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Research Paper

Modularity in KIBS: The Case of Third-Party Logistics Service Providers

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ABSTRACT This paper investigates service modularity and inter-organizational coupling in knowledge-intensive business services (KIBS). While KIBS literature traditionally emphasizes tight client–provider interactions with service customization, modularity literature emphasizes inter-organizational decoupling with service standardization. We disentangle this tension by exploring how KIBS firms utilize service modularity and shape their client–provider relationships in terms of information and knowledge sharing. Conducting two in-depth case studies of third-party logistics (TPLs), we show that TPLs extensively rely on service modularity with standard procedures as their constitutive element. We also demonstrate that service modularity and inter-organizational decoupling are aligned for knowledge sharing but not for information sharing, which remains high regardless of the service architecture. Overall, we suggest that modularity in KIBS differs in many aspects from modularity in products and that these differences significantly impact the organizational design consequences of service modularity. Theoretical and managerial implications are drawn.

KEY WORDS: Third-party logistics, knowledge-intensive business services, service modularity, inter-organizational relationships, mirroring hypothesis

JEL Classification: O32, O33

Introduction

A majority of firms face the challenge of achieving profitable and successful growth while balancing adaptation to individual customers' requirements with the necessity of serving several

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customers at once (Davies, Brady, and Hobday 2007). This challenge is peculiar in the case of knowledge-intensive business services (KIBS[4]) firms due to the customized nature of knowledge-intensive services, which are usually developed around the specific needs of individual clients with restricted possibilities for service standardization (Hertog 2000; Muller and Zenker 2001). Consequently, the production of KIBS is often the result of a joint effort of the service provider and the client through an intense knowledge-sharing and co-exploration activity (Bettencourt et al. 2002; Hertog 2000; Miles 2005; Miozzo and Grimshaw 2005).

Aside from discussing the customized nature of KIBS, recent literature has made the point that KIBS firms might adopt modular approaches to reconcile the above trade-off and to simultaneously achieve the benefits of both customization and standardization (Meyer and DeTore 2001; Miozzo and Grimshaw 2005). However, very few studies can be found on service modularity, which appears still to be in its infant stage of development (Rajahonka, Bask, and Lipponen 2013; Voss and Hsuan 2009).

On the contrary, product modularity literature is well developed, with several studies focusing on its distinctive elements, determinants, measures, benefits, costs and organizational consequences (Campagnolo and Camuffo 2009, 2010). In the product domain, modular architecture permits the design of a product by combining standard modules that can be "mixed and matched" (Campagnolo and Camuffo 2010; Sanchez and Mahoney 1996). Modules are combinable and can be designed as "black boxes," with little or no need of knowledge sharing among the organizational units involved in their design or combination processes. In the service domain, much less is known, and existing studies mainly extend the insights that emerge from product modularity to service modularity.

The literature on service modularity still lacks studies aimed at offering an in-depth understanding of the inner constitutive elements of service modules and fails to describe how firms develop and rely on modular services.

Since (knowledge-intensive) services are different from products in many aspects (Sundbo 2002), increasing our understanding of service modularity and its applicability in the KIBS context would permit better inferences with respect to the consequences of organizational design, specifically those associated with service modularity. On this subject, a theoretical tension is evident between the current insights of the modularity literature and the main findings of the KIBS literature. More specifically, the modularity literature suggests that the architecture of products mirrors the architecture of organizations; that is, products' features shape how organizations manage their intra- and inter-organizational relationships: the so-called "mirroring hypothesis" (Colfer and Baldwin 2010). This literature has expanded even further, as it has demonstrated that the fit between product and organizational architecture has performance implications. In contrast to the modularity literature, the mainstream KIBS literature emphasizes strong inter-organizational interactions related to a client's possession of much of the knowledge and competence that a KIBS firm needs to effectively design and deliver services such as the client's business/industry features, desired service attributes/goals and the client's available technologies and

[4] KIBS firms are enterprises whose primary value-added activities consist of the accumulation, creation or dissemination of knowledge for purposes of developing a customized service. Examples of KIBS firms are technical engineering services, management consultancy, software and information processing services, research and development, marketing and media services, and third- and fourth-party logistics services (Miles 2005).

routines (Sundbo 2002; Bettencourt et al. 2002). Clients collaborate on the service development and production via an intense knowledge-sharing and exploration activity with the KIBS firm (Gallouj 2002; Miles 2005). Thus, the use of modular architecture in KIBS questions the possibility of extending to knowledge-intensive services the organizational design consequences associated with modularity in products. The development of modular services within the KIBS firms' business model deserves specific attention (and a note of caution), especially concerning the application of modularity theory findings to inter-organizational relationships. It is still debated what service modularity in (knowledge-intensive) service is, and whether service modularity leads to organizational modularity.

The tension between the KIBS and the modularity literature reveals that we need studies designed to increase our understanding of service and organizational modularity in KIBS. In this paper, we take on the challenge of contributing to this debate and specifically focus on modularity at the firm level to study how the adoption of modular services affects inter-organizational relationships between the KIBS firm and its customers.

Overall, the present study aims at exploring:

(a) how KIBS firms utilize service modularity to develop their offerings and
(b) how the use of modular architecture affects inter-organizational relationships between KIBS firms and their customers.

This study explores the above research questions by analyzing the service architecture and inter-organizational relationships of two third-party logistic (TPL) providers.[5]

Our study shows that TPLs extensively rely on service modularity and that the use of *standard procedures* is the constitutive element of modular services. Concerning the organizational design consequences associated with the use of modular architecture, our results are mixed: partially in line with the mainstream modularity literature and partially in line with the KIBS literature. Specifically, our findings suggest that inter-organizational relationships are variously characterized in terms of knowledge sharing and information sharing.

