To arrive at a NE in resource acquisition strategies, we first need to derive the payoffs to the firms under each combination of strategies that they may pursue. As shown in the online Appendix, if neither firm buys the resource, the strong firm can maximize its profits with a limit price, i.e. a price just below the marginal cost of its rival: $P_1{*}=\tfrac{1}{2}-\varepsilon$. For $\varepsilon \to 0$, this would generate demand of $Q_1 = 1-\tfrac{1}{2}=\tfrac{1}{2}$ and profits of $\pi_{M1} = Q_1\left(P_1 - MC_1\right)=\tfrac{1}{2}\left(\tfrac{1}{2}-\left(\tfrac{1}{2}-a\right)\right)=\tfrac{1}{2}a$. If only the strong firm buys the resource, it increases its competitive advantage and thereby its product market profit, but also pays the price of the resource, earning $\pi_1 = \tfrac{1}{2}\left(a+c\right)-p$. The strong firm also takes the market if both firms buy the resource, but then has to lower its limit price to $P_1{*}=\tfrac{1}{2}-c-\varepsilon$, earning $\pi_1 = \left(\tfrac{1}{2}+c\right)a-p$ instead. Finally, if only the weak firm buys the resource, the outcome depends on whether the resource is strong enough to compensate for the pre-existing competitive asymmetry $\left(c>a\right)$. Assuming for now that it is, the resource-acquiring weak firm overtakes the strong firm and becomes the new market leader, sets $P_2{*}=\tfrac{1}{2}-a-\varepsilon$, and earns $\pi_2 = \left(\tfrac{1}{2}+a\right)\left(c-a\right)-p$. These payoffs are shown in the left panel of Figure 3.

*** Figure 3 about here ***

What should the resource seller do? A rational resource seller realizes that the outcome of the game will depend on the price of the resource, and anticipates the two firms' responses to any price that it may charge. We can see that no positive price will induce both firms to buy at the same time (because the weak firm earns $-p$ if they do and hence would prefer not to buy). It is possible for the resource seller to price in a way that the two firms will play a Chicken game for the resource, but this is unlikely to be optimal as it would require a relatively low price (cf. the Appendix). Hence, the best outcome the resource seller can hope for is to sell one unit of the resource to the firm with the highest reservation price. This firm turns out to be the strong firm: given that its rival does not buy the resource, it will buy as long as $\frac{1}{2}(a+c)-p>\frac{1}{2}a \Leftrightarrow p<\frac{1}{2}c$, which can be shown to be higher than the weak firm's reservation price of $\left(\frac{1}{2}+a\right)(c-a)$. The resource seller's optimal strategy is therefore to price at $p^*=\frac{1}{2}c-\varepsilon$, where ε is again a very small number. Substituting this price into the payoffs results in the matrix in the right panel of Figure 3, where the best responses of the two players are circled[3].

The unique NE of this game is one of *divergence* between the two firms: the strong firm becomes stronger while the weak firm stagnates, as shown in Figure 2 (1). This suggests that SFMs for additive resources will tend to be a source of path-dependence where an early advantage gets magnified over time. However, from a performance perspective the SFM does not change anything. The weak firm is still not able to enter the market and earns 0 as before, and, whereas the SFM resource increases the strong firm's product market rents by $\pi_{1R}=\frac{1}{2}c$, the resource seller appropriates all of these additional rents through the resource price. This outcome holds also for $c<a$ and is therefore formalized in the following proposition:

> *PROPOSITION 1: Under product market Bertrand rivalry, the existence of an SFM for a resource that is additive to the strong firm's competitive advantage will lead to* divergence*, in which only the strong firm acquires the resource, thereby augmenting its competitive advantage over the weak firm. This will have no impact on the economic profits of the strong firm, since the resource will be priced exactly at the value of the additional product market rents it provides.*

Bertrand rivalry and supplantive resources

As defined earlier, the effect of a supplantive resource is to lower the marginal cost of an acquiring firm to $\frac{1}{2}-a-c$. When only the weak firm buys the supplantive resource, it therefore

[3] The figure also assumes that $c<a/(1-2a)$, which makes resource acquisition a dominant strategy for the strong firm. However, this has no bearing on the NE since the weak firm would in any case never acquire the resource.

always becomes the new market leader, earning $\pi_2 = \left(\frac{1}{2}+a\right)c - p$ while the strong firm earns nothing. If both firms buy the resource, they will end up with identical marginal costs of $\frac{1}{2}-a-c$ and hence earn nothing in the product market, while still paying *p* in the SFM.

Like in the additive model, the two firms will not acquire the resource at the same time and we should therefore once again search for NE in which only one firm buys the resource. However, unlike in the additive model, the weak firm now has the highest reservation price $\left(\left(\frac{1}{2}+a\right)c \text{ vs. } \frac{1}{2}c\right)$. This is a natural consequence of the replacement effect (Arrow, 1962) in the sense that the resource replaces the strong firm's competitive advantage, which lowers its incentive to acquire it. Accordingly, it is optimal for the resource seller to price just below the weak firm's reservation price, setting $p^* = \left(\frac{1}{2}+a\right)c - \varepsilon$. This leads to the obverse result of the additive model: the weak firm will now use the SFM resource to *leapfrog* the strong firm's competitive position, achieving a marginal cost level below that of the strong firm as shown in Figure 2 (2). The weak firm thus takes the entire market and earns Ricardian rents of $\pi_{2R} = \left(\frac{1}{2}+a\right)c$, all of which, however, are appropriated by the resource seller through the SFM price. The SFM will have a negative impact on the strong firm, which will lose its competitive advantage and associated Ricardian rents, and in the end no one will earn any profits except possibly the resource seller. These results hold for all parameter values and are thus captured by the following proposition:

> PROPOSITION *2: Under product market Bertrand rivalry, the existence of an SFM for a resource that is supplantive of the strong firm's competitive advantage will lead to* leapfrogging, *in which only the weak firm acquires the resource, thereby reversing the competitive advantage of the strong firm. This will have no impact on the economic profits of the weak firm, since the resource will be priced exactly at the value of product market rents it generates.*

The supplantive Bertrand model can be seen as a description of how innovations diffused through SFMs can upset the competitive balance in an industry. An example is the book retail industry, where the diffusion of internet technologies such as ecommerce software and digital books has been a factor in the unsettling of the previous market leaders (e.g., Borders, Barnes & Noble). Arguably, the most important resources possessed by these firms—real estate and physical shelf space—have been supplanted by technologies that enable anyone to sell books in virtual rather than physical space. The leapfrogging outcome thus describes a mechanism for the decline of dominant firms (Pisano, 2006) and suggests that such decline can be triggered by the way in which supplantive resources are priced in SFMs. Conversely, we saw that when additive resources are sold in SFMs they will be priced so that they keep the weakest firms out of the market and thereby reinforce competitive advantages. Arguably, this is what has taken place in the media content industry where the aforementioned internet technologies were more additive to the competitive advantages of the strong firms (e.g. Disney and Time Warner)—advantages that are based on the production rather than distribution of content.

Irrespective of whether the resource is additive or supplantive, however, the profits of the acquiring firm do not change as a consequence of the SFM. In that sense, the Bertrand model supports Barney's prediction that the price of an SFM resource will be exactly as high as its economic value, precluding SFM rents, and show that this prediction is also valid in a game theoretic model. To be precise, the price of the resource will reflect its economic value *to the firm with the highest reservation price*, and this firm will acquire the resource but earn no rents on it. A comparison with the monopoly model reveals that this outcome is driven by the rivalry in the product market, because Bertrand competition, unlike monopoly, ensures that only one firm will buy the resource. This may seem surprising given the fact that it is scale-free and thus potentially could be sold to both firms at no extra cost to the resource seller. However, since it is common knowledge that two resource-armed firms will compete so strongly that at least one of them fails to earn any product market profits, they will never acquire the resource the same time, and the resource seller therefore cannot hope to sell more than one unit of the resource, regardless of how low a price it charges. Of course, this raises the question of whether a softer type of product market rivalry will change the pricing calculus of the resource supplier. The next section introduces such a setting in the form of the Cournot model.

