06-16-2021

# SYMMETRY AND THE SIXTH FORCE:
# The Essential Role of Complements

Adam Brandenburger and Barry Nalebuff[1]

Abstract

We demonstrate why complements must be a sixth force in Porter's (1980) Five Forces model. The mathematical definition of a complement is simply the flip of that of a substitute. Given the mirror-image symmetry, opportunities from complements should be treated as a force in the same way as are threats from substitutes. Porter (2008) rejects the idea that complements are a force. His first objection is the effect of complements fails a test of unidirectionality. But this test conflates the positive direct impact of complements on industry profits with the ambiguous effect complements have on the other five forces. We show by example the same ambiguity arises in the net effect of substitutes. Porter's second objection is the effect of complements can be fully understood through their impact on the existing five forces. We provide an example where the structure of the complements industry has a direct effect on industry profits but no impact on the five forces. We go on to explore ways to shape the force of complements and, in particular, why a firm may want to intervene in the complements industry. Including opportunities from complements as a sixth force makes the Five Forces framework more valuable, not less.

## 1. Introduction

The Five Forces model of Porter (1980) is designed to describe the sources of power that influence the profitability of an industry. In particular, an increase in any of the five forces serves to decrease industry profits. Grove (1996) supplements the Five Forces analysis with the force of complements to arrive at what he calls the Six Forces analysis.[2] While this extension seems obvious to us, it seems obviously wrong to Porter (2008) who argues that complements cannot be a distinct force and must be understood through their impact on the existing five forces.

---

[1] Adam Brandenburger is the J.P. Valles Professor at the Stern School of Business, distinguished professor at the Tandon School of Engineering, and faculty director of the Program on Creativity + Innovation at NYU Shanghai, all at New York University. Barry Nalebuff is the Milton Steinbach Professor of Management at the Yale School of Management. Financial support from NYU Stern School of Business, NYU Shanghai, and J.P. Valles is gratefully acknowledged. Contact information: adam.brandenburger@stern.nyu.edu and barry.nalebuff@yale.edu.

[2] In Brandenburger and Nalebuff (1996), we coined the term "complementor" to refer to firms that are providers of complementary products or services.

Why do we think complements must be a force? We begin with an observation on symmetry (For the role of symmetry in strategic analysis, see Brandenburger and Stuart (1996) and Foss and Hallberg (2014).) As we show below, the definitions of complements and substitutes are mirror images of each other. To include one—namely, substitutes—as a force but not the other, one would have to argue that there is something fundamentally different about the operation of substitutes versus complements. But there is no such difference. Opportunities from complements must be a force for exactly the same reason that threats from substitutes are a force. 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 bad for industry profitability. The net effect of strong complements (when taking into account the impact on the other forces) may be ambiguous, but, as we show, this is equally true of substitutes.

Because complements are the mirror image of substitutes, the sign of the effect on profitability is reversed. This is not an issue. The issue is whether the effect on industry profits is unidirectional. Porter (2008, p. 87) claims that complements are unlike substitutes because their effect on industry profits is not unidirectional 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. Complements affect profitability through the way they influence the five forces.

This view is reinforced by Adner and Lieberman (2021, p. 4), who write: "The pathways we describe convert initially positive relationships between complementors into something more adversarial." In their example, the presence of complements directly raises industry profits, but this is more than offset via the indirect effect of reducing product differentiation. On this basis, they follow Porter to conclude that the effect of complements is not unidirectional and complements are not a sixth 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, strong or not, 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 any direction.

The unidirectionality test for a force only need apply to the direct effect. Indeed, we provide an example in which the presence of strong substitutes is a net positive—rather than a negative—for industry profitability. The net effect of substitutes is ambiguous due to their impact on the other forces, in this case increasing product differentiation and thereby reducing rivalry. That doesn't mean threats from substitutes are not a force.

Porter (2008, p. 87) makes a second claim—that the effect of complements on industry profitability must be assessed via their influence on the Five Forces and only via that route. We saw this in the first quote, and we see it, again, in the second quote below:

> The strategist must trace the positive or negative influence of complements on all five forces to ascertain their impact on profitability.

This view is too narrow. We provide an example in which the complementors' market structure is fundamentally important to the base industry structure and yet there is no impact on any of the existing five forces. In particular, we consider a monopolized industry where buyer power is zero, supplier power is zero, there are no threats from entry, and 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.

