Paper to be presented at the DRUID 2012

on

June 19 to June 21

at

CBS, Copenhagen, Denmark,

Knowledge systematisation and the development of a business function: the case of design

Beatrice D'Ippolito
University of Manchester
Manchester Business School (MIoIR)
beatrice.dippolito@libero.it

Marcela Miozzo
University of Manchester
Manchester Business School (MIoIR)
marcela.miozzo@manchester.ac.uk

Davide Consoli
Polytechnic University of Valencia
Institute of Innovation and Knowledge Management (INGENIO) C
davide.consoli@ingenio.upv.es

Abstract

Drawing on evidence on the home furnishing sectors in Italy during the XX century, the aim is to understand the instituted processes that facilitated the translation of design know-how from being project-specific to becoming relevant to broader remits. The paper contributes to the debate on industry evolution by incorporating the institutional dimension to the organisational and technological changes taking place at both firm and industry level.

Jelcodes:O33,-

Knowledge systematisation and the development of a business function: the case of design.

DRAFT VERSION – PLEASE DO NOT QUOTE WITHOUT THE AUTHORS' PERMISSION

Keywords

Design, knowledge systematisation, industry evolution, routines, capabilities, home furnishing

1. Introduction

The paper focuses on the multidimensionality of design activities and their pervasiveness at different levels of firm and industry organisation. Design can be understood as a set of routines aimed at meeting functional or aesthetic considerations. In prima facie, design consists of a set of criteria and rules of implementation embedded in the intricate product-process relationship (Nightingale, 2000). Nevertheless, by spurring multiple associations across functionalities of products and processes, the remit of design often extends beyond the creation and modification of physical objects. We draw attention to design routines that achieve the broader scope of shaping the 'cognitive frame' (Kaplan and Tripsas, 2008), that is, the criteria by which specific know-how is transferred to other dimensions and, eventually, the very organisation of firms and industry. Accordingly, the present paper seeks to articulate in detail the processes that facilitate the development of design routines and their application to more general sets of problems. In focussing on this cumulative implementation, we emphasise the interaction between scientific knowledge, that is typically available via formal training, and practical know-how, that often stems from experiential learning and diffuses via informal channels (see Vincenti, 1990, Rosenberg, 1998).

Our study draws on and contributes to both the literature on the development of firm capabilities and on the emergence of specialisation patterns within industry (Klepper, 2002; Malerba and Orsenigo, 1996; Nelson and Winter, 1982; Rosenberg, 1963). Understanding how cross-functional activities like design are embedded within a firm's products, production and delivery, and appreciating the associated organisational consequences, resonates with the literature that stresses the mutual interdependencies between the dynamics of technological knowledge and the division of labour (Langlois, 1992; Richardson, 1972; Rosenberg, 1963). Therein, key questions concern the balance between activities carried out within and beyond firms' boundaries, as well as their relative positioning within changing industry landscapes (Antonelli, 2006; Metcalfe, 1998; Richardson, 1972). Design activities are a good case in point given the broad range of sub-sectors they contribute to and the heterogeneity of expertise that their implementation entails (Heskett, 1980; Olins, 1986; Politi, 2000; Sparke, 1983). We take the experience of the Italian home furnishing sectors as illustrative of the interplay between organisational, technological and institutional pathways in defining the systematisation of knowledge involved in design-related routines.[1]

The paper contributes to existing scholarly work both on the micro-dynamics of the firm and development of firm capabilities, from an inside-out perspective, and on industry-level dynamics, driven by interaction between firms and extant institutions. This dual lens is appropriate considering the multi-faceted nature of design, which involves decisions about a broad number of issues, including form and function of products, the modes of production and delivery, and meanings (Walsh, 1996). By exploring the pathways through which design emerges and becomes established as an independent activity, the present study provides fresh insights on the emergence of a business function, arguably a neglected theme in the organisational literature. Furthermore, the paper adds to the literature on industry evolution by suggesting that industry dynamics does not boil down to mere entry/exit of firms but encompasses the emergence of synergies amongst organisational, technological and institutional spheres (Malerba, 2002; Nelson, 1994).

The remainder of the paper is structured as follows. Section 2 reviews the literature on firm- and industry-level dynamics and introduces the context of the design activity. Section 3 presents the empirical material and illustrates the main findings on the evolution of design as an industry as well as the organisational consequences at firm level. After the discussion of Section 4, the last Section concludes and summarises.

2. Dynamics of industries and firms and the division of knowledge

This section lays out the conceptual background of the paper. In the first part, we bring together different strands of literature focusing on instituted processes for knowledge generation and diffusion at the heart of the twin dynamics of firm development and industry evolution. Subsequently, we describe the nature of design activities, account for the different angles of analysis presented in the literature, and for the pervasiveness of design at multiple levels.

