DISCUSSION PAPER SERIES

DP14549

TESTING PREDICTIONS ON SUPPLIER GOVERNANCE FROM THE GLOBAL VALUE CHAINS LITERATURE

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INDUSTRIAL ORGANIZATION

ISSN 0265-8003

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Discussion Paper DP14549
Published 01 April 2020
Submitted 31 March 2020

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Abstract

A vast empirical literature analyzes the determinants of the make-or-buy decision, but firms also need to decide how to organize their supplier relationships when they choose to buy. The global value chains framework provides predictions on the nature of buyer-supplier collaboration. We use a unique transaction-level dataset of outsourced automotive components to study carmakers' choice between four distinct types of supplier governance: market, captive, relational, or modular. The theory formulates predictions based on three characteristics: the complexity or contractibility of a transaction, the capabilities of suppliers, and how objectively codifiable performance requirements are. The results illustrate that sourcing relationships differ systematically and that proxies for the three characteristics have effects in line with the theory.

JEL Classification: L22, L23, M11

Keywords: Outsourcing, GVC, Theory of the firm, PRT, TCE

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Acknowledgements
We would like to thank participants in seminars at Bielefeld, KU Leuven, LSE, the NBER, and Utrecht, as well as Gary Gereffi, Tim Sturgeon, Steve Tadelis and Frank Verboven for their comments. Financial support from FWO, EOS, and KU Leuven Methusalem Financing is gratefully acknowledged.

Testing predictions on supplier governance from the global value chains literature*

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January 2020

Abstract

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1. Introduction

A vast literature, both theoretical and empirical, studies the determinants of the make-or-buy decision and the impact of vertical integration on performance. The way sourcing relationships are organized, what one could call the how-to-buy decision, has received much less attention. Its importance is highlighted in a few seminal papers that study intermediate forms of organization, which Powell (1990) calls networks and Ménard (2013) calls hybrids. The *Nobel Prize* award for Oliver Williamson prominently cites his work, e.g. Williamson (1979), on the governance of contractual relationships as an alternative for the choice between markets and hierarchies.

What is lacking, is systematic cross-sectoral evidence for the predictive power of theories of supplier governance. An advantage of the global value chains (GVC) framework proposed by Gereffi, Humphrey, and Sturgeon (2005) is their focus on just three determinants—complexity, codifiability, and capabilities—that are each inspired by existing theories in the literature. Even though they draw mostly on contributions outside of economics, there tends to be a close relationship with factors considered in the economic literature. What they call complexity is closely related to the extent of contract incompleteness (Maskin and Tirole, 1999). When performance requirements are difficult to codify, it may lead to hold-up problems and costly renegotiation that features prominently in transaction cost economics (Bajari and Tadelis, 2001). The emergence of capable suppliers is considered explicitly in Stigler (1951) and they are a necessary condition for outsourcing to provide strong investment incentives in the property rights theory of Grossman and Hart (1986).

The GVC framework considers optimal governance as a choice between five discrete *relationship types* or *modes of governance*. Ranked by decreasing power of the buyer over the supplier, they are hierarchy, captive, relational, modular, and market governance. Market relationships are expected to dominate for less complex products where the price is all that matters. Hierarchy or internal production is for transactions at the other extreme. Outsourcing is not a viable option when products are complex, performance is hard to codify, and existing suppliers are weak. The three intermediate forms are motivated by the authors' earlier work on different industries: the captive form dominates in textiles (Gereffi, 1999); relational in automotive (Humphrey, 2003); modular in electronics (Sturgeon, 2002). Reducing their framework to a straightforward choice between five governance modes based on three determinants does not do justice to the nuanced discussion in the original contribution, in particular with respect to the important roles played by power and coordination. A wealth of case study evidence has accumulated in this literature, providing a rich description of the intermediate governance types, but also exploring their boundaries, overlap, and evolution as circumstances change.[2]

By focusing on the straightforward predictions that relate the characteristics of a transaction or the supply base to the nature of sourcing relationships, we can assess whether sourcing patterns across a wide range of circumstances tend to agree with the theory. We study outsourcing in the automotive industry which is one of the most downstream manufacturing sectors (Antràs et al., 2012). As a result, automobile assembly firms interact with a large range of industries and they source parts of widely different levels of sophistication. In some cases, firms will find it optimal to produce a part in-house, as studied in Monteverde and Teece (1982), but that is the exception. Klier and Rubenstein (2008) describe in detail how most carmakers nowadays choose to outsource the same set of parts and sub-assemblies.

Our first contribution is to provide systematic econometric evidence in support of the predictions of the GVC framework. The theory has proven extremely popular to guide case studies of sourcing patterns in individual industries.[3] Researchers have used detailed information on sourcing practices to provide a rich description of the dominant governance mode for many industries. Our empirical work can be considered a cross-industry or cross-product confirmation of the case study evidence. Rather than using industry practices to define governance types, we rely on the case study evidence to construct for each governance type an indicator that captures one of its salient features. We further define proxies for the three key predictors and show that carmakers systematically vary the way they collaborate with suppliers depending on the complexity and codifiability of part and the capability of the supplier. In the vast majority of cases, the variation correlates with the three proxies in the direction predicted by the theory.

[2] The website www.globalvaluechains.org lists 1,087 contributions (up to 2018), including 462 journal articles, 96 books, and 165 book chapters, that study the organization of global value chains. Most of them (966) are case studies that are classified by industry. Clothing/apparel and food industries are researched most intensely, but 42 different industries are covered by at least 5 studies.

[3] In addition to the large body of work listed on the website of the GVC Initiative, the popularity of the GVC framework of Gereffi et al. (2005) is also apparent from the 7314 citations the work has attracted on scholar.google.com (up to 2019).

A second contribution is to extend the theory of the firm literature—which focuses on the make-or-buy decision—to the nature of supplier governance. A few papers, e.g. Mudambi and Helper (1998), Bensaou (1999), and Sturgeon et al. (2008), discuss features of buyer-supplier collaboration specifically for the automotive industry. Our objective is to identify theoretically-motivated predictors for the nature of this relationship and use them to explain differences between industries. Our empirical approach differs from, but is complementary to Gibbons (2005), who explicitly integrates different predictors of the make-or-buy decision in a single formal model. Based on the GVC framework, we empirically test conditional predictions of several theories holding constant the sourcing determinants that play a role in other theories. Moreover, we illustrate how supplier governance can adjust if two theories offer conflicting predictions on the choice between outsourcing and in-house production.

Third, our results help to understand observed sourcing patterns in the automotive industry. As suppliers have assumed an increasingly important role in the innovation process, it is well-known that supplier-buyer relationships have gone beyond market type of interactions (Helper 1991; Hannigan et al. 2015). The build-up of trust (Dyer and Chu, 2000) and other benefits of repeated interactions (Asanuma, 1989) can explain some patterns, but we show that even a static model has predictive power for the nature of firm interactions. While Antràs and Chor (2013) emphasize that firms face different incentives to outsource at different points in their supply chain, our results indicate that they have other options than bringing production in-house. Schmitt and Van Biesebroeck (2013) already show that automakers' preferences for supplier proximity vary across parts, but here we document effects on other dimensions than distance in the sourcing patterns as well.

The remainder of the paper is organized as follows. In Section 2 we describe the logic behind the GVC framework and the type of predictions that it generates. In Section 3 we describe the unique transaction-level database on the automotive industry. In Section 4, we discuss the construction of dependent and explanatory variables and the empirical approach used. This is followed by the estimation results in Section 5, implications for supplier performance in Section 6, and the conclusions in Section 7.

2. Global value chains in the automotive industry

2.1 The global value chains framework

The global value chains (GVC) framework is widely used in many areas of research. Policymakers and international institutions often appeal to it when framing current policy challenges. Some of the defining features of the framework can be introduced as follows. Buyers and suppliers in an industry collaborate in a network of input-output relationships that often span a wide geographic area. Activities in a value chain are often wide-ranging as well and some generate more value than others. The organization of the chain determines how the total value generated in the chain is divided among participants, but it also provides paths for firms and countries to increase their contribution and upgrade into higher value activities. The relative power of firms plays a role in the organization and division of surplus. Lead firms in the chain will choose suitable governance modes for suppliers that match the type of activity, industry features, and the local operating environment. Gereffi and Fernandez-Stark (2020), and other chapters in the same volume, provide an accessible and more extensive introduction, as well as an overview of some applications.

