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Vertical firm structure and industry evolution

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Abstract

The analysis presented here suggests that the evolution of vertical firm structure depends on contextual factors that differ in their impact across industries and produce different patterns of vertical firm structure. These contextual factors make it possible to account for specific features of the evolution of vertical firm structure using a systematic approach that evaluates the same contextual factors in every industry. The automobile and aluminum industries illustrate how these contextual factors can explain the evolution of vertical firm structure.

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A great deal of ... work has been done on vertical firm structure ... but it does not directly address the evolution of vertical firm structure in new industries.
—Steven Klepper (1997)

1. Introduction

What sort of vertical firm structure characterizes an industry at its inception, and how does vertical firm structure evolve over time? And as industries evolve, do they go through typical phases of vertical firm structure? Since the publication of Steven Klepper's article on industry lifecycles in this journal *Industrial and Corporate Change* in 1997, additional research has examined these questions. An evaluation of both theoretical analyses and empirical research, however, reveals no simple answers. Although both theory and evidence suggest that industries often start out or quickly become integrated and then disintegrate later in their lifecycles, many industries do not follow this pattern. In addition, central tendencies in the evolution of vertical firm structure often mask significant intra-industry variation. The analysis presented here suggests that the evolution of vertical firm structure in an industry depends on contextual factors that differ in their impact across industries, and produce different patterns of vertical firm structure over time in different industries. These contextual factors make it possible to account for specific features of the evolution of vertical firm structure in an industry, using a systematic approach that evaluates the roles played by the same contextual factors in every industry.

Most research on the relationship between vertical firm structure and industry evolution starts with the seminal work of Stigler (1951), who proposed a pattern and rationale for the evolution of vertical firm structure in an industry. Subsequent research has explicitly or implicitly suggested modifications of, or errors in, Stigler's (1951) approach. Different contributors, however, have focused on different factors that affect the evolution of vertical firm structure—with the attendant risk that each contribution illuminates only one or a few parts of the proverbial elephant. The following analysis provides an organized understanding of research thus far on the evolution of vertical firm structure within industries. The analysis also identifies a set of contextual factors that help to explain patterns of vertical firm structure over time. Two industries for which there is detailed information illustrate how these contextual factors can explain the evolution of vertical firm structure.

For purposes of this analysis, an industry is defined as one in which firms produce a specific product or service; vertically integrated firms are those partially or fully integrated upstream (backward) or downstream (forward) into at least one stage of the vertical chain other than production of the product or service in question. This can include integration into noncontiguous stages of the vertical chain. The analysis compares vertical integration with nonintegration (specialization in a single stage of the vertical chain). An examination of vertical alliances, joint ventures, and partnerships is beyond the scope of this analysis. Although a great deal of research has studied these intermediate types of organizational structures, little research has dealt with their long-term evolution within industries.

The analysis begins with a summary of Stigler's (1951) argument regarding the evolution of vertical firm structure within industries, followed by a synthesis of subsequent arguments. The analysis then identifies a set of contextual factors that determine the evolution of vertical firm structure, and the different patterns of vertical firm structure that may result. An examination of the evolution of vertical firm structure in the automobile and aluminum industries illustrates how contextual factors can explain the observed patterns of vertical structure. The analysis concludes with suggestions for future research.

2. Theoretical explanations

Explanations of the evolution of vertical firm structure often focus on central tendencies in an industry. The following discussion begins with these explanations, and then examines intra-industry variation in the vertical structure of firms over time.

2.1 Stigler's argument

Stigler (1951) originally proposed that the evolution of vertical firm structure in an industry depended on the size of the market and the attendant division of labor over time. Stigler (1951) argued that a new industry is populated by vertically integrated firms, followed by vertical disintegration when the market grows large enough to support economies of scale in different stages of production, followed by reintegration when the size of the market declines. As Stigler (1951: 190) explained:

> Young industries require new kinds or qualities of materials and hence make their own; they must overcome technical problems in the use of their products and cannot wait for potential users to overcome them; they must persuade customers to abandon other commodities and find no specialized merchants to undertake this task. These young industries must design their specialized equipment and often manufacture it, and they must undertake to recruit (historically, often to import) skilled labor. When the industry has attained a certain size and prospects, many of these tasks are sufficiently important to be turned over to specialists. It becomes profitable for other firms to supply equipment and raw materials, to undertake the marketing of the product and the utilization of by-products, and even to train skilled labor. And, finally, when the industry begins to decline, these subsidiary, auxiliary, and complementary industries also begin to decline, and eventually the surviving firms must begin to reappropriate functions which are no longer carried on at sufficient rate to support independent firms.

In analyzing the division of labor between upstream and downstream operations at the start of an industry, Stigler (1951) used the example of a manufacturer producing a downstream output at minimum efficient scale while also producing the necessary inputs. According to Stigler (1951), when the market expands, its larger size enables the firm to outsource the production of inputs that are subject to economies of scale rather than make them in-house at a less efficient (smaller) scale that matches the scale of production of the downstream good. That is, a specialized supplier can take advantage of economies of scale because the size of the market for the downstream good has expanded.

This depiction raises obvious questions, such as: why does not an independent supplier produce at suboptimal scale at the inception of the industry and sell the output to the downstream firm (Langlois, 1988)? As an implicit answer to this question, Stigler (1951) argued that the downstream firm cannot persuade another firm to supply these inputs early in the life of an industry. Adelman (1955) added that as industries grow, they experience a time lag between the need for a new factor and its supply, so firms initially produce the input themselves. A similar argument would apply to the need for specialized merchants identified by Stigler (1951). In making these arguments, however, both Stigler (1951) and Adelman (1955) assumed that independent rather than integrated firms would produce when a large enough market size made it possible to take advantage of economies of scale. This, however, raises the question of why the downstream firm does not expand production of an upstream good and sell any excess to other downstream firms. Questions such as these suggest that the division of labor does not provide a complete explanation of the evolution of vertical firm structure. The following discussion synthesizes several lines of argument subsequent to Stigler (1951) that provide additional explanations of the evolution of vertical firm structure. The discussion focuses on arguments that have related vertical firm structure to industry evolution, rather than on the larger universe of explanations for vertical integration. (For a survey of much of the economics literature on vertical integration, see Perry, 1989.)

