SYMMETRY AND THE SIXTH FORCE:
The Essential Role of Complements

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Research Summary: We demonstrate why complements must be a sixth force in Porter's five-forces model. Complements are the mirror-image counterpart to substitutes. Therefore, complements should be treated as a force exactly as are substitutes. But, Porter rejects complements as a force. He argues that the effect of complements fails a test of monotonicity and must be understood via the existing five forces. The monotonicity test conflates the positive direct impact of complements with the ambiguous effect complements have on the other forces. And the structure of the complements industry can have a direct effect on industry profits with *no* impact on the five forces. We explore how to shape the force of complements and why firms may want to intervene in the complements industry.

Managerial Summary: Over forty years later, Porter's five-forces model remains one of the most influential frameworks for formulating strategy. And yet there is a hole in the model, namely, the force of complements. (Think of the relationship between electric car makers and providers of charging stations.) Because of this hole, strategy towards complements is under-developed relative to strategy built on the other forces. We provide strategic insights that come from giving equal billing to complements. We start from Porter's checklist for substitutes and its associated strategies, and we create an analogous checklist for complements. Since complements are the mirror image of substitutes, the associated strategies are also mirror images. Including complements as a sixth force makes the five-forces framework logically complete and more valuable.

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1. Introduction

The five-forces model of Porter (1980) is designed to describe the sources of power that influence the profitability of an industry. The model has been expanded to include factors such as government (McGinn, 2010), demographics (Saloner, Shepard, and Podolny, 2001), consumer preferences (Besanko, Dranove, Shanley, and Schaefer, 2017), and more. One does not want to include too many additional factors. Parsimony of a model is desirable. But, at the same time, a model should not have important holes.

There is an important hole in the five-forces framework, namely, the absence of complements. Porter (2008) and many others (e.g., Saloner, Shepard, and Podolny, 2001; Besanko, Dranove, Shanley, and Schaefer, 2017; Ghemawat, 2017) clearly recognize the relevance of complements to industry profits. A hardware industry needs a software industry in order to flourish, and vice versa. However, Porter (2008) argues that complements cannot be a distinct force and must be understood through their impact on the existing five forces. The framework does not need expanding.

As we explain below, complements are on a logical par with substitutes. Complements and substitutes are mirror images. Given this symmetry, it would seem that opportunities from complements should be treated as a force in exactly the same way as are threats from substitutes; this is what we did in our value net model (Brandenburger and Nalebuff, 1996). Porter (2008, p. 22) claims that complements are unlike substitutes because their effect on industry profits is non-monotonic and, therefore, they cannot be a force:

> [C]omplements are not a sixth force determining industry profitability since the presence of strong complements is not necessarily bad (or good) for industry profitability.

As buyer power, supplier power, rivalry, threat of entry, and threat of substitutes go up, industry profits go down**.** Each of Porter's five forces has a monotonic effect on industry profits. If the effect of strong complements is ambiguous, they cannot be a force.

Adner and Lieberman (2021) reach the same conclusion in their comprehensive examination of how complementors disrupt established firms. In one of their examples, the presence of complements directly raises industry profits, but this is more than offset via an indirect effect of reducing product differentiation. On this basis, they follow Porter to conclude that the effect of complements, though important, is non-monotonic and thus complements are not a sixth force.

In fact, the effect of complements is monotonic in the very same way as substitutes. The confusion comes from conflating the direct effect of complements—which is always positive—and the indirect effect on the other five forces which can go in either direction and can possibly overturn the direct effect. Indeed, the very same ambiguity applies to substitutes: The direct effect is always monotonic (negative this time) and the indirect effect can go in either direction.

The contribution of this paper is to make the argument that complements must be a sixth force and, in the course of doing so, to point out the shortcomings in the counter-arguments that have been made. We recognize that some readers will be "pre-sold" on our conclusion. Grove (1996) supplements the five-forces analysis with the force of complements to arrive at what he

calls the six-forces analysis. Textbooks by Saloner, Shepard, and Podolny (2001, Ch. 6) and Besanko, Dranove, Shanley, and Schaefer (2017, Ch. 8) explicitly put complements on a par with substitutes. Prior research has emphasized the role of complements, outside of the five-forces model. Teece (1986, 2014) replaces industry analysis with ecosystem analysis. Profits in one part of the ecosystem—the base industry—cannot be analyzed separately from the ecosystem as a whole, complements included. Adner and Kapoor (2010), Adner (2017), Jacobides, Cennamo, and Gawer (2018), and Cusumano, Gawer, and Yoffie (2019) all consider the active role of complementors in ecosystems. *But, to the best of our knowledge, no one, ourselves included, has ever formally made the argument for complements to be a force and carefully addressed the counter-arguments.*

The paper proceeds as follows. Section 2 introduces the formal definition of complements. This definition highlights the essential symmetry between complements and substitutes. The mathematics establishes that complements must be on an equal footing with substitutes.