[1] The relevance of Italy as a context for studying design has a long tradition in the literature (Kristensen and Lojacono, 2001, Ravasi and Lojacono, 2005, Utterback et al., 2007, Verganti, 2009).

2.1 Background: technological change and innovation

Numerous empirical studies insist on the centrality of technological change for firm development and industry evolution (Marsili, 2001; Nelson and Winter, 1982; Rosenberg, 1982). Rosenberg's (1963) study on the strategic importance of manufactured durables' production in mid-XX century America is a classic point of reference for this literature. The development of the machine tool industry and the subsequent technological convergence in the late XIX and early XX century paved the way to large scale utilization of a core pool of skills, despite their specificities, across all the machine-using sectors.[2] This process bears testimony, Rosenberg suggests, to emergent interdependence across diverse industries, hinging upon a limited number of problem-solving processes that eventually became "the specialised function of a well-organised industry" (1963:443). The story of the machine tool industry is often interpreted as a primer into the broader phenomenon of industrial settings, affecting the patterns of specialisation of the firms that operate within it (Miozzo and Grimshaw, 2011). In our opinion, however, Rosenberg's analysis elucidates yet another important issue, namely, the effects of specific knowledge bases growing within firms and affecting the 'ecosystem' of competencies and selection rules. To develop this point, we look at technological change at firm level and articulate the steps through which product-specific problem-solving activities are abstracted from a specific context of use and diffused at broader levels.

According to Nelson (1994), the growth of an industry is the result of an orchestration among technology (that is, the body of knowledge underlying sets of instructions), organisations and institutions. The boundaries of firms are understood as being open to technological opportunities and complementary assets that may be available through interactions with external actors. Accordingly, industries emerge and develop depending on how rapidly and effectively industry associations, technical societies, universities, and government agencies co-evolve with firms. Of course, these ideas have deep roots in the works of Marshall and Schumpeter, who, albeit in radically different ways, concur in viewing the study of industries as a primarily dynamic exercise. Indeed, Adam Smith laid the foundations of classical economics around the notions of specialisation within enterprises, specialisation across

[2] For instance, the firearm industry was instrumental in the development of tools and accessories upon which the large-scale production of precision metal parts was dependent, such as jigs (originally employed for drilling and hand-filing), fixtures, taps and gauges, and the systematic development of die-forging techniques (Rosenberg, 1963:443).

countries, and the forces of competition. Scholarly efforts in this area call attention to either how the division of labour shapes the division of knowledge (as per Adam Smith) or vice versa (e.g., Becker et al., 1997, Stigler, 1991). Nevertheless, knowledge bases within firms develop incrementally and without a predetermined order and, as a result, it is difficult to detect whether increased specialisation prompts a division of labour at firm level or whether the process occurs the other way around. Moreover, and central to our argument, this process depends on the skills sets that are available at any time and, a fortiori, on the mechanisms that facilitate their diffusion.

Rosenberg (1976) argued long ago that progressive knowledge diversification and division of labour require the reorganisation of the transmission mechanisms that allow coherence across increasingly specialised activities. But while the point that knowledge evolves as a by-product of innovation is widely accepted, the analysis of the institutional mechanisms that permit the absorption of practical know-how in formal training is arguably underdeveloped in the innovation literature (Vona and Consoli, 2011). Rosenberg (1998) contributed to this debate by depicting curriculum development as a vehicle for channelling the latent potential of novel scientific know-how. The creation of chemical engineering in 1888 illustrates the importance of adaptive institutional settings in facilitating the emergence of a 'roundabout' discipline, that is, an area of specialisation acting as incubator for novel practices. Rosenberg (1998) emphasises the progressive interpenetration of two traditionally separate bodies of knowledge, chemistry and engineering, whose institutionalisation benefited initially the specific needs of the petroleum sector and, subsequently, became the main feedstock for a broad range of industrial users. In so doing, the newly created engineering discipline generated an inter-temporal spillover that binds together existing know-how with new knowledge: "a new blueprint today spills over to lower the cost of future blueprints" (Rosenberg, 1998:168).[3] Underpinning this story of increased specialisation and division of labour are other factors, namely: the interaction between university (notably, the newly formed chemical engineering department at MIT) and industry, which spurred the establishment of a curriculum of marketable skills; the increasing demand for chemical engineers during the First World War to ensure supply of munitions, nitrates and gasoline; and, finally, the rising use of liquid fuel due to the expansion of the automobile industry.

[3] In the words of Nelson and Winter (1982) the 'blueprint' metaphor suggests that technological knowledge is both articulable and articulated: "you could look it up. At least, you could if you had the appropriate training" (1982:60).