2.2 Transactions costs, systemic innovation, and product standardization

A number of scholars have argued that Stigler's (1951) depiction leaves out a critical determinant of firm boundaries, namely, transaction costs of using markets (Coase, 1937; Williamson, 1975, 1985). High market transaction costs (henceforth, "transaction costs") cause buyers to be wary of contracting with suppliers and vice versa, leading firms to vertically integrate (Williamson, 1971, 1975, 1985). Conversely, in the absence of transaction costs, firms can draw up a contract for joint production (Williamson, 1971, 1975; Teece, 1980). These arguments imply that transaction costs rather than economies of scale determine vertical firm structure. In particular, even when industries are too small to support economies of scale in upstream production or distribution, firms need not integrate if transaction costs are low.

Transaction costs, however, may be high at the start of an industry. Industries generally originate from an innovation, often technological, that leads to the introduction of a new product or service (Klepper, 1997). Because the design of the product and manufacturing specifications are not well developed, buyers and suppliers must coordinate under conditions of high uncertainty regarding the type and cost of inputs needed in the future (Teece, 1996). Similar logic applies to the design of a new service and the operations to deliver it. (Henceforth, a "product" refers to a product or service.) Such high uncertainty substantially raises transaction costs of negotiating and writing contracts that account for future contingencies, as well as costs of potential litigation in the future due to incompletely specified contracts (Williamson, 1971, 1975).

Additionally, if the design of the product or the production process is not standardized early in an industry's lifecycle, a buying firm may require inputs or upstream assets specific to its needs—an instance of what is termed "asset specificity" (Williamson, 1985). Buyers become dependent on individual suppliers, who may opportunistically seek to "hold up" buyers to obtain better terms of trade (Williamson, 1985). Moreover, innovations at the origin of industries may rely on proprietary technology. This raises transaction costs because a buyer with a proprietary technology would have to reveal it to a supplier, exposing the buyer to potential hold-up by the supplier who could threaten to make the technology public (Teece, 1996).

In the preceding arguments, the lack of a standardized product design at the start of an industry matters a great deal because buyers and suppliers must coordinate closely. New production processes may also require close coordination between upstream and downstream stages of production. Teece (1996) refers to these sorts of innovations and technologies as "systemic," in that they require alignment and coordinated adjustment across different stages of a vertical chain (Teece, 1996: 205). In contrast, an "autonomous" innovation or technology does not require coordination with, or modifications of, other stages of the vertical chain (Teece, 1996). Transaction costs of coordination are therefore low in a new industry based on an autonomous innovation, favoring a nonintegrated firm structure. Conversely, in a new industry based on a systemic innovation, transaction costs of close coordination through contracting are often prohibitively high, favoring vertical integration.

As an industry based on a systemic innovation evolves, the product may become more standardized (Langlois, 1992), particularly as a dominant design emerges (Abernathy and Clark, 1985; Anderson and Tushman, 1990). Product standardization reduces uncertainty about future costs and types of inputs, which lowers transaction costs. In addition, product standardization may reduce asset specificity because buyers may no longer require as many specialized inputs, again reducing transaction costs. And as products standardize, they no longer rely on proprietary technology, which also lowers transaction costs. Moreover, product design often becomes more modular as products standardize (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000), such that the interfaces between product components become codified and design changes take place only within components. Qian *et al.* (2012) have referred to transaction costs that decrease over time in this manner as "transient" (and transaction costs that persist over time as "enduring"). Under these conditions, integrated firms may disintegrate and specialized (nonintegrated) firms may enter an industry, leading to less vertical integration over time.

Toward the end of the industry lifecycle, Stigler (1951) observed that the reduced size of the market may accommodate only a small number of upstream and downstream firms at an efficient scale of production. This observation suggests that "small numbers bargaining" between upstream and downstream producers, and the potential for hold-up, may lead to high transaction costs. This in turn may promote reintegration as industries decline.

The foregoing portrayal of the evolution of vertical firm structure may not hold in every industry. Langlois and Robertson (1989) noted that firms may not disintegrate as an industry grows if firms must protect sources of supply and distribution networks (see also Penrose, 1959[1995]) due to potential threat of hold-up by suppliers and distributors. For example, physical asset specificity—such as that involving co-location of buyers and sellers—may lead to the potential for hold-up (Williamson, 1983; Joskow, 1985). A small numbers bargaining problem caused by small numbers of buyers and suppliers in some mature industries may also create supply risk, leading to vertical integration (Williamson, 1985). Additionally, if demand fluctuates randomly in downstream markets, the need for frequent renegotiations with suppliers may raise transaction costs. In a somewhat different argument, Carlton (1979) also showed that in a downstream market characterized by demand uncertainty, downstream firms may have incentives to integrate upstream to raise profits through guaranteed supply of inputs. For all of these reasons, firms may remain vertically integrated as an industry evolves.

2.3 Capabilities, systemic innovation, and product standardization

Internal firm capabilities also affect the evolution of vertical firm structure within an industry (Malerba *et al.*, 2008). For example, systemic innovations in products and services benefit from internal integrative capabilities for communication and coordination across stages in a vertical chain (Helfat and Campo-Rembado, 2014). These capabilities facilitate what Monteverde (1995: 1629) termed "unstructured technical dialog," defined as "unstructured, uncodifiable, generally verbal and often face-to-face communication" that facilitates "integrated problem solving" and "mutual adaptation" between stages of production. Therefore, new industries based on systemic innovations or technologies are likely to be vertically integrated due to the benefits of internal integrative capabilities (net of internal coordination costs) (Helfat and Campo-Rembado, 2014). Conversely, new industries based on autonomous innovations do not benefit from internal integrative capabilities and are therefore more likely to have nonintegrated firm structures.