Section 3 presents the two arguments that have been offered for why complements are not an independent force: (1) their effect is not monotonic; and (2) their effect must be understood through the impact on the other five forces. We identify the flaws in each argument.

Section 4 provides strategic insights that come from giving equal billing to complements and connects this paper to the literature on complements. We start from Porter's (1980, 2008) checklist for substitutes and its associated strategies. We create an analogous checklist for complements. As will be seen, just as complements are the mirror image of substitutes, the associated strategies are also mirror images.

Section 5 offers a brief conclusion. The Appendix provides a mathematical model to support our example where increased competition from substitutes raises industry profits.

2. Symmetry

There is a prima facie argument for why complements should be a force given that substitutes are a force. Substitutes and complements are on the same logical footing, differing only in a sign flip. The concepts are mirror-image symmetric counterparts. It is hard to understand how a "less than" relationship could be deemed a force while a "greater than" relationship is not. The prior belief must be that the two concepts should be classified in the same way.

We are not the first to recognize symmetry as a desideratum in creating better theories of strategy; see Foss and Hallberg (2014). Indeed, in the five-forces framework, there is a fundamental symmetry between buyers and suppliers—they are simply opposite sides in a buy-sell relationship. Brandenburger and Stuart (1996) extend buyer-supplier symmetry in proposing a definition of value creation in terms of willingness-to-pay minus willingness-to-sell that treats the upstream and downstream symmetrically.[2]

There is a basic symmetry between substitutes and complements as the definitions bring out. Two firms identified by their products A and B are selling substitutes for a customer if

$$\mathrm{WTP}(A \ \& \ B) \leq \mathrm{WTP}(A) + \mathrm{WTP}(B), \tag{1a}$$

[2] They originally proposed the term "opportunity cost" for the supplier analog to willingness-to-pay. The term "willingness-to-sell" comes from Oberholzer-Gee (2021).

where $\mathrm{WTP}(A \ \& \ B)$ is the willingness-to-pay for products A and B, $\mathrm{WTP}(A)$ is the willingness-to-pay for A alone when there is no B, and $\mathrm{WTP}(B)$ is the willingness-to-pay for B alone when there is no A. Another way of saying this is that a customer who owns A is less willing to pay for B than a customer who doesn't already own A:

$$\mathrm{WTP}(A \ \& \ B) - \mathrm{WTP}(A) \leq \mathrm{WTP}(B)\,. \tag{1b}$$

Similarly, a customer who owns B is less willing to pay for A than a customer who doesn't already own B.

There is a mirror-image definition: In place of "$\leq$" write "$\geq$". That is, consider the case when A and B are related in this way:

$$\mathrm{WTP}(A \ \& \ B) \geq \mathrm{WTP}(A) + \mathrm{WTP}(B), \tag{2}$$

This is the formal definition of what it means to say two products A and B are complements.[3] We see that complementarity is the symmetric counterpart to substitution. Complementarity means that the WTP for A when B is owned is greater than or equal to the WTP for A alone. Similarly, the WTP for B when A is owned is greater than or equal to the WTP for B alone.[4]

[3] The definition goes back to Fisher (1892), Edgeworth (1897), and Pareto (1909). Just as substitutes exist on both the customer and the supplier side, so do complements. Here the definition is that the cost to supply A and B together is lower than supplying A alone and B alone. (Broadway shows illustrate a complementarity relationship with respect to the supplier side. A set designer has a limited engagement working on any single show. The large number of shows on Broadway allow a set designer to find a more steady stream of income.) While we emphasize the role of complements on the customer side, all results apply equally to the supply side.

[4] Netflix and Comcast illustrate the complementor relationship. Each makes the other more valuable. Netflix increases the customer's WTP for high-speed Internet, while high-speed internet increases the WTP for Netflix.