Another milestone in the development of the discipline was the conceptualisation of ‘unit operation’ by chemist A.D. Little in 1915. This process of intellectual abstraction of problem-specific know-how opened up the implementation of chemical engineering beyond the petrochemical industry and towards the broader remit of general-purpose production activities and technical equipment. Transliterating Rosenberg (1976), the concept of ‘unit operation’ became the focusing device of a broad range of industries because it favoured the standardisation of specific tasks and, as a result, the replication of the benefits derived from undertaking innovative activities.

Vincenti’s (1990) study on the impact of engineering knowledge in the aeronautical industry is another classic reference for the analysis of knowledge systematisation. Looking at the relationship between experiential know-how and scientific knowledge in the collection of instructions for aircraft control, Vincenti describes the institutionalisation of operative standards for airplane control in the early 1920s culminating in a newly created teaching module, Control-Volume Analysis. The latter encompasses routines and specifications for engineers to apply “the physical laws governing mass, momentum, energy and (when needed) entropy” (Vincenti, 1990:113). This, Vincenti insists, is a paradigmatic example of how recursive learning in practice contributes to the abstraction and codification of operative criteria, thus consolidating the notion of engineering epistemology as an autonomous body of knowledge based on problem-solving heuristics rather than on science.

Both the contributions of Rosenberg (1998) and Vincenti (1990) elucidate important aspects of the mutual influence between scientific knowledge and practical know-how. More than this, they flesh out the interplay between pathways for knowledge transmission and experiential learning-by-doing. The establishment of a new discipline and its further development as a general-purpose technology are the result of distributed adaptive behaviour across the institutional domain and the evolving population of capabilities that make up the industry at any time.[4] This resonates with our earlier proposition that the interplay between division of knowledge and division of labour is crucial in order to appreciate how relationships across actors drive the path of industry evolution (Nelson, 1994). The next subsection will explore some possible conceptual routes to explain the coordination of the establishment and functioning of these new conjectures by looking at design activities.

[4] For example an enlarged cohort of chemical engineers was being trained as a result of a growing demand for refined petroleum products.

2.2 Context: the growing remit of design

To some extent, design has been a central part of firm strategies for as long as the physical properties of materials have demanded the implementation of dedicated routines to achieve desired product specifications. Rooted etymologically in 'making of a drawing' the term design refers to a wide variety of contexts such as creativity, organisation of production, as well as articulation of engineering principles. The paucity of statistical data about design, both as activity and as sector, is perhaps the strongest testimony to the persistent lack of agreement as to where its boundaries lie (Beltagui et al., 2008).[5] Nevertheless, the 'hidden role' of product design pervades the literature on innovative performance on strategic, financial (Potter et al., 1991; Roy and Wield, 1986; Walsh et al., 1988), economic, sociological and managerial (Rothwell and Gardiner, 1983; Walsh, 1996; Walsh and Roy, 1983) aspects. The first major initiative by the British Government in the 1980s, the Funded Consultancy Scheme/Support for Design (FCS/SFD) programme,[6] spawned numerous reports and scientific articles (Potter et al., 1991; Roy et al., 1986; Walsh and Roy, 1983; Walsh et al., 1992) suggesting that product design impacts both on prices and other factors such as product performance, ease of use, durability and product delivery (Walsh et al., 1992). More recent studies emphasise that the approach towards design management is crucial for firm performance but, still, do not spell out how design activities integrate practically with innovative practices and strategy-building (Gemser and Leenders, 2001; Hertenstein et al., 2005; Perks et al., 2005). Yet, as Chiva and Alegre (2009) argue, this research seems to be still at its infancy.

For the purpose of this paper, we understand design as a set of routines aimed at meeting functional or aesthetic specifications. These routines rely on properties of raw materials and on scientific principles learned via formal and informal processes. Design is operationalised through steps, namely, problem identification, problem categorisation and problem-solving. Each of these generates feedback on which designers act upon by trial-and-error iterations around emerging configurations. Design activities apply to diverse categories of tasks to the

[5] Even in a NACE context, one would struggle to find design-related activities in the same category. In NACE Rev. 1 the activity "Design and assembly of industrial continuous process control systems" is classified within Class 33.30 "Manufacture of industrial process control equipment"; the activity "Consulting architectural activities: building design and drafting, etc." within Class 74.20 "Architectural and engineering activities and related technical consultancy"; the activity "Fashion design related to textiles, wearing apparel, shoes, jewellery, furniture and other interior decoration and other fashion goods as well as other personal or household goods" within Class 74.84 "Other business activities n.e.c." (NACE, 2008).