Capabilities have other effects on vertical firm structure at the start of an industry as well. As suggested by Stigler (1951), suppliers and distributors in other industries may not have capabilities well suited to the new product. In addition, supply risk can arise from poor competence of suppliers within the industry (Langlois, 2003). A similar argument applies to poor competence of distributors and consequent distribution risk. Langlois and Robertson (1989) also noted that in the course of introducing a systemic innovation, integrated firms may develop lower cost production technologies than those of external suppliers, suggesting yet another reason why vertical firm structure may prevail early in the lifecycle of an industry. In addition, Argyres and Mostafa (2015) argued that when spinoffs inherit knowledge from their parent firms regarding a particular stage of production, this knowledge provides the basis for capability development in that stage of production, making vertical integration into that stage more likely.

Many industries experience a shakeout, often within 20–30 years of birth (Gort and Klepper, 1982; Agarwal and Gort, 1996). Bigelow and Argyres (2008) argued that during an industry shakeout, older nonintegrated firms with superior downstream production capabilities gained through prior experience are likely to integrate into production of critical components (those that have a large impact on costs) for the following reason: due to strong cost-based competition among manufacturers during shakeouts, suppliers of critical components have high bargaining power and therefore can hold up manufacturers' returns to prior investment in downstream production capabilities. As a result of this impact of transaction costs on the returns to capabilities, older, more experienced firms may integrate upstream into production of critical components.

As industries continue to evolve, under some conditions firms may benefit less from vertical integration. For example, if products standardize, firms need not tailor manufacturing processes to as many unique inputs, and therefore no longer require as extensive communication and coordination across stages of the vertical chain. The benefits of integrative capabilities therefore may decline, leading industries to vertically disintegrate.

In addition to the foregoing arguments, Jacobides and Winter (2005) suggested that firms may proactively seek to make stages of production more modular to benefit from capabilities within stages of production. They observed that firms are likely to have heterogeneous capabilities: some firms have better capabilities in one stage of production and other firms have better capabilities in other stages of production. This suggests that firms have an incentive to reduce transaction costs, so that each firm can focus on the stage of production where it has a relative advantage (see also, Jacobides, 2005). As a result, transaction costs fall endogenously, speeding the disintegration process.

Although standardization of products and interfaces between stages of production promotes vertical disintegration, standardization may not occur in all industries. Under such circumstances, vertical integration improves the ability of firms to adapt to complexity and uncertainty (Helfat and Teece, 1987). In addition, integrated firms may improve their integrative capabilities through learning over time, providing an additional benefit of remaining integrated (Bigelow and Argyres, 2008). Moreover, managerial economies in managing multiple stages of production—stemming from the application of "managerial capabilities" that are learned over time (Hugill and Helfat, 2014)—may lead to continuing vertical integration even if not the original reason (Penrose, 1959[1995]). Conversely, managerial diseconomies of managing multiple stages of production would have the opposite effect (Arora and Bokhari, 2007).

2.4 Additional explanations of central tendencies in the evolution of vertical structure

Scholars have suggested additional reasons why industries may or may not start out vertically integrated, and why they may or may not disintegrate later. Although Stigler (1951) argued that vertical integration at the outset of an industry would occur due to the difficulty of persuading independent firms to supply inputs and provide distribution, the converse may also hold. In particular, if producers in a new industry can use inputs or distribution and marketing services provided by firms in other industries, industries need not have a vertical structure at the outset. Adelman (1955: 318) thus characterized new industries as an "arrangement of known and available resources." Similarly, Langlois and Robertson (1989) argued that in the early phases of an industry, technologies are not well developed, firms are small, and lack managerial capability; therefore, firms use inputs available from elsewhere. As the needs of the industry become more specialized, however, "systemic rearrangements" of technology and methods of production often occur, and firms vertically integrate (Langlois and Robertson, 1989).

Whether or not industries subsequently disintegrate may depend on several factors that fall under the general category of hysteresis (history dependence), in addition to other factors discussed earlier. For example, Argyres and Liebeskind (1999) argued that firms may remain vertically integrated due to "governance inseparability," in which past choices of governance form such as vertical integration constrain changes in governance mechanisms. In addition, integrated firms may face barriers to exit, such as those arising from sunk costs (Harrigan, 1984; Nickerson and Silverman, 2003). Moreover, some industries may experience "demand lock-in" such that customers find it difficult to switch from integrated to nonintegrated producers (Malerba *et al*., 2008). Improvement of capabilities through learning, mentioned earlier, is also a form of hysteresis.

Finally, although relatively little of the literature concerned with the evolution of vertical firm structure has considered market power (with notable exceptions such as Stuckey, 1983), Klepper and Simons (2000) highlighted the role of market power in industry evolution more generally. In addition, much of the literature on vertical integration in economics has focused on the possibility that vertical integration may enable firms to increase their market power by driving out competitors or raising barriers to entry (for a review, see Riordan, 2008). Vertical integration may also enable a monopolist to price discriminate (Stigler, 1951; Perry, 1989). If these factors lead firms to vertically integrate, they may affect the evolution of vertical firm structure in an industry.

2.5 Variation within industries in vertical firm structure over time

The foregoing arguments have to do with central tendencies in the evolution of vertical firm structure within industries. Firms, however, may also differ within industries in the evolution of their vertical structure. In particular, as next explained, integrated and specialized (non-integrated) firms may coexist later in the lifecycle of an industry, such that some integrated firms may remain integrated while others disintegrate or new specialized firms enter the industry.

One of the first arguments of this type came from Christensen *et al*. (2002) based on the observation that, in some industries, "disruptive" products displace existing products partway through the industry lifecycle. Christensen *et al*. (2002) argued that new nonintegrated entrants introduce a disruptive product based on a modular design that is cheaper to make than the existing product offered by integrated firms. Christensen *et al*. (2002) reasoned that to survive, vertically integrated firms would improve the functionality of the existing product through systemic innovation using their integrated structure. These firms would then serve the most demanding customers, differentiating their products through systemic innovation, and would coexist with the lower cost nonintegrated entrants. In a related argument, Argyres and Bigelow (2010) suggested that if product designs become more modular as industries evolve, some firms may stay integrated to employ a differentiated products strategy while the remainder of the industry would disintegrate and compete based on cost-reducing innovations in components developed by suppliers. Kapoor (2013) also argued that integrated firms might survive as industries evolve by offering differentiated products based on systemic innovations. In a sense, these arguments begin to bring together the emergence of industry submarkets (Klepper and Thompson, 2006) with the evolution of vertical firm structure.