Given the symmetry in their definitions, one would expect there to be a fundamental (mirror-image) symmetry in the effects of the two forces. As we next show, indeed there is. Where the direct effect of the force from substitutes is negative, the direct effect of the force from complements is positive. For both substitutes and complements, the indirect effect they have on the other five forces can go in either direction.

3. Understanding Monotonicity and Direct Effects

Substitutes reduce willingness-to-pay. Therefore the total pie is smaller. Holding the level of all the other forces constant, the reduced pie is divided up in the same proportions, so that industry profits are reduced. For example, Netflix reduces customers' WTP for going to a movie theater and thereby reduces the profits for the movie theater industry (assuming the presence of Netflix does not also change buyer power, supplier power, rivalry, or entry).

The direct effect of strong complements must necessarily be good for industry profitability in the same way that the direct effect of strong substitutes must necessarily be bad for industry profitability. The sign of the effect on profitability is reversed, but this is simply the mirror-image effect. This is not the issue. At issue is whether the effect on industry profits is monotonic. Porter (2008, pp.22-23) claims that complements are unlike substitutes because their effect on industry profits is non-monotonic and, therefore, they cannot be a force.

The mistaken concern over the ambiguous impact of complements comes from conflating two distinct effects: (1) a direct effect, and (2) an indirect effect on the other forces. The presence of complements improves profits by raising willingness-to-pay. The second feature of complements is they can reshape the other five forces—for example, by changing barriers to

entry or rivalry—and this effect can go in either direction. The indirect effect can dominate and so the net effect of these two factors can also go in either direction.

Porter (2008) presents an example where Microsoft as a complementor provided toolsets that made it easier for firms to write application software and thereby reduced entry barriers into the base industry. Adner and Lieberman (2021) describe how DoorDash, a complementor to restaurants, reduces the importance of a restaurant's physical location, thereby lowering product differentiation which leads to increased rivalry among restaurants. In these examples, whether the reduced entry barriers or increased rivalry was enough to offset the gain from the increased WTP created by the presence of the complement is left unresolved as an empirical matter. That said, we fully agree that it is possible that the indirect effects could dominate, leading to lower industry profits.

If there is perfect symmetry, then it should equally be possible that the presence of strong substitutes can have a negative direct effect on industry profits, but can change the other five forces in a way that raises profits, and that this positive indirect effect can dominate. Just as complements can lower industry profits via their indirect effect, substitutes can raise industry profits via their indirect effect. In our example that follows, the presence of a substitute increases product differentiation and thereby reduces rivalry.

Consider the effect of the threat from a generic drug substitute to the branded drug industry. The direct effect is clearly negative since generics reduce WTP for the branded drugs. The stronger the substitute, the more it reduces WTP (and thereby leaves the branded products with a smaller market). The effect on rivalry among the branded drug makers goes in the

opposite direction. The existence of a generic drug entrant takes price-sensitive customers out of the market, leaving behind those most loyal to the branded drugs. We develop this example more formally in the Appendix, where we show that an increase in differentiation of the branded products leads to reduced rivalry and a large price increase, one more than sufficient to offset the loss in customers to the generic substitutes. We don't mean to suggest that this is a common scenario, just that it is a possible one.

Even though the net effect of substitutes in this example is positive, *this is not an argument against substitutes being a force*. The example depends on an indirect effect overriding the direct effect. We don't say that substitutes are not a force because their net effect is ambiguous. That substitutes are a force follows from their unambiguous direct effect. That complements are a force equally follows from their unambiguous direct effect.

This is one more application of symmetry: Every argument regarding a substitute has a flipped version when it comes to a complement (and vice versa). If complements can lead to more rivalry, then substitutes can lead to less rivalry. Every argument can be flipped.

In general, we subscribe to the view that the net effect of threats from substitutes is to lower industry profits in the base industry. The branded drugs example we gave is the unusual case. Similarly, we generally think the net effect of complements is higher profits. The DoorDash example is the unusual case. It is fine to have the intuition that better complements generally lead to higher industry profits just as stronger substitutes generally lead to lower industry profits. But monotonicity of the net effect is not something that must be true as a mathematical

rule for either substitutes or complements. The fact that the net effect can go either way does not affect the standing of substitutes or complements as a force.