Cournot rivalry and additive resources

A widely used method of modeling intermediate degrees of competition is found in the Cournot (1838) model, which in this section is applied to the SFM setup described above. Unlike the Bertrand model, the Cournot model turns out to be context-dependent in the sense that the optimal pricing strategy of the resource seller will depend on the parameter values, *a* and *c*. With Cournot competition in the product market, if there is no SFM, or if neither firm buys the resource, these firms will have profit functions $\pi_1 = Q_1\left(1 - Q_1 - Q_2 - \left(\frac{1}{2} - a\right)\right)$ and $\pi_2 = Q_2\left(1 - Q_2 - Q_1 - \frac{1}{2}\right)$. This leads to First-Order Conditions (FOCs) $1 - 2Q_1 - Q_2 - \frac{1}{2} + a = 0$ $\Leftrightarrow Q_1^* = \frac{1}{2}\left(\frac{1}{2} - Q_2 + a\right)$ and $1 - 2Q_2 - Q_1 - \frac{1}{2} = 0 \Leftrightarrow Q_2^* = \frac{1}{2}\left(\frac{1}{2} - Q_1\right)$. The NE in quantities is $Q_1^* = \frac{1}{6}\left(1 + 4a\right)$ and $Q_2^* = \frac{1}{6}\left(1 - 2a\right)$. The market price becomes $P^* = \frac{2}{3} - \frac{1}{3}a$, resulting in profits of $\pi_{M1} = \frac{1}{36}\left(1 + 4a\right)^2$ and $\pi_{M2} = \frac{1}{36}\left(1 - 2a\right)^2$, capturing the impact of competitive (dis)advantage on performance. With similar calculations (subtracting *c* from the marginal costs of one or both firms), it is possible to derive the product market profits of the two rivals when one of them buys an additive resource, or when both do. These payoffs are shown in the left panel of Figure 4.

*** Figure 4 About Here ***

The optimal price of the resource seller, given the game that the two product market rivals are playing, can be show to depend on the size of the strong firm's competitive advantage. If this is not too large—to be precise, if $a < \frac{1}{8} - \frac{1}{4}c$—it is optimal for the resource seller to follow a low-price strategy, i.e. choose a price that is just low enough to induce both firms to buy, and in this case that price is $p^* = \frac{2}{9}c\left(1-2a\right)-\varepsilon$. Substituting this price into the payoff matrix results in the right panel of Figure 4.

The circled payoffs highlight the dominant-strategy NE in which both firms acquire the resource, leading to *maintenance* of the strong firm's advantage at a lower marginal cost level, as seen in Figure 2 (3). However, if we analyze the resulting performance it can be shown that the firms are effectively playing a 'Prisoner's Dilemma' game, because the outcome is suboptimal for both firms relative to a hypothetical situation in which the SFM did not exist: formally, $\pi_1 < \pi_{M1} \Leftrightarrow \frac{1}{36}\left(1+4a-2c\right)^2 + \frac{4}{3}ac < \frac{1}{36}\left(1+4a\right)^2$ and $\pi_2 < \pi_{M2} \Leftrightarrow \frac{1}{36}\left(1-2a-2c\right)^2 < \frac{1}{36}\left(1-2a\right)^2$. The resource is therefore overpriced: when both firms acquire it, it increases their product market profits relative to the original situation by an amount which is smaller than the resource price, and therefore they earn *negative* SFM rents, i.e. $\pi_{Ri} < p \Leftrightarrow \pi_{Si} < 0$ for both firms $i \in \left(1,2\right)$. The firms thus spend some of their Cournot profits acquiring an overpriced resource because colluding to stay out of the resource market is unenforceable, illegal, or both. The boundary conditions of the Prisoner's dilemma game are captured by the following proposition:

> Proposition *3: Under product market Cournot rivalry between relatively homogenous firms ($a < \frac{1}{8} - \frac{1}{4}c$), the existence of an SFM for a resource that is additive to the strong firm's competitive advantage will lead to* maintenance *of this advantage, as both firms acquire the resource and reduce their marginal costs by the same amount. This will have a negative effect on the performance of both firms, since they will play a Prisoner's Dilemma game against one another and acquire the resource at a price above the product market rents it generates for them.*

Why does the result of the Cournot model differ so much from Bertrand? An important feature of the Cournot model is that the firms may still earn positive profits when both of them acquire the resource (because they are shielded from mutual rivalry to a greater extent). This means that a

Cournot rival facing a resource-acquiring competitor, unlike a Bertrand rival, will be willing to pay a positive price in order to reduce the advantage of its competitor, and the resource supplier takes advantage of this willingness. Of course, when both rivals pursue the same (individually optimal) purchasing strategy, they may both end up worse off. In that way, once the resource seller has set the low price, the availability of the resource to the firms at that price can be considered a 'Bertrand supertrap' in the sense that it is beneficial when it happens unilaterally to one firm but detrimental when it happens jointly to all firms in the industry (Cabral and Villas-Boas, 2005)[4].

An example that illustrates this type of dynamic is the rivalry between Boeing and Airbus and the challenges created for these firms by innovative engine designers. While each aircraft manufacturer has an incentive to improve its competitiveness by acquiring new, more fuel-efficient engine designs, the result of both doing so may merely be that they cannibalize their existing aircraft designs and are left worse off than if they could conspire to extend the lifetime of these less efficient designs (Economist, 2010). Precisely as in the model presented here, the winners in this game are likely to be the consumers (airlines and travelers) and the resource providers (engine designers like Pratt & Whitney or CFM International) who extract more than the value of their resources. Another example could be the dot-com bubble, as one might view early internet brands and technologies as 'overpriced resources' that were available for purchase in SFMs around 2001. However, an individual firm may have been rational to see them as offering insurance against competitive irrelevance *even if* it had been public knowledge that such investments, when made by everyone, would ultimately lead to lower profits.

[4] Note that the term 'Bertrand supertrap' does not imply a specific type of competition (which is actually Cournot here) but characterizes a more general phenomenon.

The protective effect of competitive advantage. As noted above, the two firms need to be sufficiently similar before the Prisoner's Dilemma outcome occurs. If that is not the case, i.e. if $a > \frac{1}{8} - \frac{1}{4}c$, it will no longer be optimal for the resource seller to price so low that both firms will buy, and instead the price is increased so that the strong firm is just willing to buy on its own. The result is a divergence of the two firms like in the Bertrand additive model, leaving the strong firm equally well off after paying the resource price (while, unlike in the Bertrand case, the weak firm is worse off because its competitive disadvantage is increased). This shows that strong competitive advantages may change the effect of SFMs because they change the pricing calculus of resource suppliers. In particular, the strong firm's competitive advantage makes it attractive for the resource seller to switch from a low-price to a high-price strategy, and thereby serves as protection against being drawn into a Prisoner's Dilemma game with the weak firm.

Cournot rivalry and supplantive resources

The Cournot model with supplantive resources is similar to the one with additive resources in the sense that, as long as the competitive heterogeneity of the two firms is not too large, the resource seller will choose a low price and both firms will acquire the resource. An important difference, however, is that the two firms now end up with the same level of competitiveness, leading to the *convergence* outcome seen in Figure 2 (4). Their profits, furthermore, are lower than the strong firm's original profits, but may be lower *or* higher than those of the weak firm. In the case of the latter, it is clearly no longer a Prisoner's Dilemma game like in the additive model, because the weak firm gains as a consequence of the existence of the SFM. This counterintuitive result is captured by the following proposition:

> PROPOSITION 4: *Under product market Cournot rivalry, the existence of an SFM for a resource that is supplantive of the strong firm's competitive advantage will lead to* convergence *of the two firms' marginal costs and thus eliminate that advantage, as long*

as it is not too high compared to the strength of the resource ($a < c$). This will have a negative effect on the strong firm's profit. If the pre-existing competitive advantage of the strong firm is low compared to the strength of the resource ($a < \frac{1}{2}c$), it will also have a negative effect on the weak firm's profit, leading the two firms to effectively play a Prisoner's Dilemma game. However, if this advantage is high ($a > \frac{1}{2}c$), the SFM will have a positive effect on the weak firm's profit.

As shown by the proposition, the weak firm's positive SFM rents occur when it has a moderately *strong* initial competitive disadvantage ($\frac{1}{2}c < a < c$). Hence, ironically, when SFMs for supplantive resources arise, it can in fact be an advantage to be at a competitive disadvantage. The explanation is that a larger competitive disadvantage makes a supplantive resource more attractive for the weak firm (because it by definition eliminates any pre-existing disadvantage), but the resource supplier does not raise its price accordingly because it wants to sell to the strong firm as well. However, if this disadvantage becomes too large ($a > c$), the resource seller switches to a high-price strategy and prices at the weak firm's reservation price. In that case we get a leapfrogging NE where only the weak firm buys, overtaking the strong firm to become the new market leader as in the Bertrand supplantive model. While this may seem good for the weak firm, it is actually not, because the resource seller appropriates the entire value of the resource through the high price, leaving the weak firm with the same profits as before the SFM. The strong firm, on the other hand, loses profits because it is overtaken by the weak firm.

Resource characteristics and competitive outcomes

Having now covered both the Cournot and Bertrand models, we can say something more general about the difference between additive and supplantive resources and their associated competitive outcomes illustrated in Figure 2. First, the weak firm always has the highest reservation price for a supplantive resource, leading to outcomes such as convergence and leapfrogging. This can be ascribed to the replacement effect: strong (incumbent) firms have less to gain from buying resources that supplant their existing advantage than weak (entrant) firms do (Arrow, 1962). Second, the strong firm always has the highest reservation for an additive resource, resulting in maintenance or divergence. This represents a new type of effect—one that could be called a 'competitive advantage effect' because it is driven by, and reinforces, such an advantage. Although similar in spirit to Gilbert and Newbery (1982)'s efficiency effect, the mechanism underlying this new effect is very different. The efficiency effect is driven by the ability of the incumbent monopolist to preempt entry by patenting first, but such preemption is ruled out when weaker firms can buy the same scale-free resources at the same time. The competitive advantage effect instead occurs because the profits of each firm are convex functions of any cost reduction and the strong firm has a head start on this curve (in the Cournot model), or because the weak firm must use the first part of the resource-induced cost reduction just to overcome its competitive disadvantage and only then begins to earn profit on the remaining part (in the Bertrand model). The competitive advantage effect thus works in the favor of the strong firm, just like the replacement effect works in the favor of the weak firm, with the relative strength of the two effects depending on whether the resource is additive or supplantive.