Christensen *et al*. (2002), Argyres and Bigelow (2010), and Kapoor (2013) suggested that specialized firms may coexist with integrated firms later in the industry lifecycle because these firms produce different types of products. Helfat and Campo-Rembado (2014) proposed that some firms may remain integrated later in the industry lifecycle even when specialized and integrated firms produce identical products. They argued that in industries with successive systemic product innovations, such that each innovation undergoes a cycle of systemic innovation followed by standardization, integrated firms pioneer these innovations and specialized firms can enter when the technology standardizes. Integrated firms, however, may not disintegrate each time product standardization occurs if they anticipate subsequent systemic innovations for which their vertical structure and associated integrative capabilities would prove valuable. Thus, integrated and specialized firms producing the identical product may coexist during periods in the industry lifecycle when product standardization has occurred.

These explanations suggest that industries that start out integrated may not fully disintegrate, and that integrated and nonintegrated firms may coexist later in the industry lifecycle. The arguments highlight the impact of changes in technology and product design partway through the industry lifecycle.[1] In addition, entry by specialized firms plays a role in the arguments of both Christensen *et al*. (2002) and Helfat and Campo-Rembado (2014). Finally, although not examined in these models, changes in public policy, including in law and regulation, may also affect entry, exit, and the evolution of vertical firm structure.

3. Contextual factors and the evolution of vertical firm structure

The foregoing synthesis of prior literature makes clear that the evolution of vertical firm structure depends on many different factors that vary in importance depending on the context—henceforth, termed "contextual factors." For example, a systemic innovation is a contextual factor that applies in some industries at some points in time, but not others. Additionally, some industries experience shakeouts but others do not (Klepper, 1997). And as industries evolve, products may standardize more in some industries than others. Moreover, even if products standardize, their designs may or may not become modular (Jacobides *et al*., 2014). Transaction costs and integrative capabilities may also vary in importance across industries and time. In addition, firms may find it easier to lower transaction costs in some industries than others. For example, although mortgage securitization and codification of standards for home mortgage lending lowered transaction costs and led to vertical disintegration of the industry (Jacobides, 2005), not all products are as amenable to such codification of information or creation of modular interfaces.

The following list of contextual factors, summarized in Figure 1, derives from the literature discussed above. This list does not include the size of the market as suggested by Stigler (1951), because subsequent research has suggested that more fundamental contextual factors drive firm decisions regarding vertical integration over time[2]:

1. *Systemic versus autonomous innovation or technology (product or process)*: at the origin of an industry and as the industry evolves, including for successive new products.

1 In a related argument, Balakrishnan and Wernerfelt (1986) noted that under conditions of frequent technological change and high asset specificity, firms would not vertically integrate if the time period between technological changes was too short to allow the firms to recoup the sunk costs of investing in specialized assets.

2 Bresnahan and Gambardella (1998) provide a model in which the number of downstream buyers in multiple markets affects the evolution of vertical firm structure, but the model does not apply to the evolution of a single market examined here.

Primary Factors

Systemic versus autonomous innovation or technology
Product standardization (potentially accompanied by product modularity)
Transactions costs
Capabilities (integrative, within stages of production, managerial)

Secondary Factors

Availability of suppliers, downstream producers, and distributors
Industry shakeout
Differentiated versus low cost product
Market power
Hysteresis
Punctuated change

Figure 1. Contextual factors in the evolution of vertical firm structure within industries.

2. *Product standardization*: sometimes accompanied by product modularity, subsequent to systemic innovation.
3. *Market transaction costs*: arising from factors such as small numbers bargaining and associated supply or distribution risk, asset specificity, uncertainty, and proprietary technology.
4. *Firm capabilities*: integrative capabilities and associated unstructured technical dialog, capabilities within stages of production, and managerial capabilities.
5. *Availability of competent suppliers, producers further downstream, and distributors*: in other industries or the focal industry.
6. *Industry shakeout*: impact on integration into critical components.
7. *Differentiated versus low cost product*: differentiation with reliance on systemic innovation or technology versus low cost product with reliance on autonomous innovation or technology, particularly later in the industry lifecycle.
8. *Market power*: sought and potentially maintained through vertical integration.
9. *Hysteresis*: temporary or long-lived, stemming from factors such as demand lock-in, learning, sunk costs and other barriers to exit, and governance inseparability.
10. *Punctuated change*: including with respect to technologies, products, public policy, and competitors (including entry and exit).

Prior literature has tended to focus on the first four contextual factors. The first two—systemic versus autonomous innovation or technology and whether product standardization and modularity subsequently occur for systemic innovations—are technological in nature. At the start of an industry, these technological factors have a large impact on both the extent of transaction costs and the benefits of internal integrative and managerial capabilities. The way in which the technology evolves affects subsequent transaction costs as well as the benefits of integrative and managerial capabilities. For example, successive systemic innovations cause integrative capabilities to retain their usefulness, which may lead integrated firms to remain so as industries evolve. In addition, firms may use their capabilities to alter the nature of technology as an industry evolves, including by introducing new systemic or autonomous innovations. Firms may also endogenously alter transaction costs or their capabilities in other ways that affect vertical firm structure over time. Inherited knowledge or capabilities of entrants may affect the evolution of vertical firm structure as well.