For our application, the most important feature of the framework is the heterogeneity in governance mode of suppliers, i.e. the way buyer-supplier collaboration is organized. A huge literature studies the vertical integration decision and its determinants. Lafontaine and Slade (2007) review the empirical evidence and Gibbons (2005) provides an integrated theoretical framework that nests several of the most influential theories. It has been recognized, however, that a choice to buy rather than make, is not the end of the story. Sourcing relationships are not one-size fits all and are often tailored to the specific situation. We build on the literature, mostly in management and geography, that studies the range of sourcing arrangements between the extremes of make-or-buy. Powell (1990) and Ménard (2013) highlight the varied forms of firm interaction one can observe and how several theories simultaneously influence firms' decisions. Williamson (1979) also discusses potential variations on the buyer-supplier relationship in a transaction cost economics framework. In particular, more complicated relationships are distinguished from the anonymous market transactions governed by price that dominate the formal make-or-buy models.

Table 1: Governance modes considered in different literatures

Theory of the Firm	Networks	Global Commodity Chains	**Global Value Chains**
Buy	Market		Market
	Intermediate/ Hybrid/ Network/ Community	Producer-driven	Modular
			Relational
		Buyer-	Captive
Firm boundary			
Make	Hierarchy	driven	Hierarchy

The GVC framework provides one way to systematize the study of forms of organization intermediate to the make or buy-on-market extremes. Buying firms deal with an interrelated network of suppliers whose decisions interact. A first distinction advanced by the literature on global commodity chains, see Gereffi and Korzeniewicz (1994) for a range of applications, is between buyer-driven or producer-driven value chains. In producer-driven chains, the importance of suppliers producing key inputs is larger and hence also their share of the value created and their influence in the industry's organization. Whether this is optimal, or even feasible, depends on characteristics of the activities or transactions, but also on the technological and organizational capabilities of the suppliers.

The governance mode of suppliers is a crucial aspect of the GVC framework that makes it a predictive theory. While inevitably sacrificing some of the richness of actual relationships, Gereffi, Humphrey and Sturgeon (2005) emphasize three characteristics that are prominent in the management and economic geography literatures, namely: (i) the complexity of a transaction, (ii) how easy it is to objectively define performance, and (iii) the (technological) capabilities present in the supply base.

Importantly, these three characteristics jointly influence the optimal way that buyers and suppliers interact. In economics, such interaction has been for example been used to explain different ways of establishing a price, e.g. cost-plus versus fixed-price contracts, in Bajari and Tadelis (2001). The GVC framework considers *types* of relationships that differ in the intensity of interactions, both in terms of information exchange and the scope of contracts, in how exclusive the collaboration is, which side makes crucial technology or design decisions, etc. If all three characteristics can take a high or a low value, it leads to eight possible situations that in principle each require a distinct optimal type of governance. Gereffi et al. (2005) argue that the last two dimensions loose much of their importance if transactions are not complex, in which case the other two requirements are satisfied almost automatically. This leaves the five possible types listed in Table 2.

Table 2: Determinants of GVC governance

	Complexity of transaction	Ability to codify transactions	Capability of supplier
Market	Low	High*	High*
Modular	High	High	High
Relational	High	Low	High
Captive	High	High	Low
Hierarchy	High	Low	Low

Source: Adapted from Gereffi, Humphrey and Sturgeon (2005: p. 87).

Note: * High codifiability and High supplier capability for Market governance has to be interpreted in light of the Low complexity of the transaction. They are not necessarily higher than the Low values indicated for either dimension further down in the table for transactions with High complexity.

Bensaou (1999) proposes an alternative typology of organization modes motivated specifically by the organization of the automotive sector. We choose to stay closer to the Gereffi et al. (2005) approach for two reasons which we discuss in some detail in the rest of this section. First, the three characteristics that they consider as determinants of governance modes can be directly related to prominent theories in economics. Second, their framework has already been used to study the organization of industries in a myriad of settings which provides empirical content to the different sourcing types.

The GVC theory predicts that low complexity by itself will lead to market transactions, irrespective of the codifiability or capabilities. Complexity can mean many things, but it is natural to relate it to Maskin and Tirole (1999) who show that the ability to redefine transactions such that they are describable by contracts facilitates outsourcing. Tadelis (2002) considers a model where the complexity of a transaction implicitly determines how complete a contract can be. The seminal problems in the theory of the firm—moral hazard, hold-up, renegotiation—depend on contracts being incomplete and this situation is more likely when transactions—the product or the environment—are more complex. If everything is observable and enforceable, optimal actions can be prescribed and the first best attained. High complexity can also be considered a situation where bounded rationality becomes a more limited factor. In such a situation, Simon (1951) suggests that allocating decision rights ex ante, as in the hierarchical relationship, can become preferable.

The notion of ex-post transaction costs has given rise to the field of transaction cost economics (TCE), which is closely related to the codifiability of performance requirements in the GVC theory. If it is possible to describe and for an outside court to verify whether an input meets the required quality, is reliable, and is delivered on time, ex-post transaction costs will be low as the supply contract can specify these performance features instead of the product characteristics or the suppliers' actions and investments. While the nature of the production process might still tie the buyer and supplier together, e.g. due to transaction-specific assets, the residual claims when adjustments need to be made can be assigned in advance by explicitly determining the performance requirements. If a technological change or unanticipated difficulty makes a component fall short of its required performance, the supplier will need to absorb the necessary adjustment costs. If a design change in the rest of the vehicle requires an adjustment in the functionality of a component, the buyer will need to provide compensation. If such adjustments or the costs they entail are difficult to predict, codifiability is low and ex-post transactions costs are high.

The key predictor of the make-or-buy decision in the property rights theory (PRT) of Grossman and Hart (1986), is the marginal return of a supplier's investment to the joint surplus, relative to the marginal return of the buyer's investment.[4] The GVC theory borrows more explicitly from the resource-based view of the firm of Penrose (1959) and considers the existence of strong capabilities in the supply base an important considerations in outsourcing decisions. Of course, this needs to be judged relative to the requirements of the transaction. The presence of capable external suppliers will be more crucial the optimal sourcing strategy, if the marginal effect of supplier efforts are more important for the overall value created. Capabilities are also deemed to be low if a buyer provides some crucial input and supplier investments cannot substitute for this, for example due to informational differences. While the PRT explicitly considers the relative importance and focuses on marginal effects of investments, the existence of a supply base with sufficient capabilities is more of an

[4] Outsourcing enhances the bargaining power of the supplier and raises its investment incentives. As this comes at the expense of the buyer's investment incentives, outsourcing will only be optimal if the marginal return of the supplier's investment dominate the marginal return of the buyer's investment.

equilibrium consideration. If supplier investments dominate and independent suppliers are incentivized, we expect the equilibrium supply base to possess the necessary capabilities.

While the GVC taxonomy in Table 2 is somewhat arbitrary, the empirical content of the abstract governance types has been clarified by a wealth of cases studies that considered nuanced aspects of buyer-supplier collaboration and power dynamics (Antràs, 2019). *Market* transactions are the group of non-complex transactions or situations that can be governed by appropriate contracts with little direct buyer-supplier interaction. At the other extreme are in-house transactions, governed by *Hierarchy*, which are necessarily chosen if transactions are complex, but no capable suppliers exist and it is impossible to objectively codify performance requirements.

The *Relational* and *Captive* governance modes will be discussed more extensively below, but they are fairly intuitive. In relational governance, buyer-supplier interaction is very intense and frequent and the two firms collaborate similarly as two divisions of the same firm. In captive governance, the supplier sells virtually all its output to a single buyer on which it depends for technological and commercial support.

The one governance type left to discuss is *Modular*, which is optimal when complexity is high, but supplier capabilities and performance codifiability are high as well. Sturgeon (2002) first used the term to describe buyer-supplier interactions in the electronics industry. The nature of technology in this industry, e.g. the ability to exchange electronic files that specify designs and interconnections, facilitates collaboration on highly complex components through arm’s length supply relationships. Modular suppliers tend to possess unique production capabilities and have mastered or developed unique technologies which makes them almost indispensable in a value chain. At the same time, the tasks and activities they contribute can be isolated from the remainder of the work in the value chain such that they can work relatively independently and potentially for a large number of buyers.

2.2 From theory to empirical predictions

Given that the GVC framework considers three determinants for the governance of supply relationships, we will explicitly test conditional predictions. If two of the three determining factors are held constant, how does variation in the third factor influence the make-or-buy or the how-to-buy decisions?