[6] The Programme aimed at promoting the use of professional design expertise in small and medium-sized firms across the country.

effect of conferring coherence to a set of disperse elements of a problem that, just like raw materials, do not yield a clear structure in the absence of an intentional architecture. The main (and diverse) functional aspects of design can be synthesised as:

- design is an activity that relies on a diverse knowledge base, which encompasses both analytical (engineering) and symbolic (meanings) knowledge;
- design can be regarded as a process that draws significantly on creativity (posing serious challenge to codification); and
- design is a service that provides input to the (innovation) strategy of the firm, both within and across organisational boundaries, i.e., both in relation to the specialisation of individual firms and the industrial domain within which they operate.[7]

Design encompasses the abstraction of problem-solving and the articulation of routines that apply to different projects. Our goal is to understand the instituted processes that facilitate the translation of specific design know-how from being project-specific to becoming relevant to broader remits.

Previous scholarly literature has emphasised the multiple roles of design. Kotler and Rath (1984) understand product design as strategic tool aimed at optimising consumer satisfaction and company profitability by creating performance, form, durability, and value in connection with products, environments, information, and identities. They also call attention to the importance of training general managers, marketers and engineers to understand design, and, in turn, of encouraging designers to be aware of and learn about the role and function of these staff (Kotler and Rath, 1984). Although sympathetic with this view, Dumas and Whitfield (1989) suggest that, since it is unlikely that those involved recognise the activities of all participants in the design process, it is also unlikely for a structure (that is, a business function in the conventional sense) to develop in such a way that enables effective cooperation between these professionals. This challenges the process of coalescing design expertise with firm (innovation) strategy. Another study by Verganti (2003) appraises the central role of industrial designers within those organisations that base their strategy upon radical design-driven innovations and singles out three key ingredients of competitive

[7] This working definition has been developed by the authors based on the existing literature. It attempts to encompass both the idea of the design activity as relying on symbolic knowledge (Verganti, 2008) and the strategic concept of design as a firm's innovative (and innovating) process (Rothwell and Gardiner, 1983, Walsh, 1996, von Stamm, 2008).

advantage offered by design: a personal network of stable relationships with brokers of languages; a range of alternative channels to access this knowledge; and an apt internal coordination to support the integration of these inputs (Verganti, 2003:42). More recently, von Stamm (2008) confirmed the expansion of pathways for the practical implementation of design within the matrix of firms' activities. Common across these works is the attempt not to reduce design to the proverbial 'eureka!' moment, in which a new idea takes shape. Elements such as aesthetics, envisioning new meanings, and improving functionality are all integral to the definition and implementation of design (Verganti, 2008).

While in prima facie design concerns the relation between product and process (Nightingale, 2000), we argue that by spurring multiple associations across functionalities its remit often extends beyond the creation or modification of physical objects. Our chief interest is the process by which some design routines shape the 'cognitive frame', that is, the criteria by which specific know-how is transferred to other dimensions. Interestingly, studies that focus on design concentrate on either the division of labour (Perks et al., 2005; von Stamm, 2008) or the division of knowledge (Filippetti, 2010; Ravasi and Lojacono, 2005). Yet, as argued earlier, innovation depends on how human capital is coordinated and managed as new knowledge is generated, new practices and skills are needed, and new types of firms emerge. This implies articulating the relationship between changes in design practices and the systematisation of specific knowledge. By systematisation we mean abstraction of operative principles to the effect of expanding the remit of practical routines that were initially conceived for a specific purpose (Rosenberg, 1976). Building on the cited study by Vincenti (1990) in aeronautical engineering, Nightingale (2000) elaborates a framework to articulate how technology-specific knowledge generates interdependent problem-solving tasks. He argues that innovation processes depend on the physical characteristics of the product and the institutional and organisational structure of the firm by generating a meaningful product-process-organisation relationship. But this framework arguably neglects changes in the external institutional structure of the industry whose relevance is pivotal for Nelson (1994).

We propose that the abstraction and systematisation of knowledge involved in design-related routines requires coordinated changes in the technological, organisational and institutional realms. In support of this argument, we recall Goffman's (1974) notion of 'frame' as the lens through which actors reduce the complexity of the environment in order to focus on particular features, make context-specific interpretations, decide and act. Kaplan and Tripsas (2008) use this concept to investigate technology evolution and define a technological frame as guiding the actor's interpretation of what a technology is and whether it does anything useful (Orlikowski and Gash, 1994). In the context at hand, the implementation of design rules at multiple levels constitutes a cognitive frame whereby the actors involved in the abstraction of knowledge familiarise themselves with a solution while striving to identify similar situations to which that same logic applies. Previous scholarly work explored how technologies related to design and experimentation activities can reshape the mechanisms by which heterogeneous organisational knowledge sources (i.e., from various functions and domains) and types (i.e., tacit, articulable and codified) are transferred within and across organisational boundaries and the way these are integrated into virtual and physical artefacts (D'Adderio, 2001). The present paper takes the further step of exploring how organisational and institutional routines combine to facilitate the translation of product-specific knowledge into more general problem-solving rules.