The next three contextual factors modify the impact of, or interact with, the four primary factors. For example, the availability of upstream and downstream producers in other industries may cause an industry to start out nonintegrated. However, if the technology is systemic, firms are likely to integrate soon thereafter to avoid high transaction costs and benefit from internal integrative capabilities. In addition, if an industry undergoes a shakeout in the early years of the lifecycle, nonintegrated firms with strong production capabilities may integrate into critical components to avoid transaction costs of hold-up by suppliers. Then, later in the industry lifecycle, integrated firms might choose to differentiate their products through systemic innovation, and nonintegrated firms might rely on product modularity to produce low-cost products.

The next contextual factor of market power may also interact with some of the previous contextual factors. For example, firms that initially integrated due to the systemic nature of an innovation may subsequently use vertical integration to obtain and retain market power, and therefore may remain vertically integrated over time. The second to last contextual factor of hysteresis leads to persistence of vertical integration that originally arose due to other contextual factors. Finally, punctuated change can shift vertical firm structure in an industry from integrated to nonintegrated or vice versa.

These contextual factors, which interact with one another, affect whether or not firms are vertically integrated during each phase of an industry's lifecycle. As a result, the pattern of evolution of vertical firm structure depends on the contextual factors in a particular industry at different points in time, suggesting the usefulness of "history friendly" models of industry evolution (Malerba *et al.*, 2008). The analysis here provides an initial set of contextual factors that researchers can utilize when characterizing the evolution of vertical firm structure in any industry.

These contextual factors predict several possible patterns of vertical firm structure as industries evolve (summarized in Figure 2):

1. Integration at the outset or early in the industry lifecycle due to systemic innovation or technology, followed by one of the following:
   a. disintegration, or
   b. disintegration and then reintegration, or
   c. continued integration, or
   d. coexistence of integrated and nonintegrated firms; or
2. Nonintegration at the outset due to autonomous innovation or technology, followed by one of the following:
   a. continued nonintegration, or
   b. integration and then disintegration, or
   c. integration.

These two sets of patterns derive from whether an innovation or technology at the start of an industry is systemic or autonomous. Systemic innovation leads to integration at the outset or soon thereafter, due to high transaction costs as well as benefits of internal integrative capabilities. In some instances, the industry may experience a brief early period of specialization due to initial use of external suppliers, downstream producers, or distributors; however,

Early Phase of the Industry Lifecycle		Later Phases of the Industry Lifecycle
1) Vertical integration	→	Disintegration
2) Vertical integration	→	Disintegration followed by reintegration
3) Vertical integration	→	Continued integration
4) Vertical integration	→	Co-existence of integrated and non-integrated firms
5) Non-integration	→	Non-integration
6) Non-integration	→	Integration followed by disintegration
7) Non-integration	→	Integration

Figure 2. Patterns of evolution in vertical firm structure within industries.

if the product or production process is systemic, firms are likely to integrate. Firms may subsequently disintegrate if products standardize and become more modular, again due to an impact on transaction costs and capabilities. At the end of the lifecycle, firms may reintegrate due to high transaction costs of small numbers bargaining. Alternatively, firms may remain integrated during the entire lifecycle if transaction costs do not fall over time because products do not standardize, or learning leads to more effective or efficient integrative and managerial capabilities, or firms benefit from market power, or various forms of hysteresis prevail. And if systemic technological innovations occur later in the industry lifecycle, integrated and nonintegrated firms may coexist.

Conversely, if an industry begins with an autonomous innovation, the industry is likely to start out nonintegrated due to the resulting low transaction costs and low benefits of integrative capabilities. Firms may often stay nonintegrated for these reasons as the industry evolves. If a shakeout occurs, however, firms may integrate into critical components. Subsequent to the shakeout, due to the autonomous nature of the technology, firms may revert to a nonintegrated form. If, however, firms develop strong integrative and managerial capabilities or they use vertical integration to obtain market power or hysteresis sets in, firms may remain integrated as the industry evolves.

Each of these patterns characterizes the evolution of vertical firm structure of an industry as a whole. Clearly, individual firms may make decisions that deviate from the overall pattern of evolution of vertical firm structure in a particular industry, a topic that is beyond the scope of this analysis. To illustrate the usefulness of contextual factors in explaining the overall pattern of evolution of vertical firm structure, the discussion next turns to evidence from empirical research.

4. Evidence regarding the evolution of vertical firm structure

Early empirical research compared vertical integration across industries using measures such as the ratio of income to sales, the ratio of value added by manufacturing to the total value of products (Adelman, 1955), and the ratio of employment in "auxiliary" (noncore) activities to total firm employment (Gort, 1962). Later cross-industry studies used similar measures to provide evidence regarding Stigler's argument (e.g., Levy, 1984; Tucker and Wilder, 1977). Stages of production differ in their characteristics across industries, however, complicating the use of these measures in cross-industry comparisons. Historical studies by Livesay and Porter (1969) and Chandler (1990) instead combined factual information with qualitative analysis to examine cross-industry trends in vertical integration in US manufacturing from the late 1800s to World War II, but did not provide information about the longer-term evolution of these industries. The following discussion covers a longer time period, and examines the evolution of vertical firm structure over approximately 100 years in two industries, automobiles and aluminum, for which detailed evidence is available.

4.1 US automobile industry

Many scholars have studied aspects of the evolution of vertical firm structure in the US automobile industry. Evidence that is especially relevant for purposes of this analysis comes from Langlois and Robertson (1989), Helper (1991), Bigelow and Argyres (2008), Argyres and Bigelow (2010), Jacobides *et al.* (2014), and Argyres and Mostafa (2015). Each study emphasizes somewhat different facts, and offers somewhat different interpretations of the factors driving the evolution of vertical firm structure. Bringing these studies together makes it possible to obtain a more complete picture of this evolution and the reasons behind it.

4.1.1 The early years

In the early days of the industry, vertically integrated craft shops used improvised parts (Langlois and Robertson, 1989). When commercial production began around 1900, nonintegrated assemblers replaced the craft shops. Assemblers relied on suppliers to other industries for components designed for other purposes such as bicycle wheels (Langlois and Robertson, 1989; Helper, 1991).