And yet, when complements matter, even a monopolist has to compete with its complementors for a share of industry profits. The structure of the complements industry can have a profound effect on the base industry profits. Complementor firms are similar to customers and suppliers in that they, too, have a claim on industry profits. The strength of that claim depends on the structure of the complements industry. The monopolist's profits will be higher when the complements industry is more competitive and lower when the complements industry is also monopolized. This effect on industry profits cannot be captured via by any of the other five forces. Buyer power, for example, doesn't change—it remains at zero—with a change in the complementor industry structure. The strategist therefore cannot use the five forces to trace the positive or negative influence of complements on base industry profitability.

One contribution of this paper is to highlight the difference between the direct effect of any force—which is monotonic—and its indirect effect on the other forces that can have any sign. A second contribution is to help raise the strategic profile of complements. They are often thought of as something nice to have or potentially problematic, but are addressed more as a stepchild. We believe complements deserve equal billing. This has been happening as researchers move from industry analysis to ecosystem analysis. Early examples include Teece (1986) who considered how the market structure of complementary assets affects an innovator's ability to capture profits, and Gawer and Henderson (2007) who studied Intel's many strategies for shaping its complementor industries. More recently, Adner (2017), Jacobides, Cennamo, and Gawer (2018) and Cusumano, Gawer, and Yoffie (2019) consider the active role of complementors in ecosystems. Adner and Lieberman (2021) provide a systematic examination of how complementors disrupt established firms. We provide further examples of how complementors impact the strategic landscape in Section 4.

The main contribution of this paper is to demonstrate why complements must be a sixth force. Some accept this, e.g., Ghemawat (2017), but no one, ourselves included, has ever formally made the argument and addressed the counter-arguments.

Section 2 introduces the formal definition of complements. This definition helps highlight the essential symmetry between complements and substitutes. The mathematics suggests complements must be on an equal footing to substitutes. We also provide some brief examples that show the variety of potential complement relationships.

Section 3 presents the two arguments offered for why complements are not an independent force: (1) their effect is not monotonic; and (2) their effect is best understood through the impact of the other five forces. We show the flaws in each argument. In particular, we show that the same issues of non-monotonicity apply equally to substitutes. Therefore, a consistent application of this argument would say that substitutes are not a force. As we explain, the confusion is over the direct effect versus the effect on the other five forces. The direct effect is monotonic. The indirect effect can go in either direction and can even overturn the direct effect.

We demonstrate the flaw in the second argument by providing an example in which the effect of complements cannot be understood via its impact on the other five forces. There is a direct effect and no indirect effect. Thus it is not sufficient to consider only the impact on the existing five forces.

Section 4 provides several examples of strategic insights that come from looking at complements. In particular, every strategy with regard to a substitute has a flip when it comes to a complement.

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

**2. The Argument in Favor**

We begin by highlighting the symmetry between the definitions of substitutes and complements. Two firms identified by their products *A* and *B* are selling substitutes for a customer if

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

where *WTP*(*AB*) is the willingness-to-pay for products *A* and *B* together, *WTP*(*A*) is the willingness-to-pay for *A* alone when there is no *B*, and *WTP*(*B*) is the willingness-to-pay for for *B* alone when there is no *A*. The sub-additivity of *WTP*'s is the definition of substitution between *A* and *B*.

Equivalently, products *A* and *B* are substitutes if

$$WTP(AB) - WTP(B) \leq WTP(A) \tag{1b}$$

The additional willingness-to-pay for *A* if *B* is already owned is less than or equal to the willingness-to-pay for *A* alone. Similarly, the willingness-to-pay for *B* if *A* is already owned is less than or equal to the willingness-to-pay for *B* alone.

Inequality (1) holds us when two products *A* and *B* are substitutes for a customer. There is a mirror-image definition: In place of "≤" write "≥". That is, consider the case when *A* and *B* are related in this way:

$$WTP(AB) \geq WTP(A) + WTP(B)\,. \tag{2}$$

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 mirror-image 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.

Substitutes and complements are on the same logical footing. As a general matter, it is hard to understand how a ≤ relationship could be deemed a force while a ≥ relationship is not. The prior belief must be the two relationships are on an equal footing, up to a sign flip. Unless there is a compelling argument to the contrary, the default position should be that opportunities from complementors are a sixth force.