The pricing of scale-free resources

As to SFM profits, the models above demonstrate that one of the most important determinants is the resource seller's choice between a high-price and a low-price strategy. The high-price strategy guarantees the resource-acquiring firm the same profits as it was earning before, as it will pay a price equal to the value of the resource. The low-price strategy, on the other hand, opens up for profits and losses because it leads both firms to buy, and the value of the resource to those two firms differs. This latter situation is one that, by definition, only applies to SFMs for scale-free resources, and it is therefore worthwhile to elaborate on its boundary conditions.

Essentially, these depend on the strength of the strong firm's pre-existing competitive advantage and of the product market rivalry between the two firms.

Competitive advantage. We saw in the Cournot model that the magnitude of the strong firm's competitive advantage determines whether the resource supplier chooses a low-price or a high-price strategy. We get a high-price strategy as soon as this advantage is over a certain level (defined by Propositions 3 and 4). The implication is that SFMs may create discontinuities or threshold effects in the returns to a competitive advantage, as shown in Figure 5.

*** Figure 5 about here ***

The left panel shows the profits of the strong firm as a function of its competitive advantage. In the absence of an SFM, these are steadily increasing in a as one would expect from an RBV logic. However, as soon as we introduce an SFM for an additive resource, we get a discontinuity: the strong firm earns negative SFM profits for low levels of a, but as soon as this advantage reaches a certain threshold, the profits of the strong firm jumps back to pre-SFM levels because the resource seller switches to the high-price strategy and the Prisoner's Dilemma game gives way to divergence. A similar but more complicated situation exists for the weak firm when there is an SFM for a supplantive resource, as shown in the right panel. In the absence of an SFM, the profits of the weak firm are declining in a as its market share is diminished by an increasingly superior competitor. However, after introducing an SFM for a supplantive resource, the profits of the weak firm is initially lower but actually *increases* with a, eventually becoming larger than the pre-SFM profits (as captured by Proposition 4). However, when a becomes *too* large the resource seller switches to the high-price strategy, erasing the weak firm's SFM profits. Hence, a large competitive advantage is not only more likely than a small one to be compounded by an additive resource, but *also* more likely to be reversed by a supplantive one (while a small competitive advantage will often be maintained or diminished).

Product market rivalry. If product market rivalry between potential acquirers is strong enough (as in the Bertrand model), we tend to get a high-price strategy irrespectively of the size of the strong firm's competitive advantage. Intuitively, with strong product market rivalry it is difficult for both firms to be successful in the product market at the same time, making it less attractive for a firm to buy the resource as soon as it expects its opponent to do so as well. The resource seller can therefore extract higher revenues if it keeps its price so high that only one firm will acquire it. Ironically, this may be an advantage for the acquiring firm because it protects it from destructive resource acquisition games, suggesting that SFMs in fact also change the performance implications of product market rivalry, by making weak rivalry less attractive than it would otherwise be. This reinforces the points made by Makadok (2010) and Chatain and Zemsky (2011), who showed that the returns to a resource advantage increase with the degree of product market rivalry. However, it also extends these studies by adding an SFM logic with endogenous resource pricing, showing that when a firm tries to procure such an advantage in SFMs for scale-free resources, it may either (1) fail to achieve the advantage because its rivals are pursuing the same strategy, (2) obtain the advantage but end up paying the full value of it, or (3) pay more than the full value of the advantage. The implication is that the economic impact of SFMs, and hence the managerial considerations raised by such markets, are inherently different from other modes of resource accumulation (such as natural endowment and proprietary development), and warrant the dedicated analysis effort that they are receiving. In fact, the above model can be changed to one of internal resource development by assuming, instead of an SFM price being set by a resource supplier, a development cost drawn randomly from a probability distribution (e.g. characterizing the costliness of ‘hard’ and ‘easy’ technologies). It is of course possible that such a cost, by chance, would coincide with the resource seller’s revenue-maximizing SFM price, but it is arguably more likely that it would be so low that one or both firms could earn rents, or so high that no one would develop the resource. Hence, with internal development, rent-destroying resource acquisition games are not impossible but they would be unfortunate coincidences, whereas with SFMs they are almost inevitable predicaments for firms facing profit-maximizing resource suppliers.

COMMITTING TO RESOURCE SCARCITY

The four scenarios developed above were based on the assumption that the resource seller sold the scale-free resource to anyone wishing to buy it at the prevailing price. However, in some cases, resource sellers may try to strategically restrict the supply of their scale-free resources, creating an ‘endogenous resource scarcity’ in order to enhance the value of those resources. In practice, this could take the form of an exclusive license to a technology or a brand. For example, Lucasfilm has sold exclusive rights to use its characters in computer games to Electronic Arts, and Marvel has entered into a similar agreement with Activision. In the terminology of this paper, these companies are essentially taking a resource that is by nature scale-free (intellectual property), and making it ‘artificially’ (legally) non-scale-free.

To analyze how that possibility nuances the results derived above, this section extends the model by assuming that the resource supplier has an opportunity to strategically restrict the supply of the resource to one unit in advance of the timeline shown in Figure 1. If it chooses to do so, the unique instance of the resource is subsequently offered for sale in a second-price, sealed-bid auction, where the two firms submit bids based on their expectation of the ensuing product market rivalry, and the winning firm acquires the resource at the price bid by its rival (an assumption that ensures honest bidding by the firms). The extension is developed formally in the online Appendix and the findings are summarized below.

Resource restriction under Bertrand rivalry. In the Bertrand model, it can be shown that the resource seller will never have an incentive to strategically restrict the supply of a resource that is additive to the strong firm's competitive advantage. On the other hand, the resource seller will get the *same* revenue from restricting the supply of a resource that is supplantive of the strong firm's competitive advantage (selling it to the strong firm), and not doing so (thus selling it to the weak firm). While this may seem surprising, it is actually a logical consequence of the fact that the weak firm has nothing to lose and therefore has the same reservation price in the auction and the base model. Intuitively, the resource seller is indifferent between selling the resource to the weak firm, thereby enabling it to leapfrog the strong firm, and selling the resource to the strong firm and enabling it to preempt that leapfrogging. The price that the strong firm pays for that preemption must be equal to the price that the weak firm would be willing to pay for the leapfrogging itself, because that is the highest price at which the resource seller maintains the credible (implicit) threat of selling to the weak firm instead.

If resource restriction takes place in the Bertrand supplantive model, the strong firm wins the auction at a price of $(\frac{1}{2}+a)c$, resulting in profits of $\pi_1 = \frac{1}{2}(a+c) - (\frac{1}{2}+a)c = (\frac{1}{2}-c)a$. This is lower than its pre-SFM profits $\left(\pi_{M1} = \frac{1}{2}a\right)$ by a magnitude of ac and thus implies negative SFM profits. Hence, the presence of the SFM and the decision of the resource supplier to restrict its supply leads the strong firm to suffer a performance penalty of ac that can be considered a 'preemption price premium', since it is the loss it is willing to incur in order to prevent its weaker rival from getting the resource (equivalently, this premium can be calculated by subtracting the value-in-use of the resource, $\frac{1}{2}c$, from the price, $\left(\frac{1}{2}+a\right)c$). This is exactly the effect described by Chatain (2013), in which a firm may engage in overbidding in order to keep resources out of the hands of its competitors.

Resource restriction under Cournot rivalry. With Cournot competition in the product market, the outcome becomes dependent on the parameter values. The comparative statics are shown in Figure 6 for additive resources (left panel) and for supplantive resources (right panel) and the most important findings are summed up in the following propositions.

*** Figure 6 About Here ***

> *PROPOSITION 5: Under product market Cournot rivalry, the resource seller will have an incentive to strategically restrict the supply of a resource that is additive to the strong firm's competitive advantage and sell it to the strong firm, as long as that resource is sufficiently strong $\left(c > \frac{1}{3} - \frac{2}{3}a\right)$ and the competitive heterogeneity of the two firms is not too large $\left(a < \frac{1}{14}(1-c)\right)$. This will lead to negative SFM profits for the strong firm.*

> *PROPOSITION 6: Under product market Cournot rivalry, the resource seller will have an incentive to strategically restrict the supply of a resource that is supplantive of the strong firm's competitive advantage and sell it to the strong firm, as long as the resource is strong $\left(c > \frac{1}{3}\right)$ or firm heterogeneity is large $\left(a > \frac{1}{2}c \text{ and } a > \frac{1}{3} - \frac{8}{3}c\right)$. This will result in negative SFM profits for the strong firm.*

Proposition 5 tells us that it is more attractive to restrict strong additive resources, as the strong firm is willing to pay a significant price premium to preempt the resource acquisition of its weaker rival. Hence, resource restriction occurs in the upper left part of the divergence area (bounded by the dotted line) in the left panel of Figure 6. While this outcome protects the strong firm's competitive advantage, it does not protect its profits, which are reduced from their pre-SFM levels. Finally, the Cournot supplantive model is the most complicated one. As seen in the right panel of Figure 6, three different competitive outcomes (convergence, divergence, and leapfrogging) are possible in that model when we allow for the possibility of resource restriction.

