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Expansion of engineering capacity without permanent team expansion and the role of specialized technical consulting in automotive development

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ABSTRACT
Electrification, the growing participation of software, and the reduction of development cycles have increased the demand for engineering in automakers and automotive suppliers, while cost pressure discourages the permanent expansion of internal teams. This article analyzes, through a narrative review of the literature on product development management, organizational economics, and studies on knowledge-intensive services, how companies in the sector can expand their engineering capacity by turning to external experts and what conditions make this strategy effective. The review covers classic studies on automotive project performance, transaction cost theory, essential competencies, supplier involvement, delay cost, engineering changes and absorption capacity, as well as the Brazilian regulatory framework for research and development incentives. The results indicate that hiring external engineering can reduce deadlines and rework when focused on well-defined activities and when the contracting party preserves the architectural knowledge of the product and the ability to integrate the received contributions. Without this internal base, outsourcing tends to generate dependency, loss of learning, and coordination problems. A typology of contracting modalities is proposed, associating each with its risks and theoretical foundations. It is concluded that specialized technical consulting is a complement, not a substitute, for the engineering competence of the contracting company.
Keywords: Product development. Automotive industry. Engineering outsourcing. Technical consulting. Absorption capacity.

1 INTRODUCTION

The development of a new vehicle is one of the most complex engineering ventures in the manufacturing industry. It involves thousands of components, hundreds of suppliers, and teams from different specialties, who need to converge on a safe, homologable, and economically viable product in increasingly shorter timeframes. Clark and Fujimoto (1991), in the study that became a reference on the subject, demonstrated that manufacturers from different regions showed significant differences in deadlines, engineering productivity, and product quality, and that these differences were associated with how each company organized its projects, integrated its teams, and involved its suppliers. Since then, the ability to develop products quickly and efficiently has come to be recognized as a source of competitive advantage in the sector.

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In recent decades, this capacity has come under pressure from simultaneous forces. Electrification introduced new systems and new interfaces, software has taken on a central role in vehicle functions, as discussed by Broy (2006), and competition has come to require more frequent portfolio renewals. At the same time, companies face cost constraints that discourage the permanent expansion of internal teams, especially because demand for engineering fluctuates throughout the program lifecycle. In this context, hiring engineering and specialized technical consulting emerges as an alternative to expand capacity without converting demand peaks into fixed structures. However, the literature shows that this alternative has its own conditions of effectiveness and risks, which are not always considered in hiring decisions.

The objective of this article is to analyze, based on scientific literature, how manufacturers and suppliers can expand their engineering capacity through external specialists and what factors condition the success of this strategy. It seeks to answer three main questions. What theoretical foundations explain the decision to conduct or contract engineering activities internally? Under what conditions does the participation of external agents reduce deadlines, costs, and rework? And what governance and learning mechanisms allow the contracting company to benefit from this participation without losing essential competencies? The text is organized into six thematic axes, preceded by a description of the method and followed by final considerations.

2 METHODOLOGY

The study adopts a narrative literature review approach, qualitative in nature, with an exploratory and descriptive character. This approach is suitable for topics situated at the intersection of different fields of knowledge, such as product development management, organizational economics, innovation management, and systems engineering, in which the contribution of the work lies more in the critical articulation between theories and evidence than in the statistical aggregation of results. Unlike a systematic review, narrative review allows the combination of reference books, peer-reviewed articles, working papers from recognized research centers, and legal texts, provided all are traceable and relevant to the investigated issue.

The sources were identified in academic databases and repositories of recognized integrity, including the portals of the publishers INFORMS, Wiley, Elsevier, Springer, and SAGE, the RePEc repository, the institutional repositories of the Massachusetts Institute of Technology and the University of Tokyo, the SciELO library, and the official Brazilian legislation portals. Descriptors in Portuguese

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were used] Portuguese and English related to automotive product development performance, supplier engagement, engineering outsourcing, knowledge-intensive services, contingent labor, transaction costs, core competencies, delay cost, engineering changes, design structure matrix, and absorption capacity. Each reference had authorship, year, journal, volume, and pagination individually verified. The inclusion criteria favored widely cited seminal works in their respective fields, empirical studies conducted in the automotive industry, and works that explicitly discuss the division of engineering labor among companies. Promotional materials, reports without identifiable authorship, and texts whose origin could not be confirmed were excluded. The analysis was conducted by thematic categories, which gave rise to the article's development sections, and resulted in the development of a typology of external engineering contracting modalities, presented in Table 1. It is recognized as a limitation that a significant part of the available empirical evidence was produced in specific contexts and periods, which recommends caution in generalizing results to the current scenario.