Complements are the mirror image of substitutes. Just as substitutes lower *WTP*, complements raise *WTP*. Just as there are threats from substitutes, there are opportunities from complements. Just as low-priced substitutes pose a greater threat, high-priced complements pose a smaller opportunity. And just as complements can raise or lower industry profits via their effect on the other forces, so can substitutes.

*Examples*

While the complementor relationship is commonly understood at an intuitive level, there are some interesting special cases along with the standard examples.

Netflix and Comcast illustrate the standard 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. Adner and Lieberman (2021) consider the effect of delivery service DoorDash on restaurant industry profits. DoorDash is as a complementor to restaurants since it makes take-out more convenient and reliable, while restaurants make DoorDash more valuable since they provide something to deliver.

[3] This definition goes back to Fisher (1892), Edgeworth (1897), and Pareto (1909).

There is the important special case of perfect complements (also called unique or strict complements). Here, each product has no value in isolation but together they create value: $WTP(A) = WTP(B) = 0$, $WTP(AB) > 0$. Back in the early days of the PC, there was one main option for an operating system (Microsoft) and one main option for microprocessors (Intel). Only the two together created a positive WTP. Other examples of perfect complements (or nearly so) are airplane bodies and airplane engines, mobile phone handsets and wireless networks, and pharmaceutical cocktails where the individual drugs have limited application, but the combination is effective.

The case of theaters on Broadway demonstrates that the classification of a relationship can be more complicated. There are elements of both substitution and complementarity in the relationships between theaters. Because there are many shows to choose from, more people decide to visit New York to take a theater holiday. Having many shows raises *WTP* and hence expands the market. This is Porter's (1998) cluster effect. Here we have complementarity arising *inside* the industry. On the other hand, once the customer is in the city, the shows become substitutes. More people come to the city, but the shows then compete for those customers. We call this relationship *ex ante complements and ex post substitutes*. Which effect is stronger will determine the net effect of the relationship.

Just as substitutes exist on both the customer and supplier side, so too do complements.[4] Broadway shows also illustrate a complementarity relationship with respect to the supplier side. A set designer has a limited engagement working on any single show. The fact that there are a large number of shows means a set designer can settle in New York and find a more steady stream of income. The same goes for lighting designers, costume designers, even actors and directors. Here, too, there are elements of both substitution and complementarity. The collection of shows helps expand the market of suppliers, but the shows are also competing for the same actors, directors, and designers. All the strategies discussed in relationship to complements on the customer side apply equally to complements on the supply side.

**3. The Arguments Against**

There are two arguments against making complements a sixth force: The effect of strong complements is not monotonic and the effect of complements can be entirely understood via their effect on the other five forces.

We start with the potentially negative net effect of strong complements. Porter (2008) provides an example where complements reduce entry barriers and thereby lower industry profits. In Adner and Lieberman (2021), DoorDash reduces the importance of a restaurant's geophysical

[4] More formally, two firms *A* and *B* are substitutes for a supplier if $WTS(AB) \geq WTS(A) + WTS(B)$. They are complementors if the relationship is $WTS(AB) \leq WTS(A) + WTS(B)$. Here, *WTS* stands for willingness-to-sell and represents the minimum amount a supplier requires to provide firm *A*, firm *B*, or both *A* and *B*. See Oberholzer-Gee (2021) for several examples of supply-side complements.

location, thereby lowering product differentiation which leads to increased rivalry (and lower profits).

Just as complements can lower industry profits via their indirect effect, substitutes can raise industry profits via their indirect effect. 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 inter-firm rivalry 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. In our example, developed formally in the Appendix, this 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. 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.

Note that this is one more application of symmetry: every argument regarding a substitute has a flipped version when it comes to a complement. If complementors can lead to more rivalry, we should be able to find an example where substitutes led to less rivalry. Every argument can be flipped.

We generally think that the net effect of threats from substitutes is to yield lower industry profits in the base industry. Generic drugs is the unusual case. Similarly, we generally think the net effect of opportunities from complements is to yield higher profits. DoorDash is the unusual case. It is fine to have the intuition that opportunities from complements generally lead to higher industry profits just as threats from substitutes generally lead to lower industry profits. Unidirectionality of the net effect is not something that must be true as a mathematical rule for either complements or substitutes. The fact that the net effect can go either way is not relevant to something being a force.