Direct Effects

Porter (2008, pp. 22-23) makes a second argument for why complements should not be considered a distinct force: The effect of complements on industry profitability can be fully accounted for by tracing their effect through the existing five forces. Including complements as a force would be redundant.

> Complements affect profitability through the way they influence the five forces.… The strategist must trace the positive or negative influence of complements on all five forces to ascertain their impact on profitability.

While Porter does not explicitly say that the the effect of complements on industry profitability must be assessed only via their influence on the five forces, this is the implied message. If complements are not a force, their impact is only via their indirect effect. Such a claim makes sense when one considers the effect of government or demographics on the profitability of an industry where the direct effect has no general sign. But it is not correct when it comes to the effect of complements.

We demonstrate this via a counterexample. Specifically, we consider a monopolized base industry where there are no substitutes, buyer power is near zero, supplier power is near zero, there are no threats from entry, and there is no rivalry since the firm is a monopoly. Thus it would appear that the monopoly firm would be the only player with a claim on industry profits. But this misses the “competition” with complementors. The industry structure of the

complementary product determines the extent of this competition and is thus fundamentally important to the base industry profits. This effect is wholly independent of the existing five forces since it has no impact on any of them. Therefore, complements must be a distinct force because its impact would otherwise be missed or unexplained.

To make the example concrete, we can think of the monopolist as Microsoft in the mid-1980s to mid-90s. Its customers were small relative to the size of the market and had little to no power. Most of the firm's inputs were commodities and there were many suppliers, with little to no power. (Likely, some star programmers were exceptions.) The firm was protected from rivalry or entry by its head start and IP. And there were no good substitutes.

According to the five forces, Microsoft should have captured nearly all of the value created. And while Microsoft was very profitable, there was another player which had equal claim to this value. That player was Intel, the microprocessor manufacturer and major complementor to Microsoft; see also Ghemawat (2017, p. 29). In fact, during the mid-1980s to mid-90s, Intel's profits per PC sold were roughly equal to Microsoft's (Casadesus-Masanell, Nalebuff, and Yoffie, 2008, Table 1).

If Intel were one of many commodity chip makers, it would price at close to cost and Microsoft would not have to "compete" with Intel for profits. Microsoft would have been able to double its profits.[5] Complementor firms are similar to customers and suppliers in that they, too, along with the base industry firm(s), have a claim on profits. The strength of that claim depends on

[5] Microsoft profits could more than double since it would not only be able to capture all of Intel's profits, it could also raise combined profits across the two industries by avoiding double marginalization; see Section 4.

the structure of the complements industry. Microsoft's profits will be higher when the complements industry is more competitive and lower when the complements industry is also monopolized.

Bringing this back to Porter (2008), this complementor effect cannot be understood via its influence on the five forces. *Whether microprocessors are supplied by an Intel monopoly or by many competing chip makers, the five forces for the operating-system industry do not change.* They are all near zero. There is little to no customer or supplier power, no threats from entrants or substitutes, and no firm rivalry in either situation. And yet, the profitability of the operating system industry fundamentally depends on the industry structure of the complementors.

Here we are making an important distinction between the existence of the complementary product (the microprocessor) and the structure of the microprocessor industry. The existence of the complementary product expands the pie. The structure of the microprocessor industry determines the power of complements to claim profits in the operating-system industry. Just as the concentration of buyers and suppliers influences buyer and supplier power, so too does concentration in the complements industry influence complementor power.

In summary, the potential non-monotonicity of the net effect of complements cannot rule them out as a force. We would have to rule out substitutes as a force as well. Moreover, the effect of complements cannot be understood via the existing five forces, as seen in our example of how the structure of the microprocessor industry influences profits in the operating-system industry.

4. Complementor Strategies

What is different once one recognizes that complements are a sixth force? At one level, nothing is changed. Researchers have done significant work analyzing the strategic role of complements without calling it a force; see the discussion below. But there is no simple checklist or set of heuristics underneath the heading "Opportunities from complements" to parallel the heuristics found under each of the existing five forces. And the mirror-image symmetry in potential strategies is under-appreciated. We make repeated use of symmetry to develop complement strategies.

Under "Threats from substitutes," Porter's (1980, 2008) checklist includes relative price performance for substitutes and switching costs. The strategist is meant to consider these factors in coming up with an overall assessment of the strength of the substitutes force and develop associated strategies. Here, we develop an analogous set of heuristics for complements. A firm's preferences toward complements are the mirror image of its preferences with regard toward substitutes.