3 PRODUCT COMPLEXITY AND PRESSURE ON ENGINEERING CAPACITY

Contemporary understanding of automotive product development owes much to the research program conducted by Clark and Fujimoto in the late 1980s. In a 1989 article, the authors analyzed designs from Japanese, North American, and European manufacturers and sought to explain why the former managed to develop vehicles in shorter timeframes. The authors concluded that planning and engineering timelines respond to distinct factors and estimated that the real advantage of Japanese manufacturers was on the order of 12 months, a difference considered competitively relevant in markets subject to rapid changes in demand and technology (CLARK; FUJIMOTO, 1989). In the book published in 1991, they expanded the analysis and showed that project performance depended on an integrated set of practices, such as overlap between product and process engineering stages, intense communication between areas, strong leadership from project managers, and supplier involvement in component engineering (CLARK; FUJIMOTO, 1991). This work shifted the focus from the simple number of resources to how these resources are organized.

The subsequent evolution of these differences reinforces the idea that engineering capability is a dynamic asset. Ellison et al. (1995), when updating the study to the 1990s, observed that North American and European manufacturers had advanced significantly toward the performance levels achieved by the Japanese, while Korean manufacturers proved relatively efficient in terms of lead time and productivity, but with lower design quality. Fujimoto (1997), in turn, recorded that some

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Japanese automakers reduced the engineering period from about 30 months to approximately 20 months or less in the mid-1990s, in a new cycle of competition based on capacity building. These results indicate that development performance can be learned and imitated, but also that the reference frontier continuously shifts.

The complexity of the product, however, has grown significantly since these studies. Broy (2006) described automotive software engineering as a field marked by the accelerated increase in the number of functions implemented in software, by the distribution of these functions across various electronic control units, and by strong interdependence among them, which generates unprecedented challenges in specification, integration, and validation. Electrification has added new high voltage, thermal management, and energy control systems, which add to traditional mechanical systems and require skills that many companies did not have in their teams. The result is an increase in the volume and diversity of knowledge needed to complete a program, in a period when deadlines, instead of lengthening, tended to shorten.

This combination of more complexity and less time produces a structural mismatch between engineering demand and supply in companies. Demand is not constant, as it concentrates in the phases of defining and detailing each program and decreases in the phases after launch. Keeping teams sized for peaks implies idleness in the valleys, while scaling them to average implies bottlenecks at critical moments. Clark and Fujimoto (1991) had already shown that engineering productivity, measured in hours consumed per project, varied widely between companies, which means the problem is not solved just with more people. The relevant question becomes how to combine internal and external resources in order to increase effective capacity without compromising product integration.

In the Brazilian case, this discussion has an additional dimension. Consoni and Carvalho (2002) studied the Brazilian subsidiaries of General Motors, Ford, Volkswagen, and Fiat and identified distinct trajectories of product development training. According to the authors, companies that adopted partially decentralized global strategies expanded their activities and engineering staff in the country, while others, with more centralized strategies, reduced their local research and development areas. This result shows that the installed engineering capacity in a country depends on strategic decisions of parent companies and can fluctuate over time. In such environments, the availability of qualified external specialists becomes an element of the local innovation infrastructure, capable of cushioning these fluctuations and preserving skills in the territory.

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4 MAKE OR HIRE AND THE THEORETICAL FOUNDATIONS OF THE ENGINEERING FRONTIER

The decision to carry out engineering activities internally or contract them out of third parties can be analyzed in light of transaction cost theory. Williamson (1985) argues that the choice between market and hierarchy depends on transaction attributes, especially the specificity of the assets involved, uncertainty, and frequency. The more specific the knowledge and investments required by an activity, the greater the risk of opportunistic behavior between the parties and the greater the relative advantage of vertical integration. Applied to engineering, this logic suggests that standardized activities, with clear specifications and a low degree of mutual dependence, can be contracted with moderate coordination costs, while activities requiring knowledge deeply related to the product tend to be better managed within the company.

