

Overcoming the inertia of organizational competence: Olivetti's transition from mechanical to electronic technology

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Abstract

This historical case study of Olivetti, the Italian office products firm, argues that technological competence becomes socially embedded in a firm over time as it is legitimized, backed by powerful agents, and supported by resource allocation. Paradoxically, these three building blocks of a competence—legitimacy, power, and resources—both promote inertia and enable change. Inertia can be overcome when firms employ three levers of transition: organizationally separating an emerging technology to protect it, co-opting legitimacy by using the new technology to serve the incumbent technology, and diverting resources for the emerging technology's development. Over time, the emerging technology achieves enough legitimacy, power, and resources in the firm to overtake, and ultimately displace, the incumbent competence. We develop an integrative model of technology transition that contributes to literature on resources, dynamic capabilities, competence-destroying change, and ambidexterity.

JEL classification: O32, O33

A firm's transition from one technological base to another has long been recognized as a tremendous organizational challenge (e.g., Cooper and Schendel, 1976). A competence-destroying technological change—when a new technology displaces an old one—is particularly difficult (Tushman and Anderson, 1986). Competence-destroying technological change requires building a new technological competence while simultaneously rendering an old technological competence obsolete. For Italian office products manufacturer Olivetti, the transition from mechanical technology to electronic technology was *sine qua non* for survival. In this historical case study of Olivetti, we examine the factors that initially slowed, and ultimately enabled, this contentious transition. We show that competence-destroying technological change is inherently difficult because a competence becomes socially embedded in a firm over time as it is legitimized, backed by powerful agents, and supported by resource allocation. Paradoxically, these three building blocks of a competence—legitimacy, power, and resources—both promote stability and enable change. They can be used to nurture an emerging technology until, over time, it gathers enough legitimacy, power, and resources to overtake and displace the firm's incumbent competence. In Olivetti's case, the ultimately successful transition from mechanics to electronics set the stage for the firm's later diversifications into information technology and telecom—a transition that arguably saved the firm from obsolescence.

Since Tushman and Anderson's (1986) seminal article, various explanations have been offered as to why technological competences are inert. In a highly influential article, Christensen and Bower (1996) showed that firms generally allocate resources to technologies that address the needs of mainstream customers, as opposed to disruptive technologies, which initially serve other markets. Another highly cited article by Tripsas and Gavetti (2000) focused on the cognitive inertia created by mental models, which, in the case of Polaroid, hindered the incorporation of digital imaging technology despite the firm's leading competence in it. More recently, Benner (2010) demonstrated that equity markets constrained technological transition in the digital imaging and telecom contexts, focusing primarily on how equity analysts shape the legitimacy of alternative technologies. She showed that analysts react positively to firms' strategies that maintain and extend an old technology, but they ignore or react negatively toward strategies that respond to a potentially substitute technology. Table 1 provides an overview of the existing empirical studies on technology transition that contain substantial data gathering and analysis and methods sections. In the three decades since Tushman and Anderson's (1986) seminal article, there have been eight empirical studies, each focused on explaining a particular source of inertia (see column labeled Key Concepts). Interestingly, power as a source of inertia has not been studied, despite Tushman and Anderson's (1986: 461) suggestion that "future research could explore the politics of technological change as interest groups attempt to shape technological progress to suit their own competences."

Each of the nine empirical studies provides fascinating insights on specific aspects of the phenomenon, but with such focus, each has limited theoretical scope. Collectively, this body of work has not yet produced a coherent theory. In addition, although these various articles have significantly advanced our understanding of sources of inertia, they have provided little insight into how to overcome it. The prior literature on competence-destroying technological change is almost entirely focused on inertia. But, if technological competences are inert, how is change possible?

We still have few answers to that question. The only solution specifically recommended for enabling competence-destroying technological change in a firm is to set up a separate organizational unit. The literature on structural ambidexterity has recommended separate units for exploration and exploitation, with "different competencies, systems, incentives, processes, and cultures—each internally aligned" (O'Reilly and Tushman, 2008: 192, see also Tushman and O'Reilly, 1996; O'Reilly and Tushman, 2004, 2013; Tushman *et al.*, 2010). The effectiveness of structural separation for enabling competence-destroying technological change has received some empirical support. Christensen and Bower (1996) found that incumbents that set up an organizationally separate unit to pursue new technology were successful in doing so—"the firms that accounted for the forces of resource dependence by spinning out independent organizations succeeded" (Christensen and Bower, 1996: 214). In another study, Gilbert (2005) found that a newspaper that separated its online organization experienced greater success. Olivetti did set up a separate unit as a structural way of achieving ambidexterity. However, our study shows that structural ambidexterity for competence-destroying change is especially challenging. We found that the separate unit indeed fostered the exploration of the new electronics technology, but it also triggered active resistance. Bootlegging (the illicit diversion of resources to work on new technology) has been mentioned in the popular literature as a way to overcome inertia, but we know of no scholarly examination (theoretical or empirical) of resource diversion in the context of technological change. In this study, we will provide a better understanding of organizational separation and resource diversion as two levers of transition from one technology to another. We also add cooptation as a third lever, one that is new to the literature on technological transition. We explain how these levers operate and how they are different from each other. We will argue that each of these levers lays one of the three building blocks of the new competence: resources, power, and legitimacy.

In sum, although these various lines of research on the challenges of technological transition have advanced our understanding significantly, they have provided only partial and fragmented insights into the inertia of technological competence and how it can be overcome. Trying to fill this theoretical gap, our intended contribution is to better explain the inertial *and* the dynamic aspects of competences.

We will first argue that a technological competence becomes "embedded" through the mutually reinforcing elements of legitimacy, power, and resources, and its interplay with external resource providers and audiences. The building block of legitimacy must be achieved on three fronts: the competence must be understandable (cognitive legitimacy), desirable (moral legitimacy), and useful (pragmatic legitimacy) (Suchman, 1995). The building block of power captures the extent to which a competence is reflected in the interests and influence of organizational agents. Finally, the building block of resources refers to how organizations allocate and transform resources (Danneels, 2007).

Table 1. Key empirical studies of technological transition

Author(s)	Firm/industry setting	Old/new technology	Key concepts	Key finding
Benner (2010)	Telephone Photography	Wireline/VoIP Silver halide/digital	Legitimacy with securities analysts	Analysts are more attentive and positive toward incumbents' strategies that extend and preserve the existing technology
Christensen and Bower (1996)	Hard disk drives	Various	Resource dependency—resource allocation	Resource allocation mechanisms focused on mainstream customers prevent incumbent firms from pursuing disruptive technologies, which initially target niche customers
Danneels (2011)	Typewriters (Smith Corona)	Mechanical/electronic	Dynamic capabilities—resource cognition	Executives' resource cognition (mental models about firm resources) shape the use of the modes of resource change: leveraging existing resources, creating new resources, accessing external resources, and releasing resources
Gilbert (2005)	Newspaper industry	Print/online	Resource rigidity and routine rigidity	A perception of threat helps overcome resource rigidity (failure to change resource investment patterns) but simultaneously amplifies routine rigidity (failure to change organizational processes that use those resources)
Rosenbloom (2000)	Business machines (NCR)	Mechanical/electronic	Dynamic capabilities—leadership	Top executive leadership provides the impetus for transformation of organizational processes for product development, product delivery, and marketing
Sull et al. (1997)	Tires	Bias-ply/radial	Managerial commitments to customers, employees, and community	Beyond economic incentives and established firm capabilities, commitments to employees, customer, and communities also constrain incumbents' responses to technological change
Tripsas (1997)	Typesetting	Hot metal/analog photosetter/digital CRT photosetter/laser imagesetter	Complementary assets (manufacturing capability, sales and service network, font library)	Specialized complementary assets buffer incumbents from the effects of competence destruction, if they retain their value in the technological shift
Tripsas and Gavetti (2000)	Photography (Polaroid)	Silver halide/digital	Managerial cognition/mental models	Top managers' mental models shape the development of new capabilities. Top management beliefs in the primacy of technology enabled Polaroid to develop leading-edge digital technologies, but the belief in the razor/blade business model of the previous technology prevented their commercialization
Tushman and Anderson (1986)	Minicomputer, Cement, and Airline	Various	Competence-destroying/competence-enhancing change	Competence-destroying technologies are initiated by new firms. Incumbent firms are burdened with the legacy of the old technology

We demonstrate how these three mutually reinforcing building blocks of legitimacy, power, and resources govern the process by which a new technological competence displaces an existing one. Next, we discuss the resistance to a competence-destroying technology by proponents of the incumbent technology because their legitimacy and power derives from it and it is based on a distinct and non-transferable skill-base. Therefore, it is illegitimate to them, and it threatens their status and power. In the contest between competence-destroying new technology and incumbent technology, the latter is privileged by its established legitimacy, the entrenched power of its proponents, and its superior resources.

How is this resistance overcome? We theorize that, for a new technological competence to emerge and build momentum in a hostile environment, it must draw on three levers of technological transition: organizational separation of the new technology; co-optation, in which the new technology is put at the service of the old; and the diversion of resources to the new technology. Finally, we show that as legitimacy, power, and resources become aligned around the new competence, that competence becomes fully embedded. In the final section we show how our integrative transition model contributes to literature on competence-destroying change, resources and dynamic capabilities, and ambidexterity.

1. Method

We conducted a historical case study of Olivetti (cf. Kieser, 1994). Our focal period ranges from the mid-1950s to the late 1970s, during which electronic technology arose and ultimately overtook mechanical competence. We follow Murmann's (2012: 110) call for historical research to "build deeper conceptual understanding by carrying out detailed empirical case studies about the causal processes driving a phenomenon."