The seminal study of Monteverde and Teece (1982) that studies outsourcing in the automotive industry implicitly fits this set-up. It explicitly focuses on complex parts where transaction-specific know-how is generated that is not patentable such that contracts are necessarily incomplete. A second, implicit assumption is that the unique expertise and capabilities of the supplier are not insurmountable, making in-house production of the part by the automaker a viable and relevant strategy. Conditional on these two maintained assumptions—high complexity and low capability in GVC parlance—they use the variation in "engineering effort associated with the development of a part" as the key explanatory variable for the make-or-buy decision. They explicitly mention that performance "specs" are often unknown ex ante, which illustrates the close link between their explanatory variable of interest and the codifiability concept used in the GVC framework. The finding of a higher probability of in-house production of parts requiring more engineering effort is in line with the TCE prediction.

Two tests of the PRT model, Acemoglu et al. (2010) and Nunn and Trefler (2013), also stick to conditional predictions. They study whether high buyer or headquarter investments make it more likely that an input is sourced in-house, but they focus on investments that are explicitly not contractible and where technology intensity is high, such as R&D inputs or skill-intensity of the labor input. Importantly, their results only associate higher (relative) investments by the buyer/headquarter side of the transaction to integration; they do not consider the overall level of investments. Reinterpreted in the GVC framework, they condition on situations where complexity is high and codifiability is low, in which case the optimal choice between hierarchy and sourcing is determined by the supplier capabilities.

In addition to conditional predictions on the make-or-buy decision, the GVC framework can generate additional predictions as well. Once we condition on high complexity, which makes market transactions unsuitable, we can represent the governance options as a two-by-two choice, as shown in Table 3. We used the TCE and PRT labels in the row and column to describe the determinants as these theories might be more familiar, but as discussed, there is a straightforward relationship with the GVC determinants. Situations with high ex-post transaction costs can be interpreted as low codifiability and if marginal returns of the buyer dominate, the capabilities in the supply chain are low, at least in a relative sense.

Table 3: Different sourcing relationships for complex transactions

		Ex-post transaction costs (TCE)			
		High	Low		
Dominant Marginal Returns (PRT)	Buyer	Make (*Hierarchy*)	Buy (*Captive*)	Low	**Supplier Capabilities (GVC)**
	Supplier	Buy (*Relational*)	Buy (*Modular*)	High	
		Low	High		
		Codifiability (GVC)			

The optimal sourcing choice is straightforward when both theories agree. If transaction costs are high and suppliers do not provide important inputs, it is optimal to bring the transaction in-house. That way the firm does not run a hold-up risk while at the same time no important investment incentives are sacrificed. In the reverse situation, when transaction costs are low and the supplier's investments are crucial, both theories advocate outsourcing the transaction and such a relationship is called modular. It is almost as transactional as a market relationship, but the complexity of the product requires more information exchange, quality control, and more sophisticated suppliers.

As discussed, the optimal trade-off is also straightforward when the predictor of one theory is held constant and in-house production is viable. The TCE logic from Monteverde and Teece (1982) is illustrated in the first row, comparing across the two columns: How does the importance of ex-post transaction costs, or codifiability, determine the choice between hierarchy and (captive) outsourcing. Comparing across the two rows in the first column illustrates the PRT logic: How does the relative capability of the two parties determine the choice between hierarchy and (relational) outsourcing.

But what if predictions of the two theories conflict? This is the case in the second row and second column of Table 3. What should a firm do if the risk of a hold-up problem is high, but suppliers make by far the most important investments? TCE considerations call for producing internally, while PRT considerations favor outsourcing. Woodruff (2002) encounters such a conflict in his study of shoe retailing in Mexico. Female fashion evolves very idiosyncratically which makes it important to discover the fashion of the day, something only the retailer can do. The first consideration raises relationship-specificity (gathering the right information) and uncertainty which favors internal production according to TCE, while PRT considerations favors outsourcing to give the retailer strong incentives. The empirical analysis suggests that PRT considerations dominate here and retail outlets for female shoes are less likely to be vertically integrated. In contrast, the GVC framework would predict that the TCE considerations could be accommodated by organizing the collaboration between producer and retailer in a particular way.

The trade-offs in Table 3 capture this conflict. If supplier capabilities are high and their investments have a higher marginal contribution to joint production, hierarchy is not attractive. Only the two options in the second row are relevant and they both indicate outsourcing, but the codifiability influences how the sourcing relationship should be organized. The GVC framework would call for relational governance if codifiability is low. The two firms should work closely with intense and frequent interactions and information exchanges. It is a "make-like" form of sourcing relationship where the buyer and supplier collaborate intensely and repeatedly. From the TCE perspective this set-up is not really outsourcing as the collaboration is similar to that between internal divisions of the same firm. The close interaction on many projects over an extended period minimize the risk of either party engaging in hold-up behavior. However, from the PRT perspective, the supplier is a separate legal entity that maximizes its own profits and has to look after its own stakeholders. If bargaining would happen to break down, the supplier is fully entitled to put its assets to a different use.

The second column of Table 3 features a similar trade-off. In that case, codifiability is high and the product complex. Market transactions are not feasible, but there is no real need to bring the production in-house to avoid a hold-up problem (low uncertainty, few specific assets,…). Low capabilities in the supply chain or a strong need to give the buyer strong investment incentives does not require in-house production if sourcing is organized appropriately. In particular, the buying firm will prefer a captive relationship. They will transfer the necessary know-how for production to the unsophisticated supplier, after all it is codifiable, but in return they will request exclusivity and not allow the supplier to work for its competitors. From the PRT perspective, the captive relationship is very much like make or hierarchy. Even though the supplier is an independent firm, it has minimal bargaining power as its own capabilities are low and it has no commercial relationships with other potential buyers. They are legally independent firms, which might for example give more flexibility in the labor market, but in the product market they are barely more independent than an in-house division.

From an applied perspective, lumping all forms of outsourcing into a single "buy" category ignores a lot of interesting variation in the nature of collaboration between buyers and suppliers. The differences in organizational design that we discussed can be considered compromises when make-or-buy predictions of different theories are in conflict. When products are not complex and contracts are complete, market transactions can similarly differ in the type of performance contract used.[5]

2.3 Sourcing in the automotive industry

The automotive industry is an excellent place to study heterogeneity in buyer-supplier interactions. Cars are complex products that are assembled from a bewildering number of components. It makes the automotive industry one of the most downstream manufacturing industries (Antràs et al., 2012). It sources components that differ in technological sophistication, maturity and scope for differentiation which are produced subject to widely different economies of scale and scope. As a result, carmakers need to interact with virtually all other manufacturing industries that all operate under widely differing circumstances.

Many of the case studies in the GVC literature investigate in detail whether the sourcing practice for a particular product that is sold to a particular industry corresponds to the predicted governance type. This is similar to the approach in economics, where industries are characterized by a set of primitives that makes one type of governance optimal. Given the broad range of carmakers' interactions with suppliers, in this case it is possible to investigate for a single industry whether firms tailor their supplier governance, i.e. the way they collaborate with suppliers, in accordance with the predictions of the GVC framework.

We already know from the existing literature that sourcing practices in the automotive industry differ across products and suppliers. For example, all carmakers have preferred tier-1 suppliers that they collaborate with repeatedly on many of their models.[6] Buyers and

[5] Bajari and Tadelis (2001) is one example that studies differences in contract choice, fixed-price or cost-plus, depending on the feasibility of providing the supplier with a comprehensive design (complexity).

[6] Helper (1991) describes how the US automotive industry has gone from very close collaboration between carmakers and suppliers at the start of the twentieth century, and again starting in the 1980s, while the intervening post-war period was characterized by greater prominence of in-house production and arm's length

suppliers even station some employees at each other's premises, they coordinate their IT systems in order to facilitate joint design and just-in-time, even just-in-sequence, deliveries to the assembly line. This corresponds to the *relational* mode of governance discussed earlier. At the same time, *captive* supply relationships also have a long history in the automotive industry. Klein (2007) documents the failed attempt of General Motors to preclude Fisher Body from broadening its range of clients (around 1920). The *keiretsu* groups in the Japanese automotive industry are well-known for the subsidiary relationships between a dominant carmaker and its network of smaller supplier firms.[7]

The remaining two types of supplier governance are also found in the industry, in particular for parts at opposite sides of the technological sophistication spectrum. Jacobides et al. (2016) describe how in the late 1990s a strategy of modularization of component bundles coupled with the outsourcing of design and production risked shifting strategic control of the industry to suppliers. Their description of *full-service* suppliers "that could handle the design, purchasing, and production of all components in a complex subassembly/module" is reminiscent of *modular* suppliers in the electronics industry (Sturgeon, 2002). Some of these firms were formed from spun-off parts divisions of car manufacturers, e.g. Visteon from Ford and Delphi from General Motors, while others developed unique capabilities to produce sub-systems relatively independently, e.g. JCI for seats and Magna for interiors. At the other side of the spectrum, countries with strong automotive industries, especially Japan and Germany, import increasing amounts of automotive parts from China. The aggregate value of China's parts exports rose from 1.2 billion USD in 1995 to 32.4 billion USD already by 2008 (Amighini, 2012).[8] Such long distance sourcing, especially at a time when the Chinese industry still lagged substantially in technological sophistication, is bound to be dominated by market governance where the competitive advantage of Chinese firms are lower prices for relatively standardized components, e.g. wheel, tires, lights, etc.