Proposition 6 tells us that the resource seller will exploit the strong firm, which is willing to pay a preemption price premium in order avoid leapfrogging, if the resource is sufficiently strong or the competitive advantage is large (the two divergence areas in Figure 6). However, it is also possible that the resource seller will restrict the resource in order to sell the resource to the weak firm, with similar negative performance consequences (the upper part of the leapfrogging area in the figure).

Contingencies for resource restriction

In general, as demonstrated by this extension, supplantive resources are more likely to be restricted than additive ones, and especially so when one of the firms has a strong competitive advantage. Also, resource restriction is likely to occur when the resource is strong relative to the preexisting competitive asymmetry in the product market. The intuition is that when a strong resource that is supplantive of a large competitive advantage is offered for sale, the strong firm has a lot to lose, and the weak firm a lot to win, by buying it. This intensifies the bidding contest between the two firms, to the benefit of the resource supplier. The strong firm is most likely to 'win' this contest as it is willing to pay a high price to preempt resource acquisition by a weaker competitor. Returning to the example in the beginning of this section, this may explain why the two market-leading electronic game producers have been able to acquire exclusive licenses to inherently scale-free intellectual property (Activision to Marvel-based games and Electronic Arts to Star Wars-based games). While these firms arguably already have very strong proprietary content development capabilities, signing exclusive licenses effectively prevents smaller competitors from using SFM content to catch up or leapfrog them. In light of that fact, it seems plausible that the resource suppliers (Marvel and Lucasfilm) can maximize their revenues by following a strategy of endogenous resource scarcity, at the expense of the overbidding firms.

An important aspect of such resource restriction is that it can reverse the competitive result of SFMs by changing leapfrogging into divergence outcomes. A supplantive resource which would otherwise be sold to the weak firm (who has the most to gain from buying it) may end up, as a consequence of scarcity, being sold to the strong firm (who has the most to lose from *not* buying it). One reason for this is that, as soon as the resource seller commits to scarcity, Gilbert and Newbery's (1982) efficiency effect becomes relevant: the acquiring firm can now preempt the resource-acquisition of its rival, and we know that the incumbent's incentive to preempt is always larger than the entrant's incentive to enter (Tirole, 2003: 392-394)—a logic that extends to the strong and weak firms in this model. This may explain why exclusive licenses are sometimes perceived as anticompetitive devices (see, for example, Mazzoleni and Nelson, 1988) and may therefore be subject to legal constraints. For example, the National Football League (NFL) was sued for anticompetitive behavior as a consequence of issuing an exclusive license allowing Reebok to produce NFL-branded apparel, and Electronic Arts for using exclusive licensing with the NFL and other organizations to prevent competitors from entering the market for interactive football software. Indeed, in the present model, resource restriction is never good for consumers (ceteris paribus), as it leads either to lower NE quantities (in Cournot) or to a less contestable market with a higher limit price (in Bertrand). On the other hand, this model does not consider the effect of the resource scarcity option on the resource supplier's incentive to develop the resource in the first place.

CONCLUSIONS

In his seminal paper, Barney (1986) identified the conditions under which the price of an SFM resource would be bid up to its economic value. This paper adds to that idea by demonstrating that the (appropriable) economic value of a resource is a moving target that depends on an interaction of: (1) the synergies between the resource and the acquiring firm, (2) the type of product market rivalry facing that firm, (3) the actions of product market rivals in the SFM, (4) the pre-existing competitive (dis)advantage of the firm, and (5) the potential of the resource to disrupt or sustain that pre-existing asymmetry. The first of these determinants is present in the models by Makadok (2001), Makadok and Barney (2001), and Adegbesan (2009), and the second and third in Chatain (2013); the rest are new to the SFM conversation.

One of the key contributions of this paper to that conversation is thereby to show the asymmetric effect of SFMs on strong and weak firms. This analysis also provides insights of potential interest to innovation and IO scholars. In particular, it moves beyond the incumbent-entrant dichotomy to show that competitively advantaged firms will acquire additive resources in SFMs while competitively disadvantaged firms will acquire supplantive ones, and to explore how the size of the pre-existing competitive gap between the firms interacts with the nature of the resource and the type of product market rivalry to discriminate between possible outcomes. These outcomes, in turn, are not restricted to the persistence or disruption of monopoly, but include more subtle changes to competitive relations such as convergence, divergence, leapfrogging, and maintenance. As such, this paper can be seen as a first step towards integrating IO thinking (Arrow, 1962; Gilbert and Newbery, 1982) with recent advances in RBV thinking (e.g. Makadok, 2010; Chatain, 2013).

At the same time, the consequences of these outcomes for firm performance are both surprising and sobering for the implicated firms. For example, when the strong firm increases its competitive advantage by buying an additive resource, and when the weak firm overtakes the strong firm by buying a supplantive one, all incremental product market rents are appropriated by the resource seller. Worse, if the seller can entice both firms to acquire the resource at the same time—or if it can restrict the resource and thereby inspire the firms to compete for it—the acquiring firms will lose some of their pre-existing market power rents. In these scenarios, the SFM behavior is a direct extension of the product market rivalry between the firms, suggesting that we cannot separate the two. Indeed, we saw initially that negative SFM profit could never occur for a product market monopolist, who would buy the resource only if the price was below the economic value of implementing it. It is when SFMs are also open to one's product market rivals, that there is a risk of rents being destroyed in a negative-sum resource-acquisition game.

These results are indicative of the way in which SFMs create a *disconnect* between competitive advantage and performance, suggesting that product market leadership—a prize coveted by most managers—may not be as attractive as sometimes believed. This reinforces Pacheco-de-Almeida and Zemsky's (2007: 664) point that "the association between resource asymmetry and superior performance need not be tautological … once one accounts for the cost of resource development." When that cost is an endogenously determined SFM price, the association largely breaks down. An example which may illustrate this conundrum can be found in the mobile phone industry, where new supplantive resources have enabled firms like HTC, LG, and Sony to leapfrog Nokia, but without making any economic profit by doing so, because the value created by these firms have largely been appropriated by consumers and by resource suppliers on the hardware and software side (e.g. ARM Holdings, Qualcomm, and Google), similar to the scenario predicted by Proposition 2.

This disconnect also has important implications for the hypothesized positive correlation between resource possession and firm performance, which has so far received mixed support in empirical studies. As noted by Newbert (2007: 141) "firms may often fail to appropriate all of the value they create and, thus, the resource-based rents they earn may not accurately reflect the advantages they have attained." The models presented in this paper support this idea and suggest that empirical scholars should therefore try to capture whether a given resource is acquired (implying that appropriability is low) or developed internally (implying that it is high). A complicating factor, furthermore, is that firms report aggregate profits (π) rather than its SFM components $(\pi_M + \pi_R - p)$, making it difficult to assess the performance effect of an acquired resource (π_R). This causes a particular challenge when using resource possession as predictor, because it is not an exogenous one. For example, in the Bertrand model in this paper, additive resources will only be acquired by firms with pre-existing competitive advantages, and empirically we would therefore find firms possessing an additive SFM resource to have superior performance—but this effect would be spurious as it would be entirely driven by their pre-existing competitive advantage rather than by the resource itself (which would be priced exactly at its economic value). Hence, failing to control for *all* the resources and capabilities possessed by a firm—a difficult task indeed—may result in an endogeneity problem when assessing the performance implications of specific SFM resources. To circumvent this problem, a more direct test of the performance implications of SFMs could use resource *acquisition* rather than resource *possession* as independent variable, deploying an event study methodology, for example, to regress abnormal stock market returns on the announcements of licensing agreements.

Scale-free resources and performance

Whereas Levinthal and Wu (2010) have demonstrated the implications of scale-free resources for diversification, this paper demonstrates the implications of such resources for competitive advantage and performance. These implications, in turn, depend crucially on the choices made by the resource seller: whether it sets a low or a high price for the resource, or, alternatively, artificially restricts the supply of the resource. Importantly, these choices are unique to sellers of scale-free resources, since non-scale-free ones by definition are already restricted and can only be sold to one firm—and will be priced at the willingness to pay of that firm. Interestingly, it turns out that the resource seller sometimes has an interest in making a scale-free resource non-scale-free and that this leads to exactly the same overbidding phenomenon described by Chatain (2013)—only in a more extreme form since in the present model it *always* leads to negative SFM profits. In that sense, the extension of the model is a step towards integration of the research streams focusing on these two types of resources, as it essentially endogenizes the 'scale-freeness' of the SFM resource. However, this only reinforces the robustness of the main conclusion from the base model: even with possible resource restriction, firms may still end up acquiring the same overpriced resource in a Prisoner's Dilemma game and using it against one another in product market competition. This will tend to happen when product market rivalry is not too intense, the acquiring firms are not too heterogeneous, and the resource is not too strong—in which case it will be in the interest of the resource seller to fully exploit the scale-free property of the resource.