We collected data from interviews, archives, books, videos, teaching cases, and the international and Italian business press. These sources provide exceptional first-hand accounts, some contemporaneous and some retrospective (cf. Howell and Prevenir, 2001). There are nine books about the mechanics-electronics transition at Olivetti written by the protagonists themselves (Cagliaris, 1991; Perotto, 1995; de Witt, 1997, 2005; Beltrami, 2004; Piol, 2004; Colaninno and Gianola, 2006; Silmo, 2007, 2008), and two additional books include interviews with the protagonists (La Rosa *et al.*, 2004; Novara *et al.*, 2005). A series of cases was written about Olivetti in the period of our study (Learned *et al.*, 1969: 860–1042; Molteni, 1980). Four videos that contain speeches and interviews with some of the protagonists refer specifically to the transition from mechanics to electronics (Gandin, 1957; Risi, 1960; Rao, 2001, 2004). We supplemented these materials with 14 visits to the Olivetti and the Capellaro Foundation archives in Ivrea (Italy). The archives contain a wide variety of published and unpublished documents, as well as products.

We identified the key actors in the transition from mechanics to electronics (Supplementary Table A1 provides a list). While many of the focal executives have died, we were able to locate and interview 18 of them. Interviews commonly lasted from 1 to 2 h and were recorded and transcribed verbatim. The interviews focused on the specific period and events in which the informant was a direct participant. We encouraged informants to illustrate their statements with specific events and examples. We checked our emerging insights on an on-going basis with the informants, asking for their feedback, sometimes in follow-up interviews or by email. Five of the interviewees were interviewed multiple times, for a total of 26 interviews. Though much time had passed since the focal events, informants were able to vividly recount the events of interest. We systematically pieced together evidence from these various sources. Any discrepancies or gaps we encountered led us to perform additional data collection (Kieser, 1994), which we ended when we reached saturation (Glaser and Strauss, 1967). We then subjected our analysis to member checks (Lincoln and Guba, 1985) by obtaining detailed feedback on our manuscript from seven interviewees and one expert on the company (Giuseppe Rao).

We followed the extended case method, which uses empirical data gathered through case study to re-conceptualize and extend theory (Burawoy, 1991, see also Danneels, 2002, 2007; Wadham and Warren, 2014). This approach goes through many cycles of confrontation between data and theory, with each iteration directing the analyst to additional data, concepts, and theories. The extended case method consists of two "running exchanges" (Burawoy 1991: 10–11): between literature review and data analysis, and between data analysis and data collection (i.e., literature review \leftrightarrow data analysis \leftrightarrow data collection). Consistent with these methods, the following sections will jointly develop the theoretical framework and chronicle the facts of Olivetti's transition from mechanical to electronic technology. In Figure 1 we list key events and indicate the various sections of our findings that focus on them.

To illustrate the interplay of literature and data, consider how we derived the three components of organizational competence. We first familiarized ourselves with the history of the technological transition at Olivetti by reading the

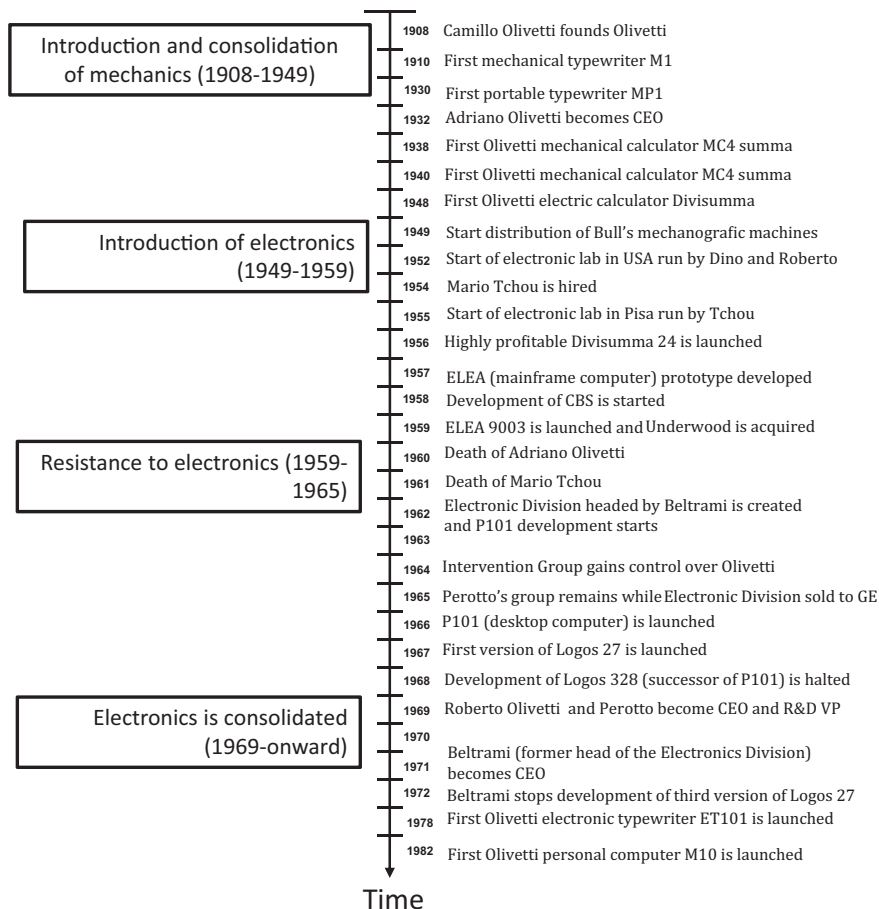


Figure 1. Timeline of core events at Olivetti.

books authored by its protagonists. We were struck by the wax, wane, and resurgence of electronics over three decades. The protagonists described the competing technologies in value-laden terms, which pointed us to the idea that the concept of legitimacy would be pertinent. Hence we set out to track the evolution of the legitimacy of mechanical and electronic technologies in the case. Concurrently the literature provided conceptual models to aid in the interpretation of the data. We explored the literature on legitimacy, and found the distinction made between cognitive, moral, and pragmatic legitimacy particularly helpful (Suchman, 1995) as it helped account for the multiple and inconsistent bases of the legitimacy of the technologies. However, we were puzzled by the fact that the decrease and increase of the legitimacy of the mechanical and electronic technologies, respectively, was not monotonous, and we noted our interviewees' accounts of the vested interests and power of organizational actors. This led us to explore the literature on power (Pfeffer, 1982, 1997) while at the same time examining in detail the key events which shifted the power balance (e.g., the sale of the Electronics Division in 1964 and the change in top management in 1967). But power by itself was not sufficient to account for the fluctuating legitimacy of the technologies. The proponents used their power to allocate resources to the competing technologies, which in turn influenced their legitimacy. Further running exchanges between data collection and analysis and theoretical exploration consistently converged around the three underlying constructs of legitimacy, power, and resources and their reinforcing links.

As discussed, analysis of the data and analysis of the existing literature were interwoven in deriving the findings of the study. Consistent with the method of constant comparison between data and theory used to derive the findings (Burawoy, 1991), the following sections will jointly develop the theoretical framework and chronologically tell the story of Olivetti's transition from mechanical to electronic technology.

2. Findings

Olivetti was founded as a typewriter manufacturer in 1908. It later diversified its product range by adding office furnishings (1930), telexes (1938), and accounting machines (1948). It also diversified into calculators, which operated using a mechanical technology similar to typewriters. By the beginning of our study period, in the late 1950s, mechanics had become Olivetti's core technology and mechanical calculators were its most lucrative product.

The organizational competence in mechanics was stable and upheld by mutually reinforcing relationships between legitimacy, power, and resources. Mechanical technology also had strong cognitive, moral, and pragmatic legitimacy because it was well understood, considered appropriate for Olivetti. Overall production increased tenfold between 1946 and 1958, and 60% of it was exported. Power at Olivetti belonged to the technicians and management supporting mechanics. Mechanics was also rich in resources: the expansion of mechanical production in Italy and abroad, the introduction of new mechanical products, and Olivetti's acquisition of the US typewriter firm Underwood in 1959 each allocated substantial resources to mechanical technology.

Before we discuss the emergence of electronics in the next section, we briefly preview our conceptual model of organizational competence, depicted in [Figure 2](#). The three building blocks of competence—legitimacy, power, and resources—and the mutually reinforcing relationships among them lead an organizational competence to become increasingly embedded over time. Legitimacy is also impacted by external constituents. Because of their open-systems nature, organizations must transact with sections of their environment to obtain the resources necessary for their survival and prosperity ([Pfeffer and Salancik, 2003/1978](#)). These resources are garnered through exchanges with resource providers, including customers, banks, and the equity market (cf. [Pfeffer and Salancik, 2003/1978](#); [Zott and Huy, 2007](#)). Audiences that do not provide the firm resources, such as media, government, and organizational models, are labeled external audiences.¹ In what follows, we will describe the evolution of these building blocks and external constituencies to explain the emergence of an electronics competence at Olivetti.

2.1 Introduction of electronics

In 1949, Olivetti started distributing mechanographic machines in Italy made by the French manufacturer Bull. These machines incorporated some embryonic electronics technology to transfer data, and hence introduced Olivetti to this new technology ([Piol, 2004](#)). Reinforced by the keen interest of his son Roberto and his younger brother Dino, who had observed the first mainframe computers in America, Adriano Olivetti used his power as president to allocate substantial resources to create an electronics lab and pursue development of mainframe computers. In 1952, Olivetti established a small electronics R&D lab in New Canaan, Connecticut, in an effort to benefit from knowledge spillovers from American firms ([Amidei *et al.*, 2012](#)). An electronics lab (Laboratorio di Ricerche Elettroniche—LRE) was established in Pisa in 1955.

Adriano Olivetti hired Mario Tchou as lab director. Tchou, a former research associate of electrical engineering at Columbia University, had previously worked on electronics at Watson Labs, which were financed by IBM ([Parolini, 2008](#)). Financing to pursue electronics came from sales of mechanical office products, particularly from Olivetti's extraordinarily high margins of the top-selling Divisumma line of calculators. This led to resentment. In his book about the emergence of electronics at Olivetti, electronics lab engineer Pier Giorgio [Perotto \(1995: 3\)](#) said, "The truth was that researchers at Pisa were hardly tolerated by the Ivrea establishment, as they were considered to be chasing butterflies." Olivetti actors often referred to the power holders at headquarters in Ivrea as "the mechanics establishment."