The automotive industry provided one of the first empirical evidence of this proposition. Monteverde and Teece (1982) tested transaction cost theory with data from components from American automakers and concluded that costs associated with the development and deepening of human skills, that is, the engineering knowledge accumulated in component design, help explain where efficient boundaries are established between companies. Components that required greater specific engineering effort were more likely to be produced internally. This finding is relevant to the current discussion because it indicates that engineering knowledge is, in itself, an asset whose transfer between companies has costs, and that outsourcing decisions need to consider these costs as much as contracted prices.

A second theoretical perspective starts from the notion of essential competencies. Prahalad and Hamel (1990) define these competencies as the collective learning of the organization, especially the ability to coordinate diverse production skills and integrate multiple technology streams, and warn of the risk that indiscriminate outsourcing will empty the company's knowledge base. Quinn and Hilmer (1994) developed this argument in the field of strategic outsourcing, proposing that companies concentrate resources on a limited set of competencies in which they can achieve a prominent position and contract from specialized suppliers the activities in which they have no advantage or strategic need for dominance. The combination of the two approaches suggests that the engineering frontier should be drawn from the strategic value of knowledge, not just the hourly cost.

The distinction between what the company does and what it needs to know is central to this discussion. Brusoni, Prencipe, and Pavitt (2001), when studying companies that act as system integrators, showed

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that these organizations maintain broader technological knowledge than necessary for the activities they perform directly, precisely to coordinate suppliers and integrate externally developed components. The expression that gives the work its title, according to which companies know more than they do, synthesizes an important conclusion for the automotive industry. The automaker can contract the development of product parts but needs to retain enough knowledge to specify, evaluate, and integrate what is received, otherwise it loses control over the vehicle's architecture.

These approaches converge toward a view that expanding engineering capacity through external agents is not a purely operational decision. It involves defining which knowledge the company considers essential, which activities can be separated with clear interfaces, and what level of internal knowledge should be maintained to oversee the

contracted work. Transaction cost theory offers criteria to assess the specificity and uncertainty of activities, the perspective of essential competencies guides the preservation of competitive advantage bases, and the concept of system integration explains why the contracting party's knowledge must go beyond the scope of what it performs. Together, these lenses allow for a more rigorous assessment of when hiring expands capacity and when it merely transfers the problem. **5 SERVICES INTENSIVE IN KNOWLEDGE E MODALITIES OF TECHNICAL CONSULTING**

The literature on knowledge-intensive business services, known by the acronym KIBS, provides a conceptual basis for understanding the role of engineering and technical consulting companies. Den Hertog (2000) describes these organizations as facilitators, carriers, or sources of innovation for their clients and argues that some of them act as co-producers of innovation, due to the close, almost symbiotic relationship they establish with the companies they serve. The author highlights that the knowledge flows involved in this relationship are not limited to tangible deliveries, such as reports or drawings, and include intangible knowledge, transmitted through continuous interaction between specialists, and raises the hypothesis that these services are becoming a second knowledge infrastructure alongside the public one.

Muller and Zenker (2001) analyzed the role of these services in regional and national innovation systems and characterized them as agents of knowledge transformation. In interaction with their clients, knowledge-intensive service companies acquire information about concrete problems, recombine this knowledge with their own skills, and disseminate it to other organizations,

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contributing to the circulation of practices between companies and sectors. Based on a survey conducted in regions of France and Germany, the authors associated interaction with these services with a greater propensity to innovate among small and medium-sized industrial enterprises, describing them as bridges to innovation. For the automotive industry, this perspective helps explain why consultants and engineering service providers function as channels for transferring methods, tools, and technical solutions between automakers, suppliers, and regions, expanding the repertoire available to each company individually.

The notion of open innovation, proposed by Chesbrough (2003), reinforces this reading. According to the author, companies can and should use external ideas and knowledge, as well as internal ones, to advance their technologies, breaking with the model in which all research and development were carried out within their own laboratories. In the field of automotive engineering, open innovation manifests in the participation of suppliers, universities, research institutes, and companies specialized in developing solutions. Specialized technical consulting fits into this model as a source of external knowledge that can be mobilized on a punctual basis, without the company needing to permanently internalize all the skills it needs in each program.