We have shown that complements satisfy the same monotonicity property as substitutes—the direct effect is unambiguous even though the net effect can go either way—and thus have equal claim to be a force. And by symmetry, complements work just like substitutes except in the opposite direction. They are on a logical par with substitutes.

Porter (2008) makes a second claim: The effect of complements on industry profitability must be assessed via their influence on the Five Forces and only via that route. We agree that complements can influence any of the Five Forces. Our issue is whether this is the only or even primary way to understand their influence. The influence of complements can have a direct effect, and this direct effect, just like with substitutes, must be understood as a distinct force.

Consider a firm, in particular a monopolist, that is in the most favorable position according to the Five Forces. Customers are all small relative to the size of the market and have no power. The firm's inputs are commodities and there are many suppliers, with no power. The firm is protected from rivalry or entry by its head start and IP. And there are no good substitutes. This was a reasonable description of Microsoft in the mid-1980s to mid-90s.

According to the Five Forces, Microsoft should have taken home literally all of the value in the value chain. And while Microsoft did do very well, there was another player who also had equal claim to this value. That player was Intel, Microsoft's complementor. In fact, during the mid-1980s to mid-90s, Intel's profits per PC sold were roughly equal to Microsoft's; see 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]

Bringing this back to Porter (2008), none of these effects can be understood via their influence on the Five Forces. Whether microprocessors are supplied by an Intel monopoly or many competing chip makers, the Five Forces for the operating system industry do not change. They are all zero. There is no customer or supplier power, no threats from entrants or substitutes, and no firm rivalry in either situation. And yet, industry profitability fundamentally depends on the industry structure of the complementors.

Another way of saying this is to follow Teece (2014) who argues we should replace 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. The force of complementors is as important as the other five forces in determining the division of ecosystem profits.

In summary, the non-monotonicity of the net effect cannot rule out complements as a force. It would have to rule out substitutes as well. And the effect of complementors 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 software industry (and vice versa).

Symmetry says that complements must be on equal footing with substitutes and we've shown the arguments against their being a sixth force don't hold up. Properly understood, the force of complements is always a positive—it is an opportunity, not a threat. Complements have a direct effect in terms of the creation of value. Opportunities from complements are on an equal footing and perfectly symmetric with threats from substitutes. This is why opportunities from complements must be a sixth force.

---

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

**4. Complementor Strategies**

We now turn to examining some economics of complements. Not surprisingly, since they are a new force, complements present some novel features.

Symmetry helped us understand why complementors are a force. Symmetry also helps us translate known strategies for substitutes into less known strategies for complements. Every strategy toward a competitor has a symmetric counterpart toward a complementor.[6] These flipped strategies are less familiar and thus provide an opportunity for fresh strategic thinking.

1. A firm prefers few or no competitors. A firm prefers many complementors.

2. A firm prefers competitor products to be low quality. A firm prefers complementor products to be high quality.

3. A firm prefers its competitors to have high unit cost. A firm prefers its complementors to have low unit cost and thereby charge a low price. This is because the extent to which a complement raises willingness-to-pay depends on its price. The higher the price, the less the residual willingness-to-pay of the customer, who considers both prices when evaluating a purchase.

4. A firm should be wary of entering the substitutes market since that may lead to increased rivalry and lower prices in the substitutes industry, and thus greater threats from the substitutes. Conversely, a firm may enter the complementor market with the direct intent to lower the price there. A lower price in the complementary market allows the firm to raise its price in its original market.

5. 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 again leads to higher profits, but here coordination raises consumer welfare. This is an argument in favor of coordination or mergers among complementors.

6. Cost competition between competitors is generally fierce. If a firm is able to lower its costs, not only will it save money on its market share, it can use the improved cost structure to take share away from rivals. Thus the profit incentive to reduce costs is large. Conversely, there is insufficient incentive to reduce costs in the strategic

[6] By "competitor" we mean providers of substitutes, whether those substitutes are inside or outside the industry in question. In particular, our use of the term "competitor" includes what in the Five Forces are called providers of substitutes. The philosophy is that customers don't care about industry boundaries. Any product that competes for their dollars needs to be considered by firms in the base industry.

interaction between complementors. This is a second argument in favor of coordination or merger among complementors.