In 1957 Olivetti produced its first electronic computer prototype, using vacuum tube technology, called the "Laboratore Elettronico Automatico" (ELEA). By 1958, 300 engineers and technicians were employed in electronics R&D, and another 1,000 workers were employed in manufacturing electronic products. Olivetti launched the ELEA 9003, the first Italian computer, in 1959. An ELEA 9003 was the size of a large room and required several technicians to supervise and maintain it. It was followed by two more computer models: the ELEA 6001 in 1961 and the smaller and cheaper ELEA 4001 in 1963. In 1962, Olivetti inaugurated its first division for electronics, led by Ottorino Beltrami.

¹ Government can be a resource provider rather than an audience. This was the case for IBM, which received substantial funding from the US government.

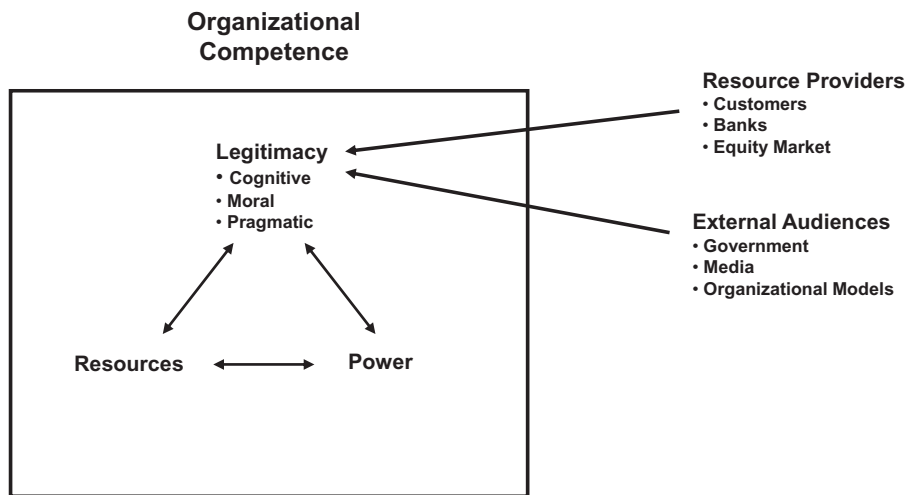


Figure 2. The building blocks and environmental constituents of organizational competence.

2.2 Reaction of external constituents to electronics

The introduction of electronics did not receive support from Olivetti's resource providers or from external audiences: its customers, banks, the equity market, government, and the media. From its founding, Olivetti had specialized in small-scale office automation, mainly for small and medium firms. Until the mid-sixties, electronics technologies served a different market because they could only be incorporated into large mainframe computers such as the ELEA 9003. Electronics served large corporations' need for data processing centers to perform corporate functions such as accounting and payroll. It also served the scientific computation needs of research centers and universities. For instance, IBM's initial customers for computers and peripherals were the US military and scientific institutions, and later financial institutions (Yost, 2005). Elserino Piol, marketing and sales vice president of Olivetti's electronics division in that period, explained, "Let's take for instance banks, which used to buy typewriters, calculators, and so on. These products had nothing to do with computers. Therefore the people that I went to visit to sell the computer were different from those we used to visit. The only advantage was that Olivetti was well known as a firm." The technological transition thus required a shift in market-related resources (Danneels, 2006). Marketing mechanical products involved a large direct-sales force, an extensive service network to repair and maintain machines, and company-owned branch offices (Majumdar, 1982). Selling higher-priced electronic items required a sophisticated sales force with expertise in central data processing (de Witt interview; Beltrami, 2004). The sales force needed to be changed from "product peddlers into sophisticated systems specialists who are intimate with customer operations" (Business Week, 1974: 113).

Banks and the equity market are the second type of resource providers depicted in Figure 1. During the advent of electronics technology at Olivetti, Italy's capital markets were not sufficiently developed to permit a major equity or long-term debt offering (Forbes, 1978). Hence the company was forced to obtain short-term bank loans. This made Olivetti's cost of capital very high and severely curtailed its options when, in 1964, banks refused any further loans.

These external audiences did not foster the legitimacy of electronics. Unlike the French government's support of Bull (Chandler, 2001), the Italian government failed to support its country's nascent computer industry. The US electronics industry, and IBM in particular, received substantial government financing, especially through the Armed Forces, the Department of Defense, NASA, and the National Science Foundation (Gallino and Ceri, 2001; Yost 2005). But Olivetti's electronics efforts were entirely self-funded; it even gave its first ELEA 9003 computer to the Italian government for free (Rao, 2004).

The media is another vehicle for bringing legitimacy to a new technology (Kennedy, 2008). There was very little mention of the ELEA in the international media. The only reference we found was one paragraph in an extensive article on Olivetti published in Fortune magazine in September 1960. There was only slightly more coverage of the ELEA in the Italian press. Roberto Olivetti believed that "specialized publications and the press failed to help the

political and managerial elites of the country understand the positive implications, on social, political, and technological grounds, which could be brought about by the electronic calculator [mainframe], especially if coupled with communication technology” (Piol, 2004: 71). In the early- to mid-sixties, the media did not anticipate that the commercial success of electronic calculators was just around the corner. An article reviewing “figuring machines” for office use stated, “Electronic calculators . . . have just arrived on the scene, and only a few models are available at present. . . . Only full-time use for complicated problems would justify the high cost of an electronic calculator. For that reason, manufacturers do not envision the electronic calculator replacing the other basic types in the foreseeable future” (Weill, 1964: 55). Media observers considered investing in electronics as a “folly or, at best, a weird idea” (Sacerdoti and Ranci, 1993: 124).

In sum, while mechanical technology was supported by Olivetti’s resource providers and external audiences in this period, electronic technology was ignored or fought outright.

2.3 Internal resistance to electronics

Mechanical and electronic technologies were distinct competences with little transferability of skills (de Witt interview; De Sandre interview; Salvetti interview). Training in the mechanical competence was through apprenticeship, while in electronic technology it was through formal, science-based higher education. Mechanical devices, and calculators in particular, were intricate “marvels of mechanical design, craftsmanship, and precision” (Majumdar, 1982: 89). They consisted of metal components—sheet, screws, springs, etc.—that could be touched and tweaked (Bolognani, 2004; de Witt, 1997; Perotto, 1995). As Piero Salvetti, an engineer, stated:

Mechanics was based on manual capabilities, on crafting skills. Electronics was based on the ability to master scientific instruments. Tooling was paramount in mechanics, while procurement and testing were key for electronics. In mechanics you would buy simple materials, in electronics sophisticated components. Finally, you had to train human resources internally in mechanics, while in electronics you had an international pool of resources to recruit from.

These differences meant that electronics initially lacked the three organizational building blocks of a competence—that is, it was judged to be illegitimate, it was not supported by powerful actors, and it was devoid of resources. In terms of cognitive legitimacy, Piol told us, “They just didn’t understand, so they openly rejected electronics.” Similarly, Giovanni De Sandre, a project manager at the electronics lab, explained in our interview, “Mechanical designers showed almost no interest in exploring this new technology. They were smart, curious, but utterly sure that mechanics would be the key to the future. They were outstanding artisans, but most only had an elementary school degree, just like Natale Capellaro [VP of R&D]. That made it essentially impossible for them to understand the new technology.” An often-cited incident (recounted in Salvetti and Pacchioli, 2002: 49) illustrates that electronics lacked cognitive legitimacy among the top executives as well:

During a very tense executive meeting in the mid 60s, then-CEO Aurelio Peccei accused the designers of the P101 [electronic calculator] of failing to develop a completely safe and functional product, telling them he didn’t understand how it was possible to develop cars that could drive in muddy terrains while they failed to develop a product destined to the safe environment of an office. [Note the analogy from Peccei’s Fiat experience.] . . . Capellaro replied the following: “Let’s give the technicians a chance to deal with this, as it’s clear that neither you nor I really understand anything about electronics.”

As Luigino Tozzi, a project manager in electronics explained to us, “We were like aliens. We did things that they could not understand.”

Electronics lacked pragmatic legitimacy as well. Pragmatic legitimacy is conferred to practices that support the survival and prosperity of the company (Suchman, 1995). As is typical with exploration, while the costs of exploring an electronics competence were immediate and high, the possible returns seemed remote and uncertain (March, 1991). This lack of pragmatic legitimacy of electronics is evident from several sources. Bruno Lamborghini, business analyst and later chairman of Olivetti, told us, “It was not clear when the electronic division would bring profits.” According to Giovanni de Witt, an electronics engineer who worked at Olivetti from 1965 to 1990 and wrote two books on its technology transition, “In terms of commercial success, Olivetti’s computers were doing quite well, with a 25% Italian market share in 1963. But still, they needed huge investments.” *Business Week* (1964a) explained:

Computers never did represent a large part of Olivetti’s sales. Last year they probably accounted for no more than 5% of total consolidated sales of \$422.7-million. [. . .] The computer operation absorbed a disproportionate amount of money. [. . .] “Sales,”

as in most computer operations, were actually almost entirely rentals, so that each computer sold meant more capital tied up. At the end of last year, Olivetti listed on its balance sheet \$11.4 million as the value of the computers rented out. The computer business was a luxury Olivetti couldn't afford.

The lack of moral legitimacy of the technology is reflected in the words chosen by its antagonists to describe it: a hobby, a luxury, a mole, chasing butterflies. Perotto stated in a speech, "We at Pisa were considered free riders [*mangiapane a sbafo*—a slang expression meaning that you eat without paying]: people that wasted the precious resources that the company accumulated thanks to the great profits of mechanical machines like the *Divisumma 24*, which had given Olivetti a position in the global marketplace." According to Elserino Piol, then a manager in the sales unit of electronics, "Executives in Ivrea initially saw it [electronics] as a personal hobby of Roberto [Olivetti] and then, when costs started to increase, as a great danger for the entire organization" (Piol, 2004: 29–30).