1. A firm prefers that its complementor products offer an attractive price-performance combination. Ideally, complements are high quality, low cost, and proprietary.

2. A firm prefers that its complementors have low market power. For example, it is desirable if customers can easily switch among different complement options.

We expand on each item in turn. Following McIntyre and Srinivasan (2017), our answers integrate strategic management and IO economics.

Under (1), we ask: How can a firm encourage its complements to make high-quality products? One answer is to commit not to compete with them in the complements space and thereby help ensure that they will earn a return on upfront investments in quality; see Farrell and Katz (2000) and Gawer and Cusumano (2002). As explained by Gawer and Henderson (2007), Intel created the Intel Architecture Lab and structured it as a standalone not-for-profit unit as just such a commitment device. Absent a commitment, a firm can instead develop a reputation for treating its complementors fairly; see Gans and Stern (2003) and Zhu and Liu (2018).

Another solution is to help customers identify high-quality complements and thereby give high-quality complementors a leg up and low-quality ones a leg down. Apple polices the quality of the programs available on iOS to ensure that iPhone customers don't end up being disappointed with low-quality apps. (It is generally agreed that the Google Play Store is more open than the Apple App Store, but has a larger number of low-quality apps.[6]) It is also possible to ally with high-quality proprietary complementors in order to raise profits by increasing differentiation. Taeuscher and Rothe (2021) investigate the online learning space (MOOCs) in which high-quality complements signal overall quality and thereby increase the value of horizontal product differentiation.

There is a traditional view that a firm should "stick to its knitting." This is not true in the case of nascent ecosystems, where complements may be inferior or missing. In the residential solar power industry, bottlenecks were caused by an underdeveloped complement, specifically, financing. To solve this problem, one firm developed its own financing product; see Hannah and

[6] See businessinsider.com/android-low-quality-apps-technological-ghetto-glenn-derene-2011-11 and appbrain.com/stats/number-of-android-apps.

Eisenhardt (2018). Even when complements exist, a firm cannot count on the market to supply the desired quantity and quality of complements. It may need to be more actively involved.

Consider the case of car companies and electric charging stations. Providers of high-speed electric charging stations are unlikely to charge prices that lead to large profits. (This is in part due to the fact that customers have some ability to substitute by slow charging at home or at work.) Thus independent companies have not entered the charging station market with the magnitude and speed necessary to support the electric-car business. To the extent they have entered, they have focused on the most profitable geographies. This has led to charging deserts which impact the overall sales of electric vehicles (EV's).[7]

Building a national high-speed charging network requires coordination. The charging stations are complements to each other, not just with EV's, since a bigger network leads EV owners to take longer trips where they rely on away-from-home chargers. This suggests the need for a large player that can solve the coordination problem. But a large player will have some market power. To avoid this issue, an EV maker may want to enter its complements market. Tesla, for example, wants to ensure that an extensive network exists and is not controlled by a complementor with market power—because that complementor would have a claim on the total pie.

[7] As of June 14, 2022, there were 43,172 level II charging stations and 6,295 DC fast charging stations in the US (US Department of Energy, 2022, afdc.energy.gov/fuels/electricity_locations.html) compared with over 115,000 gas stations (each with multiple pumps). Excluding Tesla chargers, the US DOE map shows large gaps in the Midwest. In Europe, carmakers have come together to form Ionity in order to build out a comprehensive high-speed charging network (ionity.eu).

Since Tesla had the greatest need for the complement and the greatest ability to monetize its value, Elon Musk built a proprietary charging network when he launched the Tesla EV; see Van den Steen (2020). Whether or not profits would be earned on the charging network, the network created the potential for the large market value Tesla has been able to achieve. Indeed, one of Tesla's competitive advantages is having the best proprietary supply of complements.

Also under (1) is the strategy of helping complementors lower their costs. This may lead a firm to help its complementors lower cost by, for example, sharing demand forecasts or providing access to forthcoming technologies. Nintendo, Sony, and Microsoft provide developer interfaces and stage conferences to make it easier to write games.[8] The incentives are most pronounced when the complements are proprietary, so that the benefits are not shared across the entire industry. Miller and Toh (2020) discuss the use of standards setting across complements.