The first two points are self-evident. But they can overturn conventional wisdom concerning focus. There is a common view that a firm should "stick to its knitting." This is not true in the case of complements in nascent ecosystems. These ecosystems often have bottlenecks and coordination issues caused by missing or inferior complements. In the residential solar power industry, one firm solved this problem by identifying and overcoming bottlenecks caused by an underdeveloped complement, specifically financing; see Hannah and Eisenhardt (2005). Even when complements do exist, a firm can't 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 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, a firm 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—since that complementor would then have a claim on the the total pie.

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 (2015). 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, Tesla has achieved a competitive advantage by having the best proprietary supply of complements.

Even in established industries, firms will take an active role in promoting the entry and development of complementors. Gawer and Henderson (2007, p. 3) describe how Intel "subsidize[s] entry into complementary markets … largely, but not only, by the development and widespread dissemination of intellectual property." At the time, Intel had over 80 percent

[7] As of June 2021, there were 38,500 Level II charging stations and 5,150 DC Fast charging stations in the US (US Dept. of Energy, 2021) 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.

market share in CPUs and understood the only way to grow substantially was to expand the market, not market share (Gawer and Henderson, 2007). That led Intel to pursue a strategy of supporting complementors.

Point 3 is also clear. Since some customers care about the combined price of the complementary products, a firm will look for strategies that will reduce the price charged by its complementors.[8] A lower cost structure for the complementor will help support a lower price. This may lead a firm to help its complementor lower its cost by, for example, sharing demand forecasts or providing access to forthcoming technologies.

Generally speaking, firms in an industry want their complements to have a low price, and the lower the better. The case of ex ante complements and ex post substitutes provides a partial exception to this rule. Here, a firm wants such products to have a low-enough price to be effective in expanding the market, but a high-enough price not to take away its customers.

Point 4 helps us understand the complicated dynamic between complementor firms. Complementors are both friend and foe (Brandenburger and Nalebuff, 1996). While a firm wants to have complementors in the market, it generally wants the complements to be inexpensive. A firm has two ways to expand demand via pricing: reduce its price or reduce the price of its complementor. Reducing its price leads to lower margins. Reducing the price of its complementor increases demand with no effect on margin. Thus firms have an incentive to reduce the pricing power of their complementors.

For this reason, a firm might want to enter the complementor market or intervene in ways that make the complements market more competitive. Microsoft and Intel have each at times worked to make the industry structure of the other more competitive. Microsoft seeks to make the chip industry more competitive. Thus we have seen Microsoft support AMD to help it be a more effective rival to Intel. Turning the tables, Intel doesn't want Microsoft to have power in its industry, and this has led Intel to support Linux and Apple as rival operating systems; see Casadesus-Masanell and Yoffie (2007).

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 firm *B*'s, if there are several) 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 home market with higher prices (Nalebuff, 2005).

---

[8] In the case of perfect complements, customers only buy *A* and *B* together and thus customers only care about the combined price. In other cases, some but not all customers will buy the two complements together. Those customers (along with those on the margin) care about the combined price.

While a firm wants the price of its complementors to be low, if the price is too low that can lead to problems. A firm wants to preserve the investment incentives on the part of complementors; see Farrell and Katz (2000).[9] As explained by Gawer and Henderson (2007), Intel created the Intel Architecture Lab and structured it as a standalone not-for-profit unit; the structure was a commitment device to help Intel support the complementor markets without also sucking up all the profits in those markets and thereby deterring investment and entry. This example of Intel's intervention in the complements industry is another illustration of why the force of complements cannot be understood only through their impact on the existing five forces. The industry structure of the complements market directly impacts the base industry profits, separate from any effect on buyer power, supplier power, rivalry, entry, or substitutes.

Point 5, that coordination between complementors leads to lower prices and higher profits, is a result going back to Cournot (1838, pp. 100–103), who observed that prices are inflated when separate monopolists control the pricing of perfect complements. The problem with a lack of coordination between complementors is identical to the problem of double marginalization along a 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.