The paper proceeds as follows. The next section discusses the current theoretical debate of modularity in services and organizations. The third section outlines the research method, including the research setting, study design and some background data on the two case studies. The fourth section contains the within- and cross-case analyses and advances a set of testable propositions. Our findings are discussed in the fifth section, while the final (sixth) section contains our conclusions and identifies avenues for future research.

Theoretical Background: Modularity in Services and in Organizations

Service Modularity

Modularity refers to the way in which a system can be divided into different parts or modules. Modularity helps the problem of complexity of service design be mitigated and service development be shared between specialized groups within the same organization or across

[5] TPLs are considered KIBS firms as, over time, they have increased the number and variety of their services as well as their knowledge and technology content (Hertz and Alfredsson 2003).

firm boundaries (Sanchez and Mahoney 1996). The managerial literature has mainly used and deepened the concept of modularity in the product domain, while scholars have only recently started debating it as it applies to services (Voss and Hsuan 2009).

According to the modularity literature, modular service architecture consists of standard modules containing standard sub-modules that can be freely mixed and matched with one another; that is, they are combinable (Meyer and DeTore 2001). Langlois and Robertson (1992) make the point that a modular system can be seen as a service that customers can separate into subgroups, which they can then arrange into various combinations that suit their personal preferences. Modularity offers flexible solutions that help customers co-create their unique value through multiple-service usage patterns and allow suppliers to exploit their knowledge base in a number of supply relationships.

Pekkarinen and Ulkuniemi (2008) suggest a three-dimensional concept of modularity in service production, which includes modularity in services, processes and organizations. *Modularity in services* refers to the opportunity (visible to a customer) to combine different service modules to meet a client's particular needs. Modular services are developed as standard and stand-alone services that clients can mix and match as they are linked via standardized interfaces (Voss and Hsuan 2009). For example, in logistic services, the order management, supply chain management and vendor-inventory management services are modular services that can be combined with additional services.

Modularity in processes refers to standardized, indivisible process steps that can be combined to produce the service as a whole. Bask et al. (2010) define service-process modularity as "the usage of reusable process steps that can be combined ('mixed and matched') to accomplish flexibility and customization for different customers or situations in service implementation" (368). Examples of modularity in processes include the management of information flows and the physical movement of goods, both of which can be divided into several sub-processes, such as ordering and booking processes.

Finally, *modularity in organizations* refers to the way in which the firm uses its own and other firms' resources through internal or external organizational units (Colfer and Baldwin 2010). With regard to how the firm uses other firms' resources, organizational modularity refers to the firm's reliance on loosely coupled inter-organizational relationships, characterized by low levels of knowledge and information sharing (Cabigiosu and Camuffo 2012). This last concept is widely known as *across-firm modularity* (Colfer and Baldwin 2010).

Modularity Across Firms: Knowledge and Information Sharing

The degree of coupling of organizations, which is an inverse proxy of across-firm modularity, depends on the extent to which organizations exchange business and technological information and coordinate their decisions, actions and efforts.

As Colfer and Baldwin (2010) argue, organizational ties can be diversely defined and measured. Measurable organizational ties might take the form of firm co-membership, organizational integration, geographical location and formal and informal communication. Among the studies that measure organizational ties, a usual distinction is between information and knowledge sharing.

The degree of coupling of buyer–supplier relationships depends on the extent of the everyday information required to manage their ongoing relationship. Information sharing is an

integration mechanism that coordinates inter-organizational relationships and the ordering, logistics, inventory management and new-product development processes. In addition, information sharing lowers opportunism and reduces risk (Cabigiosu and Camuffo 2012; Cabigiosu, Camuffo, and Schilling 2011; Furlan, Cabigiosu, and Camuffo 2014).[6]

Knowledge sharing regards the exchange of knowledge during new-product development activities related to product service/technologies and how to design and produce a service or a product (Baldwin and Clark 1997, 2000; Brusoni and Prencipe 2001; Zirpoli and Becker 2011).

Following the mainstream modularity literature, buyer–supplier knowledge and information sharing are inversely related to the level of modularity of products/services.[7]

Bridging Service Modularity and Buyer–Supplier Relations

As the mainstream modularity literature highlights, modularity in design allows for information and knowledge to be hidden within modules' boundaries. In other words, standardization in modules, other things being equal, reduces the need for buyer–supplier knowledge transfer and information sharing. Modules can also be developed as so-called black boxes; thus, knowledge about the inner workings of one module does not need to be shared with the makers of other modules. Modularity permits specialized firms to acquire the complementary suppliers' knowledge bases by buying the modules the complementary suppliers produce (Baldwin and Clark 1997, 2000). Complex integration mechanisms aimed at understanding how these modules function are not necessary because modules are combinable and can be plugged into the final product as black boxes. Also, when products are modular, less information exchange is required because more information is already available. As a result, modular products and organizations are expected to be related (Hoetker 2006; Langlois 2002).

Reviewing the existent literature, Colfer and Baldwin (2010) found that the majority of contributions (74 per cent) support the hypothesis that product and organizational architectures mirror each other and that modular architectures are developed by loosely coupled organizations (i.e., the mirroring hypothesis).