One might think that complementors, in their competition with one another, have sufficient incentive to lower costs. This turns out to be incorrect. The reason is that the complementor only captures a fraction of the gain created. When a complementor lowers its cost, this allows it to lower its price and thereby gain share and profits. The lower price of the complement also expands demand in the base industry and allows those firms to raise their price. Some fraction of the gain from lowering cost escapes the complementor industry and goes over to the base industry. To the extent that the complementor only captures a fraction of the gain created, it will have insufficient incentive to invest in cost-reducing activity.

[8] See developer.nintendo.com/tools; developer.sony.com; developer.microsoft.com/en-us/games.

The extreme version of this is seen in the example perfect complements. Here A and B are each worthless on their own but together they create value. In this case, when A and B are each monopolists, the profits of the two complementors are equal regardless of their potentially different cost structure; see Cournot (1838, p. 102) and Casadesus-Masanell, Nalebuff, and Yoffie (2008). This means that half the gains from lower costs "leak" over to the complement. One strategy to address this issue is horizontal integration with the complementor.

There is a potential wrinkle. In some circumstances a firm does not want its complementor's price-performance combination to be too favorable. Amazon, for example, welcomes third-party sellers to participate on its platform but then may decide to compete with them. (Zhu and Liu, 2018 show that Amazon is most likely to enter complementors' product spaces if they have high sales and don't use Amazon's fulfillment services.) The reason for this inconsistency is that the two firms are both complements and substitutes. A third-party seller is a complement when it comes to making the Amazon platform more attractive and bringing more people to Amazon.com. But once the customers are there, the seller becomes a substitute. Amazon intervenes if it makes more money when the purchase is made directly through them rather than the third party. We call this relationship between the two firms one of *ex-ante complements and ex-post substitutes*.

The phenomenon of ex-ante complements and ex-post substitutes is common. For example, the different theme parks in Orlando are complements when it comes to bringing visitors to Orlando, but substitutes once the tourist has arrived. In these situations, a firm wants its complementors to have favorable price-performance positions (so as to be a good ex-ante complement), but not so favorable as to be a superior offering in the ex-post competition stage.

Returning to the checklist, under (2), we ask: How can a firm reduce the power of its complementors?

One strategy is to enter the complements market with the intent to lower prices. Unlike a typical entry strategy, a firm need not earn profits in the complements market—it is sufficient to lower prices and thereby allow more of the ecosystem profits to be captured in the base industry.

Separate from direct entry, a firm can support the existing smaller firms or challenger firms in the complements industry. In this regard, Intel supported Linux to provide competition to Microsoft, and Microsoft supported AMD in order to provide greater competition to Intel; see Casadesus-Masanell and Yoffie (2007).[9]

In a similar vein, a firm might withhold support in order to keep a check on a complementor's power. Wang and Miller (2020) show how travel-book publishers strategically withheld some of their best revenue-generating books from the Kindle platform with the goal of maintaining their bargaining power with Amazon by supporting alternative distribution channels. These publishers were concerned about limiting the strength of an important complement. (In the

[9] A firm might want to enter the complementor market without actually selling any product. In particular, if firm B is more efficient in the complementary market, firm A's goal is not to sell the complementary product but to get firm B (or several such firms) to lower their price. This can be done via a price squeeze (Ordover, Sykes, and Willig, 1985) or an access squeeze (in which firm A gives a complementor exclusive or preferential treatment conditional on a low price). Unlike traditional predation, the firm does not need to recoup losses from low-price entry in the complements market; it can recoup the profits right away in the base market with higher prices (Nalebuff, 2005).

end, publishers gained more control over pricing and practically all books are available on the Kindle platform.)

There is a second issue that arises when there is market power in each of two complements industries: Each industry's attempt to capture profits leads to double marginalization and thus inefficiently high prices, an observation going back to Cournot (1838, pp. 100–103).[10] The natural solution is to coordinate pricing.

When competitors coordinate, they restrict output and raise price. This leads to higher profits and lower consumer welfare. When complementors coordinate, they expand output and *lower* price. This also leads to higher profits. Here, however, coordination raises consumer welfare. This is an argument in favor of coordination or mergers among complementors.

In Heeb (2003), the monopolist integrates with the complementor and thereafter provides the complement product at cost. Even though profits are zero in the complements market, integration solves the double-marginalization problem and expands the incentive to innovate. Two complementors that merge solve the double-marginalization problem and thereby achieve an advantage over rivals in the two markets whose pricing is independent and thus inflated; see Nalebuff (2000).