In 1908, Ford introduced the Model T (Langlois and Roberston, 1989). Between 1909 and 1914, Ford purchased most materials and parts from outside suppliers (Helper, 1991). Assemblers in general had specialized auto designs and parts were not standardized, requiring parts suppliers to make large investments specific to individual assemblers (Helper, 1991). Suppliers that did not make the needed investments became high-cost producers, leading companies such as Ford, which could make its own parts more cheaply, to integrate upstream (Helper, 1991). In addition, to obtain a critical input—namely, management—the auto assemblers acquired established parts suppliers, further increasing vertical integration. Helper (1991) argued that the skills of these managers facilitated internal coordination.

As Ford developed its mass production process for the Model T, and the focus shifted from product to process innovation, the company required special purpose machinery. Langlois and Robertson (1989) argued that Ford had to design the equipment itself because only it understood the uses to which the machinery would be put. In addition, the systemic nature of the components of the Ford car favored vertical integration.

General Motors (GM) also vertically integrated in the period prior to 1920, bringing together several automobile assemblers and component suppliers (Langlois and Roberston, 1989). In addition, GM integrated downstream by establishing its own marketing and distribution network.

In summary, during the "pre-production" or "incubation" period (Jovanovic, 2004; Moeen and Agarwal, 2015), automakers were vertically integrated craft shops. When commercial production began, a disintegrated structure emerged because the assemblers could obtain inputs from suppliers in other industries. However, systemic product innovation in the form of co-specialized automobile and parts designs led to high transaction costs due to asset specificity. Suppliers that were unwilling or unable to make large investments in specialized parts had high production costs, leading Ford in particular to integrate upstream. As the emphasis shifted to systemic process innovation, vertical integration provided additional coordination benefits. As a result, Ford integrated into equipment design. Moreover, automakers vertically integrated through acquisition to acquire managerial talent needed for coordination and production economies.

Thus, the evolution of vertical firm structure in this early period depended on systemic innovation in both products and production processes, the availability of qualified suppliers and distributors in other industries and in the auto industry, transaction costs, and the benefits of integrative as well as managerial capabilities.

4.1.2 1920s–1940s

The 1920s and 1930s brought consumer demand for product innovation. The advent of the annual model change, as well as a growing used car market that created competition for new cars, led assemblers to place high priority on developing new models (Langlois and Robertson, 1989). Initially, external suppliers developed product innovations such as the closed steel body, and less integrated assemblers like Chrysler could best incorporate these innovations (Langlois and Robertson, 1989; Helper, 1991). As a result, some firms became less integrated.

By the mid-1920s, a dominant design for autos had emerged (Abernathy, 1978). Nevertheless, because each automaker maintained its own specialized designs, modularity based on industry-wide component interfaces did not take hold (Jacobides *et al.*, 2014). A dominant design also stimulated an aftermarket for auto parts (Abernathy, 1978; Argyres and Bigelow, 2010). Langlois and Robertson (1989) argued that assemblers vertically integrated into replacement parts because they could obtain higher profit margins on them, and because they could more easily obtain economies of scale in production of original equipment and replacement parts when managed and organized together.

In 1920, GM put the M-form organization in place, which reduced costs of internal organization associated with vertical integration (Langlois and Robertson, 1989). Additionally, through vertical integration in the past, GM had learned to coordinate its upstream and downstream activities, thereby lowering coordination costs of subsequent vertical integration (e.g., the acquisition of Fisher Auto Body) (Langlois and Robertson, 1989).

Beginning in 1909 through the early 1930s, the industry underwent a shakeout (Klepper and Simons, 1997). Bigelow and Argyres (2008) found that vertical integration by assemblers into engines between 1917 and 1933 was positively associated with the extent of asset specificity. Older firms (with more industry experience) also tended to integrate into engine production during this period, consistent with the application of a capability for low-cost production to a critical component during a shakeout. Large, often vertically integrated, firms were more likely to survive than small firms as well. In a separate analysis of nine other components, Argyres and Bigelow (2010) found that assemblers with more differentiated products were more vertically integrated. In addition, spinoffs whose parent firms were integrated into engines were more likely to integrate into engine production during this period, consistent with inheritance of knowledge and the potential to develop capabilities for engine production (Argyres and Mostafa, 2015).

Finally, Helper (1991) documented how large assemblers, especially Ford and GM, reduced the bargaining power of suppliers. The large assemblers were vertically integrated into complex functions such as engineering and R&D, and used their staff to divide components into small, easy-to-produce parts. The automakers then provided blueprints for components to suppliers and coordinated assembly in-house, insuring that suppliers did not develop expertise in design or auto assembly (Helper, 1991). This impeded modularity in auto design as well (Jacobides *et al*., 2014). In addition, the simplicity of suppliers' tasks lowered barriers to entry, enabling assemblers to have six to eight competing suppliers for many parts (Helper, 1991). For inputs with high transaction costs (e.g., due to sole source suppliers or complex inputs), however, the assemblers often vertically integrated (Helper, 1991).

In summary, the extent of upstream vertical integration in particular differed by type of input. Although product standardization enabled greater outsourcing of components, the assemblers kept complex, critical components and functions in-house due to high transaction costs as well as benefits of internal capabilities. In addition, although the assemblers endogenously reduced transaction costs by giving blueprints to suppliers, they did so only for some components. Moreover, prior experience and learning—and associated integrative, managerial, and production capabilities—provided a basis for subsequent integration. Larger and older integrated assemblers were also more likely to survive the shakeout for reasons unconnected to asset specificity and bargaining power, again suggesting the importance of factors connected to size and age such as greater experience and internal economies in production and coordination. Finally, none of the accounts suggest that the assemblers integrated to improve their market power in what became an oligopolistic industry (Klepper, 2002); indeed, the automakers purposely fostered competition upstream for supply of some parts.