Following the rationale of the mirroring hypothesis, the knowledge-intensive nature of KIBS should have an effect on the relationship between modularity in design and in organizations. As Bettencourt et al. (2002) argue, KIBS are customized services because "clients themselves possess much of the knowledge and competence that a KIBS firm

[6] The modularity literature has so far focused on the information sharing regarding the cost breakdown structure of the analyzed component/service, detailed information concerning inventory levels, information about production plans/demand forecasts, information about the attributes and performance parameters of the product/service and of the analyzed component, information about delivery schedules and other supply services, information about the supplier's production capacity and its level of saturation, information about changes in volume, mix and sequencing of production, information about key financials, such as supplier's turnover, cash flows and profitability ratios, and information about supplier's R&D investment and innovation efforts (product, processes, etc.; Cabigiosu and Camuffo 2012; Furlan, Cabigiosu, and Camuffo 2014).

[7] A stream of the modularity literature suggests that modules cannot be purchased as black boxes and that the mirroring hypothesis might not hold for knowledge sharing. Buyer–supplier knowledge sharing allows buyers to absorb component-specific knowledge, keep up with technological changes and maintain a cognitive overlap with suppliers (Brusoni and Prencipe 2001; Zirpoli and Becker 2011).

needs to successfully deliver its service solution (101)." The relationship between a service provider and a client demands intensive knowledge sharing and information sharing about the client's business and needs, especially when the nature of their relationship is complex. Interactions with clients thus enhance KIBS firms' knowledge bases and ensure the required level of service customization (Muller and Zenker 2001).

Now more than ever, the empirical evidence on the extent of both information and knowledge sharing in the service provider–client relationship, and of the subsequent customization of KIBS, is not straightforward. Due to the nature of KIBS and their peculiarities, both with respect to service content and client–supplier interaction, we believe that the adoption of a modular approach to KIBS is an area of research that requires further empirical investigation. Specifically, an in-depth understanding of the constitutive elements of service modularity and organizational modularity in KIBS, as well as of their relationship, is lacking. There is a need to investigate

(a) the concept of service modularity in KIBS;
(b) how inter-organizational relationships between KIBS and their clients are characterized in terms of both information and knowledge and
(c) the relationship between service modularity and the extent of knowledge and information sharing between TPLs and their clients.

Method

Research Setting

TPLs are external providers that manage, control and deliver logistic activities on behalf of a shipper (Hertz and Alfredsson 2003). Scholars' recent interest in TPLs stems from the growing tendency to outsource logistics in a variety of industrial sectors, which has been generating an ever-growing demand for advanced logistic services. TPLs are typically companies with the capability of offering sophisticated logistic solutions. To be classified as a TPL, a firm has to handle both transportation and warehousing, but TPLs often also provide a bundle of additional services, such as packaging, quality control, order handling, forecasting and inventory management, delivery planning and management, and tracking and tracing (Stefansson 2006).

TPLs consequently differ from standard logistic service providers (LSPs) in that they offer a wider range of knowledge-intensive services and combine and adapt their resources to sell customized solutions (Hertz and Alfredsson 2003). In line with the definition of KIBS, a TPL relies on a project-based organization and adapts its knowledge and expertise to meet each individual client's needs (Bettencourt et al. 2002).

Research Design

To address our research questions, we studied two TPLs located in northeast Italy using the case-study methodology. In line with Yin's (2009) recommendations about case-study suitability, we believe that this approach is appropriate as our research questions are *how* questions.

Adopting the case-study methodology, we applied the replication approach to multiple-case studies using both within-case and cross-case analysis (Eisenhardt 1989; Yin 2009).

For data collection purposes, we developed a research protocol based on three main analytical domains derived from our literature review:

(a) the service architecture;
(b) the extent of knowledge and information sharing between TPLs and their clients and
(c) the relationship between service architecture and the extent of knowledge and information sharing between TPLs and their clients.

Our study started at the end of 2008. We first selected a sample of LSPs from the "Analisi Informatizzata delle Aziende Italiane" (Aida) database, which provides the economic and financial records of over 950,000 Italian ltd. companies. Then, we searched the websites of each of these firms in order to distinguish TPLs from LSPs. This preliminary analysis gave us a short list comprising a dozen TPLs from which we selected two independent, multi-customer firms (Cablog and Solaris) that work mainly for the same industrial sector, specifically the food industry. We chose multi-customer firms because we aimed to analyze how TPLs design their service architecture to satisfy a number of equally important clients. Both firms performed above the industry's average (an overview of the two firms is given in the next section).

We next conducted four rounds of interviews for each firm, interviewing the CEOs and several key informants who were most knowledgeable about important client relationships (see Appendix 1). The interviews lasted approximately three hours each and were conducted by a team of three investigators. Eisenhardt (1989) maintains that the presence of multiple investigators adds to the reliability of the results and increases the likelihood of surprising findings. Each interview was recorded and transcribed for subsequent within- and cross-case analysis.

We conducted our interviews following a research protocol we developed based on the existing literature (see Appendix 2). The research protocol contains an initial section on the firm's background and data. We first collected detailed information on the firms' core business and services, sector characteristics, competitors, customers and suppliers. We then moved on to analyze the TPLs' service architecture in terms of modularity. We also investigated how TPLs manage their client–provider relationships, particularly focusing on knowledge and information sharing and adopted coordination mechanisms. Finally, we analyzed how TPL service architecture is related to the client–provider relationship as viewed through the lens of the mirroring hypothesis utilized in our study.

To triangulate our data, the information from the interviews was pooled with details obtained from other sources, such as websites, archival sources, internal documents and site visits.

Based on the method proposed by Eisenhardt (1989) and Yin (2009), we used the replication approach to multiple-case studies analysis in order to increase the external validity of our results and to make them generalizable. We conducted two separate case studies and wrote individual case reports before comparing them by drawing cross-case similarities and differences. Where data from the two cases were consistent, we tried to generalize a proposition; where they were not, we looked for a possible explanation. We went through frequent iterations of both theory (i.e., the emerging propositions) and data before developing our final propositions.