When a complementor chooses a price to maximize profits, it is indifferent between raising or lowering its price by a small amount (say $1). But the firm is not indifferent as to the price its complementor charges: it would like to see its complementor lower its price since that increases demand.[10] Thus two complementors could propose the following trade: Firm *A* will lower its price by $1 if firm *B* will lower its price by $1. The direct effect of a lower price is a wash for both firms. But the indirect effect is a pure win since demand is increased with no hit to margin.

This also suggests that two complementors that merge can 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).

The situation is more complicated if there are multiple firms providing each of the complements. A merger of complementors may lower the number of options consumers have to mix-and-match across complements. If all complements are sold as packages, the resulting bundle-against-bundle competition lowers prices when there are only two competing bundles

---

[9] 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.

[10] This argument relies a reduction in the price of the complement leading to an increase in demand. Cheng and Nahm (2007) consider a model in which the essential nature of the complements only runs one way: *A* is essential to *B*, but *B* is not essential to *A*. (In our notation, $WTP(AB) \geq WTP(A) > 0$ and $WTP(B) = 0$.) In such cases, they show there will not be a double marginalization problem if the customer indifferent to buying *A* does not also buy *B*. Lowering the price of *B* has no effect on the demand for *A* since the demand for the complements are, in effect, "independent" at the equilibrium prices.

but will raise prices as the number of bundles becomes large; see Nalebuff (2000) and Zhou (2017). If only some of the complements are sold as packages, it may be hard for single-product firms to compete against a multi-product firm that offers a bundled pricing discount; see Whinston (1990), Nalebuff (2004), and Choi (2008). The complements sold independently face a coordination problem that hampers them from matching the bundle price. We saw this in the early days of Microsoft Office software. It was far cheaper to purchase the bundle of Microsoft's Word, Excel, and Powerpoint than to buy WordPerfect, Lotus, and Harvard Graphics separately. The single-product firms all lost out.

Point 6, that there are insufficient incentives to lower costs, follows from the equal-profit result for perfect complements; see Cournot (1838, p. 102) and Casadesus-Masanell, Nalebuff, and Yoffie (2010). Two monopolists, *A* and *B*, selling perfect complements earn equal profits *even when their costs differ*.[11] Since each firm's product is essential, demand for each firm must be the same. It depends only on the combined price and is therefore equal to $D(p_A + p_B)$. Thus the change in demand from an increase in price, $D'(p_A + p_B)$, is identical for firms *A* and *B*. Since $D$ is the same for both firms and likewise for $D'$, we get $p_A - c_A = p_B - c_B$. Since profit margins are the same, so are profits: $\Pi_A = \Pi_B$.[12]

If profits are always equal, this means if firm *A* is able to lower its unit costs by $1, it will only save 50¢ per unit on its existing market. Remember that profits will still be equal after the cost reduction. Thus the complementor firm *B* will increase its price by 50¢ while firm *A* (after cost reduction) will reduce its price by 50¢.[13] Firm *A* with the $1 cost reduction will see an increase in profits primarily due to the 50¢ increase in profit margin, as will the complementor firm *B* that has increased price by 50¢.

The incentive to reduce cost is cut in half. The expenses associated with cost reduction activity are entirely borne by one firm, while the gains are spread equally between the firm and its complementor. Thus we expect to see inflated costs when there is a complementary relationship between firms. Even if the two complements are not essential, so that profits need not be equal, provided any of the increased profits from reduced cost flow to the complementor, the leakage leads to an insufficient incentive to lower cost.

There is a public policy implication of the fact that complementarity is the mirror image of substitution. We have two reasons for mergers between complementors. The first is to provide proper incentives to cut costs. The second is to provide incentives to reduce double

---

[11] As previously noted, lifetime profits earned by Intel and Microsoft from each PC were roughly equal over the mid 80s to mid 90s; see Table 1 in Casadesus-Masanell, Nalebuff, and Yoffie (2008). This was true even though hardware has much higher marginal costs than software.

[12] This result assumes constant marginal costs and equal fixed costs.

[13] In addition, the base price for both firms will fall a small amount and demand will rise, but this will have no first-order impact on profits.

marginalization. While mergers between competitors generally lead to higher prices, here *both* effects lead to lower prices and greater consumer welfare.[14]

**5. Conclusion**

Complements are more than something nice to have. They constitute a force and one that has been less studied and less understood. One proof of this is there has had to be a debate about whether or not they are on equal footing with 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 opportunities from complements any differently than threats from substitutes. The objection that opportunities from 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. In particular, the structure of the complements industry will have a direct effect on 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). How does one discover strategies that have not been considered? Symmetry points where to look. We have shown that the tool of symmetry is essential to providing a more complete map and therefore essential to shaping the business landscape. In particular, the strategist can flip any existing strategy toward substitutes and apply it to complements.