3. The case of home furnishing sectors

The research context of the present study is the home furnishing sectors, which comprise the following industries: wooden furniture, lighting systems, kitchen furniture, living room furniture, bathroom furniture, office furniture, and contract design.[8] We rely on four sets of primary and secondary data sources to explore the connection between the relevant technological, organisational and institutional advancements of these sectors.

3.1 Data Sources

First, we inspected books and design catalogues from the Faculty of Architecture and Industrial Design library in Milan (Polytechnic of Milan) to gather information on: (i) the technological changes of the sectors and the advancement of the relevant knowledge bases, (ii) the mission and objectives of the relevant actors and institutions, and (iii) the birth of a new (institutionalised) domain. Secondly, we analysed publicly available interviews with leading design experts on Italian design (www.rai.it).[9] The list of interviewees is reported in

[8] From both a theoretical and a methodological point of view it would be incoherent to treat innovation in materials in a furniture firm akin to innovation in fabrics taking place within a fashion design studio: the knowledge base is different and it would be difficult to test existing theories or develop new principles.

[9] RAI Radiotelevisione Italiana S.p.A. (known as Radio Audizioni Italiane since 1954) is the Italian state owned public service broadcaster controlled by the Italian Ministry of Economy and Finance. It operates many television channels and radio stations and broadcasts via different means included the web. Rai Educational is a section within the RAI website that is dedicated to delve deeply into selected themes. One of these regards the Italian design and contains a list of interviews that have been conducted with designers and other experts who are recognised worldwide because of the active role they have played within the design scene in Italy. The

Table A.1 (Appendix A). Third, we explored the curricula for professional training in major schools of industrial design (e.g., Polytechnic of Milan, European Institute of Design). Finally, we carried out face-to-face interviews with chief executives and senior managers of different business units (i.e., product development, R&D, marketing, art direction) in a set of furniture manufacturing firms (see details in Table 1). These were selected from the pool of exhibitors at the *Salone Internazionale del Mobile 2010*, based on the experience of these firms with design and a history of frequent new product development,[10] all elements that have contributed to their international reputation.[11]

Through this set of primary interviews we captured the adaptation of firms´ organisational structures, the development and deployment of specialised competencies, and the emergence of new practices both at the micro- and meso-level. Due to limited empirical evidence available, a case study methodology has been used for its ability to offer contextual richness (Yin, 2009) and foster a debate in a field where variables are not totally defined (Meredith, 1998).[12] Our focus on home furnishing sectors offers the advantage of dealing with a domain that is economically and technologically homogenous (Chiva and Alegre, 2007). In the remainder, we articulate interesting lessons from the study of innovation in this established domain by considering key technological and industrial developments.

---

interviews are available at: www.educational.rai.it/lezionididesign/designers/index.htm (first access date: 17/12/2009).

[10] The average product life cycle within the sector ranges between 1.5 and 3 years. We chose firms that develop new products on a yearly basis.

[11] This choice prevents industry-biased findings and leaves room for cross-industry analysis. It also guarantees some homogeneity in the articulation of design knowledge. It is worth mentioning that in a design-dominated context reputation is built not only by increasing a firm’s visibility but also by establishing long-term collaborations with renown designers. This draws attention to the (intangible) prestige elements of design, and it confirms the difficulty in disentangling its contribution to innovation.

[12] The reader should be reminded of the challenge associated to the case study methodology and the limited possibility for generalisation. It is idiosyncratic to case study that the research flows from data to theory, yet this depends on the extent to which new theoretical insights can be generated. The adoption of multiple case studies has often been criticised (as opposed to single case study research) because of the likely lack of depth (Dyer and Wilkins, 1991). However, in the context of this research, it is believed that selecting more than one case can be appropriate to outweigh the differences and gain additional insights about the theoretical phenomenon in object. Furthermore, due to the lack of an agreed definition of design, it would have been difficult to develop a positive, more deductive methodology to answer the posed research questions.

Table 1: List of firms and interviewees

Firm	Location	Size*	Area(s) of expertise	Informant
Aran World	Pesaro	Large	Kitchen, office	Marketing Director (also Member of the Board)
Boffi	Milan	Large	Living rooms, bathrooms	Marketing Director
Citterio	Milan	medium	Office, living rooms	Marketing Director
Dieffebi	Treviso	Medium	Office, contract	Marketing Director
Edra	Pisa	Medium	Living rooms	Art Director
Lago	Padua	Medium	Living rooms, bathrooms	Marketing Director
Luceplan	Milan	Medium	Lighting systems	President (Co-founder)
Magis	Treviso	Medium	Living rooms, contract	President (Founder)
Molteni&C	Milan	Large	Living rooms, office bedrooms, contract	Marketing Director
Mussi	Milan	Small	Bedrooms	Art Director
Ozzio Design	Milan	Small	Living rooms	Marketing Director
Presotto Industrie	Pordenone	Medium	Bedrooms, living rooms, contract	R&D and Marketing Director
SMA	Treviso	Medium	Bedrooms, living rooms	President
Valcucine	Pordenone	Medium	Kitchen, living rooms	President (Co-founder) and Art Director

* Small: turnover < €7mln; Medium: €7mln < turnover < €40mln; Large: turnover > €40mln.