Firms' Background Details

Cablog. Cablog was founded in 1983 as a transporter. In 1990, Cablog started to focus on warehousing and, in 1995, it entered the more profitable industry segment of distribution management.

Cablog operates in Italy and specializes in the packaged and canned foods and beverage sectors, which, overall, account for 97 per cent of its revenues.[8] Cablog has a market share of about 10 per cent, with total revenues of 72 million euros in 2009. Cablog's revenues are higher than the Italian average for the transport and logistics sector, which was 31.67 million euros in 2007 (Confetra 2009). Cablog's most important customers are manufacturers such as Nestlé-Purina (pet food) and Pepsi Cola (soft drinks). These customers account for 30 per cent of the firm's total revenues. Overall, Cablog runs five central warehouses (located mainly in the north of Italy) and 14 transit points. The firm owns only a fraction of these physical assets.

The company employs 323 people. About 50 employees are in charge of non-operational functions, such as administration, project planning, customer care and distribution. The firm's services include warehousing, transportation and distribution. The firm directly designs, coordinates and supplies its distribution activities, while warehousing and transportation are designed and coordinated by Cablog but are physically handled by third parties. Cablog integrates a network of companies, including several transport contractors, for point-to-point transportation services. Two worker cooperatives provide the labor employed at the warehouses.

Solaris Italia Group. Solaris Italia Group (Solaris) is a consortium founded in 1990 in Vicenza. Solaris includes nine firms that offer logistic, janitorial and security services. The firm coordinates transportation and distribution services, operating mainly in northern Italy, and employs 533 people. Like Cablog, Solaris has revenues (39 million euros in 2009) that are higher than the Italian average. Solaris's core business is logistics, which represents about 80 per cent of its overall business, while janitorial and security services complete its range of services. Warehousing and advanced logistics, such as layout design and optimization, packaging, quality control, order administration and item traceability, are Solaris's main sources of revenue.

Solaris operates in several sectors, the most important being the packaged and canned food and beverage sectors (54 per cent of sales), followed by the manufacturing sector (24 per cent). The firm also manages shop stores (11 per cent of sales) and has customers in the public administration (9 per cent) and healthcare (2 per cent) sectors. Solaris operates both its customers' and its own warehouses (it owns five warehouses). Solaris's main clients account for 64 per cent of its revenues and include Despar (food retail) and San Benedetto (beverages).

Case Analysis

Table 1 shows the main findings from our case analysis. The information is categorized into the three main domains of our research protocol: the nature of the firms' service

[8] The remaining 3 per cent of the firm's revenues come from the automotive industry.

Table 1. Main findings of the case analysis

	Cablog	Solaris
Service modularity	Three services: transportation, warehousing and distribution. Services are bundles of services comprising a number of sub-services. Services and/or sub-services are combinable	Warehousing, transportation, janitorial and security services. Logistics are its core business. Services are bundles of services comprising a number of sub-services
	Combinability is ensured by standard procedures. Cablog relies either on transforming resources shared by several clients or on client-dedicated transforming resources, such as warehouses and trucks	Services are combinable thanks to procedures that are standardized for each industrial sector. Services make use of either transforming resources shared among several clients or client-dedicated resources
TPL–client relations: knowledge and information sharing	Services are integrated into clients' operations. Cablog extensively shares data and information with clients concerning warehousing and transportation using customer-specific forms and interfaces	Services are integrated in clients' operations. Solaris shares data and information with clients about warehouse management mainly via customer-specific interfaces
	Cablog shares knowledge with clients and co-develops new services only when Cablog does not have the required expertise	Solaris acquires industry-specific warehouse management practices when it enters a new sector through client observation and tacit transfers of knowledge
Bridging service modularity and TPL–client relations	Cablog and Solaris match high levels of service modularity with high levels of information sharing. Tightly coupled relationships are managed via customer-specific interfaces	
	Cablog and Solaris match high levels of modularity with no knowledge sharing with clients. In cases where clients are involved in service development, both TPLs develop new services that do not rely on standard procedures. In these situations, TPL–clients relationships are tightly coupled, and services are non-modular	

architecture, the extent of knowledge and information sharing between the TPL and the client, and a third subsection that relates the findings about the service architecture with the findings about TPL–client relations in order to gather evidence on how service modularity and buyer–supplier relationships are related to each other. Our objective is to draw general testable propositions for each of these sections that match up with our research questions.

In the following subsections, we report the results of the cross-case analysis for each of these three domains.

Service Modularity in TPL Service Projects

Modularity is a key attribute of the services offered by the two TPLs (Cablog and Solaris). Each TPL offers bundles of services that are combinable with each other. Cablog provides transportation, warehousing and distribution services, while Solaris offers warehousing, transportation, janitorial and security services. Any of these can be mixed and matched into customized service projects. In addition, each service can comprise a number of sub-services that clients can choose in order to meet their own operational needs or preferences. For example, sub-services may include insurance services for transportation or packaging for warehousing.

Services and sub-services are modular as they are combinable with each other. Service combinability is ensured by the use of standard procedures that define the constitutive elements of service modularity. Cablog uses standard procedures for transportation, warehousing and distribution. The procedure for distribution is carried out on a daily basis by nine planners once the order-receiving phase has been completed. The most appropriate distribution solution is determined by computer software and then validated by planners according to a set of constraints associated with the specific characteristics of goods (e.g., volumes, weights and number of items). Customers are not involved in the distribution phase, as Cablog's CEO explains:

> We perform the distribution service internally, without the participation of the client. The client is not interested in how we plan it, but only in the outcome. Planning is not touched by the client that only wants a competitive price and a high quality, reliable service. For us, planning is a complete standard procedure that is routinely and consistently performed over time.