While endogenizing key variables such as resource quantity and price, this paper still leaves a number of important factors for future work to explore. An example is the pre-existing competitive advantage of the strong firm, which could be modeled as an outcome of previous SFMs and internal resource development in a dynamic setting. The model also speaks to the interplay between resource building and resource buying (Adegbesan, 2009; Maritan and Peteraf, 2011), suggesting that firms with certain types of resources will benefit more (or lose less) than others from SFMs, and this could influence their incentives to obtain competitive advantages in advance of such SFMs by, for example, investing in advertising or R&D. Finally, the properties of the SFM resource itself are determined outside of the present model, leaving open questions such as when resource suppliers will strive to develop additive or supplantive resources, and when they will develop strong or weak ones. Based on the models in this paper it is possible to say that strong and supplantive resources provide higher revenues to the resource seller than weak and additive resources do, but as these are also presumably the most costly and difficult types of resources to develop, we need a specific cost function for the resource supplier (see e.g. Chatain, 2013) to be more precise about this issue.

Nevertheless, this paper aims to contribute to a nascent (or resurgent) stream of literature. At a high level, it can be seen as supporting the idea that it is useful to combine product and factor market perspectives in an RBV context (Priem and Butler, 2001, Leiblein, 2011) and, in particular, that we must be careful when generalizing about the impact of SFMs without explicitly specifying the type of product market rivalry faced by the resource-acquiring firms. Future work may take these ideas into account so as to further advance our knowledge about competitive advantage and performance.

Figure 1: Timing of the model

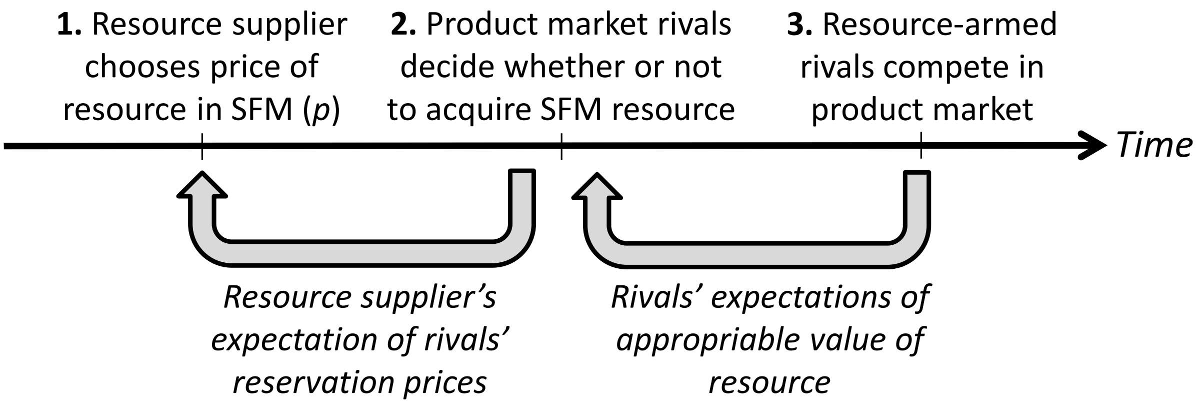


Figure 2: Competitive outcomes of SFMs for scale-free resources

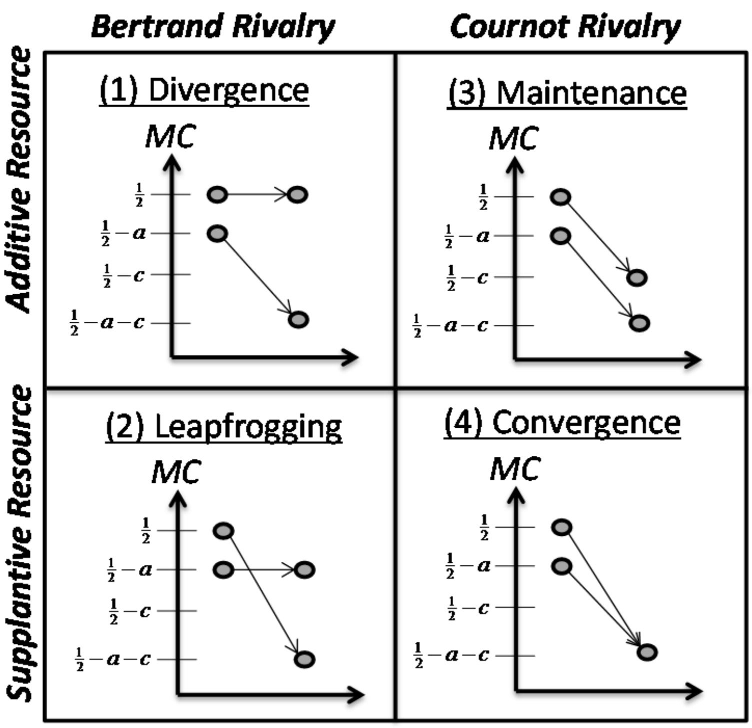


Figure 3: Bertrand rivals in SFM for additive resource $\left(a < c < a/(1-2a)\right)$

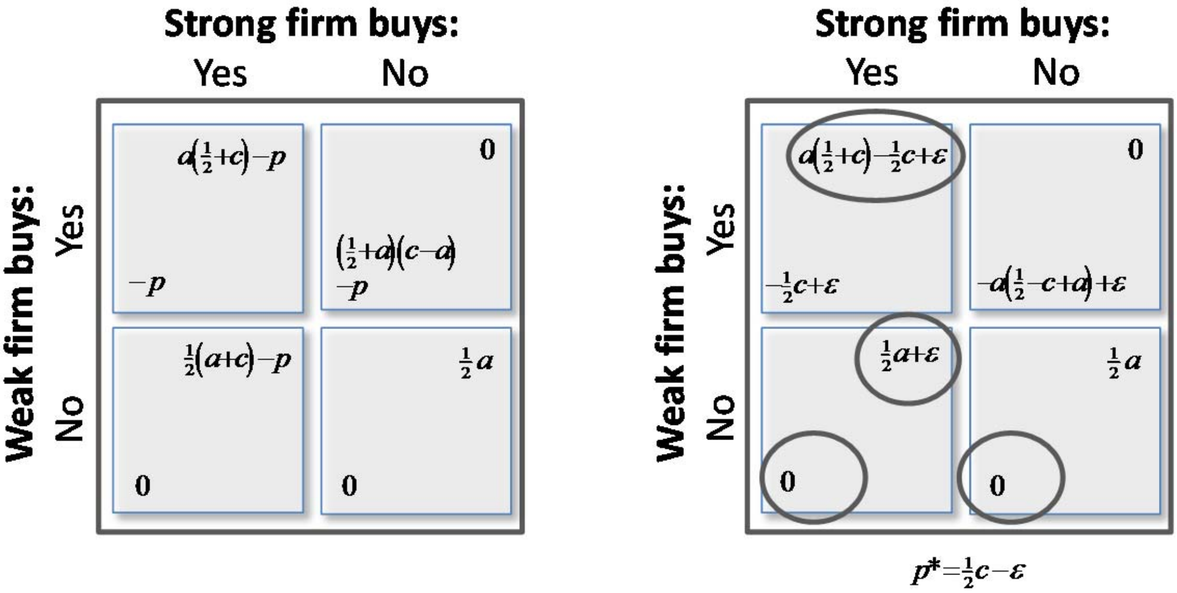


Figure 4: Cournot rivals in SFM for additive resource $\left(a < \frac{1}{8}-\frac{1}{4}c\right)$