4.1.3 1950–1979

From the 1950s through the 1970s, the Big Three automakers (Ford, GM, and Chrysler) manufactured engines, transmissions, and axles in-house, in part to assure supply of these critical components (Helper, 1991). Nevertheless, some of the original rationale for vertical integration, such as improved coordination, had broken down by the end of this period. For example, some in-house suppliers held so much power that they dictated component designs and refused to share cost information (Helper, 1991). The automakers also relied on a limited set of external suppliers for some technically demanding parts, and sometimes had closer coordination with these long-term suppliers than with in-house divisions (Helper, 1991). For the remainder of the parts sourced externally, the assemblers maintained their system of control over suppliers through provision of blueprints, multiple sourcing, and in-house parts assembly.

During this time period, some disadvantages of hysteresis (persistence of vertical integration) set in, perhaps due to governance inseparability. As the problem posed by strong in-house suppliers indicates, the benefits of coordination do not automatically follow from vertical integration, and instead require that firms maintain their managerial and integrative capabilities. One might speculate that firm size plays a role as well: as internal divisions become large, they gain more power that management at the top may have difficulty keeping in check.

4.1.4 The 1980s and beyond

By 1980 Japanese auto manufacturers had made significant inroads in the US market. In response to the loss in market share, the US automakers sought to promote greater innovation (Helper, 1991). They began to rely more heavily on their suppliers for innovations in components, accompanied by multi-year contracts (Helper, 1991). The assemblers also put in place new in-house coordination mechanisms such as cross-functional teams, which improved product development times due in part to better coordination between product and process innovation (Helper, 1991).

Essentially, a competitive shock in the form of entry by Japanese producers led the automakers to increase their reliance on external suppliers, despite higher transaction costs of outsourcing unique components and services. The large automakers, however, ultimately remained systems integrators, vertically integrated into automotive design and final assembly. As Jacobides *et al*. (2104: 11) state: "To this day, OEMs [original equipment manufacturers, the assemblers] do most R&D, develop product architecture, design specific models, and set (mostly proprietary) specifications for components."

4.1.5 Summary of the evolution of vertical firm structure in the US automobile industry

The US auto industry began in the preproduction phase as vertically integrated craft shops, disintegrated with the advent of commercial production, reintegrated with the coming of mass production, became less integrated as the product standardized, disintegrated further in response to a competitive shock, but nevertheless remained integrated into design and assembly. The overall pattern is one of early integration followed by partial disintegration. Of note, the auto industry has yet to fully disintegrate. As discussed above, many of the contextual factors identified earlier played a role in different phases of the industry lifecycle, most notably systemic innovation and technology, transaction costs, and capabilities, as well as an industry shakeout, product differentiation, and hysteresis.

4.2 Aluminum Industry

To probe the generality of the patterns and contextual factors observed in the auto industry, it is useful to examine the evolution of vertical firm structure in an industry producing a very different type of product. The aluminum industry provides one such example. In his book entitled *Vertical Integration and Joint Ventures in the Aluminum Industry*, Stuckey (1983) documented the evolution of vertical firm structure from the inception of the industry in the late 1800s through 1979. The discussion below relies on key facts and analysis in Stuckey's (1983) work, supplemented with additional analysis of contextual factors.

Upstream aluminum production consists of three stages: the mining of bauxite, which is refined into alumina, which is further processed in the primary smelting stage. The invention of the Hall-Heroult process for aluminum smelting in 1886 lowered the cost of aluminum production dramatically; the Bayer process for extracting large amounts of alumina from bauxite was developed in 1887 (Aluminum Association, 2014). These innovations led to the start of the modern aluminum industry.

At the inception of the industry, the three upstream stages of production were not vertically integrated, but became so within the first decade or two. Bauxite deposits have unique chemical and physical characteristics to which alumina plants must be tailored, and bauxite from different mines often differs substantially (Stuckey, 1983). In addition, smelters cannot substitute one type of alumina for another except at high cost. Essentially, the production technology is systemic. High transportation costs of bauxite from mines in isolated locales also led to co-location of mines and alumina refineries. These factors resulted in what Stuckey (1983) termed "bilateral oligopoly" between bauxite producers and alumina refiners, and between alumina refiners and smelters—a small numbers bargaining situation arising from asset specificity. Refiners faced a high threat of hold-up for other reasons as well. Because aluminum refining has large economies of scale due to high fixed costs, and refiners need only cover their marginal costs in the short run, this created the potential for opportunistic price squeezes by bauxite suppliers (Stuckey, 1983). Frequent and large swings in final demand exacerbated the situation; arms-length contracts would have required frequent renegotiations of prices and quantities. All of these factors led to high transaction costs (Stuckey, 1983).

The small number of large firms that participated in these upstream markets also raises the possibility that the firms vertically integrated in pursuit of market power. Stuckey (1983), however, argued that although high fixed costs created barriers to entry into upstream production, the overriding importance of imperfect substitution of inputs between plants made it unlikely that firms vertically integrated to obtain market power. But subsequently, the major companies had incentives to remain integrated so as to deter entry and maintain market power (Stuckey, 1983).

Aluminum companies also integrated downstream early in the industry lifecycle (Stuckey, 1983). For example, in the US Alcoa could not persuade fabricators of other metals to fabricate aluminum products, much as Stigler (1951) argued. Alcoa therefore integrated downstream into fabrication, as did the European aluminum companies (Stuckey, 1983). Moreover, the extent of downstream vertical integration did not decrease over time even though producers in other industries became more familiar with the properties of aluminum and demand for fabricated products increased. In fact, the reverse occurred. Stuckey (1983) attributed this continued downstream integration in part to the ability of upstream producers to earn rents through price discrimination downstream. Nevertheless, Stuckey (1983) stated that the primary reason for the integration of smelting and fabrication was that it enabled smooth adjustments to exogenous shifts in demand. Thus, integrated producers avoided high transaction costs.

Some of the smelters integrated into end products as well, particularly industrial and aluminum foil, to develop markets for these products, consistent with Stigler (1951). However, the firms remained integrated long after they had developed these markets. Stuckey (1983) attributed this continuing integration to the compatibility of foil production with the producers' traditional production and technical skills, and to the ability to earn rents through branding of consumer foil, a differentiated product. Stuckey's (1983) explanation of skill compatibility across stages of production suggests the presence of managerial and integrative capabilities, perhaps made possible by learning over time from prior integration. With respect to rents from product differentiation, the integrated firms who entered early continued to prosper without threat of entry due to the relatively small size of the mature market (Stuckey, 1983), suggesting a role for hysteresis.