Like Cablog, Solaris uses standard procedures when designing the most appropriate warehousing solution. The procedure dictates the steps needed to complete the organizational and economic assessment of the current warehousing solution the client adopts. These analyses help set productivity targets (e.g., handling costs and lead times) and calculate the corresponding variable costs on which the service rate is eventually based.

The procedures TPLs use are either the standard per service type or the standard at the industry level. Solaris, for example, operates in a number of industrial sectors, each of which demands specific procedures. As Solaris's CEO explains:

> The construction industry is different from the large-scale distribution industry, which in turn differs from manufacturing industries. To give an example, in the food sector, warehousing often has to cope with seasonality, while in the mechanical industry there is often the problem of just-in-time deliveries. Within each industry, however, logistics is relatively standard in terms

> of equipment, layout, handling and storage practices, and skills. Here in Solaris, we have an office that codifies tacit knowledge into job descriptions, one for each industry, which are used by employees as a guide for their jobs. These job descriptions explain, for example, how to handle and package items and how to arrange and sort pallets.

Proposition 1 follows:

Proposition 1: Modular services use standard procedures that help service modules and sub-modules be combined (mixed and matched) to meet different customers' needs.

The bundle of services that TPLs provide to a client is specified in a service project. In addition to the list of all services and sub-services, each service project indicates the transforming resources[9] TPLs will use to deliver the service, the coordination mechanisms to integrate the TPL's services and the client's operations and the service levels agreed upon between the TPL and the client through a set of *key performance indicators* (KPIs).

In each of the TPLs examined for this study, transforming resources contribute to qualifying the attributes of the service project they provide. TPLs use transforming resources that are either shared by several clients or dedicated to a given client. In the first case, TPLs use their transforming resources to deliver services to several customers, while in the second case, TPLs use customer-dedicated transforming resources exclusively. For example, Cablog generally uses its own warehouses to consolidate different clients' products and to serve clients without depots of their own (or that temporarily need extra space). On the contrary, Cablog uses dedicated transforming resources when managing its clients' warehouses or when a client demands transportation that requires resources specifically dedicated to that client. Similarly, Solaris combines the use of both dedicated and shared warehouses to deliver its services. Interestingly, the use of dedicated transforming resources enhances service customization as, while still using standard procedures, TPLs are forced to cope with peculiar transforming resources constraints (e.g., specific layouts or storage equipment).

Proposition 2 follows:

Proposition 2: Modular services rely on transforming resources that may either be shared by several clients or dedicated to a given client. The use of dedicated transforming resources enhances service customization.

TPL–Client Relations: Knowledge and Information Sharing

Information sharing in TPL–client relationships involves the exchange of data that TPLs need to (a) design the service project, (b) manage the planned service (e.g., scheduled deliveries), (c) update clients about the service delivery status and (d) cope with unexpected extra requests from clients (such as unplanned warehouse visits or urgent deliveries).

[9] Transforming resources are the resources that act upon the transformed resources (e.g., materials, information and customers). In our paper, transforming resources are facilities (plants, equipment, trucks and process technology; Slack, Chambers, and Johnston 2007).

TPLs share information with clients via a number of coordination mechanisms or interfaces. First, TPLs rely on technological interfaces to share information about planned services. Cablog uses Internet-based software compatible with all types of systems (SAP or others) to connect with the client's ordering process and a proprietary trans-codification system to read the data. Trans-codification facilitates the adaptation of outbound information from Cablog to each customer's software system, as well as the transformation of inbound information into standard, readable formats. On the whole, this system engenders a technological interface that is specific to each customer as it permits idiosyncratic exchanges of information. Solaris, meanwhile, relies on client-dedicated software solutions, developed by an information and communication technology (ICT) service provider, which connect each client's production plans to Solaris in the form of inbound and/or outbound logistics. In each case, the technological interfaces are customer-specific and allow TPLs to successfully integrate the processes of multiple clients. Second, TPLs share information with clients via email, telephone calls, meetings and through the exchange of modules and forms. Typically, each client has its own document formats and communication needs, which have to be established in advance and then strictly adhered to by TPLs. Some of these interfaces complement technological interfaces in managing planned services, while others facilitate managing unexpected and/or more complex interactions.

Overall, both Cablog and Solaris share a large amount of information with their clients in order to successfully integrate their services into the clients' operations.

Proposition 3 follows:

Proposition 3: TPL–client relationships are characterized by high levels of information sharing via customer-specific interfaces that allow the successful integration of TPL services into clients' operations.

Although both Cablog and Solaris share large amounts of information with their clients, knowledge sharing—that is, the exchange of knowledge of service procedures during the service development phase (Bettencourt et al. 2002; Sanchez and Mahoney 1996)—is rather limited to relationships involving the development of new services with competent clients. In fact, our empirical evidence indicates that interaction between the client and the TPL during the service development phase is usually minimal. Most of the time, clients seek to outsource the logistic function (which is usually not seen as a core competence) while keeping strict control over the service provider's performance.