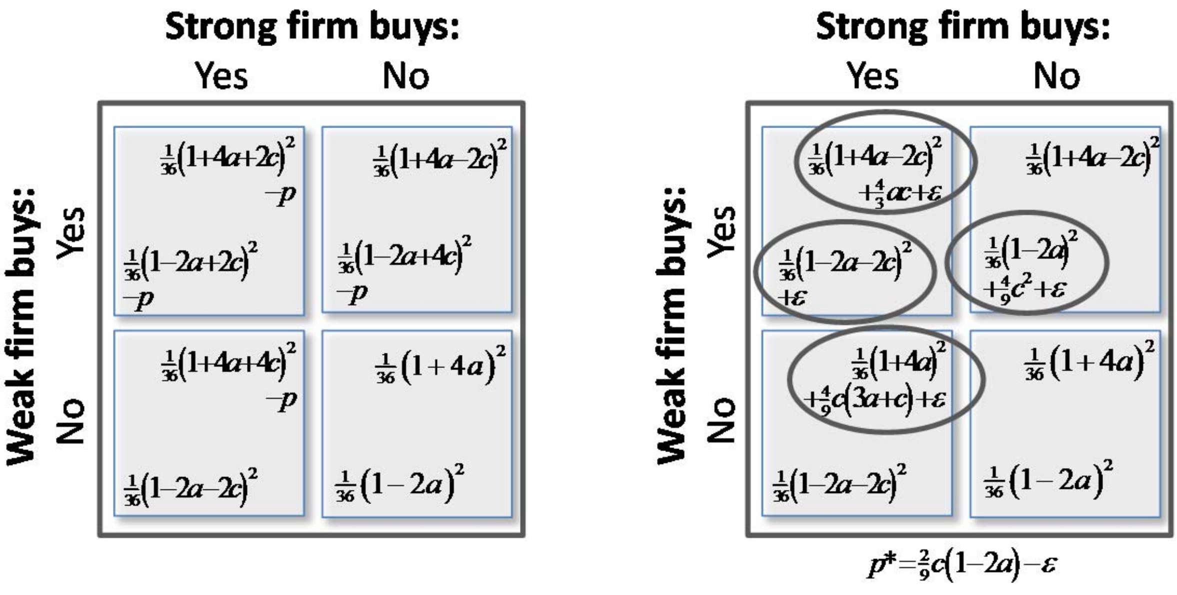


Figure 5: SFMs and returns to competitive (dis)advantages

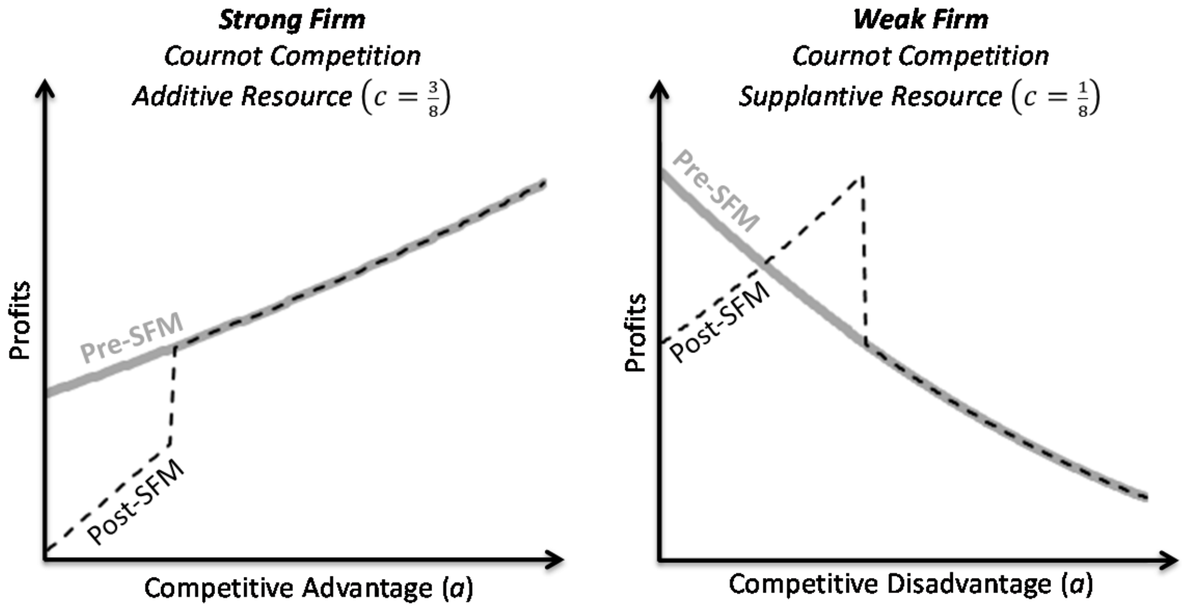
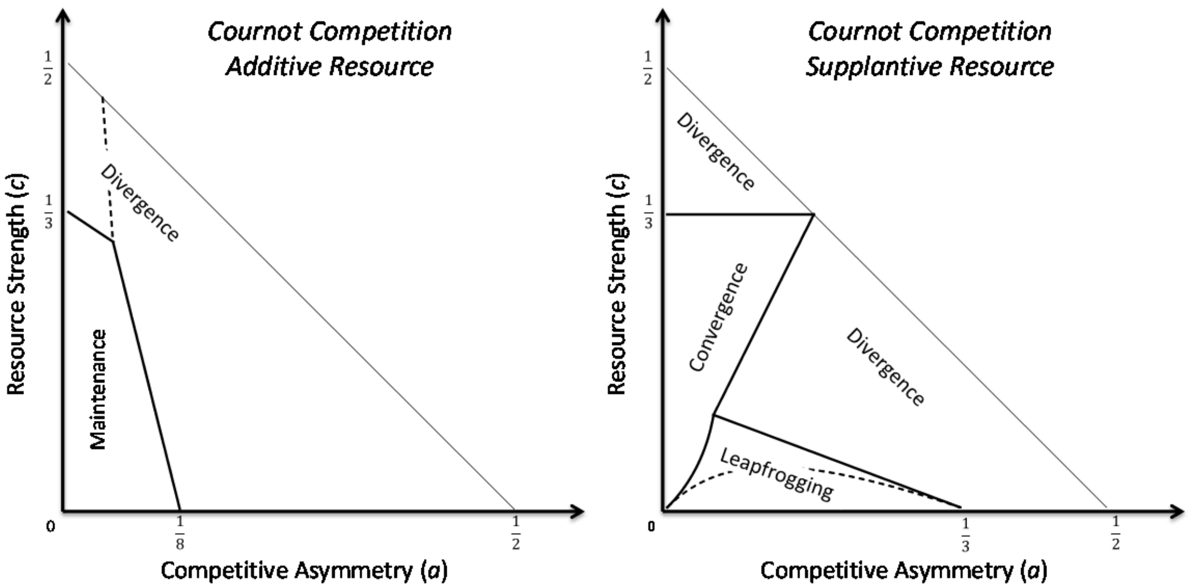


Figure 6: SFM outcomes with Cournot competition and endogenous resource scarcity



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STRATEGIC FACTOR MARKETS, SCALE-FREE RESOURCES, AND ECONOMIC PERFORMANCE: THE IMPACT OF PRODUCT MARKET RIVALRY

Online Mathematical Appendix

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Product Market Bertrand Rivalry with Additive Resources

With Bertrand competition, the firm with the lowest marginal cost will take the entire market because it can profitably undercut its rival until the rival no longer wishes to compete. This firm maximizes its profits by setting a 'limit price' (just below the rival's marginal cost) or by setting its price at the monopoly price, whichever is lower. The limit price is $MC^* - \varepsilon$, where MC^* is the other firm's marginal cost and ε is a very small number, whereas the monopoly price is $\text{argmax}_P(P - MC)(1 - P) = \frac{1}{2} + \frac{1}{2}MC$, where MC is the firm's own marginal cost. As the firms' marginal costs are in the range $[0, \frac{1}{2}]$ by construction, it follows that the limit price is also in the range $[0, \frac{1}{2}]$, and that the monopoly price is in the range $[\frac{1}{2}, \frac{3}{4}]$. This implies that the monopoly price is never lower than the limit price. Hence, in the allowed parameter space, it will always be optimal for the firm with the lowest marginal cost to use a limit price. This result is used to calculate the payoffs in the Bertrand model. As explained in the paper, the strong firm has the lowest marginal cost and therefore takes the market if no firm buys the SFM resource (earning $\pi_{M1} = \frac{1}{2}a$); if it buys the resource itself (earning $\pi_1 = \frac{1}{2}(a + c) - p$); and if both firms buy the resource (earning $\pi_1 = (\frac{1}{2} + c)a - p$). If only the weak firm buys the resource, there are two cases to consider. If $c < a$, the weak firm has a higher marginal cost even after acquiring the resource, and the strong firm still takes the market, earning $\pi_1 = (\frac{1}{2} + c)(a - c)$. If $c > a$, the weak firm overtakes the strong firm and earns $\pi_2 = (\frac{1}{2} + a)(c - a) - p$.

Proof of Proposition 1

If $c < a$, the weak firm can never earn any profits. Therefore, it has a dominant strategy of not acquiring the resource. Realizing this, the strong firm will buy the resource as long as

$$\tfrac{1}{2}(a + c) - p > \tfrac{1}{2}a \iff p < \tfrac{1}{2}c\,.$$

The resource buyer sets a price just below this reservation price, which leads to divergence with the strong firm earning $\frac{1}{2}a$ as before. If $c > a$, there may also be a non-empty price range $[(\frac{1}{2} + c)a, (\frac{1}{2} + a)(c - a)]$ with two Nash equilibria (NE): (No, Yes) and (Yes, No), so that the two firms play a Chicken game. Which NE will prevail is indeterminate in the model (in practice, the outcome may be a focal point NE, such as Harsanyi and Selten's (1988) payoff- or risk-dominant NE, or it may be decided by the speed with which the two firms can commit to their strategies). There is a mixed-strategy NE in this Chicken game in which both firms buy the resource with a positive probability, leading to a possibility of ex-post coordination failure in which both firms buy the resource or none do. However, that possibility is disregarded in this paper, as it depends crucially on the assumption of coordination failure—an assumption that is vulnerable to either a focal point or a very small deviation from the simultaneity of the firms' strategies. Hence, irrespective of which NE is the outcome, the resource seller earns revenue of $(\frac{1}{2} + a)(c - a)$ by pricing at the top of the Chicken range, which can be compared to revenue of $\frac{1}{2}c$ when pricing at the strong firm's reservation price. The latter will be higher because $c < \frac{1}{2} + a$. Therefore, divergence will always be the outcome.