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relationships with the remaining outside suppliers. The close collaboration was characterized by intense exchange of information and long-term relationships.

[7] Ahmadjian and Oxley (2011) describe this close collaboration where carmakers often take an equity position in their suppliers, but also help them to smooth production when demand fluctuates.

[8] This corresponds to a 0.7% global market share for China in 1995 rising to 6.7% in 2008. The next year, in 2009, China overtook France to become the fourth largest automotive parts exporter in the world.

The observed sourcing patterns are shaped by several forces that tend to feature in distinct theories. As these forces operate simultaneously, it can leading to contradictory predictions. The GVC framework was conceived to synthesize the multitude of factors that firms need to consider. Historically, auto manufacturers based in different countries organized their supply chains somewhat differently, but as the industry matured, sourcing practices converged, as discussed in Womack et al. (1990), Helper (1991), Sturgeon et al. (2008) and Klier and Rubenstein (2008).

3. Data

3.1 Sourcing transactions

We work with a unique dataset of more than 57,000 sourcing transactions of automotive parts, information that is usually confidential and rarely observed. The data comes from *SupplierBusiness*, a consulting firm to the industry. Each transaction is identified as the unique combination of a car model, supplier firm, and automotive component.

The initial sample covers transactions for 421 models that entered production in Europe or North America between 1993 and 2012. They are produced by one of the major car manufacturers, 15 firms in total, and marketed under 52 brands.[9] We keep 350 models in the analysis, dropping observations from niche models, e.g. from high-end sports or luxury brands, and some models with few sourcing observations. Even though vehicles marketed under different brands are sometimes based on a common platform, they are designed separately and brands tend to have a lot of autonomy regarding purchasing decisions. Exports of cars and light trucks between Europe and North America are relatively unimportant as most vehicles are assembled in the region where they are sold (Sturgeon et al. 2008). Hence, we identify 64 buyers as unique brand-region combinations.[10]

Along the second dimension, we observe transactions for almost all globally operating first-tier suppliers, as well as contracts awarded to more than one thousand small and medium

[9] The firms, in order of the number of observations, are Ford, Volkswagen, General Motors, Renault-Nissan, PSA, Daimler, Fiat, BMW, Chrysler, Toyota, Honda, Porsche, Hyundai, Suzuki, Tata. Note that Volkswagen acquired full control of Porsche in 2011 and after our sample period Fiat and Chrysler merged and General Motors sold its Opel/Vauxhall brands to PSA.

[10] For example, we consider Ford-Europe and Ford-North America as separate buyers, as well as Volkswagen-Europe and Audi-Europe.

size supplier firms located in Europe, North America and Asia. In the actual analysis we omit many of the smaller suppliers as we do not observe anything about them apart from their name. Often we also observe too few transactions to determine the nature of their supply relationships. The largest suppliers operate in both regions and they contribute parts to more than one of six broad component areas in a vehicle. Because technologies and commercial contacts with clients will along both dimensions, we define 2,205 suppliers as unique product division by region combinations. The majority of supplier firms only have a single product division and supply parts only in one region.

Finally, contracts are observed for 213 unique automotive parts which are defined using the component categories provided by *SupplierBusiness*. This is a 3-level nested classification, with six broad component areas of a vehicle (chassis, powertrain, exterior, interior, electrical, and miscellaneous) at the first level. While most transactions are for detailed components, e.g. a brake line or brake caliper, some transactions are for entire sub-systems or modules, e.g. a transmission or seat, that are supplied in their entirety by a single (tier-1) supplier which will organize a supply chain of its own to produce the module.

We only observe a subset of all sourcing transactions for the models that are included in the analysis, but with 55,354 observations out of a potential total of 74,550 (350 models x 213 parts) coverage is relatively complete. In some cases, observations will be missing because the part is made in-house by the car manufacturer itself. This is likely to be relatively rare because we omitted from the sample parts that firms regularly do not outsource. Those parts are included in the analysis of Schmitt and Van Biesebroeck (2017) who study the make-or-buy decision. Here we focus on predicting the organization of sourcing relationships for parts that all firms outsource.

The four dependent variables, proxies for the different types of supplier governance, are constructed based on conditional market shares as discussed below. A transaction's contribution to a market share is calculated by multiplying the projected monthly production volume of the model by the expected duration of the contract. Both of these variables are provided in our dataset and reflect expectations before the model enters production.

3.2 Firm information

To construct the proxy for capability and the control variables, we added firm-level information on buyers and suppliers from the *Amadeus* database with accounting information for a broad sample of European firms and subsidiaries. The *Amadeus* database contains information on balance sheet variables, firms' address and industry classification. The matching process to the transaction data is described in more detail in Schmitt and Van Biesebroeck (2013). Unfortunately, the sample is reduced substantially if we include the control variables as only suppliers that account for 16,548 observations could be matched.

Geographic proximity is known to play an important part in both the decision to outsource and the choice of supplier (Schmitt and Van Biesebroeck, 2013). We therefore include the distance from the closest supplier plant to the model's assembly plant and a dummy variable for the presence of a country border between the two plants. Cultural, historic or institutional ties can also influence the organization of outsourcing relationships. We include a variable of cultural distance measured at the (headquarter) country level using survey data of Hofstede (1980). The index is calculated as the Mahalanobis distance over four dimensions: individualism, power distance, uncertainty avoidance, and masculinity.

We experimented with two variables to control for the production technology of the supplier, capital intensity (total value of assets per employee), and a proxy for value added, defined as operating revenues over total assets. As the first variable almost invariably became statistically insignificant if the second one was included, we only kept the value added proxy. A final control variable, the contract length, is observed in the sourcing data and measured by the number of months between the start and end of production of a model. It is expected to capture the uncertainty in a buyer-supplier relation (Joskow, 1985).

4. Empirical framework

We estimate the likelihood that buyers choose a particular form of supplier governance as a function of the three explanatory variables of interest: complexity, codifiability, and supplier capabilities. As the governance types are not directly observed and it is not obvious how to measure the theoretical constructs in the data, we need to rely on proxies for both the dependent and explanatory variables. It is important to emphasize upfront that the dependent variables are constructed using only observed sourcing patterns in the data, e.g. the frequency of collaboration or concentration of buyers or products. In contrast, the explanatory variables are not constructed from the sourcing patterns, but only rely on characteristics of parts or suppliers.[11]

4.1 Specification

If the various governance types (indexed by *k*) could be unambiguously identified in the data, as is the case when studying the make-or-buy decision, one could simply estimate a multinomial logit model at the transaction level. The probability that a buyer chooses type *k* is simply a function of the explanatory variables of interest and controls:

$$Pr[type = k] \sim f(\beta_{1k}\, complex + \beta_{2k}\, codify + \beta_{3k}\, capable + controls).$$

Unfortunately, the type of governance is not recorded and we need to rely on observable proxies to identify it. It might even be the case that a buyer-supplier relationship is of an intermediate form and does not correspond exactly to one of the four distinct types. Rather than partitioning relationships exhaustively in four groups, we calculate for each transaction four continuous variables that are each monotonically related to one of the governance types. Note that transactions that use *hierarchy* or in-house production (the fifth governance mode) are by construction excluded from the sample.

The regressions we estimate take the following form:

$$y^k_{bsp} = \beta_{1k}\, complex_p + \beta_{2k}\, codify_p + \beta_{3k}\, capable_s + controls + \epsilon_{bsp}, \quad (1)$$

with $y^k = \{market_{sp},\ captive_{bs},\ relational_{bsp},\ modular_{bs}\}$. The actual variables used vary at the levels indicated by the subscripts in equation (1) and we describe in the next sub-sections how they are constructed and what motivated these choices. We estimate four sets of coefficients $\{\beta_1,\ \beta_2,\ \beta_3\}$, one for each governance type, using the full sample of transactions *bsp*.[12]

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[11] It mirrors the approach in Monteverde and Teece (1982) who surveyed experts to independently assess engineering requirements of the design and production of components as a predictor of outsourcing decision.