There is a public policy implication of the fact that complementarity is the mirror image of substitution. We find two reasons for mergers between complementors. The first is to provide

[10] The problem with a lack of coordination between complementors is identical to the problem of double marginalization along a vertical supply chain (Spengler, 1950). Each firm charges a markup over cost in order to earn a profit. Those combined markups add up to an inefficiently high total.

proper incentives to cut costs. The second is to provide incentives to reduce double marginalization. While mergers between competitors generally lead to higher prices, here *both* effects lead to lower prices and greater consumer welfare.[11]

5. Conclusion

Complements do more than expand industry profits and shape the existing five forces. They constitute a force in their own right and one that has been less understood. Evidence of this is we had to overcome objections and explicitly make the case that complements are on an equal footing with the other forces.

The mathematical definition of a complement is simply the flip of a substitute. Given the mirror-image symmetry, there is no reason to treat complements any differently from substitutes. The objection that complements cannot be a force because their effect is not always positive is a confusion that results from conflating the positive direct impact of complements with the ambiguous effect complements can have on the other five forces. The same ambiguity arises in the net effect of substitutes.

The effect of complements cannot be fully understood through their impact on the existing five forces, as we saw in the example of a monopolized industry. The structure of the complements

[11] On the flip side, if the merged firm only sells the complements as a package, this will make it harder for potential rivals to enter, since they will be forced to develop both complementary products, not just one; see Choi and Stefanadis (2001), Nalebuff (2004), and Choi (2008). Even if the merged firm engages in mixed bundling, Masson, Dalkir, and Eisenstadt (2014) demonstrate potential downsides for consumer welfare. Consumers may be driven away from making their ideal mix-and-match combination of complements and the combined monopolist may be able to engage in more effective price discrimination.

industry will have a direct effect on base industry profits. For this reason, a firm may want to intervene in the complements industry.

The strategist has to both see and shape the landscape. It is hard, perhaps impossible, to shape what one does not see. As Intel cofounder Andrew Grove said, part of the strategist's job is to spot the errors of omission, not just commission (Ramo, 1997). Employing symmetry is one tool for overcoming errors of omission. In particular, the strategist can flip any existing strategy toward substitutes and apply it to complements. The result is a more complete map of the landscape and a more complete set of strategic options.

We see complements as a complement to the five-forces framework. Including complements as a sixth force makes the framework more valuable, not less.

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7. Appendix

Here we show that an increased threat from substitutes can lead to an increase in industry profits. In our example, the entry of a generic drug (the substitute) takes away market share from the industry and thereby lowers profits. But, in the process, the entry also removes price-sensitive customers from the market and thereby reduces inter-firm rivalry. The reduction in rivalry more than offsets the loss of market share. The equilibrium model below provides the details.

Customers are uniformly located along the line segment $[0,1]$. There are two incumbent firms; firm 0 is located at 0 and firm 1 is located at 1. Initially, there are only branded drugs available in the market. The customer located at x has a value $V_B(x) - x$ for the branded drug from firm 0 and $V_B(x) - |1 - x|$ from firm 1. We assume that $V_B(x) = 3$ for all customers $x \in [0,0.3)$ and $x \in (0.7,1]$, and $V_B(x) = 2$ for all customers $x \in [0.3,0.7]$.

When a generic substitute arrives in the market, there are two firms selling identical generic products, both located at 0.5. The customer located at x has utility $V_G(x) - |x - 0.5|$, where we assume $V_G(x) = 0.92$ for all customers. The generic is less valuable than the branded drug, but it is very well positioned for customers located near the center of the market.

Our point in choosing these parameters is to provide a simple illustration of how increased competition from substitutes can lead to greater product differentiation and thereby raise profits. When the generics enter the market, they capture all the price-sensitive customers in the "middle" of the market and leave those near the original firms. The remaining customers have strong preferences for the incumbents and this leads to an increase in price that more than compensates for the lost market share.

Price equilibrium prior to entry

Proposition: It is a Nash equilibrium for both firms to charge $p = 1$. Each firm captures the half of the market closest to its position. Firm profits are each 0.5 and so industry profits equal 1.