3.2 Key technological and institutional developments in home furnishing throughout the XX century

The home furnishing sectors experienced little technical advance in the early XX century. While countless new machine-tools were being developed, advances in materials were limited to the field of metals until the late 1940s. Iron, in its cast state, and, later, in the form of steel, was the material of the day.[13] In this environment, craft-manufactured products such as furniture started being influenced by the advent of new materials: existing materials were being substituted by new ones in order to decrease costs and increase efficiency and it was only with the development of tubular steel, bent plywood and plastics that furniture designers began to respond aesthetically to the potential of new materials, inventing new forms

[13] The French Art Deco was taking advantage of those new materials for decorative purposes (e.g., balconies and metro stations), the US had a more operative approach by developing the all-steel car body, an innovation which was made possible by using the new steel-stamping machinery (Falabrino, 2004).

appropriate to the modern age.[14] The challenge had become to produce objects from everyday life in a simple and efficient way. The availability of these materials and of specialised craftsmanship (that is, availability of both knowledge and labour skills) favoured the development of a new industrial context for which no knowledge base existed before, yet a widespread enthusiasm was encouraging new entrepreneurial initiatives. Due to demand from people living in cities,[15] prefabricated construction elements were introduced for the first time in an attempt to promote economies in construction and a response to shrinking living spaces. Along with the trend of making household products modular, manufacturers started to explore seating possibilities more systematically in the 1970s, and this led to a 60% increase in furniture production (Wulfing, 2003:44).

Throughout this process, several practitioner-based activities played an important role in promoting Italian design. Three of them deserve special mention. First, the *Triennial*, an international exhibition created in the 1920s and dedicated to decorative arts that takes place every three years. Under the direction of architect Piero Bottoni, efforts went into the construction of a quarter in the suburbs of Milan to the effect of creating an experimental space for new architecture. The project was successful in attracting interest on themes that would be at the centre of future exhibitions.[16] *Triennials* played mainly an informative role by encouraging ideas and experience exchange as well as providing incentives to production and critical assessment on town planning, social architecture and high-quality industrial production. Such an approach was resumed in 1947 when different curators proposed to tackle the post-war recovery more systematically, thus making the *Triennial Foundation* an established locus for the diffusion and exchange of design culture and discipline.

Secondly, the *Compasso d'Oro* is an award for designers and manufacturers in the field of large-consumption products which achieve a synthesis of form and function. The prize was the idea of a few influential individuals of that time (the architect Gio Ponti, the deputy of 'La Rinascente' Cesare Brustio, and the critic Augusto Morello) following a successful exhibit in 1953 that highlighted the talent of many artists. The jury was composed by art critics, leaders in the design field, distinguished lecturers and historians. From 1959 to 1965, the competition was co-organised by the Association for Industrial Design (ADI), which then assumed full

[14] For instance, with the introduction of the 'plastic procedure' (as defined by a designer interviewed), it was possible to produce one piece instead of three or four as before, and curves were even more pleasant.
[15] In 1971, the Italian population was around 54,600,000 inhabitants and almost 50 percent of them were living in cities where there was a clear shortage of urban housing (Ambasz, 1972).
[16] Source: www.triennale.org.

charge of the prestigious affair in 1965 (Wulfing, 2003). ADI was founded in 1956 with the goal of supporting manufacturing and practitioners in the field and favour knowledge sharing through forums, exhibitions and other events. The competition includes a pre-selection process managed by the Permanent Design Observatory, where a panel of design language experts (critics, historians, journalists, designers, architects and professors) collects information, evaluates it and selects the best products. The jury is international, consisting of more than five members randomly selected from a pool of qualified researchers and experts from several industries (Dell'Era and Verganti, 2010). To date, 1,080 practitioners and 238 design-dominated firms are members of the Association.[17]

The third practitioner activity in support of the reputation of Italian design was the *Salone Internazionale del Mobile* (International Furniture Exhibition). The first exhibition took place in Milan in September 1961, it included 328 exhibitors covering 11,860 square meters of floor space and attracted more than 10,000 visitors (Sparke, 1986). Since then, the yearly *Salone* has become central to the advancement of design knowledge and Milan a key hub for the diffusion and promotion of Italian design and the locus where exhibitors and clients meet and discuss future collaborations.