[12] Observations are really identified by *bm* rather than *b*—the specific car or light truck model *m* produced by buyer *b*—but explanatory and control variables only use information on the buyers, ignoring individual models. In the construction of the dependent variables we always sum over all models produced by a buyer.

When we use one dependent variable, say $y^k = market$, all transactions that are sourced using one of the three non-market types are expected to have relatively low values for this variable. Only for an explanatory variable that is high for market governance and low for all three other types, or vice versa, do we expect a systematic relationship. From Table 2 we see that this is the case for complexity, which is expected to be low for market and high for captive, relational, and modular, thus we expect a negative sign on the complexity variable in the market regression. It is not the case for codifiability or capability, which are expected to be high for market transactions, but also for some of the other types of transactions, and there is no clear sign predictions for them. The only other unambiguous sign predictions are a negative effect on capability in the captive regression and on codifiability in the relational regression.

Pairwise comparisons between governance types generates several more unambiguous predictions. For example, if the sample only contained market and captive transactions, we would additionally expect a positive relationship between capability and the likelihood of a market transaction. One way to investigate these pairwise predictions is to take the difference between the equations for two governance types and estimate regressions of this form:

$$y^k_{bsp} - y^l_{bsp} = (\beta_{1k} - \beta_{1l})*complex_p + (\beta_{2k} - \beta_{2l})*codify_p + (\beta_{3k} - \beta_{3l})*capable_s + controls + \tilde{\epsilon}_{bsp}. \quad (2)$$

For example, using as dependent variable $\left(market_{sp} - captive_{bs}\right)$ makes it possible to test whether the prediction $\left(\beta_{3market} - \beta_{3captive}\right) > 0$ holds.

An alternative way to make pairwise comparisons is to classify transactions as one of the two types, depending on the values it attains in the distribution of both dependent variables. To avoid misclassifications, we only keep transactions with a high value for one dependent variable and a low value for the other, omitting those that have values on the same side of the median for both dependent variable. Pairwise comparisons can then simply be performed with a probit regression on the sub-sample of transactions assigned to one of the two types under consideration:

$$Pr\left[y^k_{bsp} > p^k_{50\%} \ \& \ y^l_{bsp} < p^l_{50\%}\right] = \Phi\left(\beta_{1kl}\, complex_p + \beta_{2kl}\, codify_p + \beta_{3kl}\, capable_s + controls\right), \quad (3)$$

with $\Phi(.)$ the normal distribution function and $p_{50\%}^{k}$ the median value for variable y_{bsp}^{k} in the full sample and similarly for type *l*.

4.2 Dependent variables: Four types of supplier governance

The heterogeneity of existing buyer-supplier relationships is illustrated in Table 4 for three suppliers in our dataset. It shows the fraction of sales going to a supplier's most important buyer, the supplier's market share in its principal product in the full sample, and the share of a product's market share accounted for by an average client. The large differences between suppliers along these dimensions suggest that lumping together all forms of outsourcing, as in the make-or-buy literature, hides a lot of interesting variation.

Table 4: Examples of heterogeneity in buyer-supplier interactions

Supplier name	Most important component	Fraction of sales accounted for by most important buyer	Market share of this supplier for its primary product	Market share for this product of firm's average buyer
Smarteq	infotainment	97%	1%	19%
Gallino Plasturgia	bumper	15%	1%	3%
Wescast	exhaust manifolds	34%	39%	8%

Note: These market shares are calculated in the full sample of transactions that we observe.

To go beyond the make-or-buy dichotomy, some theoretical contributions explicitly consider more complex forms of firm-to-firm relationships, called *networks* of suppliers in Powell (1990) or *hybrid* modes of organization in Ménard (2013). While the legal definition of firm ownership straightforwardly distinguishes in-house production from arm's length outsourcing, it is more difficult to objectively identify different types of governance. One needs a mapping from the observable features of buyer-supplier interactions to a set of types. Preferably, this mapping should apply in a variety of economic settings.

Rather than partitioning all buyer-supplier pairs exhaustively in a few governance types, we associate each type that we consider with a proxy variable that captures an essential feature of the type. For example, in a captive relationship the buyer provides the supplier with technological support and guarantees a stream of sales, but demands exclusivity in return. The number of clients that a supplier works for will vary inversely with the probability that the relationship is of the captive type. These continuous proxy variables are the dependent variables in our regressions and replace the vertical integration dummy in the make-or-buy literature.[13]

To define variables that are monotonically increasing in the likelihood that a transaction is of a given governance type, we were inspired by the industry case studies in the GVC literature, but still followed an approach that works generically. Looking across all transactions (indexed by *bmsp*), we measure the frequency that they involve the same supplier or supplier-buyer-product combination and normalize this by the frequency that the corresponding buyer, product or supplier-buyer combination occurs. We measure these frequencies not simply by the number of transactions, which would give them a probability interpretation, but weight them by the projected production volume of the relevant model, which gives them a market share interpretation. We propose as proxy for each governance type a ratio of two shares, where the case literature has guided us in the selection of the different shares in the numerator and denominator. Each proxy measures how concentrated contracting is along the dimension intuitively most closely connected with a particular governance type (in the numerator) and normalizes this by the concentration along another dimension.

The market shares that enter these calculations are listed in the third column of Table 5. They are the total market shares of the buyer, seller, or product over the entire sample (σ_b, σ_s and σ_p), the market share of a particular buyer-supplier pair over all products they exchange (σ_{bs}), and the same share limited to a single product p (σ_{bsp}), but still summing over all models. Some ratios are multiplied by –1 such that a higher value is always associated with a higher probability for the type. Table A.1 in the Appendix lists the mean and standard deviations of all four dependent variables.

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[13] If the sample had included buyer-component pairs that are often produced in-house, we could have added the integration dummy as a fifth proxy variable and add *hierarchy* as an additional governance type in the analysis. Schmitt and Van Biesebroeck (2017) propose a way to expand the sample and study the make-or-buy decision with the same dataset.

Table 5: Definitions of the dependent variables that proxy for the governance types

Governance type	Interpretation	Definition	
Captive	Supplier s has a low market share while buyer b has a high market share.	$-\ln\frac{\sigma_s}{\sigma_b}$	$= \ln\frac{\sum_m \sum_s \sum_p q_{bmsp}}{\sum_b \sum_m \sum_p q_{bmsp}}$
Relational	The specific buyer-product relationship *bp* accounts only for a small fraction of the total market share of supplier s.	$-\ln\frac{\sigma_{bsp}}{\sigma_s}$	$= \ln\frac{\sum_b \sum_m \sum_p q_{bmsp}}{\sum_m q_{bmsp}}$
Modular	Supplier s has a relatively high market share compared to the set of products ('module') that it supplies to a buyer b.	$+\ln\frac{\sigma_s}{\sigma_{bs}}$	$= \ln\frac{\sum_b \sum_m \sum_p q_{bmsp}}{\sum_m \sum_p q_{bmsp}}$
Market	A low market share for supplier s relative to the total market share of product p.	$-\ln\frac{\sigma_s}{\sigma_p}$	$= \ln\frac{\sum_b \sum_m \sum_s q_{bmsp}}{\sum_b \sum_m \sum_p q_{bmsp}}$

Note: The subscripts *bmsp* stand for buyer, model, supplier, and product, respectively. The sum of quantities in the numerators and denominators become market shares after dividing by the quantity for the entire market.

Captive relationships are characterized by a small market share for the supplier relative to the buyer it sells to, i.e. σ_s/σ_b is low and the negative of the logarithm of this relative market share—the dependent variable shown in Table 5—is high (Ahmadjian and Oxley, 2006).[14] In *Relational* governance, the supplier is independent and sought after for its unique expertise. This expertise tends to be at the level of a product which is often uniquely tailored to a buyer's needs (Bensaou, 1999; Pietrobelli and Rabellotti, 2011). As a result, the share of each buyer-product share in the supplier's overall sales is limited, i.e. σ_{bsp}/σ_s is low (Sturgeon et al., 2008). A supplier will operate with a similar independence in *Modular* relationships, but here one particular product can account for a large share of a supplier's market share (Sturgeon, 2002). The entire business of each buyer will still account for a relative small fraction of a supplier's overall market share, but individual components might dominate a buyer-supplier relationship (Humphrey, 2003). Finally, *Market* relationships will have low supplier market shares relative to the overall product market (Stigler, 1951) because there is a lot of competition if products are relatively common.