Its lack of legitimacy made the allocation of resources to the electronics highly contentious. As recalled by electronics engineer De Sandre, "I remember mechanical designers telling me, half jokingly and half seriously: 'Remember it's us paying your wage . . . it's only thanks to us that you can still go about experimenting with all your electronics toys'." Ultimately, a major allocation of resources was only possible in this period because of the power of Adriano Olivetti. His decision to invest in electronics was made against widespread resistance within the company, including from other members of the family (with the only exceptions of his son Roberto and brother Dino) and managers (Perotto, 1995). In contrast, the people involved with the R&D and manufacturing of mechanical products, led by Capellaro, were shrouded in an aura of genius and infallibility, as they had built the success of the company.

Adriano's power to decide Olivetti's future was contentious. Fortune magazine described the power dynamics this way:

Ironically, the greatest difficulty Adriano encountered was in maintaining his own position and authority in the company. Although old Camillo [Olivetti – the founder] had given every indication of wanting Adriano to run the firm, he had left his 60 per cent share of Olivetti stock divided equally among his six children. Thereafter Adriano had to fight many a battle against family dissidents. (Fortune, 1960: 241)

Despite these disagreements, Adriano succeeded in devoting significant resources to the development of electronics because of his formal position as president, his personal charisma, and his credibility based on his successful leadership in the prior decades.²

The transition to electronics also triggered resistance motivated by self-preservation. Ottorino Beltrami, then director of the Electronics Division, explained that there was hostility from some managers who "saw their prestige compromised by the early success of electronics. They were not against electronics per se, but were annoyed that new persons were rising, like Tchou and Roberto who before were on the sidelines" (Novara *et al.*, 2005: 569). Tushman and Anderson (1986) suggested that individuals derive status and power from the competences that they embody, and that this allegiance creates resistance to change. The mechanics establishment feared that the technology would represent a threat to their positions, and sought to protect their interests vested in the mechanical competence. As recalled by de Witt, "They were scared to death of having to change. I was an electronics guy, but I could see my mechanics colleagues worried."

Change is resisted when it erodes the influence base of individuals and coalitions who hold much of the power in the organization (Pfeffer, 1982). The mechanical competence was not transferable, so its possessors stood to lose in the distribution of prestige, power, and resources; "The workers in the parent company regarded the new technology with suspicion and worried about their own jobs and existence" (Kicherer, 1990: 39). The mechanics establishment feared that the advent of electronics would wipe away all the "professional know-how that had accumulated over so many years" (Perotto, 1995: 48). As reported by Bosticco (1974: 17), "Older executives worry about their status. Often those who have made valuable contributions in the past are frightened by the new technologies and alarmed to see younger people coming in who know more than they do." Consequently, proponents of the competing technologies engaged in a "dynamic, purposive, and politically charged process of meaning construction" (Kaplan, 2011: 685; see also Kaplan and Tripsas, 2008).

2 Adriano had a one-sixth share of the company, equal to his siblings. Roberto, especially after the stock sale to the Intervention Group, had a much smaller share.

By the end of 1964, Olivetti had sold about 145 ELEA computers (about 45 in the 9000 class and 100 in the 6000 and 4000 classes), which amounted to roughly 25% of the Italian market, which was largely dominated by IBM (Notizie Olivetti, 1964; Parolini, 2008; Rao, 2003). The overall revenue of the electronics division was \$22 million, of which 50% was due to Bull products distributed by Olivetti. ELEA computers accounted for 25%, while the other 25% consisted of an invoicing machine that was complementary to traditional mechanical accounting machines (Sacerdoti and Ranci, 1993; Perotto, 1995). Nonetheless, the electronics division had considerable deficits due to the large R&D investments. In addition, because the computers were leased, each sale required additional capital (Learned *et al.*, 1969).

2.4 Sale of the electronics division

Electronics proponents suffered a major blow with the sudden disappearance of two key agents. The deaths of Adriano Olivetti, in 1960, and of Mario Tchou, in 1961, left the electronics division devoid of support. Also in the early 1960s, several factors converged to cause financial distress at Olivetti. The macro-economic situation was poor, with increasing labor costs and decreasing growth. In 1959 Olivetti became the first Italian firm to acquire a major US manufacturer: the US typewriter manufacturer Underwood. Underwood had a strong brand and sales force, but its plants, processes, and know-how had become obsolete. In particular, its outdated and inefficient plant in Hartford needed a complete overhaul (Amidei *et al.*, 2012). Olivetti's subsequent restructuring of Underwood required tremendous financial resources. Underwood had cost \$100 million in cash and loans, and had not yet turned a profit (*Newsweek*, 1964; *Business Week*, 1964b).

The considerable investments in electronics had also drained Olivetti's finances. The company's exponential growth in the 1950s had not been matched by an increase in capital. The Olivetti family retained a controlling share until 1964, when they asked a consortium of banking and manufacturing firms, called the "Intervention Group" to enter new capital. The group consisted of Fiat (the car company), Pirelli (the tire and rubber company), Mediobanca (an investment bank), La Centrale (a holding company), and Istituto Mobiliare Italiano (a state finance agency). The Intervention Group obtained a majority position on the board of directors, and Aurelio Peccei, a former president of Fiat, became Olivetti's new CEO. The consortium decided to address the firm's financial distress by strengthening the company's mechanics businesses and divesting the electronics business. As Piol (2004: 91) explained, "Given the financial strains Olivetti was undergoing, they had to choose whether to give up Underwood, which was mechanical, or the Electronics Division. And the choice came easily, almost unanimously."

Valletta, then president of Fiat, reported the following to the shareholders meeting on 30 April 1964: "[Olivetti] is a structurally solid organization and will be able to overcome this difficult moment. There's only one menace weighing on its future, one mole that needs to be removed: the entrance in the electronics market, which requires investments that no Italian firm can afford" (Perotto, 1995: 80–81). The choice of the word mole indicates the lack of moral legitimacy ascribed to electronics: a mole is undesirable, it is sneaky, it undermines what is solid and beautiful, and it is hard to get rid of. The cognitive legitimacy and pragmatic legitimacy of electronics were also contested. In our interview, Salvetti recounted the sale of the Electronics Division to General Electric (GE): "They tried to convince us that it was necessary to balance financial losses. . . . But it wasn't true at all, in retrospect. It was a lie. They just didn't understand this technology, and wanted to do away with it." The ELEA operation was reported by *Fortune* (1967) to have lost only \$3 million in 1961 and \$1.5 million in subsequent years—a small amount relative to Underwood's cumulative losses of \$50 million in 1960–1963 (*Fortune*, 1967) and to Olivetti sales of about \$400 million in 1964. Roberto Olivetti reportedly insisted that the computer losses were "well within the capacity of the corporation to sustain" (*Fortune*, 1967: 97). This suggests that pragmatic legitimacy cannot explain the divestment of the electronics division. In contrast, in 1959 Olivetti took on \$17 million of Underwood debt and paid \$9 million for one-third of the Underwood stock. Additional outlays were made for this mechanics-based company over the next 5 years: for buying the remaining stock, for modernization, and to cover operating losses. Meanwhile, the tremendous growth of the mainframe market was ignored. Since its inception in 1955 until the sale to GE in 1964, the Italian market for mainframes had grown by 50% to 150% each year, with an annual average growth of 103% (Bonfanti, 2004). A similarly astounding level of growth held for the European market. The Italian market for computers later continued to grow, from 850 overall units in 1965 to 2550 in 1969 (Sacerdoti and Ranci, 1993).³

3 After its transfer to GE, the ELEA 4001 became the base of the GE 100 line of mainframes, which sold 4000 units, about half of which in the US market.

The Intervention Group channeled the illegitimacy of electronics in the eyes of the Italian industrial-financial elite. Bruno Visentini, head of the Intervention Group and subsequently chairman of Olivetti, was strongly influenced by Enrico Cuccia, the boss of Mediobanca. This Italian investment bank had been founded in 1946 to facilitate the post-war reconstruction of Italian industry, and ever since had an active and decisive role in major business dealings in Italy. Cuccia himself held close ties with the “Salotto Buono”—an informal network of leading Italian industrial families, of which the Agnelli family (Fiat) was the most prominent. As noted by Beltrami (2004: 153), “This new electronic thing bothered a lot of people in Italy, and particularly at Fiat. They failed to understand the importance of electronics. My opinion is that electronics disturbed many in Italy who feared it would have diverted interest and financing from other activities. Selling electronics to the Americans surely appeased them.”

Fiat’s role as an external model of legitimacy is particularly noteworthy. Fiat was initially an organizational model as another prominent Italian corporation, but when Fiat brought capital to the Intervention Group it also became a resource provider for Olivetti. Olivetti had long been the nemesis of Fiat, as one of the few other Italian multinationals, and also located close by (in Turin).⁴ When Fiat, as part of the Intervention Group, gained partial control over Olivetti it tried to make over Olivetti in its own image, particularly by forcing it to eliminate electronic technology. As Lamborghini put it to us: “Once they could finally put their hands on Olivetti, they tried to make us less different.”

In 1964, the Electronics Division was sold to GE for \$12 million (Oldfield, 1996) and renamed “Olivetti General Electric.” Formally it was a joint venture, with GE holding 75% of shares, until 1968, when GE bought the remaining 25%. As part of this acquisition, 3000 people left Olivetti to be employed by GE (Learned *et al.*, 1969). In an attempt to increase its commercial presence in Europe, GE also acquired the French manufacturer Bull (Oldfield, 1996). Bull’s acquisition by GE aroused vibrant opposition from the French government, political parties, trade unions, and public opinion, while in Italy the sale of Olivetti’s electronics division caused no outcry (Soria, 1979).