Clients participate in service development only when TPLs are not fully competent; for example, when they have not yet developed standard procedures for a particular service or when clients operate in an industrial sector new to the TPL.[10] More specifically, these

[10] One might wonder why a client should establish a relationship with a TPL that is not fully competent in the former's area of interest. When seeking an answer to this query, we were told by both TPLs that reputation is important in their business and that it is costly for a company to switch TPLs. If a TPL is recognized as being reliable and providing efficient services of good quality, it is likely to attract clients asking for new services or clients from "new" industries. For example, if a customer decides to go a step further in the outsourcing of its logistics, it tends to rely on its current TPL and is prepared to share its knowledge with the TPL if the latter is willing to expand its current offering of services. The customer will replace the TPL only if the latter is unwilling to do so or unable to provide a service of acceptable quality within a reasonable period of time. The TPL's competitive advantage also stems from its in-depth knowledge of the supply base and of the institutional characteristics of the geographical area in which it operates.

situations promote an exploratory phase supported by meetings, face-to-face interactions, direct observations and other similar customer-specific coordination mechanisms/interfaces. During this exploration, TPLs develop internal knowledge about new activities and exploit this newly acquired knowledge to serve clients with similar requirements or which operate in similar sectors. These dynamics explain why, in client–TPL interactions, the knowledge transfer between the client and the TPL usually occurs from the former to the latter rather than vice versa. The Cablog CEO reports an example of dynamics such as these involving an important customer, Nestlè Purina. In his words:

> Nestlé Purina had a central role for our know-how because it anticipated requirements that subsequently became standard for the industry. This happened in 2000 when it asked for an advanced traceability system that was new for us and for the industry as a whole. Our engineers started working with Nestlé Purina engineers, who had already started implementing the project. They sent us the software specifications and other procedures they had developed. Then, we worked together to complete the software and implement the traceability system. In 2005, the same service became mandatory for the industry. Our previous collaboration with Nestlé Purina was fundamental in enabling us to develop the know-how ahead of our competitors. Similarly, we worked with Nestlé Purina to develop accurate pest prevention practices in line with the client's requirements and we jointly invested in a voice-controlled picking technology. All these services, originally developed with Nestlé, are now part of the range of services Cablog can offer to the rest of its customers.

Solaris acquires new knowledge from clients when it ventures into previously unknown industrial sectors. As Solaris's CEO stated:

> When supply relationships are new it is easier to acquire a client's specific product knowledge by directly observing how it operates and working side-by-side. To give an example, this happened when Solaris signed the contract to manage the warehouse for Deroma, a world leader in earthenware and pottery. The highly fragile nature of these products posed a new challenge for Solaris, an organization not used to handling and storing very delicate products. Solaris could not use its proved and well-known procedures and practices, but instead had to develop new procedures by cooperating with Deroma and adopting its handling and storing techniques. To learn such techniques, Solaris worked side by side with Deroma and even moved some of its employees into the Deroma warehouse. As Solaris learned how the handling and storing of fragile products worked, it developed a set of refined techniques that it was then able to extend to its services and clients on other, similar sectors.

Proposition 4 follows:

Proposition 4: TPL–client knowledge sharing is uncommon and restricted to relationships involving new types of services and competent clients.

Bridging Service Modularity and TPL–Client Relations

The sections above highlight that (a) TPLs' services are modular and rely on standard procedures; (b) TPL–client relationships are characterized by a high level of information

sharing with customer-specific interfaces and (c) TPL–client knowledge sharing is uncommon and restricted to competent clients requiring new services.

Modules in TPLs have standard procedures that are mixed and matched to satisfy clients' needs. TPL–client interfaces are customized because they filter information flows that ensure the required coordination between the TPL and the client. TPL services have to be plugged into clients' operations, which have their own characteristics and needs, thus driving the customization of the client–supplier interfaces. Indeed, TPLs match high levels of service modularity (they mix and match standard procedures) with tightly coupled relationships and non-modular organizations (they share high levels of information with clients). Tightly coupled relationships are managed via customer-specific interfaces. Therefore, as far as information sharing is concerned, modular services do not match with loosely coupled inter-organizational relationships, and the mirroring hypothesis seems not to hold. Even if TPLs deliver services that rely on standard procedures or modules, they manage the associated client relationships by drawing on high levels of information sharing in order to integrate their clients' operating processes. All in all, modular services do not lead to modular organizations.

Proposition 5 follows:

Proposition 5: In TPL–client relationships, the mirroring hypothesis does not hold for information sharing.

According to the TPLs examined for this study, the majority of clients do not participate in the development of new services due to their lack of competencies and their strategic orientation, which focuses on core processes. Clients share information with TPLs about their needs and KPIs, while they generally perceive service procedures to be black boxes. Indeed, when TPLs do not need clients' knowledge, they can rely on their own standard procedures. In other words, TPL–client relationships are loosely coupled, and the service is modular. On the contrary, in those few cases in which clients are actually involved in service development, the process leads to the development of new services that do not rely on standard procedures. In these situations, TPL–client relationships are tightly coupled and services are non-modular.[11] Our study also suggests that once new services have been introduced to meet the needs of one customer, they can be codified and eventually replicated in other relationships.

Therefore, TPLs can either replicate existing procedures without sharing knowledge with clients or design new services by sharing a large amount of knowledge with clients. As modularity in services increases (TPLs increasingly rely on the replication of standard procedures), the degree of organizational modularity increases (and the extent to which TPLs and clients share knowledge decreases). In other words, when knowledge sharing is concerned, the mirroring hypothesis is supported.

Proposition 6 follows:

Proposition 6: In TPL–client relationships, the mirroring hypothesis holds for knowledge sharing.

[11] As clients typically promote innovation in processes, new procedures are specific to customer requirements and will become modular only when TPLs metabolize and replicate them for other clients.