Product Market Bertrand Rivalry with Supplantive Resources

The payoffs for the supplantive resource are identical to those for the additive resource when the weak firm does not buy. However, when the weak firm is the only firm to buy, its marginal cost is lowered by $a + c$ and it thereby earns $\pi_2 = (\frac{1}{2} + a)c - p$ while the strong firm earns nothing. If both firms buy, they get identical marginal costs. Therefore, neither of them earn any product market rents, while they both pay the price of the resource. This means that it can never be a best response (BR) to buy the resource if the other firm does so.

Proof of Proposition 2

If the weak firm does not buy, then the strong firm has a reservation price of $\frac{1}{2}c$, as in the additive model. If the strong firm does not buy, the weak firm's reservation price is given by

$$(\tfrac{1}{2}+a)c - p > 0 \iff p < (\tfrac{1}{2}+a)c\,.$$

Clearly, this latter reservation price is higher. Therefore, if the price is in the range $[\frac{1}{2}c, (\frac{1}{2}+a)c]$, then the weak firm will be the only firm to buy. Within this range, $(\frac{1}{2}+a)c$ will be the revenue-maximizing price.[1] This means that only the weak firm will get the resource, thereby leapfrogging the strong firm to become the market leader. However, both firms end up with 0 profit, as the resource is priced exactly at its value for the weak firm, and as the strong firm is priced out of the product market and thereby loses its prior rents of $\frac{1}{2}a$.

Product Market Cournot Rivalry with Additive Resources

In the Cournot model, when neither firm buys the resource or the SFM does not exist, the firms' profits are $\pi_{M1} = \frac{1}{36}(1+4a)^2$ and $\pi_{M2} = \frac{1}{36}(1-2a)^2$. As the resource lowers the marginal cost by c, these expressions can be used to find the solutions when only the strong firm acquires the resource ($\pi_1 = \frac{1}{36}(1+4a+4c)^2 - p$ and $\pi_2 = \frac{1}{36}(1-2a-2c)^2$); when only the weak firm acquires the resource ($\pi_1 = \frac{1}{36}(1+4a-2c)^2$ and $\pi_2 = \frac{1}{36}(1-2a+4c)^2 - p$); and when they both acquire the resource ($\pi_1 = \frac{1}{36}(1+4a+2c)^2 - p$ and $\pi_2 = \frac{1}{36}(1-2a+2c)^2 - p$). Based on these expressions it is possible to find the reservation prices of each firm given the action of its rival. If the weak firm does not buy, the strong firm's BR is to buy the resource if

$$\tfrac{1}{36}(1+4a+4c)^2 - p > \tfrac{1}{36}(1+4a)^2 \iff p < \tfrac{2}{9}c(1+4a+2c)\,.$$

If the weak firm does buy, this reservation price becomes

$$\tfrac{1}{36}(1+4a+2c)^2 - p > \tfrac{1}{36}(1+4a-2c)^2 \iff p < \tfrac{2}{9}c(1+4a)\,.$$

The latter reservation price is clearly lower than the former, suggesting that the weak firm's acquisition makes the resource less attractive for the strong firm (intuitively, this is because some of the value of the resource is appropriated by the consumers). With similar calculations, the weak firm's reservation price is $\frac{2}{9}c(1-2a+2c)$ if the strong firm does not buy and $\frac{2}{9}c(1-2a)$ if it does (the latter is again lower than the former).

We can see that the strong firm's reservation price is higher than the weak firm's reservation price, both as a BR to Yes and to No. Hence, the resource seller

[1] If the price is below $\frac{1}{2}c$, the two firms will play a Chicken game for the resource. However, as argued above, it will not be in the resource seller's interest to lower the price to that level.

could either pursue a high-price strategy in which it prices at the strong firm's highest reservation price, sells one unit, and earns revenue of $\frac{2}{9}c(1+4a+2c)$, or a low-price strategy in which it prices at the weak firm's lowest reservation price, sells two units, and earns $\frac{4}{9}c(1-2a)$. It is also possible that there will be an intermediate Chicken price, as in the Bertrand model. However, given that this will only result in one resource sale, it is always strictly dominated by the high price.

Proof of Proposition 3

The resource supplier prefers the low price over the high price if

$$\tfrac{2}{9}c(1+4a+2c) < \tfrac{4}{9}c(1-2a) \iff a < \tfrac{1}{8} - \tfrac{1}{4}c\,.$$

At a low price, both firms buy the resource and the weak firm earns profits of

$$\pi_2 = \tfrac{1}{36}(1-2a+2c)^2 - \tfrac{2}{9}c(1-2a) = \tfrac{1}{36}(1-2a-2c)^2\,,$$

which is evidently lower than its pre-SFM profits of $\pi_{M2} = \frac{1}{36}(1-2a)^2$ at any positive c. Similarly, the strong firm earns

$$\pi_1 = \tfrac{1}{36}(1+4a+2c)^2 - \tfrac{2}{9}c(1-2a) = \tfrac{1}{36}(1+4a-2c)^2 + \tfrac{4}{3}ac\,.$$

This can be shown to be lower than its pre-SFM profits as long as $a < \frac{1}{8} - \frac{1}{8}c$, which is implied by the condition $a < \frac{1}{8} - \frac{1}{4}c$. As the two firms have dominant acquisition strategies that make them both worse off, this is a Prisoner's Dilemma game as described in the Proposition.

Product Market Cournot Rivalry with Supplantive Resources

As shown above, the pre-SFM profits of the two firms are $\pi_{M1} = \frac{1}{36}(1+4a)^2$ and $\pi_{M2} = \frac{1}{36}(1-2a)^2$. As a supplantive resource lowers marginal cost to $\frac{1}{2}-a-c$, these expressions can be used to find the solutions when only the strong firm acquires the resource ($\pi_1 = \frac{1}{36}(1+4a+4c)^2 - p$ and $\pi_2 = \frac{1}{36}(1-2a-2c)^2$); when only the weak firm acquires the resource ($\pi_1 = \frac{1}{36}(1+2a-2c)^2$ and $\pi_2 = \frac{1}{36}(1+2a+4c)^2 - p$); and when they both acquire the resource($\pi_1 = \pi_2 = \frac{1}{36}(1+2a+2c)^2 - p$). If the weak firm does not buy, the strong firm's BR is to buy the resource if $p < \frac{2}{9}c(1+4a+2c)$ as in the additive model. If the weak firm does buy, this reservation price becomes

$$\tfrac{1}{36}(1+2a+2c)^2 - p > \tfrac{1}{36}(1+2a-2c)^2 \iff p < \tfrac{2}{9}c(1+2a)\,,$$

which is clearly lower. Similar calculations show that the weak firm's reservation price is $\frac{2}{9}(a+c)(1+2c)$ if the strong firm does not buy and $\frac{2}{9}(a+c)$ if it does. The latter reservation price is lower than the former. It can be shown that, in contrast to the additive model, the weak firm's reservation price is higher than the strong firm's reservation price both as a BR to Yes and to No (in both cases, by the magnitude $\frac{2}{9}(1-2c)a$). Hence, the resource seller could pursue a high-price strategy aimed at the weak firm's highest reservation price, sell one unit, and earn revenue of $\frac{2}{9}(a+c)(1+2c)$, whereas a low-price strategy would lead it to aim at the strong firm's lowest reservation price, sell two units, and earn $\frac{4}{9}c(1+2a)$.

Proof of Proposition 4

A low-price strategy is better than a high-price strategy if

$$\tfrac{4}{9}c(1+2a) > \tfrac{2}{9}(a+c)(1+2c) \iff c > a\,.$$

At the low price, both firms buy the resource and the strong firm earns profits of

$$\pi_1 = \tfrac{1}{36}(1+2a+2c)^2 - \tfrac{2}{9}c(1+2a) = \tfrac{1}{36}(1+2a-2c)^2\,,$$

which are evidently lower than its pre-SFM profits of $\pi_{M1} = \frac{1}{36}(1+4a)^2$. The weak firm earns the same post-SFM profits, which can be shown to be greater than its pre-SFM profits (and hence imply SFM rents) as long as

$$\pi_2 > \pi_{M2} \iff \tfrac{1}{36}(1+2a-2c)^2 > \tfrac{1}{36}(1-2a)^2 \iff a > \tfrac{1}{2}c\,,$$

and smaller otherwise.