The use of external professionals and specialists, however, involves a tension that Matusik and Hill (1998) analyzed when discussing contingent work. The authors argue that temporary and contracted workers can bring to the company knowledge available in the market, encouraging knowledge creation and reducing costs, but that this same circulation creates the risk that private and strategic company knowledge will be taken out when the employment relationship ends. The resulting recommendation is that the company differentiate the type of knowledge involved in each activity, using external agents more intensively where knowledge is more public in nature and protecting activities where its distinctive knowledge is concentrated.

Based on these contributions, it is possible to distinguish external engineering contracting modalities that differ in scope, knowledge control, and the risks involved. Table 1 summarizes these modalities and associates each with the theoretical references that underpin its analysis. The typology shows that there is no single way to contract engineering and that each modality imposes different requirements on the contracting company. The allocation of professionals requires direct management and attention to the retention of the generated knowledge. The work package requires well-specified interfaces. Specialized consulting requires internal absorption capacity. Complete development by third parties requires the contractor to retain sufficient competence to evaluate and integrate the result.

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Table 1 – Types of hiring external engineering in automotive development

Modality	Typical scope	Knowledge control	Main risks	Reasoning
Allocation of professionals	Experts circulate on the team integrated with the internal ones, but can go out with the contracting party, upon termination of the your direct link management	Knowledge from teams from	Dependence on people and exit knowledge private	Matusik e Hill (1998)
Work package	Technical deliveries delimited, such as calculations, architectural and the simulations and breakdown of Components	Contracting party withholds knowledge partner, the specific	Interface template specified and Rework in integration	Takeishi (2002); Eppinger et al. (1994)
Specialized technical consulting	Diagnosis, review of design, analysis of failures and transfer of	Knowledge transferred from explicit form to Contracting methods	Low utilization when internal absorption capacity is lacking	The Duke (2000); Cohen and Levinthal (1990)
Modality	**Typical scope**	**Knowledge control**	**Main risks**	**Reasoning**
Complete third-party development	System or subsystem developed externally from specifications	Partner-focused knowledge	Loss of jurisdiction, Dependency and transfer costs	Clark (1989); Monteverde and Teece (1982)

Source: prepared by the author (2026), based on the authors indicated in the last column.

6 INTEGRATION OF EXTERNAL SUPPLIERS AND PARTNERS IN THE DEVELOPMENT PROCESS

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The involvement of external agents in automotive engineering is not a recent phenomenon, and the accumulated experience with component suppliers offers direct lessons for hiring engineering services. Clark (1989) analyzed the relationship between project scope, defined by the proportion of unique parts developed internally, and the on-time performance and productivity of engineering. The author found that the scope varied considerably among manufacturers, even for comparable products, and that differences in parts strategy and supplier involvement explained a significant portion of the lead time and cost advantages observed in Japanese manufacturers, which combined a high proportion of exclusive parts with intense supplier involvement in engineering.

This result demonstrates that transferring part of the engineering to external agents can increase the effective capacity of a program, provided it is accompanied by appropriate coordination mechanisms. Takeishi (2001), in a study conducted in the Japanese automotive industry, investigated why some automakers performed better than others by sharing development work with the same suppliers. His results showed that performance in component development depended on coordination both with the supplier and within the automaker's own organization, and the author concluded that outsourcing is not effective without substantial internal effort. Engineering hiring, therefore, does not reduce the need for management, but changes its nature.

The internal coordination mentioned by Takeishi (2001) involves activities such as clearly defining requirements, technical evaluation of proposals, integrating results with other vehicle systems, and communication between the contracting areas that will be affected by the contracted work. When these activities are neglected, the external agent works with incomplete or outdated information, and inconsistencies tend to appear only in the integration and validation phases, when correction is more expensive. For engineering technical consultancies, this means that a significant part of the value delivered depends on the quality of customer interfaces, and that the participation of external experts in technical meetings, design reviews, and failure analyses is a condition for knowledge to flow both ways.

The way knowledge is shared between contractor and contractor also influences results. Takeishi (2002) showed that outsourcing the design of a component does not mean the automaker can give up knowledge about it. In regular projects, architectural knowledge, which deals with how components articulate in the vehicle, proved more important to the automaker than the specific knowledge of the component, expected from the supplier. In projects involving new technology for the supplier, however, the automaker needed more specific knowledge to face, together with the partner,

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engineering problems not yet explored. In these cases, the overlap of knowledge between the parties proved preferable to rigidly separated boundaries.