Olivetti now refocused its core business around mechanical office product technology, launching a variety of new and particularly sophisticated mechanical models and committing investments to set up new plants. Despite its initial losses, the Underwood acquisition allowed Olivetti to penetrate the US market, where by the mid-1960s it had half of the market in calculators.

2.5 Levers of technological transition

We proposed in the previous sections that the building blocks of an organizational competence—legitimacy, power, and resources—serve as mechanisms of social control that ensure continuity and inhibit organizational change. In this section, we will explain how, despite resistance, a new technological competence can emerge and build momentum. We propose that *the same organizational building blocks that buttress a technological competence can be employed to break its hold*. That is, even though they are mutually reinforcing, the elements of legitimacy, power, and resources can also provide the basis for the emergence of its alternative. We documented this process at Olivetti, where the building blocks of the mechanical competence also fostered the growth of a new electronics competence. More specifically, we found that three “transition levers”—*organizational separation*, *co-optation*, and the *diversion of organizational resources*—link the dominant and emerging competences. During a period of contentious co-existence, the emerging competence is able to take root and grow over time until finally it attracts sufficient legitimacy, power, and resources to rival or even displace the incumbent. Figure 3 depicts these levers graphically.

The dashed arrows in Figure 3 refer to links between the existing competence (competence A) and the new one (competence B). These transition levers originate in the building blocks of one competence but serve to support its rival.

2.5.1 Organizational separation

The organizational separation lever starts in the power of the old competence and ends in the resources of the new competence, as agents who derive their power from the incumbent technology use their influence to devote resources

- 4 The labor practices of the two firms were one particular point of contrast. “Fiat’s workforce strategy was essentially aimed at driving a passive and obedient attitude from its employees. Olivetti, on the contrary, always encouraged active participation at all employee levels. ... Adriano always accused Italian industrialists of a severe lack of social responsibility.” (Berta, 1980: 15/18).

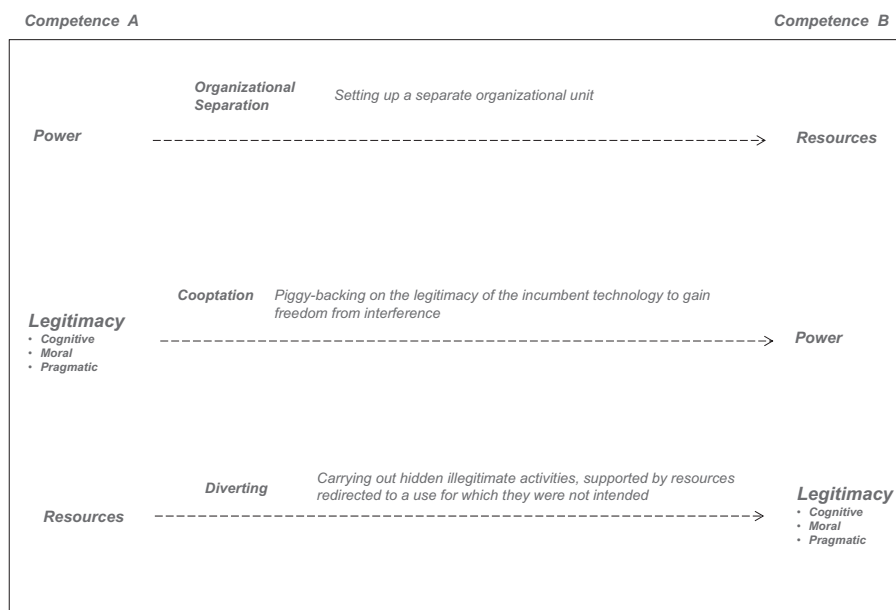


Figure 3. Levers of transition.

to the emergence of the new technology. This approach is consistent with recommendations to use a separate organizational unit to generate innovation that is inconsistent with the mainstream organization (cf. Duncan, 1976; Christensen and Bower, 1996; Tushman and O'Reilly, 1996; O'Reilly and Tushman, 2004, 2008, 2013; Gilbert, 2005; Tushman *et al.*, 2010).

At Olivetti, Adriano Olivetti was aware of the incompatibility between electronic and mechanic technologies, and believed that electronics could not emerge without separation. Therefore, in the 1950s, he used his power as president to allocate significant resources to organizationally and physically separate the two technologies, setting up a separate unit for electronics in Pisa (later moved to Milan), at a distance of several hundred miles from the Ivrea headquarters. In the company newsletter, Roberto Olivetti (1960) explained the physical separation of the electronics group this way:

It is not by chance that the activity of tomorrow is located outside the Canavese area [area around the Olivetti headquarters in Ivrea]. ... Over time electronics will come to Ivrea, the natural and traditional development location for our firm, but we must not run ahead. ... At this moment, Ivrea is preoccupied with other matters ... a doubling of our conventional products in the upcoming years. In this light, it is correct to keep electronics separated, as the interference of today's interests should not hinder those of the long term. ... The language, terminology, and working methods of young electronic designers are extremely different from those of our mechanical technicians.

While Adriano succeeded at creating a protected environment where a competence in electronics could grow, our study also highlights pitfalls of organizational separation that have not been explicated in the literature. On the one hand, electronics development proceeded with little interference from the hostility of the mechanical establishment in Ivrea. However, the separation widened the rift between mechanics and electronics. The individuals and social groups associated with the two competing technologies were clearly defined and they were separated along several dimensions: physically by location, occupationally by different professional cultures, and organizationally by departmental boundaries. Consequently, electronics was perceived by many within Olivetti as a separate entity, "an external body, something different from the real Olivetti" (De Sandre interview). Had there been more formal integration of small groups of electronics working with mechanics, the process might have been faster. Second, the separation did little to transform the mainstream organization, as the change remained isolated to a section of the organization. Piol (2004: 72) argued that "this choice, unfortunately, contributed to the formation of a kind of 'second Olivetti' with an electronic imprint, side by side with 'mechanical Olivetti', slowing down the transformation of the entire

firm and facilitating, later on, the exit from electronics.” Third, the separation made the Electronics Division easy to monitor and eliminate. According to de Witt, “They made the Electronic Lab as transparent as possible, by setting it apart from the rest of Olivetti, both physically and in terms of accounting and control, so that anyone could see any-time how much the whole thing cost, how much a single computer cost, etc.” This ultimately exposed electronics to greater scrutiny and attacks. It was isolated and hence easy to cut, as happened with the sale to GE in 1964.

2.5.2 Co-optation

The co-optation lever starts in the legitimacy of the old competence and ends in the power of the new competence, as agents tap the legitimacy of the incumbent technology to obtain a degree of autonomy to pursue the new technology (cf. Starr and MacMillan, 1990).

Cooptation at Olivetti happened when agents such as Tchou and Perotto put electronics at the service of mechanical products. Electronics lab director Mario Tchou and engineer Pier Giorgio Perotto deliberately co-opted the legitimacy of the mechanical technology by finding ways to use electronics to enhance mechanical products. By working on electronic devices to be applied to mechanical products, their lab could argue that it was carrying out useful projects, not just wasting money. As De Sandre, the electronics engineer, explained it, “Tchou didn’t want to be regarded as responsible for dissipating Olivetti’s resources, but as someone who was contributing to the company.” He continued:

There were two sides to electronics, which both Adriano and Roberto acknowledged very well. There were the big computers, on one side, and then another kind of electronics, one that was better tolerated by the Ivrea establishment, the electronics of small applications for mechanics. . . . Compared with ELEA computers, the electronic unit invested very little financial and human resources in these hybrid projects. But in terms of visibility, integration, and legitimization for us, they were very, very important.

Tchou set up ancillary projects that were aimed at devising electronic components to enhance the performance of mechanical products. In 1957, he put Perotto in charge of the development of an electronic-mechanical converter, which allowed data exchange between mechanical accounting machines and computers, the *Convertitore Banda Scheda*. Perotto explained in a speech that Tchou’s intent was to co-opt the mechanical establishment:

Tchou gave me a special task: what useful thing could LRE [electronics lab] do for Ivrea’s products? After all, office products were entirely mechanical. . . . So we had this idea of creating a product that could be useful for Ivrea and that could convert the punched tape [produced by the Olivetti Audit mechanical accounting machines] into punch cards, so they could be read by a central computer. . . . That machine had a political meaning because it constituted a sort of liaison between Ivrea, its technicians, its mechanical designers, and the electronic lab, which was negatively viewed. Therefore it added an element of legitimacy to the entire activity of the lab. . . . It’s like we found a solution that was in some parts technical and in some other parts political to legitimize our lab in the eyes of the central power, which was Ivrea.

In other words, Tchou piggy-backed on the legitimacy of mechanics by putting electronics in the service of mechanics, and this allowed his lab to receive less interference. This minor project turned into a success for the electronics division, as the converter became the first electronic product ever produced by Olivetti.

Tchou’s and Perotto’s efforts at co-optation ultimately allowed electronics to survive at Olivetti. By the time the Electronics Division was sold to GE, electronics R&D consisted of two units. The largest unit, which employed about 450 people, was focused on large-scale electronic calculators, that is, mainframe computers. The small unit, run by Perotto and employing 15–20 people, worked on electronic applications for traditional mechanical products. This unit was not sold to GE, but stayed in Olivetti. Perotto, in turn, coopted the legitimacy of mechanical technology by stating that the project he was pursuing in the remaining electronics unit involved “small electronics” and would lead to products similar to the old mechanical products. Perotto justified his work on the company’s first electronic desktop calculator, the highly successful P101 released in 1965 as follows:

I explained that my plan was to explore the potential usage of electronics for future small calculators for higher-end markets than those developed at Ivrea, not to work on large expensive electronic calculators [i.e., mainframes]. My proposal did not generate opposition and Natale Capellaro [head of R&D and legendary mechanical designer] in person showed some interest towards my project To me it was enough that the information circulating in Ivrea was that my activity was not disliked particularly and I had some kind of support from Capellaro. (Perotto 1995: 32)

2.5.3 Resource diverting

The lever of resource diversion, or what we call “resource diverting,” starts in the resources of the old competence and ends in the legitimacy of the new competence, as resources are diverted from the incumbent competence and surreptitiously redirected to a use for which they were not intended: the development of the new, emerging competence. Although the social control imposed by a socially embedded competence suppresses illegitimate activities such as resource diversion, these can still be carried on secretly (Christensen and Bower, 1996). Burgelman (1991, 1994) examined the use of resources in ways inconsistent with strategic intent by exploring the use of manufacturing capacity to make microprocessor versus memory chips at “memory company” Intel. The notion of resource diverting we developed by observing Olivetti is broader than Burgelman’s in that it includes a clandestine aspect.