Proof: Firm 0's profits when it charges a price $0 \leq p \leq 1$ and firm 1 charges 1 are:

$$\Pi_0 = p(0.5 + 0.5(1 - p)) = p(1 - 0.5p).$$

Firm 0 would have to charge $p = 0$ in order to capture the entire market and a price above 2 leads to zero demand and zero profits. This quadratic profit function is maximized at $p = 1$. A parallel argument shows that firm 1 maximizes profits at $p = 1$ when firm 0 is charging 1.

Given that all customers have a valuation of at least 2 and transportation costs are no more than 0.5, even the customer located at 0.5 prefers to purchase at $p = 1$ than to buy nothing. This confirms that both firms capture half the market at a common price of 1 and that profits are 0.5 for each incumbent firm.

Price equilibrium after generic entry

Proposition: The two generic firms are identical in terms of product and location. This lack of differentiation leads them to charge a price of 0. In the resulting Nash equilibrium, all customers in $[0.3,0.7]$ purchase the generic product, while those located closer to the two endpoints purchase the original branded product from their nearest incumbent firm at a price of 1.98. Profits are 0.3×1.98 for each branded firm, and therefore industry profits are $1.188 > 1$.

Proof: The zero price for the generic firms follows from Bertrand competition. For the branded products, consider the pricing options for firm 0 when firm 1 is charging 1.98:

$$\Pi_0 = p(0.3 - 0.5(p - 1.98)) \quad \text{for } 2.58 \geq p \geq 1.98,$$

$$\Pi_0 = p(0.3) \quad \text{for } 1.98 > p \geq 1.58,$$

$$\Pi_0 = p(0.3 + 0.5(1.58 - p)) \quad \text{for } 0.98 \leq p \leq 1.58,$$

$$\Pi_0 = p(0.6 + 0.5(0.98 - p)) \quad \text{for } 0.58 < p \leq 0.98.$$

$$\Pi_0 = p(1) \quad \text{for } p \leq 0.58.$$

If firm 0 chooses to raise its price above 1.98, it will start to lose customers to the generic product. The customer located just below 0.3 has utility $0.92 - 0.2 = 0.72$ from buying the

generic and utility $3 - 0.3 - 1.98 = 0.72$ from buying the premium product. The first-order condition is:

$$d\Pi_0/dp = (0.3 + 1.98/2) - p < 0 \quad \text{for } p \geq 1.98.$$

In this interval, firm 0 maximizes profits by charging $p = 1.98$. Profits are $0.3 \times 1.98 = 0.594$.

In the next interval, firm 0 does not gain any of the generic customers. It would have to lower its price all the way to 0.98 to attract the generic customer located at 0.3. Therefore, there is no gain in lowering price unless the price is low enough to steal some customers from the other branded firm. This starts happening once firm 0 has undercut by 0.4. Thus profits are strictly lower than if the firm charges $p = 1.98$.

In order to capture any of firm 1's consumers, firm 0 must undercut firm 1 by at least 0.4 (and thereby attract the consumer located at 0.7). By the time firm 0 has undercut firm 1 by 1, it will have taken all of firm 1's market of $x \in (0.7,1]$.

If firm 0 chooses to undercut, its optimal price is $0.3 + 1.58/2 = 1.09$, and its profits will be 0.594. There is no gain from undercutting. (We assume that an indifferent firm picks the high-price strategy.)

The final option is to price so low as to recover some of the generic customers. At this point, firm 0 has stolen away all of firm 1's customers. Provided the price is above 0.58, firm 0 will only capture generic customers below 0.5. Here the price is so low that the first-order condition is always positive:

$$d\Pi_0/dp = (0.6 + 1.98/2) - p > 0 \quad \text{for } p \geq 0.98.$$

Once firm 0 charges 0.58, it captures the generic customer at 0.5 and all the other generic customers in $[0.5,07]$. Profits in this case are 0.58, which is lower than the profits of 0.594 when firm 0 charges 1.98.

If firm 1 is pricing at 1.98, firm 0's optimal response is also to price at 1.98. Equilibrium profits are 0.594 which exceed the profits of 0.5 obtained prior to generic entry. The intuition is the

generic firms have removed all the price-sensitive customers from the market, leaving the incumbents the ability to raise prices substantially. What limits a further price rise is a concern of losing high-value brand customers to the generic. Prices almost double, which raises profits since the generic only captures 40 percent of the market. But prices have not risen so much that a rival has an incentive to undercut and thereby undermine the equilibrium.