Resource Seller's Endogenous Scarcity Option

This section derives the conditions under which the resource supplier, if given the chance, will find it optimal to restrict supply of the resource to one unit and sell it in a sealed-bid, second-price auction. As explained by Chatain (2013: 17), the rational bid of each firm will be "the difference between its profits in the product market if it owns the resource and those profits if its competitor owns the resource instead."

Bertrand Rivalry

Suppose that the resource is additive and that $c > a$. The strong firm will then earn $\frac{1}{2}(a+c)-p$ if it acquires the resource and 0 if it instead allows its competitor to do so. It is indifferent if $p = \frac{1}{2}(a+c)$, which thus becomes its optimal bid in the auction. Similarly, the weak firm's optimal bid is $(\frac{1}{2}+a)(c-a)$, which is lower than the strong firm's bid because $c < 1+a$. The outcome of the second-price auction is therefore that the strong firm acquires the resource and pays $(\frac{1}{2}+a)(c-a)$ in revenue to the resource seller. This revenue is lower than the revenue from the divergence price ($\frac{1}{2}c$) because, by construction, $c < \frac{1}{2}+a$. Hence, for $c > a$, it is never optimal for the resource seller to restrict supply. For $c < a$, the weak firm will have no incentive to bid on the resource and the revenue to the resource seller in the auction will therefore always be 0. Hence, in the Bertrand additive model, the auction is never (at any parameter values) an optimal solution for the resource seller.

The strong firm's optimal bid is the same for a supplantive resource as for an additive one ($\frac{1}{2}(a+c)$) because its payoff structure is the same. The weak firm, on the other hand, now earns $(\frac{1}{2}+a)c - p$ if it buys the resource (and 0 otherwise), resulting in a bid of $(\frac{1}{2}+a)c$. The strong firm's bid is still higher (because $c < \frac{1}{2}$) and it will therefore acquire the resource at the price of the weak firm's bid. The resource seller thus earns revenue of $(\frac{1}{2}+a)c$ from the auction, which is the same as the base-model revenue. If the auction occurs, the strong firm earns

$$\pi_1 = \tfrac{1}{2}(a+c) - (\tfrac{1}{2}+a)c = (\tfrac{1}{2}-c)a = \tfrac{1}{2}a - ac\,,$$

which is clearly lower than its pre-SFM profits of $\pi_{M1} = \frac{1}{2}a$ and thus implies a preemption price premium of ac.

Proof of Proposition 5

In the Cournot model, the strong firm will earn $\frac{1}{36}(1+4a+4c)^2 - p$ if it acquires an additive resource and $\frac{1}{36}(1+4a-2c)^2$ if it instead allows its competitor to do so. It is indifferent if $p = \frac{1}{3}c(1+4a+c)$, which thus becomes its optimal bid in the auction. Similarly, the weak firm's optimal bid is $\frac{1}{3}c(1-2a+c)$, which is clearly lower. Hence, the strong firm obtains the resource at the price of the weak firm's bid. The resource seller prefers this outcome over the high-price strategy as long as

$$\tfrac{1}{3}c(1-2a+c) > \tfrac{2}{9}c(1+4a+2c) \iff a < \tfrac{1}{14}(1-c)\,,$$

and over the low-price strategy if

$$\tfrac{1}{3}c(1-2a+c) > \tfrac{4}{9}c(1-2a) \iff c > \tfrac{1}{3} - \tfrac{2}{3}a\,.$$

If we superimpose these conditions on the one identified in Proposition 3, we arrive at the left panel of Figure 6. As a result of the auction, the strong firm earns

$$\pi_1 = \tfrac{1}{36}(1+4a+4c)^2 - \tfrac{1}{3}c(1-2a+c)\,.$$

Compared to its original Cournot profits, this represents SFM profits of

$$\pi_{S1} = \pi_1 - \pi_{M1} = -\tfrac{1}{9}c(1 - 14a - c)\,,$$

which is negative as long as $a < \frac{1}{14}(1-c)$, which is already a condition for resource restriction to be chosen.

Cournot Rivalry with Supplantive Resource

With Cournot rivalry, the strong firm will earn $\frac{1}{36}(1+4a+4c)^2 - p$ if it acquires a supplantive resource and $\frac{1}{36}(1+2a-2c)^2$ if it instead allows its competitor to do so. It is indifferent if $p = \frac{1}{9}(1+3a+c)(a+3c)$, which thus becomes its bid in the auction. Similarly, the weak firm's bid is $\frac{1}{9}(1+c)(2a+3c)$, which is higher than the strong firm's bid as long as $c < \frac{1}{8} - \frac{3}{8}a$ and lower otherwise.

First, suppose that $c < \frac{1}{8} - \frac{3}{8}a$. The weak firm then offers the highest bid, and the resource seller earns the strong firm's bid ($\frac{1}{9}(1+3a+c)(a+3c)$) in revenue. The resource seller prefers this outcome over the high-price strategy if

$$\tfrac{1}{9}(1+3a+c)(a+3c) > \tfrac{2}{9}(a+c)(1+2c) \iff c > \tfrac{1}{2} + 3a - \rho_H(a)\,,$$

and over the low-price strategy if

$$\tfrac{1}{9}(1+3a+c)(a+3c) > \tfrac{4}{9}c(1+2a) \iff c < \tfrac{1}{6} - \tfrac{1}{3}a - \rho_L(a)\,,$$

where $\rho_H(a) = \frac{1}{2}\sqrt{1+8a+48a^2}$ and $\rho_L(a) = \frac{1}{6}\sqrt{1-16a-32a^2}$. Hence, for low values of a and c, the resource seller will choose an auction and sell to the weak firm if both of these inequalities are fulfilled[2] (choosing a high price instead if the first one is violated and a low price if the second one is violated). In this auction, the weak firm earns

$$\pi_2 = \tfrac{1}{36}(1+2a+4c)^2 - \tfrac{1}{9}(1+3a+c)(a+3c)\,.$$

The subtraction of the weak firm's pre-SFM profits from this amount results in SFM profits of

$$\pi_{S2} = \pi_2 - \pi_{M2} = \tfrac{1}{9}\big(a(1-3a-6c) + c(c-1)\big)\,,$$

which can be shown to be negative as long as $c < \frac{1}{2} + 3a + \rho_H(a)$ (which is always fulfilled as $c < \frac{1}{2}$ by definition) and $c > \frac{1}{2} + 3a - \rho_H(a)$ (which is exactly one of the conditions for the auction to occur in the first place). Hence, when the resource supplier restricts the resource in order to sell it to the weak firm, the weak firm will earn negative SFM profits.

[2] Note that within the parameter space where this choice takes place ($c < \frac{1}{8} - \frac{3}{8}a$), the constraints given by the large roots ($\frac{1}{2} + 3a + \rho_H(a)$ and $\frac{1}{6} - \frac{1}{3}a + \rho_L(a)$, respectively) can be shown to be non-binding and are therefore not included in the above solutions.

Proof of Proposition 6

Second, suppose that $c > \frac{1}{8} - \frac{3}{8}a$. The strong firm offers the highest bid, and the resource seller earns the weak firm's bid ($\frac{1}{9}(1+c)(2a+3c)$) in revenue. It prefers this outcome over the high-price strategy if

$$\tfrac{1}{9}(1+c)(2a+3c) > \tfrac{2}{9}(a+c)(1+2c) \iff c < 1-2a\,,$$

which is always the case. Hence, the resource seller's problem is reduced to a comparison between the auction revenue and the low-price revenue, the former being higher than the latter if

$$\tfrac{1}{9}(1+c)(2a+3c) > \tfrac{4}{9}c(1+2a) \iff (2a-c)(1-3c) > 0\,.$$

Within the allowed parameter space $c < \frac{1}{2} - a$, this inequality will be fulfilled if either $c > \frac{1}{3}$ or $a > \frac{1}{2}c$. If we superimpose these conditions[3] on the one identified in Proposition 4, we arrive at the right panel of Figure 6. When the auction occurs and the strong firm acquires the resource, it earns

$$\pi_1 = \tfrac{1}{36}(1+4a+4c)^2 - \tfrac{1}{9}(1+c)(2a+3c)\,.$$

Compared to its original Cournot profits, this represents SFM profits of

$$\pi_{S1} = \pi_1 - \pi_{M1} = -\tfrac{1}{9}\big(c(1-c) + a(2-6c)\big)\,,$$

which can be shown to be negative for all $c < \frac{1}{2} - a$, thus capturing the preemption price premium.

[3]Note that the first inequality ($c > \frac{1}{3}$) implies $c > \frac{1}{8} - \frac{3}{8}a$ and therefore is a sufficient condition for the auction to both occur and be won by the strong firm. In contrast, the second inequality ($a > \frac{1}{2}c$) must be satisfied *jointly* with $c > \frac{1}{8} - \frac{3}{8}a \iff a > \frac{1}{3} - \frac{8}{3}c$, as stated in the Proposition.