[14] In some industries, e.g. the apparel industry, supply chains can be buyer-driven leading to captive upstream suppliers, or producer-driven leading to captive downstream retailers (Gereffi, 1999). In the automotive sector only the former type is relevant.

4.3 Explanatory variables: Characteristics of parts and suppliers

Complexity

To ascertain whether a part is complex or not, we exploit the hierarchical structure of the component classification as defined by the data provider. We measure the complexity of individual parts by the number of sub-categories that are contained in the module that the part belongs to. Our objective is not to capture the technological sophistication required to produce the part, but the extent and intensity of interactions with the buyer and with other firms that supply parts that are assembled into the same module. If such linkages are extensive, suppliers face more uncertainty about possible future modifications. It makes it more difficult to incorporate all eventualities in a contract or makes it more costly to provide a complete design (Bajari and Tadelis, 2001).

We count the number of sub-categories in each module and all parts that belong to that module receive the same value. As we do not want to give this simple count a cardinal interpretation of complexity, we stick close to the theory and reduce the complexity proxy into a dummy variable that indicates whether a value is below or above the sample median.[15] Table A.1 in the Appendix shows the means and standard deviations of all three explanatory variables. 58% of transactions involve products that are part of a complex module. It differs from an exact 50-50 split because approximately 10% of the transactions in the dataset have a number of sub-categories exactly equal to the median value.

Codifiability

A useful, but narrow definition of codifiability is "the ability to precisely characterize in electronic format the nature of the product/service contracted for, including delivery requirements and any other contractual/fulfillment requirements that may pertain to a specific transaction, in a manner understandable to relevant parties." (Levi et al., 2003, p. 79) This definition involves the codifiability of the component itself, as well as the interactions between the buyer and supplier. More generally, a component is codifiable if the buyer is able to specify in advance and in a readily verifiable way the performance characteristics that

[15] An even simpler indicator we experimented with classifies components as either stand-alone parts or as sub-assemblies or larger modules that consist of several parts and need to be assembled themselves. Results were qualitatively similar using this alternative measure.

a part has to meet. If a part occurs in several modules in different places of a vehicle, it is less application-specific and more likely to appear in multiple outsourcing relationships. Standardization of its performance requirements will be more valuable, as it can generate scale economies and allow for more competition between suppliers. While components might still be complex, e.g. because they interact with many other parts, the standardization of functionality makes them less model-specific and reduces the scope for ex-post hold-up.

To operationalize this insight, we again rely on the hierarchical way *SupplierBusiness* has organized the components in the dataset. Transactions are first classified into a broad *area*, such as the engine, body & trim, interior, or chassis. Within each area there is a second level of sub-categories by function, called *modules*, such as a bumper, braking system, console, etc. In the third level of detail, all *components* in a module are partitioned in unique categories that share few characteristics with other third-level components. The more complex a module is, the more groups there are at this third level. Components with standardized characteristics are sometimes used in several modules (not necessarily produced by the same supplier), common examples include bearings, gaskets, and sensors. One measure of codifiability is a count of the number of times a component occurs in distinct third-level sub-categories over the entire set of 213 components that we observe. To make the variable less sensitive to outliers and facilitate interpretation of the regression coefficients, we again code it as one or zero, relative to the median value.

We experimented with an alternative measure using information from outside our dataset that classified a component as codifiable if it was covered by AUTOSAR (Automotive Open System Architecture). This is a collaboration of car assemblers and suppliers to develop open industry standards. The initiative addresses the increasing sophistication of electric and electronic systems in cars which makes exchange of extensive information between assemblers and suppliers more important, but also more feasible. An objective is to move away from proprietary solutions, prevalent in the car industry, and to optimize the interfaces of and interactions between components.[16] Results using this variable had almost always the same signs as the benchmark codifiability variable, but it reduced the sample size as not all components could be classified unambiguously.

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[16] Further information on the AUTOSAR initiative can be found at http://www.autosar.org/.

Capability

The third predictor for the type of governance is supplier capability which we measure by firm size. We draw inspiration from the literature on equilibrium market selection which explains firm-level growth from differences in innate productivity that firms discover themselves from past market success. More productive firms will gradually learn their ability, grow over time, and survive for a longer period. Haltiwanger et al. (2013) show that it is important to control for age as firms need time to reach their desired size.

This selection mechanism is relevant for the evolution of the automotive industry over the last 20 years, as it consolidated through mergers and supplier exit, especially in the 2008-2009 recession. The industry also globalized, further allowing the most efficient firms to increase in size (Sturgeon et al., 2008). A related literature on firm capability and learning argues that firms compete on the basis of internal resources that take time to develop (Penrose, 1959). These capabilities are not only technological sophistication, but can be any skill that helps a firm prosper and survive. R&D expenditures, for example, are observed for many fewer observations, but they tend to increase strongly with firm size.

We measure size using turnover (operating revenues) and divide by the age of the main EU branch or regional headquarters, both are observed in the *Amadeus* dataset. We prefer to measure firm size by sales rather than R&D expenditures as the latter variable would also capture the complexity of components. We again make the variable binary by comparing it with the sample median. While the correlation between complexity and codifiability, which are both based only on the component classification, is relatively high, the capability measure is almost orthogonal to the other two variables.

5. Results

Table 6 contains the results for specification (1) based on a separate regression for each governance type. At the top, we summarize the theoretical predictions from the GVC framework for the relationship between each type and the three key explanatory variables. The shaded areas indicate instances with an unambiguous sign prediction on the full sample of transactions. This occurs when only one of the four governance types is associated with a low value of a characteristic.

Table 6: Results by governance type

	Market	Captive	Relational	Modular
Complexity	Low	High	High	High
Capability	High	Low	High	High
Codifiability	High	High	Low	High
	(1a)	(2a)	(3a)	(4a)
Complexity	-0.628***			
	(0.0212)			
Capability		-0.0666**		
		(0.0265)		
Codifiability			-0.500***	
			(0.0298)	
Capability & Codifiability				0.0721**
				(0.0353)
Observations	16,537	16,159	15,331	15,805
	(1b)	(2b)	(3b)	(4b)
Complexity	-0.545***	-0.458***	0.373***	0.0923**
	(0.0325)	(0.0424)	(0.0427)	(0.0360)
Capability	-0.00553	-0.0580**	0.0906***	0.0358
	(0.0201)	(0.0263)	(0.0261)	(0.0223)
Codifiability	0.119***	-0.0392	-0.192***	0.00011
	(0.0350)	(0.0457)	(0.0459)	(0.0388)
Observations	16,537	16,159	15,331	15,805
Adjusted R^2	0.051	0.015	0.023	0.001
	(1c)	(2c)	(3c)	(4c)
Complexity	-0.530***	-0.501***	0.406***	0.110***
	(0.0366)	(0.0480)	(0.0465)	(0.0399)
Capability	-0.136***	-0.286***	0.409***	0.182***
	(0.0241)	(0.0316)	(0.0306)	(0.0262)
Codifiability	0.0675*	-0.102**	-0.121**	0.00372
	(0.0391)	(0.0512)	(0.0496)	(0.0425)
Distance	0.0768***	-0.0221**	-0.00303	-0.00921
	(0.00734)	(0.00961)	(0.00935)	(0.00796)
Hofstede culture	-0.117***	0.380***	-0.260***	-0.586***
	(0.0232)	(0.0304)	(0.0294)	(0.0252)
Border effect	0.0712***	-0.000509	-0.00480	0.109***
	(0.0271)	(0.0355)	(0.0344)	(0.0295)
Contract length	-0.00703***	-0.00335***	0.0131***	0.00739***
	(0.000588)	(0.000771)	(0.000748)	(0.00064)
Value added	-0.0449***	-0.0351***	0.0475***	0.0170***
	(0.00194)	(0.00254)	(0.00245)	(0.00210)
Observations	12,341	12,341	12,241	12,241
Adjusted R^2	0.133	0.051	0.096	0.071

Note: Table 5 contains the definitions of the (continuous) dependent variables. Shaded areas refer to coefficients with a theoretically unambiguous sign prediction. All regressions include a constant term (not reported). Standard errors in brackets; ***, **, * indicate statistical significance at the 1%, 5%, 10% level.

In the first panel, only the characteristic that can be unambiguously related to a governance type is included in the regressions. All three predictions are strongly supported. Market governance is negatively related to complexity, as the more sophisticated governance modes are only chosen if complexity is high. Similarly, the captivity proxy is negatively related to supplier capability and the relational proxy negatively related to codifiability. Each of the three point estimates is significantly different from zero. There is no unambiguous prediction for modular governance, as at least one other governance type also predicts a high value for each of the three characteristics. Only modular and market relationships combine high capability and high codifiability, but in market relationships these characteristics are not necessarily high in an absolute sense, as transactions are not complex. The proxy for modular governance is positively correlated with a dummy variable for simultaneously high values of capability and codifiability.