We see complements as a complement to the Five Forces framework. Including opportunities from complements as a sixth force makes the framework more valuable, not less.

[14] 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) and Nalebuff (2004). Even if the merged firm engages in mixed bundling, Masson, Dalkir, and Eisenstadt (2014) demonstrate potential downsides to consumer welfare. Customers may be driven away from making their ideal mix-and-match combination of complements and the combined monopolist may be able to do a better job of price discrimination.

**6. References**


Adner R (2017) Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*, 43: 39 –58.

Adner R, Lieberman M (2021) Disruption Through Complements. *Strategy Science*, 6: 91–109.

Brandenburger A, Nalebuff B (1996) *Co-opetition* (Doubleday, New York).

Brandenburger A, Stuart H (1996) Value-Based Business Strategy. *Journal of Economics and Management Studies* 5: 5–24.

Casadesus-Masanell R, Nalebuff B, Yoffie D (2008) Competing Complements. Harvard Business School Working Paper, No. 09-009.

Casadesus-Masanell R, Yoffie D, (2007) Wintel: Cooperation and Conflict. *Management Science* 53: 584–598.

Cheng L, Nahm J (2007) Product Boundary, Vertical Competition, and the Double Mark-up Problem. *RAND Journal of Economics*, 38: 447–466.

Choi J (2008) Mergers with Bundling in Complementary Markets. *The Journal of Industrial Economics*, 56: 553–577.

Choi J, Stefanadis C (2001) Tying, Investment, and the Dynamic Leverage Theory. *RAND Journal of Economic*s, 32: 52–71.

Cournot A, *Recherches sur les Principes Mathématiques de la Théorie des Richesses* (1838) Paris: Hachette. English translation: (Bacon N, trans.), *Research into the Mathematical Principles of the Theory of Wealth* (James and Gordon, Mountain Center: CA, 1995).

Cusumano M, Gawer A, and Yoffie D (2019), *The Business of Platforms: Strategy in the Age of Digital Competition, Innovation, and Power* (Harper Business, New York).

Economides N, Salop S (1992) Competition and Integration Among Complements, and Network Market Structure. *Journal of Industrial Economics*, 40: 105–123.

Edgeworth, F (1897) Teoria Pura del Monopolio. *Giornale degli Economisti* 15: 13–31. Translated as “The Pure Theory of Monopoly” in *Papers Relating to Political Economy*, Vol. I. (Macmillan and Co., London, 1925) 111–142.

Farrell J, Katz M (2000) Innovation, Rent Extraction, and Integration in Systems Markets. *Journal of Industrial Economics.* 48: 413–432.

Fisher I (1892) *Mathematical Investigations in the Theory of Value and Prices* (Yale University Press, New Haven reproduction, 1925) of Yale dissertation appearing in *Transactions of the Connecticut Academy of Arts and Sciences*, 9: 1–124.

Foss N, Hallberg N (2014) How Symmetrical Assumptions Advance Strategic Management Research. *Strategic Management Science* 35: 903–913.

Gawer A, Henderson RM (2007) Platform Owner Entry and Innovation in Complementary Markets: Evidence from Intel. *Journal of Economics and Management Strategy* 16: 1–34.

Ghemawat P (2017) *Strategy and the Business Landscape* Ghemawat Publishing, 4th edition.

Grove A (1996) *Only the Paranoid Survive: How to Identify and Exploit the Crisis Points That Challenge Every Business* (Doubleday, New York).

Hannah D, Eisenhardt K (2018) How Firms Navigate Cooperation and Competition in Nascent Ecosystems. Special issue on the Interplay of Competition and Cooperation. *Strategic Management Journal* 39: 3163–3192.

Heeb R (2003) Innovation and Vertical Integration in Complementary Markets. *Journal of Economics and Management Strategy* 12: 387–417.

Jacobides M, Cennamo C, Gawer A (2018) Towards a Theory of Ecosystems. *Strategic Management Journal*, 39: 2255–2276.