In 1962, when Perotto set up a team to design the small, user-friendly electronic calculator that would become the P101, his goal was to bridge the gap between the complexities and cost of large-scale calculators (mainframes) and the ease of use of mechanical office products. Nevertheless, he initially kept the project secret: “Considering the delicate situation my team and I were in, I was determined not to talk about that with anyone, at least until we could produce a working prototype” (Perotto, 1995: 40–41). The P101 (later nicknamed “Perottina”) would ultimately revive electronics at Olivetti, but at the time its development was possible only because the project team maintained a low profile, avoiding visibility to the mechanics establishment (interviews with Garziera and de Witt). De Sandre, who was working with Perotto at the time, recalled in an interview that Perotto’s political abilities and personal connections were instrumental in protecting the development of the P101:

The guy always shielded us [team working on P101] from the Ivrea people. We were sealed off, and could focus solely on the technical issues regarding the development of the prototype. He would deal with all the politics, at which he was very good. He also had a direct relationship with Roberto Olivetti who, despite being put aside at that moment, was still a key actor at Olivetti.

In his book, Perotto (1995: 31–32) himself explained:

My aim was to gain access to a number of resources and labs in Ivrea, without which I’d have accomplished nothing. . . . I wasn’t given any kind of hierarchical authority, but that didn’t bother me, I just wanted people to know that my work was welcomed by Capellaro [the legendary mechanics genius and then VP of R&D]. This highly informal situation turned out to be extremely fruitful, as I managed to have all the doors opened without having to explain what exactly I had in mind to do.

In 1965 the group completed the P101 prototype, unveiling a calculator based on transistors. Many consider the desktop-sized P101 a forerunner of the personal computer (De Marco *et al.*, 1999), as it was programmable and had a magnetic memory card and a printer (Bricco, 2005). Yet, where the earlier ELEA computer had received very little coverage, the P101 received substantial attention from national and international media (Perotto, 1995). Ten years later, *Business Week* (1974: 113) labeled it “the world’s first electronic desk-top minicomputer.” In contrast with sophisticated mechanical calculators, such as the Divisumma, it was much faster, and had a memory unit. Further, while at the time complex calculations required computers as big as a room operated by arcane experts, the small P101 could be operated by anyone following simple and intuitive instructions. It formed the foundation for the restoration of electronics at Olivetti.

2.6 Electronics gains dominance

Ultimately, as electronics became the new dominant technology, the constituent elements of legitimacy, power, and resources became aligned, and its legitimacy gained support from external constituents. The success of the P101 enhanced the pragmatic legitimacy of electronics within Olivetti, and its cognitive and moral legitimacy gradually followed. Natale Capellaro, Olivetti’s R&D VP, upon first seeing the new model in operation declared that “the era of mechanics is over” (de Witt, 2005: 130).⁵ The prototype was presented at the Business Equipment Exposition in New York in October 1965 and was met with instant success. *Business Week* (1965: 188) wrote that Olivetti had “developed a desk-top computer that’s truly small enough to fit on top of a desk.”

The external legitimacy accorded to the P101 prototype enhanced the power of Roberto Olivetti, who together with his father had supported electronics from the outset. He used this power to assign facilities to Perotto for the P101’s manufacture. In 1965, the company launched the P101 in the USA, considered the most advanced and

5 Garziera, an electronics project manager, recounted in our interview that he was present at this meeting and that he remembers the statement as “the era of mechanical calculation is over.”

innovation-receptive market. An initial launch in the USA also protected the new model from the widespread skepticism enduring at the Italian headquarters (Piol, 2004: 66).

The P101 was met with instant demand, especially in scientific contexts. NASA, for instance, was among the first clients, and used it to make computations for the moon expeditions (Bonfanti, 2007; *Notizie Olivetti*, 1969). About 44,000 units were produced, of which 90% were sold in the USA for \$3200 (Perotto, 1995). Although its price was four times that of mechanical calculators, customers recognized extra value in its superior performance. In 1967, Hewlett Packard introduced a similar model, the HP9100, and was accused by Olivetti of breaching its patent. The issue was settled out of court, and HP agreed to pay Olivetti royalties for using identical technology.

At this point, enthusiasm for P101 was rapidly spreading within Olivetti. De Sandre recalls that “all middle-managers, in any unit, were in fierce competition to get their hands on a P101 themselves. They would use it as a very basic calculator, without exploiting its potential, but still, it had become a status-symbol.” The success of the P101 ushered in a resurgence of electronics at Olivetti, even though the Electronics Division had been sold just the year before.

2.6.1 The final resistance of mechanics

Notwithstanding its success, the P101 was aimed at an elite market niche and Olivetti was still surviving thanks to the ongoing success of its older generation of mechanical products. Teresio Gassino, a dominant figure of the mechanical establishment, tried to respond by accelerating investments in new mechanical product development, while blocking investments in electronic products. Logos 328, a follow-up to the P101, was put on hold for an entire year, until mid-1967. De Sandre recalled in our interview:

We electronic people kept meeting with resistance. After the P101 we came up with a new electronic model, Logos 328. But the prototype for that machine was basically ignored for more than a year, and it was done on purpose. When I asked Perotto why we wouldn't complete the Logos 328 project, he simply told me that we couldn't. Then I asked him again: “But why, exactly?” He answered: “We just cannot. The project has been halted from above.”

Gassino used his power to accelerate investments in mechanical new product development while starving electronics projects of resources. In 1966 Natale Capellaro, then still R&D VP, tried to stop Gassino's development of new mechanical calculators because he thought they would be too complex to manufacture, and wished to redirect investments to electronics. Gassino managed to bypass Capellaro's authority by pleading his cause with Roberto Olivetti, who, despite being the strongest advocate of electronics among top executives, allowed Gassino to pursue his project. In an interview with us, engineer Salvetti explained, “Mechanics still permeated most of the company, at all levels, and Roberto didn't want to spur additional tensions. He feared these might fire back on the infant electronics, which was gradually gaining consensus.”

Roberto's strategy was not to impose electronics, but let it gain legitimacy by demonstrating its technical superiority, while providing mechanical designers equal opportunity to compete. In other words, rather than using his power, Roberto Olivetti let the internal selection of projects evolve based on pragmatic legitimacy (cf. Burgelman, 1991).

Over time, the functionality of electronics increased steadily while mechanical technology hit a frontier. In the late 1960s many companies launched electronic calculators, but proponents of mechanics nevertheless kept up their resistance. As Lamborghini recounted in our interview:

The market was invaded by these new products that were cheap and small. Even facing the electronic invasion the mechanical people used to say: “Forget it, we produce splendid machines.” They insisted continuing these machines. They tried to build the ultimate mechanical machine: a beautiful, incredible machine. We did not even sell one [the Logos 27].

Even as late as 1968, upon claiming in a top management meeting that “we could not expect anything from mechanics in development and that we should move our attention exclusively to electronics,” Piol was scolded by chairman Visentini for “destabilizing the company with our vision about electronics” (Piol's Preface to Silmo, 2008: 7). At that time, electronics was already well established in calculators and there were many competitors offering models (Silmo, 2008). Despite the legitimacy of electronics in the external environment, electronics was still being internally contested.

Mechanical designers tried to compete with electronic designers to match the performance levels of electronic machines, and used their power to allocate the necessary resources. In the words of de Witt:

It was like a contest, between electronics and mechanics guys, with the latter aiming to show that they could do it as well, but in their own way! . . . It was the old generation fighting against the new one, trying to show they were also capable of making it. . . . You basically had two groups, with completely different backgrounds, working on the same product category!

The first version of the last mechanical calculator, the Logos 27, was introduced in 1965, at the same time as the P101, but it was never commercialized because of production and reliability problems. According to de Witt, “Logos 27 was a calculator that tried to force the technical features and performance, like speed and memory, of the Divisumma, but that was completely unreliable because it put mechanical technology under excessive strain.” The second, improved version of the Logos 27 was introduced in 1967, but could not compete with cheaper and more functional electronic calculators that were becoming widely available. As Pier Carlo Bottino, an accounting machines engineer, explained (quoted in *Novara et al., 2005: 275*), “The corporate influence of some people rooted in mechanics made us waste time in a mechanical monster that weighed a ton and was made of an infinite number of small pieces.” A proposal by Gassino for a third version of the Logos 27 was finally cut by CEO Beltrami in 1972. According to Salvetti, the total loss on the Logos 27 was \$32 million.

The new mechanical models of calculators and accounting machines were very difficult to manufacture due to their extreme complexity. The performance limits of mechanical technology were reached (Fogaroli interview; *Perotto, 1995*). Moreover, the market showed little enthusiasm for these new models. Consequently, Olivetti’s top management was in the embarrassing situation of facing strong difficulties in mechanics and considerable success in electronics, a division it had recently divested.