This evidence allows for the formulation of practical criteria for integrating engineering consultancies and service providers into automotive programs. In routine activities with known technology, the client can focus on architectural knowledge and delegate technical detailing to the partner, provided the interfaces are well defined. In activities involving new technologies, such as those associated with electrification, collaboration should be more intense, with mixed teams and continuous information exchange. In both cases, external participation increases the company's capacity only when the contracting party retains people with sufficient knowledge to engage in technical dialogue with the partner, evaluate their proposals, and be responsible for integrating the product as a whole.

7 COST OF DELAY, REWORK, AND ENGINEERING CHANGES

The economic justification for expanding engineering capacity with external resources is directly linked to the value of time in product development. Smith and Reinertsen (1998) proposed that companies explicitly estimate the economic cost of delay in product launch, through models that relate the project schedule to the flow of revenues and profits throughout the life cycle. The authors argue that, without this quantification, design decisions tend to favor the reduction of directly visible costs, such as engineering hours or component pricing, over timeframe, whose value remains implicit. When the cost of delay is made explicit, hiring additional capacity to eliminate a bottleneck can prove economically advantageous, even if the unit cost of that capacity is higher than that of the internal team.

Reinertsen (2009) deepened this approach by advocating that the cost of delay should be adopted as the main metric to guide economic decisions in product development. The author shows that work queues in overloaded engineering teams increase cycle time, delay information retrieval, and increase technical risk, and that these queues are often invisible in traditional management systems. From this perspective, the use of external specialists during peak demand moments can be interpreted as a mechanism to reduce queues and protect project flow. The effectiveness of this mechanism, however, depends on the contracted resources being applied exactly where queues form.

Rework is another central component of development cost. Jarratt et al. (2011), in a comprehensive review of the literature on engineering changes, define change as any modification in parts, drawings, or software after their release, regardless of size or type. The authors show that the frequency and

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impact of changes are associated with the complexity of the product, its architecture, and the degree of innovation, as well as organizational factors such as team structure and professional attitude. Changes originating in one part of the product can propagate to other systems, generating chain effects on costs and deadlines. In automotive programs, where interdependencies between systems are numerous, change management becomes an activity that consumes a significant portion of the available engineering capacity.

Reducing rework largely depends on anticipating the identification and solving of problems. Thomke and Fujimoto (2000) called this strategy front-loading and defined it as the shift from identifying and solving design problems to the early stages of development. The authors describe two complementary approaches. The first consists of transferring knowledge about problems and solutions from previous projects to new ones. The second consists of employing advanced technologies and methods, such as computer simulation, to detect problems before they materialize into physical prototypes. External specialists with accumulated experience in different programs can contribute to both approaches, especially the first, by bringing to the project knowledge of problems already faced in other contexts.

The organization of engineering activities also influences the occurrence of rework and the effectiveness of outsourcing. Eppinger et al. (1994) proposed the use of the design structure matrix, known by the acronym DSM, to represent information dependencies between tasks and identify tightly coupled sets of activities that require iterations. Browning (2001) reviewed the applications of this tool to system decomposition and integration and showed that it can represent components, teams, activities, and parameters. For the decision to hire engineering, this approach offers an objective criterion, since loosely coupled activities can be separated and contracted with lower risk, while strongly coupled activities require closeness and intense communication among those involved.

8 RISKS, GOVERNANCE, AND ABSORPTION CAPACITY

The main risk associated with expanding engineering capacity through external agents is the gradual erosion of internal competence. Cohen and Levinthal (1990) demonstrated that a company's ability to recognize the value of external information, assimilate it, and apply it for commercial purposes, which they called absorption capacity, depends heavily on its prior related knowledge and is largely built as a byproduct of its own research and development activities. A company that ceases to carry out engineering activities in a given domain loses, over time, the ability to evaluate and leverage

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knowledge produced by third parties in that same domain. Technical consulting, in this sense, produces more value precisely in companies that maintain a solid internal base.

Takeishi (2002) identified concrete consequences of this risk in the automotive industry. The author observed that outsourcing component design limits the automaker's practical learning and that shared suppliers can transmit knowledge to competitors. In his study, one automaker stood out from the others in managing different types of knowledge by combining career development, extensive documentation, internal training, and incentives. The author emphasizes, however, that implementing and combining these mechanisms consistently is difficult, which helps explain the performance differences between companies that used the same suppliers. The lesson for engineering hiring is that the result depends less on the chosen partner and

more of the contractor's discipline in knowledge management.