Results in the second panel confirm these findings for specifications that include all three explanatory variables simultaneously. The three shaded point estimates are lower in absolute value, but that is expected given the strong correlation between complexity and codifiability. For modular governance, all three signs are estimated to be positive, but only the complexity variable shows a statistically significant coefficient. With all control variables included, results reported in the third panel, none of the coefficients of interest change sign, and the statistical significance of several estimates even increase.[17] We now discuss the results in greater detail by governance type.

Market governance

The proxy for market governance shows a strong negative relationship with complexity, but the theory also predicts a high levels of codifiability and supplier capability. To some extent, this is almost by construction as the reverse would be difficult to imagine for transactions that are not complex. Still, there is no unambiguous sign prediction for capability because transactions with a low value for the market proxy could be relational or modular, in which case capability is also predicted to be high. The same holds for codifiability, as modular or captive transactions are also predicted to have high codifiability.

[17] Because corporate strategy might influence governance choices, we also estimated a specification with region-fixed effects (for the supplier and buyer) or even with firm-fixed effects for the buyer as additional controls. Some of these patterns are interesting in their own right, but it did not influence the signs and significance of the three explanatory variables of interest.

Table 7: Results for pairwise comparisons

First type = 1 Second type = 0	Market v. Captive	Market v. Relational	Market v. Modular	Captive v. Relational	Captive v. Modular	Modular v. Relational
Complexity	Low v. High	Low v. High	Low v. High	High	High	High
Capability	High v. Low	High	High	Low v. High	Low v. High	High
Codifiability	High	High v. Low	High	High v. Low	High	High v. Low

(a) Dependent variables are difference of two continuous variables

	(1a)	(2a)	(3a)	(4a)	(5a)	(6a)
Complexity	-0.0293	-0.940***	-0.639***	-0.911***	-0.606***	-0.289***
	(0.0434)	(0.0735)	(0.0609)	(0.0884)	(0.0831)	(0.0300)
Capability	0.151***	-0.544***	-0.319***	-0.704***	-0.481***	-0.232***
	(0.0285)	(0.0483)	(0.0400)	(0.0581)	(0.0546)	(0.0197)
Codifiability	0.169***	0.186**	0.0654	0.0258	-0.0940	0.127***
	(0.0462)	(0.0783)	(0.0649)	(0.0943)	(0.0886)	(0.0320)
Distance	0.0989***	0.0796***	0.0855***	-0.0194	-0.0132	-0.00653
	(0.00869)	(0.0148)	(0.0122)	(0.0178)	(0.0166)	(0.00603)
Hofstede culture	-0.497***	0.140***	0.469***	0.637***	0.962***	-0.326***
	(0.0275)	(0.0465)	(0.0385)	(0.0559)	(0.0525)	(0.0190)
Border effect	0.0717**	0.0723	-0.0381	-0.0175	-0.122**	0.121***
	(0.0321)	(0.0543)	(0.0450)	(0.0653)	(0.0614)	(0.0222)
Contract length	-0.00368***	-0.0201***	-0.0144***	-0.0163***	-0.0107***	-0.00578***
	(0.00070)	(0.00118)	(0.00098)	(0.00142)	(0.00133)	(0.00048)
Value added	-0.00980***	-0.0923***	-0.0618***	-0.0833***	-0.0527***	-0.0304***
	(0.00230)	(0.00387)	(0.00321)	(0.00466)	(0.00439)	(0.00158)
Observations	12,341	12,241	12,290	12,241	12,290	12,241
Adjusted-R^2	0.051	0.130	0.105	0.078	0.059	0.108

(b) Dependent variables are discrete

	(1b)	(2b)	(3b)	(4b)	(5b)	(6b)
Complexity	0.0297	-0.458***	-0.316***	-0.441***	-0.278***	-0.568***
	(0.0700)	(0.0458)	(0.0485)	(0.0422)	(0.0425)	(0.0910)
Capability	0.384***	-0.219***	-0.106***	-0.381***	-0.245***	-0.497***
	(0.0448)	(0.0312)	(0.0331)	(0.0286)	(0.0284)	(0.0549)
Codifiability	0.347***	0.225***	0.166***	0.0477	0.00355	0.147
	(0.0728)	(0.0489)	(0.0520)	(0.0452)	(0.0454)	(0.0954)
Distance	0.152***	0.0334***	0.0544***	-0.0210**	-0.00907	-0.0331*
	(0.0164)	(0.00903)	(0.00987)	(0.00871)	(0.00865)	(0.0177)
Hofstede culture	-0.378***	0.0372	0.271***	0.255***	0.467***	-0.594***
	(0.0441)	(0.0306)	(0.0330)	(0.0277)	(0.0276)	(0.0530)
Border effect	0.0360	0.0358	-0.0432	0.0153	-0.0742**	0.217***
	(0.0528)	(0.0356)	(0.0373)	(0.0325)	(0.0325)	(0.0654)
Contract length	-0.0051***	-0.0105***	-0.0098***	-0.0070***	-0.0059***	-0.00236
	(0.0011)	(0.00078)	(0.00083)	(0.00071)	(0.00070)	(0.00145)
Value added	-0.00685	-0.0380***	-0.0393***	-0.0369***	-0.0347***	-0.0249***
	(0.00530)	(0.00289)	(0.00326)	(0.00251)	(0.00263)	(0.00447)
Observations	3,705	8,857	7,501	9,862	9,556	2,816
Quasi-R^2	0.069	0.092	0.084	0.068	0.060	0.135

Note: In panel (a), the dependent variables are pairwise differences between the variables defined in Table 5 and estimation is with OLS. Panel (b) reports results from from Probit regressions using dummy dependent variables as described in the text. All specifications include a constant term which is not reported. Standard errors in brackets; ***, **, * indicate statistical significance at the 1%, 5%, and 10% level.

We resolve this ambiguity by making pairwise comparisons and report those results in Table 7. The theoretical predictions are again summarized at the top and the more numerous sign predictions are shaded. Results in panel (a) use specification (2), i.e. with the differences between two continuous governance proxies as dependent variables; results in panel (b) use dummy dependent variables according to specification (3). Across the 96 coefficient estimates reported in Table 7, there are only three instances where the coefficients in the two panels have a different sign, and they are never statistically significant.

In pairwise comparisons of market governance relative to the three alternatives, the complexity variable remains negative in five of the six cases, but the effects are not statistically significant for the comparison with captive governance in column (1). It is intuitive that market transactions are much less complex than relational or modular transactions, but not so different from captive transactions.

In the comparison with captive governance, market transactions also have the predicted positive sign on codifiability. The same holds true in column (2), for the comparison with relational transactions. We already found this effect in the unconditional comparison in Table 6, but the point estimates are now much higher and estimated more precisely than before. Finally, capability and codifiability are expected to be high for both market and modular governance, which are compared in column (3), but the results indicate that supplier capabilities are especially high for modular, while codifiability is especially high for market. It is intuitive that non-complex components are fairly easy to standardize and do not require such high supplier capabilities.

Some of the control variables also show intuitive patterns. In particular, market relationships that are governed by contracts should be more suitable for international trade and shipping over great distances. Distance has a positive and significant coefficient in column (1c) of Table 6 and in columns (1)-(3) of Table 7. Market governance is also systematically associated with contracts of shorter duration and contracts that generate lower value added.

Captive governance

The results in Table 6 that suppliers are more likely to be captive when their capabilities are low are in line with the theoretical prediction. The estimates in columns (1), (4), and (5) of Table 7 confirm this pattern in all pairwise comparisons.[18]

While complexity and codifiability are also predicted to be high for captive relationships, the point estimates on these two characteristics are negative in Table 6. It does not necessarily conflict with the theory as other governance types are also expected to have high values for them and they might very well be higher than for captive relationships. The sign on codifiability turns positive in columns (4a) and (4b) Table 7, in line with the prediction that captive governance is more likely than relational governance if codifiability is high. But the high standard errors suggest that the distinction is not very pronounced. Codifiability appears to be similar for modular relationships, but even higher for market relationships. Transactions under captive governance show much lower complexity than relational or modular transactions, but there is no difference with market transactions.

Three control variable that capture geographic or cultural distance show a systematically negative relationship with captive governance. The negative association with physical distance and the presence of country borders is consistent with frequent co-location of captive suppliers with the assembly plant. Carmakers also choose to maintain stronger control over suppliers that come from culturally very distinct countries.