Discussion

Theoretical Implications

We find that TPLs rely extensively on service modularity and that the use of *standard procedures* is the constitutive element of modular services. TPLs develop new procedures only when they cooperate with competent clients or extend existing services to new industrial sectors. While procedures are typically standard, TPLs' transforming resources may be shared by several clients or dedicated to a given client. Our study suggests that TPLs swim in a sea of modularity that allows for customization. We add to this general conclusion a nuance associated to the nature of transforming resources that singles out our study within KIBS and in the modularity literature: we find that the use of dedicated transforming resources enhances the possibilities for TPLs to customize services beyond the mix-and-match options allowed by modularity.

All in all, TPLs' services are described by the procedures and transforming resources involved. Different types of services stem from different combinations of these domains. Those services that rely on standard procedures and use shared transforming resources can be considered "standard modular services." On the other hand, those services that rely on standard procedures but use dedicated transforming resources can be defined as "customized modular services" as they strictly cling to the customer's operations.

We also find that TPLs' services and their clients' operations need to be integrated via a number of interfaces. Most of these interfaces are customer-specific. Our evidence shows that the concept of modularity in TPLs does not overlap with that found in the product modularity literature (Campagnolo and Camuffo 2010). Moreover, our evidence partially contrasts with the concept of service modularity advanced by Voss and Hsuan (2009). While the product and service modularity literature ascribes modules' combinability to standard interfaces, we find that the combinability of modules is ensured by the use of standard procedures and customer-specific interfaces. In other words, TPLs are plugged into clients' operations, and this integration requires customer-specific interfaces. Interestingly enough, this finding stands out for its apparent contradiction with the insights of the mainstream modularity literature, which is grounded in the concept of standard interfaces and their associated benefits (Cabigiosu, Zirpoli, and Camuffo 2013). Our findings suggest that modularity in TPLs relates to the procedures (i.e., the inner constitutive elements of modules) and not to modules' boundaries and their interfaces. The use of standard interfaces ensures modules combinability in the product domain, no matter how modules are internally developed and characterized. In the KIBS domain, combinability is allowed by standard procedures, but customized interfaces permit effective customer–supplier interactions. In both products and services, combinability exists when the inner constitutive elements of modules are not affected by their combination and firms can develop modules as black boxes. Combinability in products is achieved through standard interfaces (both across-firm and within-firm), while combinability in KIBS is achieved via standard mechanisms that dictate how to mix and match internal procedures[12] while KIBS–clients' interfaces are customized.

[12] An example of internal standard mechanism used to combine procedures is that used by Cablog to transfer the distribution plans to its warehouses. This procedure combines two service modules (i.e., distribution and warehousing), which, being an internal procedure, does not need to be customized on the basis of clients' needs.

We have also investigated the organizational design consequences associated with the adoption of modular architectures—the so-called mirroring hypothesis, which states that products' features shape how organizations manage their intra- and inter-organizational relationships. Overall, modular products should be designed and produced by modular organizations, while integral products should be produced by integral organizations characterized by tight relationships and knowledge sharing (Sanchez and Mahoney 1996). While the mainstream modularity literature argues that modular systems should be developed by loosely coupled organizations, the KIBS literature emphasizes intense knowledge and information sharing between clients and suppliers. This difference between the two streams of literature opens up a tension that is interesting to investigate, since the alignment between product/service architecture and organizational architecture has been demonstrated to have performance implications. Firms that develop modular (integral) products and have loosely coupled (tightly coupled) relationships perform better than firms that develop modular (integral) products via tightly coupled (loosely coupled) relationships (Cabigiosu and Camuffo 2012; Colfer and Baldwin 2010). In this study, we find that modular services are developed and managed via TPL–client relationships that are characterized by (a) an intense exchange of information and (b) a scant sharing of knowledge.

TPLs share information with clients to design the service project and to integrate their activities, exchanging daily information by means of ICT, telephone calls, emails, reports and meetings. Miozzo and Grimshaw (2005) obtained similar results when they studied ICT firms in Germany and in the UK. Therefore, the mirroring hypothesis does not apply when we look at the information sharing because KIBS are business-to-business services that have to be integrated into clients' operations via customized interfaces and nurtured via an intense exchange of information. Buyers and suppliers have tightly coupled relationships that typically last several years, even if the parties rely on modular services. While modular products may be developed, produced and delivered as black boxes relying on standard interfaces and loosely coupled relationships, modular KIBS have to be coordinated and harmonized with clients' processes and procedures, thus requiring an extra integration effort (and an intense information sharing).

While our study does not support the mirroring hypothesis for information sharing, it does confirm the mirroring hypothesis for knowledge sharing. Indeed, TPLs develop modular services without sharing knowledge with clients. Knowledge sharing is restricted to the development of new non-modular services with a few competent clients. Our findings contrast with the prevalent literature on KIBS, which tends to emphasize the role of strong interactions and knowledge sharing between KIBS firms and their clients for the purpose of new service development (Bettencourt et al. 2002). The reason why knowledge sharing is limited is twofold: first, clients do not usually consider logistics to be a core competence and thus often decide to outsource the tasks and knowledge associated with it; second, customers usually require simple, low-tech, standardized logistics solutions that are easy to maintain and use (Ceci and Prencipe 2008; Ceci and Masini 2011). The development of these services does not require the involvement of the customer and can be autonomously generated by TPLs. On the contrary, more experienced or sophisticated customers are not fully satisfied with standardized solutions and often require new services that have to be developed, building on their knowledge (Davies, Brady, and Hobday, 2007). In these cases, TPLs have to absorb the knowledge of customers by engaging them in dense relationships aimed at developing new services. These

relationships are of importance because TPLs, staying in close communication with some knowledgeable customers, acquire the fundamental information to develop a successful modularity strategy. Before developing a modular service, these relationships are relevant in understanding customers' needs and acquiring valuable knowledge.