2.6.2 Electronics is consolidated

During the 1970s, the electronics competence was consolidated: it was considered legitimate, its agents held formal power positions, resources were focused on it, and external constituents were supportive of it. Changes in formal positions of agents indicate change in the power distribution in favor of electronics. We tracked carefully over time the formal positions of all the key actors including exact time of transition from one position to another. Once the electronic competence gained sufficient legitimacy, electronics people obtained top management positions. Most importantly, in 1967 Perotto became vice president of R&D, and CEO Aurelio Peccei, formerly of Fiat, was replaced by Roberto Olivetti. Their power changed from informal and undefined to formal and well-defined. In 1967, an organizational restructuring brought about significant changes, especially in the R&D unit of which Perotto became vice president. The new R&D function nonetheless had two distinct sub-units, one developing electronic products and one working on mechanics. In the words of De Sandre: “There were about 1000 people working in mechanical R&D in 1967. You couldn’t push 1000 people out of the door to make room for electronics, so in the beginning we lived together, under the same roof.” De Sandre also said:

It all happened so quickly that we [electronics people] were taken by surprise. We had fully understood that things had started to go in our direction, but we didn’t expect that all would go so fast. After all, electronics had been kicked out only three years before, then we almost had to hide to develop the P101 and, finally, projects like Logos 328 had been put on hold for almost a year.

The R&D function was furiously hiring electronics personnel. Fortuitously, the situation in OlivettiGE was quickly deteriorating. As recalled by de Witt, “In Italy GE was interested in acquiring markets rather than technology A number of people decided to leave and go back to Olivetti, where Perotto had stayed.” *Perotto (1995: 62)* “kept receiving phone calls from former colleagues, asking me for information about our programs, as well as about the possibility of coming back to Olivetti. And such inflow of human resources turned out to be most precious. We started to regain invaluable assets of expertise and know-how, which had seemed lost for good.” Consequently, there “began a sort of biblical exodus of designers, researchers, software developers, and peripheral unit designers from the former electronics division back to Olivetti, which was fostered by the enduring crisis of OlivettiGE and by the strategic uncertainties at GE, which in 1970 would eventually abandon the IT market” (*Perotto, 1995: 76–77*). GE sold its computer division to Honeywell in 1970.

Electronics at Olivetti could now draw legitimacy from the company’s traditional customers. Lamborghini highlighted that before, “. . . electronics meant big mainframes. Mainframes were so distant from the office products made by Olivetti! It was only when we built small calculators with Perotto that we could target the same market.”

Small calculators emerged in the mid-60s as electronics became increasingly miniaturized (Majumdar, 1982) and could fit in the same housing as the mechanical products.

At this stage resource allocations were also brought in line with the legitimacy and power of the new electronic competence. The decision to stop R&D for mechanical products, and to progressively reassign these funds to electronics, was made in 1968 (Piol, 2004: 79). When Beltrami returned to Olivetti in 1971 as CEO, he cancelled obsolete mechanical R&D and devoted most resources to developing electronic products and converting factories to their manufacturing.

Under Beltrami's leadership the cumulative investment in R&D from 1972 to 1976 was \$170 million, most of it in electronics. By 1976 the Olivetti R&D lab employed 2000 (de Witt, 2005: 114). Olivetti launched a slew of additional electronic products, such as telecommunications equipment, integrated circuits for minicomputers, and operating and applied software. In 1969, the company set up a new plant for distributed terminals and minicomputers (de Witt, 2005: 96). In 1971, it launched the P602, successor to the P101, as well as a new electronic accounting machine, the Auditronic 770. In 1974, it released the first electronic telex and two electronic accounting machines, the A5 and A7.

In a reversal of the moral legitimacy accorded to electronics, Visentini, who had been chairman and champion of selling Olivetti's fledgling computer division a decade before, said the sale had been "the biggest mistake we ever made" (Business Week, 1974: 113) and that the once-celebrated purchase of Underwood was "a very bad buy" (Forbes, 1978: 86).

In 1978, when integrated circuit technology (miniaturized transistors) allowed the production of ever smaller-scale electronic products, Olivetti became the first company in the world to release an electronic typewriter, the ET 101. Electronic products rapidly increased, from 32.9% of overall revenue in 1971 to 46% in 1973 and 75% in 1980 (de Witt, 2005). Upon introducing electronic typewriters, "there was no resistance, neither by internal politics nor by the market" (Piol, 2004: 108), evidence that electronics had achieved legitimacy at Olivetti, both internally and with the firm's external constituents.

Consolidation of electronics technology was complete by the late 70s, which is therefore the endpoint of our study period. The transition to electronics formed the foundation of the past two decades of Olivetti's history, although high-precision mechanics continued to be useful for devices such as printers and cash registers. Rather than being completely substituted by electronics, mechanics took on a supporting role. Mechanical technology was put at the service of electronic products, in a reversal of the earlier situation.

Olivetti's successful transition to electronic technology reshaped the future of the firm. In 1982, Olivetti introduced its first PC, the M10, soon followed by the M20 and the very successful M24 launched in 1984. By 1985, Olivetti had become the third PC manufacturer in the world, after IBM and Apple, with sales amounting to \$885 million (Piol, 2004: 153). Olivetti became a leader in central computers that governed a system of peripheral devices, including terminals and printers, which communicated via digital data transmission. Olivetti was also highly successful in the field of terminals (ATM and POS) for commercial and banking applications.

3. Discussion

Figure 4 presents our complete theoretical model of competence-destroying technological transition. The two boxes represent two distinct competences, A and B. The top-left box represents organizational competence A, which, through the self-reinforcing relationship between legitimacy, power, and resources (the building blocks of the competence), has become embedded in the organization. Social embedding occurs over time through a mutually reinforcing feedback loop among building blocks. In addition, the legitimacy of a technology competence is influenced by external constituents (resource providers and external audiences).

The building blocks of an existing competence can also give rise to the emergence of a competing one. The building blocks of competence A can foster competence B through transition levers that link to their consequent counterpart in competence B. These levers are activated when actors in an organization create *organizational separation* (to shelter an emerging technology), engage in *co-optation* (to justify the emerging technology), or *divert resources* (to develop the emerging technology). The dashed arrows from top-left to the bottom-right of Figure 4 depict the transition levers connecting competence A to competence B. These levers of transition are linked to both old and new

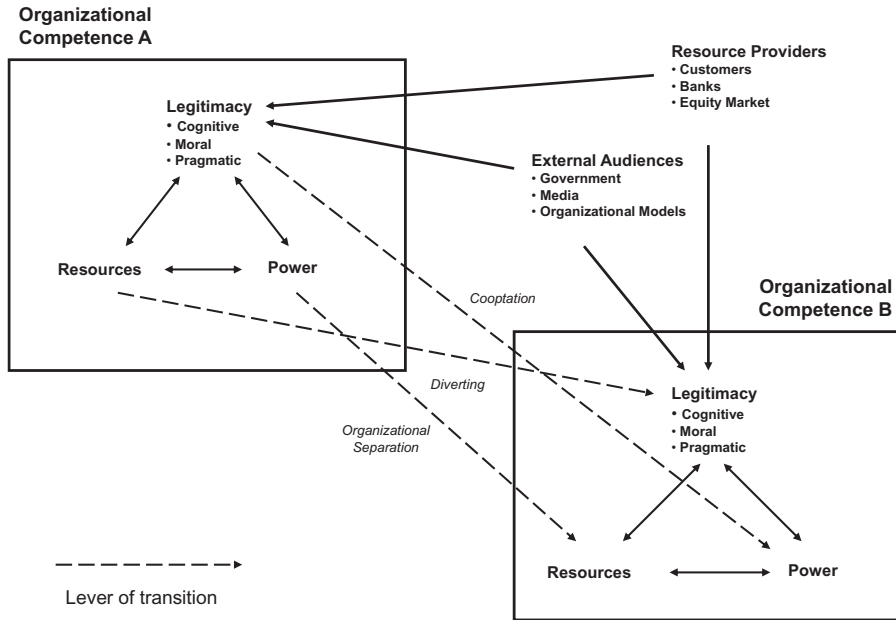


Figure 4. Model of technological transition.

competences, and thereby play complementary roles in putting a new technology in place. Paradoxically, the levers of transition originate in the old competence and support the emergence of the new one.

Over time, the three transition levers make it possible for an emerging technology to develop its own legitimacy, power, and resources. Thus, paradoxically, the organizational building blocks are both a source of stability and a potential source of change, because a block in one competence can lay the foundation for its alternative. When the building blocks of a new competence become sufficiently developed, they become linked in a mutually reinforcing relationship that causes the new competence to become socially embedded, and to be externally recognized as legitimate. Just as the new competence takes hold by *gaining* legitimacy, power, and resources, the organizational transition from the old competence to the new is complete when the old competence *loses* its legitimacy, power, and resources.

Olivetti provides a case of successful transition, and is in that sense unusual among previous firm-level studies of failed firms (Polaroid and Smith Corona). This makes the case of Olivetti an important counter-example to study (cf. Glaser and Strauss, 1967), due to its ability to eventually put in place all three building blocks of the new technology while engaging the operation of all three levers of transition. It also provides an empirical case of presence of dynamic capabilities, in contrast with Smith Corona (Danneels, 2011). Olivetti provided us the opportunity to build a comprehensive framework, encompassing all three building blocks (resources, power, and legitimacy) and all three levers of transition (separation, diverting, and cooptation).

In generalizing the findings from this study to other cases of competence-destroying technological change, it is important to remember the idiosyncratic nature of the Italian national context. In Italy, especially at the time of the study, a small elite of manufacturers and banks had substantial impact on industrial policy. These organizations accorded little legitimacy to the new electronics technology. In addition, the stock market in Italy was very small. Limited access to additional capital made Olivetti dependent on the existing industrial and financial elite as capital providers. An idiosyncrasy of the Olivetti company may also limit the generalizability of our findings. At Olivetti, employee relations were amicable, which contrasted sharply with the antagonism at other Italian firms such as Fiat. This was a legacy of Adriano Olivetti, who in his benevolence provided Olivetti workers with many social and cultural services, thereby making rank-and-file employees more receptive to retraining when electronics production was ramped up, and making it less likely that employees used unions for resistance.