Masson R, Dalkir S, Eisenstadt D (2014) A Note on Complementary Goods Mergers between Oligopolists with Market Power: Cournot Effects, Bundling and Antitrust. *Review of Law and Economics* 10: 59–79.

Nalebuff B (2000) Competing Against Bundles. In Hammond, P, Myles G (eds.), *Incentives, Organization, and Public Economics*, (Oxford University Press, Oxford).

Nalebuff B (2004) Bundling as an Entry Barrier. *Quarterly Journal of Economics* 119: 159–187.

Nalebuff B (2005) Exclusionary Bundling. *The Antitrust Bulletin* 50(3): 321–370.

Oberholzer-Gee F (2021) *Better, Simpler Strategy: A Value-Based Guide to Exceptional Performance* forthcoming (Harvard Business Review Press, Boston).

Ordover J, Sykes A, Willig R (1985) Nonprice Anticompetitive Behavior by Dominant Firms Toward the Producers of Complementary Products. In Fisher, F. (ed.), *Antitrust and Regulation: Essays in Memory of John J. McGowan* (MIT Press, Cambridge: MA).

Pareto V (1909) *Manuel D'economie Politique* (V. Giard & E. Briere, Paris).

Porter M (1980) *Competitive Strategy: Techniques for Analyzing Industries and Competitors* (Free Press, New York).

Porter M (1998) Clusters and New Economics of Competition. *Harvard Business Review.* 76: 77–90.

Porter M (2008) The Five Competitive Forces That Shape Strategy. *Harvard Business Review.* 86: 79–93.

Ramo J (1997) Andrew Grove: A Survivor's Tale. *TIME* at http://content.time.com/time/subscriber/article/0,33009,987588-1,00.html.

Spengler J (1950) Vertical Integration and Antitrust Policy. *Journal of Political Economy* 58: 347–352.

Teece D (1986) Profiting from Technological Innovation. *Research Policy* 15: 285–305.

Teece D (2014) Business Ecosystems. Entry in *Palgrave Encyclopedia of Management*, Augier M, Teece D, Eds. (Palgrave, MacMillan, London).

US Department of Energy (2021) https://afdc.energy.gov/fuels/electricity_locations.html#.

Van den Steen E (rev. 2015) "Tesla Motors," Harvard Business School case 9-714-413.

Whinston M (1990) Tying, Foreclosure, and Exclusion. *American Economic Review* 80: 837–859.

Zhou J (2017) Competitive Bundling. *Econometrica* 85: 145–172.

## 7. Appendix

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 consumers 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.

We assume 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(x) – x for the branded drug from firm 0 and V(x) – (1–x) from firm 1. We assume that V(x) = 3 for all customers in [0, 0.3) and (0.7, 1], and V(x) is 2 for all customers 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 VG(x) – |x – 0.5|, where we assume VG(x) = 0.92 for all customers. The generic is less valuable than the branded drug, but it is also 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 consumers in the "middle" of the market and leave those near the original firms. The remaining consumers 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.*

In the Nash equilibrium, both firms charge a price p = 1. Each firm captures the half of the market closest to its position. Profits are 0.5 for each firm.

*Proof:* Firm 0's profits when it charges a price p 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. 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 consumers have a valuation of at least 2 and transportation costs are no more than 0.5, even the consumer 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.*

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 consumers 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.

*Proof*: The 0 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:

$$\Pi_0 = p(0.3 - 0.5(p - 1.98)) \quad for \ p \geq 1.98,$$

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

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

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

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

If firm 0 chooses to raise its price above 1.98, it will start to lose consumers to the generic product. The consumer 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:

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

In this interval, firm 0 maximizes its profits by charging p = 1.98. Profits are 1.98 x 0.3 = 0.594.

In the next interval, firm 0 doesn't gain any of the generic consumers. It would have to lower its price all the way to 0.98 to attract the generic consumer located at 0.3. Therefore there is no gain in lowering price unless the price is low enough to steal some consumers 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 steal 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 0.3 market share.

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 a firm that is indifferent picks the

high-price strategy. We can also adjust the prices slightly so that the firm strictly prefers the high price.)

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:

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

Once firm zero 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 0.594 profits 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 consumers from the market, leaving the incumbents the ability to raise prices substantially. What limits the price rise is a concern of losing more consumers 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.