In parallel to these activities, the influence of product design on firm competitiveness and performance motivated firms to adopt a more systematic approach to the management of design-related skills. Many small workshops designed internal processes by accounting for both efficiency and innovativeness and started experimenting with new materials or technologies that could foster the systematisation and exploitation of design-related knowledge.[18] Despite the increasing interest in innovative methods of production, designers and manufacturers had still to understand the requirements of certain materials and the constraints related to production such as technical and economic aspects. Ernesto Gismondi[19] - one of the leading furniture manufacturers - describes the difficulty of both technical and economic nature attached to the use of plastics. He emphasises the high complexity of the steel moulds needed to treat plastics, due to the fact that these may need up to two thousand

[17] Source: www.adi-design.org//elenco-soci.html (access date: 10/09/2011).
[18] Interviews with Boffi, Lago, Molteni&C and Mussi.
[19] Ernesto Gismondi is the founder and chief executive of Artemide, a manufacturing group holding a worldwide reputation for having revolutionised the residential illumination sector. With an international market presence, the *Artemide Group* was founded in 1959 in Milan (Italy) and is known for its “The Human Light” culture, that is, a way to imagine and design light that changed the way lighting equipment is conceived. The Italian design owes high recognition to Gismondi also for his pioneering activity in plastic furniture manufacturing, through the establishment of *Memphis*, a laboratory where he and his team could conduct their experiments.

tons of strength and high pressure, and the extent of investments required to put them into place.[20]

The simple lines of the designs of the 1950s and 1960s made of wood, glass and metal by the masters of their day were again being appreciated as the poor aging process of plastics became apparent (Wulfing, 2003). Nevertheless, research in artificial materials and new treatment of plastics continued and IT and globalisation led to a common interest: the sharing of knowledge and design concepts across sectors.[21] Thus, just as in the case of the machine tool industry (Rosenberg, 1963), where the application of a specialised knowledge base in many industries led to product innovations through new production techniques, the use of IT for undertaking design activities fostered the sharing of knowledge across disciplines and increased exponentially their applicability. For instance, the artisanal production of wooden cabinetmaking was being increasingly replaced by numerical-controlled production machines, and the artisans were dealing mainly with the finishing touches;[22] even further, the discovery of new ways to treat materials allowed furniture makers to use plastics in more traditional pieces of furniture, such as cabinets, tables, but also in more particular objects such as chairs.[23]

With events and exhibitions becoming more regular, and the widespread use of new materials and production processes, firms could rely on the emerging knowledge base and routines for sourcing their innovations. Even education institutions designed training qualifications both at the professional and graduate level and addressed to practitioners.[24] Initially, firms used to rely on graduates from architecture faculties or post-graduates from design schools, prominently the *Domus Academy*. By mid-1990s, the *Polytechnic of Milan* had founded the first university-based *School of Industrial Design*, which engaged with themes as diverse as aesthetics, ergonomics, properties of materials, sociology of space, design methods and instruments, history of design, space representation, and communications. Let us turn next to the institutional orchestration of old and new capabilities underpinning the evolution of the Italian design industry.

[20] Interview with Gismondi Ernesto (source: www.rai.it, access date: 17/12/2009).
[21] Interviews with Luceplan and Valcucine.
[22] Interview with Amadori Carlo (source: www.rai.it, access date: 17/12/2009).
[23] Interviews with Lago and Magis.
[24] Interviews with Boffi, Presotto Industrie and SMA.

3.3 Interplay between division of knowledge and division of labour

The 1950s saw the adoption by architects of a suite of new materials and technologies. For instance, Carlo Mollino launched the first tests on how to use wood in furniture manufacturing with the support of the emerging and flourishing industry in the nearby Brianza region.[25] Once post-war reconstruction was over, the perception of product design changed: furniture firms were using design expertise (and knowledge) to combine the benefits of technologies with product ergonomics, functionality, aesthetics, and image. For instance, the production of plastic chairs stemmed from many years of research with no particular search for a 'new' shape, but rather aimed at producing a shape that could best exploit the properties of plastics.[26] Another example is the employment of paper in lamps which was not part of the Western tradition until the discovery that the passage of light through the discontinuous filters of paper generates warmth around the lamp led to a successful product line.[27] These practical discoveries resonate with Vincenti's (1990) and Rosenberg's (1998) accounts of learning processes in the emergence of a field. In view of these contributions, our analysis seeks to capture turning points in the evolution of the complex set of design-related activities within the home furnishing sectors.

Regarding the supply of skills, the initial changes took place as a result of initiatives by both education institutions and firms becoming aware that, however important for designers, theoretical tools and quantitative data needed to be complemented by practical experience, which is often not formalised, but expressed through rules of thumb or embedded into learning-by-doing processes. This stimulated collaborations between designers and craftsmen aimed at perfecting the programming of machines and technical tools that had acquired an increasing recognition amongst furniture manufacturers. In the reminder of the section, we illustrate three instances of how the interplay between division of knowledge and division of labour impacted on organisational boundaries and the surrounding industry.