Between 1925 and 1955, other factors affected the worldwide industry including the Great Depression, World War II, the entry of new government producers, the entry of new competitors in the United States, and the prosecution of Alcoa for antitrust violations in the United States. These events failed to change vertical firm structure overall in the industry. In the 1960s, however, vertical integration into smelting began to lessen, as alumina inputs became more homogeneous, and governments of industrializing countries promoted nonintegrated entry into smelting (Stuckey, 1983).

In summary, upstream stages of production became highly integrated due in part to systemic production technology, which resulted in high transaction costs associated with asset specificity and small numbers bargaining. In addition, producers faced high transaction costs due to fluctuations in demand. As the industry evolved, transaction costs did not decline in the mining–refining relationship, due to the inherent difficulty of standardizing bauxite inputs, but greater homogeneity in alumina made integration into smelting less attractive. In addition, government policies encouraged nonintegrated entry into smelting.

The evidence also suggests that continuing upstream integration in the aluminum industry benefited from integrative capabilities learned over time, and that producers may have used vertical integration to deter entry and benefit from market power. The primary reasons for continued downstream integration in aluminum included the ability to price discriminate downstream—presumably providing greater control than contracts with independent producers would have permitted—as well as shared expertise between stages of production, indicative of managerial and integrative capabilities.

Conditions at the inception of the aluminum industry differed in some respects from those in the automobile industry. Unlike the automakers, the aluminum companies could not utilize suppliers from other industries—consistent with Stigler (1951)—arguably contributing to the relatively quick upstream integration of the industry. Also consistent with Stigler (1951), the industry could not convince fabricators to make aluminum products, leading to downstream integration. Thus, although both the auto and aluminum industries were not integrated at the start of commercial production and quickly became so, conditions differed with regard to the initial use of suppliers in other industries.

Despite differences in the evolution of vertical firm structure in the two industries, some of the same contextual factors apply in both, especially the systemic nature of the products and the production process, as well as the impact of subsequent standardization or lack thereof. These in turn affected transaction costs and, arguably, the development of integrative and managerial capabilities. In addition, the availability (or lack thereof) of suppliers, downstream producers, and distributors played a role in both industries, as did hysteresis, albeit in different ways.

5. Conclusion

The foregoing analysis has shown that unlike the industry lifecycle, the evolution of vertical firm structure does not necessarily follow a typical pattern. Although evidence from a number of industries suggests that industries often become integrated early in their lifecycle and then disintegrate, this does not necessarily occur rapidly, or completely, or even at all. For example, although the US automobile industry became less integrated over time, it has yet to fully disintegrate. The aluminum industry also remained heavily vertically integrated for nearly a full century.

As argued here, the pattern of evolution of vertical firm structure depends on contextual factors. These contextual factors enable history-friendly analysis of individual industries while relying on a common set of factors across industries. That is, although the same contextual factors determine the evolution of vertical firm structure in every industry, differences in their applicability and importance across industries produce different patterns of vertical structure over time. In particular, the nature of innovation and technology (systemic versus autonomous) at the start of an industry, as well as subsequent evolution of technology (standardization of products and processes, or lack thereof), are critical factors. These in turn affect transaction costs and firm capabilities, as shown by the examination of the evolution of vertical firm structure in the automobile and aluminum industries. Firm capabilities may also affect subsequent innovation and transaction costs, and existing capabilities may improve through learning, all of which influence vertical firm structure over time. Other contextual factors affect the evolution of vertical firm structure as well.

The contextual factors identified here provide a starting point for future analysis, and new research may point to additional contextual factors. For example, the evolution of the auto industry suggests a role for firm size and age, as well as the emergence of submarkets (Klepper and Thompson, 2006). Intellectual property protection may be another important contextual factor. In the chemical industry, Arora (1997) documented the emergence of specialized engineering firms that relied on strong patent protection for their process innovations. These firms licensed their process technologies to chemical companies, facilitating entry by nonintegrated producers into chemical industry submarkets (Arora, 1997; Klepper, 1997; Arora *et al*., 2009).

Some of the contextual factors examined here may have additional effects on the evolution of vertical firm structure. For example, Qian *et al*. (2012) suggested that diversifying entrants may be more likely to enter another industry in vertically integrated form due to their integrative capabilities accumulated through prior experience. More generally, pre-entry capabilities (Helfat and Lieberman, 2002) may affect the evolution of vertical firm structure in an industry.

Improving our understanding of the evolution of vertical firm structure and the role of contextual factors would benefit from more empirical studies in other industries. In addition, many of the contextual factors interact with and depend on one another as industries evolve, and it would be helpful to better understand these interactions. Moreover, a number of industries have complementary products that co-evolve with the focal product, such as operating system software and personal computers. Some of the contextual factors identified here may affect integration into these complementary products, as well as the coevolution of vertical firm structure in complementary product industries.

Although contextual factors can help to explain the observed pattern of evolution of vertical firm structure in an industry, predicting this evolution may be more difficult. For example, consider the automobile and aluminum industries. Would it have been possible to predict how vertical firm structure would evolve based on contextual factors in these industries? Perhaps this might have been possible in some respects. For example, in the aluminum industry, the systemic nature of upstream production, resulting from the need to align inputs and plants, made it likely that those stages would quickly become integrated. However, it might have been more difficult to predict that many decades after the birth of the industry, alumina inputs would become more homogenous, weakening the benefit of integration between refining and smelting (Stuckey, 1983). It might also have been possible to predict that the auto companies would have had an incentive to lower transaction costs and create competitive supplier industries for some components, but incentives do not automatically imply action. As these examples indicate, although contextual factors may enable limited predictions about the evolution of vertical firm structure, humility about the likely accuracy of these predictions is in order.

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