Relational governance

All results for relational governance correspond to the theoretical predictions. The negative coefficient on codifiability that we found in the initial regressions is confirmed by the six positive coefficients in columns (2), (4), and (6) of Table 7.[19] The initial regressions already showed an overall positive association between complexity and relational governance, but the pairwise comparisons show that complexity is higher for relational than for all three other governance types, not only market. The same holds for capabilities. The theory predicts more

[18] Note that the positive sign on capability in column (1) is also in line with the prediction, because the sign would reverse if the dependent variable were defined as (*captive* – *market*) instead of (*market* – *captive*).

[19] In each of the three pairwise comparisons the dependent variable is defined to be low for relational governance.

capable suppliers in relational than in captive governance, but this even holds when comparing with the capabilities of market and modular suppliers.

The nature of technology in the automotive sector tends to favor relational governance. Helper (1991), Humphrey (2003), and Sturgeon et al. (2008) all describe the difficulty of outsourcing complex modules that are frequently tailored to individual models. The complexity stems not only from customization, but also from interactions with other components in the vehicle, and the mechanical (as opposed to electronic) technology that makes it more difficult to exchange knowledge. Many of the case studies in the GVC literature discuss the automotive sector as a prime example where outsourcing requires close collaboration and frequent interactions. Carmakers often bring such production in-house, but that is also costly as it cuts them off from crucial knowledge of technologically advanced suppliers, while in-house divisions rarely have the same innovative track-record of external suppliers. It is not surprising that these type of close relationships are distinguished from other relationships in our sample by simultaneously high complexity, high supplier capabilities, and low codifiability.

In terms of control variables, it is also intuitive that these collaborative relationships are associated with low values of cultural distance, longer contract length, and high value added. Distances are also lower than for market or modular.

Modular governance

In the initial comparison across all governance types there were no unique predictions for modular relationships. The values for all three characteristics should be high, but that is always the case for at least one other governance type as well. The pairwise comparisons with other governance modes that are preferred if one of the characteristics is low all generate the expected signs: a negative coefficient on complexity in the market vs. modular comparison; a negative coefficient on capability in the captive vs. modular comparison; and a positive coefficient on codifiability in the modular vs. relational comparison.

It is not directly predicted by the theory, but it is reasonable that modular governance involves more capable suppliers than market governance. In the latter case, suppliers only need to be capable enough to produce non-complex parts, which might not require very high capabilities in absolute terms. Modular relationships also involve more complex components than captive relationships, which is reasonable given the low capabilities and relatively non-complex parts produced under captive governance.

6. Supplier governance over a component's lifecycle

The results suggest that most of the theoretical predictions at the level of individual transactions, i.e. the nature of the sourcing relationship between a buyer and supplier for a particular part, are supported in the data. We now take a step back to see what this implies for differences between suppliers. We first classify all transactions into one of the four governance types, based on which of the proxies attains the highest value within its respective distribution. Next, we classify each supplier to the governance type that occurs most frequently across all its transactions.

In Table 8 we show the average values of two performance characteristics across all suppliers allocated to a type. The profit margin as a percentage of sales is by far the highest for suppliers that are mostly engaged in modular relationships, let's call them modular suppliers, and it is lowest for market and captive suppliers. In contrast, expenditures on R&D are highest for captive suppliers and lowest for market suppliers.

Table 8: Performance difference between supplier-types

	Market	Modular	Relational	Captive
Number of firms	20	16	27	25
Profit margin (% of sales)	0.5%	6.9%	1.9%	0.7%
	(16.1)	(45.3)	(14.0)	(14.4)
R&D expenditure (thousands €)	52	204	261	349
	(55)	(289)	(509)	(595)

Note: Average across suppliers for 2007. Supplier-type is determined based on the mode of the governance type over all their transactions. Standard deviations in brackets.

These differences fit a dynamic interpretation in terms of a product lifecycle. When new technologies emerge and are embodied in new components, carmakers often have to produce them in-house as no market for them exists (Stigler, 1951). Once performance standards become codified, production can be outsourced to captive suppliers, but the buyers structure the collaboration to capture most of the surplus (Helper, 1991). Captive suppliers initially receive training and knowledge transfers from their clients, but they invest strongly in R&D to build up their own capabilities. The objective is to graduate to a modular, more independent type of governance, that is much more profitable for suppliers. However, as the technology continues to mature, other suppliers also acquire the necessary expertise and inevitably products become standardized, such that market relationships governed by prices and contracts becomes feasible and profit margins of suppliers collapse again.

In the above evolution, codifiability increases before capabilities, but the order can also be reversed. In some cases, highly capable and specialized suppliers possess crucial expertise and they introduce new products or new functionalities. Suppliers spend a lot of resources on R&D, but are able to generate a decent profit margin. At first, collaboration with carmakers takes the relational form. The close collaboration that the new technology requires makes it only feasible to sell their services to relatively few clients. Only when it becomes possible to codify specifications in a more objective and easily transmittable fashion can they engage in more arm's length, modular collaborations, supply more clients, achieve greater bargaining power, and raise their profit margin. This process does not necessarily require as much R&D as creating a new technology, but it still requires highly capable suppliers to standardize the technology. As this process continues, eventually the technology will lose its complexity. Increasingly, suppliers will be chosen based on price and relationships will be governed by contracts. In sum, governance becomes more market-like, which lowers supplier profits.

7. Conclusions

The main objective of our study was to illustrate that empirical work can and should go beyond firms' make-or-buy decisions. The GVC framework distinguishes five stylized governance types, but in the analysis we exclude in-house production (*hierarchy*) as that choice is not observed in our dataset of supply contracts. In earlier work, we used the absolute frequency that a transaction is observed in the dataset as a proxy for the (inverse of the) likelihood that a transaction is performed in-house by carmakers. While this is a very indirect proxy, results in Schmitt and Van Biesebroeck (2017) show that the effects of the same three explanatory variables also have the predicted signs on the make-or-buy decisions.

The results in this paper support the GVC predictions. Less complex components are sourced through arm's length *market* interactions and more involved supplier governance is chosen when complexity is high. Components for which it is difficult to objectively codify performance requirements are more likely to be sourced through a *relational* type of governance where suppliers produce only a few components, but collaborate closely with a few buyers. Suppliers with low capabilities are more likely to work in a *captive* relationship, where they are beholden to a large buyer, but receive technological or commercial support.

A key takeaway from the analysis is thus that it is possible to distinguish different “buy” relationships and that the predictive power of the explanatory variables extends from the make-or-buy to the how-to-buy decision. As one of the most downstream manufacturing industries, the automotive industry sources inputs from a wide range of supplier industries. We find that car producers adjust their way of sourcing in a predictable way.

Another takeaway is that even complex components are only produced in-house if both codifiability and supplier capability are low. If only one of these dimensions is problematic, outsourcing is still feasible, but the collaboration with suppliers will take a particular form. In a captive relationship, the buyer retains almost all of the bargaining power and will have the same strong investment incentives that the PRT assigns to in-house production. In relational governance, the supplier and buyer interact almost as closely as an in-house division, which retains the advantages that the TCE assigns to in-house production. When both dimensions are high, both TCE and PRT predict outsourcing, but the complexity of the transactions requires what the GVC framework calls *modular* governance, involving more design responsibility and bargaining power for suppliers than in market relationship that is governed by contract.

Finally, assigning suppliers to the governance type they use most frequently reveals distinct patterns in performance. The differences are consistent with R&D expenditures leading to higher capabilities and an evolution in governance. They are also consistent with technologies becoming more standardized over their life-cycle, raising the profitability of suppliers as they gain greater independence, until eventually products become standardized and profits are competed away. Such a dynamic interpretation of the evolution of sourcing is appealing, but not explicitly shown. We leave a rigorous exploration of such sourcing dynamics for future work.

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Appendix

Table A.1 Summary statistics

	Number of observations	Mean	Standard deviation
(a) Dependent variables			
Market	16,537	0.642	1.322
Modular	15,805	2.833	1.396
Relational	15,331	3.963	1.628
Captive	16,159	1.890	1.678
(b) Key explanatory variables			
Complexity	16,537	0.666	0.472
Capability	16,537	0.453	0.498
Codifiability	16,537	0.259	0.438
(c) Control variables			
Distance	16,047	0.966	2.152
Hofstede culture	16,537	0.402	0.490
Border effect	16,537	0.356	0.479
Contract length	14,343	81.694	19.486
Value Added	14,569	2.931	6.129