4. Contributions

Following the logic of the extended case study (Burawoy, 1991), we used our case study of Olivetti to integrate, extend, reveal, and ultimately fill in the gaps of existing theory. Accordingly, we built an empirically grounded framework (summarized in Figure 4) that encompasses prior work and reveals several gaps. We provide an empirically grounded framework for understanding the connections among a broad range of studies. Prior empirical studies (see again Table 1) have provided partial answers to the question of why it is so difficult to accomplish competence-destroying technological change. Tushman and Anderson (1986) originally developed the notion of competence-destroying technological change and stated that industry incumbents are burdened by their prior technological competences, but they did not explain the nature of this burden. As the new competence destroys the old competence, the two are by their very nature antithetical. Our theory explicates the ways in which new and old technological competences can be incompatible. The competition for resources has been well recognized, as for instance March (1991) argued that exploration of a new competence competes for resources with the exploitation of an existing competence. However, our model shows that contest between competences involves more than resource allocation, it also involves a power struggle driven by conflicting interests and a contest for legitimacy over what is understandable, desirable, and useful. Hence, our three building blocks of legitimacy, power, and resources shed light on why competences are so hard to replace. However, these building blocks also provide insight into some ways in which transition might be achieved.

The other empirical studies each fit with part of our integrative theory of technological transition as summarized in Figure 4, which encompasses seemingly disconnected lines of prior work. Each perspective on its own provides a partial view on competence-destroying technological change. Christensen and Bower's (1996) explanation of how customers drive resource allocation in favor of certain technologies is included in the Resource Providers/Customers link to the Organizational Competences. Benner (2010) points to the role of another type of resource provider: the equity market. Her focus is primarily on how equity analysts shape the legitimacy of alternative technologies, as pictured in the Resource Providers/Equity Market link to the Legitimacy of Organizational Competences. Tripsas and Gavetti's (2000) mental models are encompassed in cognitive legitimacy, in particular the beliefs held by agents on what business model is appropriate for the technology. Their study suggests that the business model for digital photography was misunderstood, as it differed sharply from Polaroid's traditional razor/blade model. The Gilbert (2005), Danneels (2011), and Rosenbloom (2000) studies are mainly focused on the resources part of organizational competence. Gilbert (2005) was mainly concerned with rigidity in resource allocation and use, Danneels (2011) focused on the cognitive legitimacy of resources, while Rosenbloom (2000) emphasizes the role of the top executive. Sull *et al.* (1997) demonstrated local commitments constrained technological transition among tire manufacturers, demonstrating the importance of external constituents (Resource Providers and External Audiences). Tripsas (1997) studied technological transitions that were only partially competence-destroying, as only some of the technological resources become obsolete (such manufacturing skills), while others retain value (font libraries). In addition, the subsequent generations only partially involve new resource providers (mostly the same customers, but also some new ones).

In sum, our integrative theory—as summarized in Figure 4—connects a set of previously disparate bodies of work regarding technological transition and provides a holistic account of the organizational process by which a new technological competence displaces an existing technological competence. Beyond providing a more comprehensive theoretical framework for understanding competence-destroying technological change, our study also fills several gaps.

First, as seen in the introduction, the existing theory has trouble accounting for both stability (sources of inertia) and change (overcoming inertia). Inertia has often been invoked as an explanation of the difficulty of change. We found inertia sustained by mechanisms of organizational control involving legitimacy, power, and resources. However, the cycle between the mutually reinforcing elements of legitimacy, power, and resources may also be broken to aid in competence-destroying organizational change. Our unifying framework comprises both inertia and levers of change. We propose that technological competences become socially embedded in the organization because over time they gain cognitive, pragmatic, and moral legitimacy, become aligned with power, receive resources, and are supported by external constituents. As such, they become more inert. However, these same building blocks also form the basis of distinct levers of transition, providing insight into some ways in which transition might be achieved. Hence, our model provides an explanation for both inertial and dynamic sides of competences.

Second, we highlighted the role of individual agents in both inertia and change. While we present a socialized view of organizational competence, our theory leaves room for the role of individual agents in technological transition. We theorized that competences are constituted through social interactions, and become embedded in the social fabric of the organization. As such they both enable and constrain individual actors in terms of their perceptions of legitimacy, the power they can draw on, and the resources at their disposal. Agents at Olivetti drew on and attempted to change the legitimacy of the alternative technologies, used their power or co-opted that of others, and allocated and built on resources. We highlighted the active, purposeful element of inertia. Paradoxically, inertia at Olivetti was not passive or complacent, but rather involved an active and deliberate struggle for resources and power and a self-conscious contest for legitimacy. As agency explains how inertia is purposely maintained, it also explains how it is mutable when agents employ the levers of transition.

Third, our model explicates the critical role of power in technological transition, a topic on which the prior literature has been silent. By explicitly considering power, we fill a gap identified by Tushman and Anderson (1986) 30 years ago, as we show how the influence of power through formal position is constrained by the internal legitimacy and resources attached to the old competence, and the support to the old technology by the external stakeholders. Therefore, power holders cannot impose competence-destroying technological change top-down. The new technology also needs to become legitimate and garner sufficient resources.

Fourth, we highlight the challenge of achieving competence-destroying technological change through organizational separation. Prior work on ambidexterity has highlighted the benefits of exploring new technology in a separate organizational unit (e.g., Christensen and Bower, 1996; Tushman and O'Reilly, 1996; O'Reilly and Tushman, 2004; Tushman *et al.*, 2010). However, a crucial distinction needs to be made between exploration of new competences that complement the mainstream organization and of those that are incompatible with it. In their empirical study of six exploratory units, Raisch and Tushman (2016) found that in the four successful cases the capabilities pursued were complementary, while fear of cannibalization and internal competition characterized two failed cases. In competence-destroying change, the new unit is antithetical to the mainstream organization. We have shown that separation indeed fostered the emergence and growth of the electronics competence in Olivetti. Indeed, the different values and decision criteria of the Electronics Division at Olivetti, its dedicated resources, and its autonomy from interference allowed the new technological competence to emerge to the extent that it developed a sophisticated and functional product (the ELEA mainframe). However, we also noted possible pitfalls of separation. This separation did little to transform the mainstream organization, as the change remained isolated to a section of the organization. In addition, the separation made the Electronics Division easy to monitor and eliminate, and reinforced the antagonism between the competing technologies. We show the fragility of this lever by showing that a semi-autonomous subunit needs not only resources, but also (continued) support by power holders, and legitimacy supported by internal and external players. At Olivetti, paradoxically, organizational separation facilitated opposition against (and excision of) the electronics competence. In other words, while organizational separation enabled the electronics competence to develop, it also made it more vulnerable. To overcome the legacy of the old competence, to engage in the “destruction” part of competence-destroying technological change, the mainstream organizational competence needs to be dis-embedded. Facing resistance from the incumbent competence, more subversive tactics such as co-optation and resource diversion are necessary.

Fifth, our model also provides a more socialized view of organizational competences than has hitherto been articulated, thereby contributing to the emerging research on their micro-foundations. The extensive literature on resource-based theory recognizes the social nature of competences, but only implicitly. There, a competence is defined as a configuration of resources that enables the firm to accomplish a particular task (Grant, 1991; McGrath *et al.*, 1995; Helfat and Peteraf, 2003). Amit and Schoemaker (1993: 135) define a competence (or capability) as “a firm’s capacity to deploy resources, usually in combination, using organizational processes.” Helfat and Peteraf (2003: 999) add that a capability “refers to the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result.” A competence in this view must be more than a collection of resources, because coordinating and bundling resources into competences requires patterns of social interaction—that is, it requires social coordination among actors—to become embedded in the social fabric of an organization (cf. Granovetter, 1992). Resource-based theory has also argued that, because competences are socially complex, they are imperfectly imitable and thereby a potential source of competitive advantage (Barney, 1991).

We discovered that a deep and comprehensive explanation of competence-destroying change requires an appreciation of the socially embedded nature of capabilities. Social embeddedness helps explain why technological transition is not simply the result of market forces and income streams. This appreciation allows us to understand why transitioning to a new technology is not a straightforward pursuit of organizational survival and prosperity. We demonstrated that pragmatic legitimacy and transactions with external resource providers are insufficient to explain technological transition, and that the legitimacy of a technology also consists of moral and cognitive dimensions, which, during transition, can become misaligned and contested among competing organizational agents. Our model also emphasizes that, in this internal contest, the incumbent technological competence is privileged by the entrenched power of its proponents and its superior resources. At Olivetti, the electronics division was divested even after it had attained a substantial share of a fast-growing mainframe market. In contrast, a draining investment in updating the mechanic facilities of Underwood was maintained. And later, the mechanics establishment succeeded in impeding electronics projects, allocating substantial resources to fruitless mechanical projects even when electronic calculators had become prevalent and mechanical technology hit a performance frontier.

Appreciating that resources and competences are organizationally embedded sheds light on why dynamic capabilities are so hard to achieve. At Olivetti, competence change was internally contested and coupled to external resource providers and legitimating audiences. Reconfiguring resources through dynamic capabilities (cf. Teece, 2007) requires rupturing and rebuilding the social fabric of the organization, particularly in the case of competence-destroying change.

5. Conclusion

We started this article by noting the difficulties incumbent firms have in accomplishing competence-destroying technological change. We used an extended case study of Olivetti to develop an integrated framework for understanding technological transition and to identify levers of transition from one technological competence to another. Because organizational competences are socially embedded, they become resistant to simple managerial manipulation and less responsive to environmental change. We found that an embedded technological competence is hard to displace because it is legitimate, backed by powerful agents, supported by resources, and constrained by external resource providers and audiences. Despite their inertia, competences are also mutable when organizational agents employ the levers of transition (cf. Giddens, 1991/1984). Our study shows how legitimacy, power, and resources, the building blocks of an organizational competence, not only promote stability but also permit change.

Supplementary Material

Supplementary material is available online

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