The governance of the relationship with external experts must, therefore, include explicit mechanisms for knowledge transfer and retention. Among these mechanisms are the documentation of technical decisions and their justifications, the participation of the contracting party's professionals in activities carried out by partners, the contractual definition of intellectual property over the results, and the holding of structured transfer sessions at the end of each stage. Matusik and Hill (1998) add that the company must protect the activities in which its distinctive knowledge is focused by limiting the exposure of strategic information. The combination of these precautions allows the company to temporarily expand its capacity without transferring outward what sustains its competitive position.

The institutional environment also conditions these decisions. In Brazil, Law No. 13,755, of December 10, 2018, established the Rota 2030 Program and provided for the deduction, from income tax and social contribution on net profit, of amounts calculated on up to 30% of the expenditures made in the country on research and development, including experimental development activities, supplier training, and technical support services (BRAZIL, 2018). This provision was later repealed by Law No. 14,902, of June 27, 2024, which established the Green Mobility and Innovation Program and kept investment in research and development among the policy guidelines for the sector (BRAZIL, 2024). The existence of these instruments indicates that the installed engineering capacity in the country is treated as an object of public policy.

The articulation between the reviewed evidence allows for the outlining of conditions for specialized technical consulting to actually expand the engineering capacity of automotive companies. The first is the clear delimitation of the scope, based on the analysis of the coupling between activities and the specificity of the knowledge involved. The second is the preservation, by the contracting party, of

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architectural knowledge and the capacity for product integration. The third is the existence of formal mechanisms for knowledge transfer and protection of essential competencies. The fourth is the economic evaluation of contracts based on the cost of delay, and not just the cost of the engineering hour. When these conditions are present, the participation of external experts tends to reduce deadlines and rework, instead of just shifting the problem to another stage of the program.

CONCLUSION

This article analyzed the expansion of engineering capacity in the automotive industry through external experts, a topic that gained relevance in light of the increasing complexity of vehicles, the growing participation of software, and pressure for shorter development cycles. The review showed that hiring engineering and technical consulting is a legitimate response to the mismatch between the fluctuating demand of programs and the permanent structure of internal teams. Classic studies on automotive development performance have shown that engineering timeline and productivity depend more on resource organization than on their volume. A

Updating these studies and the evidence about deadline reductions in the following decades indicate that these capabilities can be learned, but the performance benchmark continuously shifts, which imposes a permanent effort on companies to update themselves.

At the theoretical level, transaction cost theory, the perspective of essential competencies, and the concept of system integration offer complementary criteria to define the engineering frontier. Activities with low specificity and clear interfaces can be contracted with less risk, while architectural knowledge and competencies that support competitive advantage must remain under the company's control, which needs to know more than it actually performs.

The literature on knowledge-intensive services and open innovation shows that consulting firms and engineering firms act as co-producers of innovation and as channels for knowledge circulation between companies and sectors. This role, however, comes with the risk of strategic knowledge leakage, which requires the contracting party to differentiate the nature of the knowledge involved in each activity before defining the most appropriate contracting modality.

Experience with supplier involvement in automotive development confirms that external participation can increase the effective capacity of programs, but only when accompanied by internal coordination efforts. Outsourcing does not reduce the need for management, it only changes its nature, and the

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quality of interfaces between contractor and contractor becomes decisive for technical and economic results.

The analysis of the cost of delays, rework, and engineering changes shows that the value of technical consulting should not be measured solely by the cost of the contracted hour. When additional capacity eliminates bottlenecks, reduces queues, and anticipates problem resolution, its benefit can far outweigh its direct cost. Tools like the project structure matrix help identify activities that can be safely separated.

The main identified risk is the erosion of the contracting company's absorption capacity. Companies that cease to carry out engineering activities in a given domain lose the ability to evaluate the work of third parties in that same domain. Therefore, relationship governance must include documentation, participation of internal professionals, definition of intellectual property, and structured mechanisms for knowledge transfer.

It is concluded that specialized technical consulting is a complement, not a substitute, for the engineering competence of automotive companies. Its contribution is greater when the scope is well defined, when the contracting party preserves architectural knowledge, and when decisions are guided by the cost of delay. As a research agenda, empirical studies on the performance of programs using contracted engineering in Brazil and other emerging markets are recommended.

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