Managerial Implications

Two managerial implications can be drawn from our findings:

First, KIBS firms should lever on the combination of standard procedures and transforming resources as a viable means to simultaneously economizing on production costs, increasing service combinability and allowing service customization. In order to reach this objective, the TPL has to be able to develop logistics practices that are significantly affected by the features of the products (e.g., size, weight and fragility). As TPLs develop such practices, they should commit to codify them into standard procedures in order to replicate them across a large customer base. Moreover, such standard procedures need to be combined with the right configuration of transforming resources to deliver a service tailored to customers' needs.

Second, service firms should design suitable inter-organizational coordination mechanisms to match the corresponding integration requirements of client–supplier relationships. Specifically, even in the presence of modular services, managers should develop costly integration mechanisms (e.g., key accounts, meetings and face-to-face interactions) to manage the high integration needs associated with information sharing. Interestingly enough, this implication is substantially different from the main implication of the traditional mirroring hypothesis. In KIBS, inter-organizational integration is the functional equivalent of customized interfaces needed to integrate TPLs' processes into customers' operations.

Conclusions and Limitations

This study contributes to the growing debate about service modularity, as well as to the KIBS literature. This debate is still in its early stage of development and has not yet demonstrated whether extending product-based findings to service modularity is appropriate.

First, this study suggests that modularity in (knowledge-intensive) services differs from modularity in products, both in terms of modules' characteristics and organizational design consequences. We maintain that the theoretical implications of service modularity should be developed while taking into account that product modularity theory cannot be extended to KIBS as it is. In particular, the mirroring hypothesis (the backbone of modularity literature) does not apply to KIBS–client relationships with regard to information sharing. Modularity in KIBS is different from modularity in products, as KIBS have higher integration needs than products. Information sharing levels are higher, and interfaces are customized regardless of the procedures standardization.

Second, this study sheds light on the interplay between modularity and the KIBS literature. Modularity literature assumes that buyers and suppliers can be loosely coupled if they exchange modular products. Our study suggests that firms outsourcing logistics functions to KIBS cannot be loosely coupled in information sharing but can be loosely coupled in knowledge sharing. In contrast to what is normally maintained by KIBS literature,

TPLs maintain high levels of knowledge sharing *only* with a few competent clients when they are pushed to develop new services. Knowledge sharing is usually triggered by customers' requests for new services; this takes place through a process of knowledge absorption by TPLs.

Overall, our paper contributes to the KIBS and modularity literature by generating the seeds of an across-firm mirroring hypothesis in KIBS by (a) providing a more in-depth understanding of modularity, which is a necessary precondition for building a theory that relates service and inter-organizational features and (b) reframing the existing across-firm mirroring hypothesis for KIBS.

This study has limitations that can provide clues for future research. First, future studies aimed at expanding our comprehension of the organizational design consequences of service modularity may take into account the component (or sub-module) level of analysis and study how the relationships between the TPLs' organizational units are characterized in terms of information and knowledge sharing (i.e., the within-firm mirroring hypothesis). Second, future studies should investigate other KIBS sectors, a larger number of firms, and compare well-performing and poorly performing firms. Third, our propositions offer testable hypotheses that should undergo quantitative validation. Last, a contingency approach can be useful in exploring how different industry features (e.g., technological dynamism or the availability of industry standards) can influence buyer–supplier dynamics, especially in terms of knowledge sharing.

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Appendix 1

Table of the interviews

Number of the interview	Role of the interviewee	Duration in Cablog (hours)	Duration in Solaris (hours)
1	CEO	3	3
2	CEO	4	3
3	Account manager	2.5	3
4	Project manager	2.5	3

Appendix 2

Questionnaire

Subject	Questions	Main references
Firm's background and data	1. Name of the company	Hertz and Alfredsson (2003)
	2. Year of establishment	Miles (2005)
	3. Revenues and operative margins of the last three years	Stefansson (2006)
	4. Number of employees, qualification and types of contracts	
	5. Who are the competitors of the company? How do they operate?	
	6. Describe the organizational structure of the company	
TPL's service	1. What are the services the company provides, and how relevant are they in terms of revenues?	Bask et al. (2010)
	2. Describe the main services the company provides	Miozzo and Grimshaw (2005)
	3. Per each of the main services, describe how the service is designed and delivered (e.g., are the services standard among customers? Are they customized? On which contents are services customized?)	Pekkarinen and Ulkuniemi (2008)
	4. Describe the assets the company uses to provide its services	Rajahonka, Bask, and Lipponen (2013)
	5. Are services combinable among each other? If yes, describe which services are combinable and how	Voss and Hsuan (2009)
	6. Describe the main clauses that are included in the contract	
	7. Does the contract include service-level agreement (SLA) clauses? If yes, describe the contents of the contract that are regulated by SLA and how they are established, negotiated and controlled	
TPL–client relationships	8. Who are the main customers? Describe the relationship the company maintains with customers	Bettencourt et al. (2002)
	9. Are customers involved in the design and delivery of services? Describe how the relationship is born and managed over time	Colfer and Baldwin (2010)
	10. Describe how the company operates when services that are not currently part of the company's offerings are required. How does the company perform innovation activities? Who are the organizational members involved, and how are they involved?	Hertog (2000)
	11. Describe the coordination mechanisms the company uses to manage day-by-day relationships with customers (e.g., meetings, telephone calls and standard forms)	
	12. Does the company involve customers in the innovation process? If yes, describe two recent examples.	Sanchez and Mahoney (1996)
	13. After the development of new services, does the company value if they can enter the regular offer? If yes, describe how it occurs and two recent examples of services specifically developed for a customer that have been included in the standard offerings of the company	