3.3.1 Technology developments and changing role of craftsmanship

The advent of new information technologies in the 1980s and the search for new professional standards in the 1990s brought about important changes. Our interviews indicate that both

[25] Interview with Colombari Rossella (source: www.rai.it, access date: 17/12/2009).
[26] Interviews with Edra and Magis.
[27] Interview with Branzi Andrea (source: www.rai.it, access date: 17/12/2009). A similar example can be found in the interview with Busnelli Piero Ambrogio with regard to fabrics (source: www.rai.it, access date: 17/12/2009).

designers and manufacturers agree on the influence of collaboration with craftsmen on the knowledge base of design.[28] It is clear that Italian craftsmanship has undergone a change due to discoveries of new materials or technologies that have, in turn, paved the way to further developments in the production processes. In the 1950s and 1960s, craftsmanship was the alternative to large-scale production and the latter was only accessible to large manufacturing firms.[29] With the increasing specialisation and the development of various capabilities in-house, the role of craftsmen changed: small workshops were no longer the alternative option, but the loci where engineers or designers could carry out their experiments. In fact, despite large-scale production already taking place, trial-and-error activities by craftsmen in workshops were essential for the completion of those design projects where the relevant knowledge could not be easily routinised.[30]

3.3.2 Prototyping and training of professionals

Technological development and regular collaboration between designers and craftsmen favoured the emergence and establishment of prototyping as a crucial step for efficient production processes. In fact, prototyping constituted the stage during which trial-and-error could take place before setting the manufacturing plants for high-volume production.[31] An example of this is offered by the case of the chairman of *Olivetti*, one of the first advocates of the relevance of prototyping for innovation.[32] This division of labour led universities and post-graduate schools to provide more structured training courses centred on the meaning and role of prototyping in design.[33] Looking at the curricula of major schools of industrial design (e.g., Polytechnic of Milan and European Institute of Design), one can observe that beyond the preliminary sketching skills to apply in computer-generated 3D models and rapid prototypes, central modules include principles of ergonomics, design for manufacturing production, and design for sustainability (environmental practices). The latter are referred to by interviewees as the ‘hands-on’ component of design.

[28] Interviews with Aran World, Citterio, Boffi, Molteni&C, Ozzio Design and SMA.
[29] Interviews with Dieffebi and Presotto Industrie.
[30] Interviews with Boffi, Edra, Molteni&C and Presotto Industrie.
[31] Interviews with Boffi, Lago, Luceplan, Magis, Molteni&C and Valcucine.
[32] Interview with Giulio Castelli (source: www.rai.it, access date: 17/12/2009).
[33] Interviews with Boffi, Luceplan and Molteni&C.

3.3.3 New technologies and change in the skills required

The advent of new technologies affected the design process and the demand for skills. Prior to the automation of manufacturing prototypes used to follow the sketch finalised by either the designer or the architect. After prototyping became established as a conventional phase of product development, the breadth of testing that could be carried out was widened and the very meaning of 'testing' changed: trial-and-error activities were undertaken with software, hence impacting positively on the efficient use of resources.[34] Even at the educational level, graduate qualifications started to include 'Rapid prototyping' and 'Use of Computer-Aided Design (CAD) software' as mandatory modules. However, as the interview data indicate, although software played a crucial role in the product development processes, designers fell out of practice with the treatment of specific materials or the use of technology.[35] This is another instance, we believe, in which external dynamics have shaped the design process (e.g., prototyping being split into digital and physical processes) and, in turn, the specialisation of professionals (e.g., designers involved first with the definition of the brief, and then with the realisation of the physical prototype).

3.4 Organisational dynamics, firm and industry evolution

In the mid-1980s a wave of technological changes across a diverse set of industries influenced significantly the development of the home furnishing sectors. On the one hand, the discovery of new materials encouraged firms to undertake R&D activities and modify internal processes to accommodate new production methods. On the other hand, furniture manufacturing firms' increased interest in technology motivated institutions to promote proactively the strategic role of design.

The development of new knowledge led firms to search for new skills. Acknowledging that design is not a one-off activity but a process that impinges on factors such as functionality, ergonomics, and aesthetics, firms initiated a steady collaboration with designers to develop technological innovations and meet a growing and increasingly sophisticated market demand.[36] The new projects received high support and firms seized the opportunity of scaling up production volumes.[37] Thus, firms exploited design not only for (product) innovation, but also to implement production methods that would support the adoption of new technologies

[34] Interviews with Ozzio Design, Presotto Industrie and Valcucine.
[35] Interviews with Boffi, Magis, Mussi and SMA.
[36] Interviews with Boffi, Citterio, Edra, Luceplan, Molteni&C and Valcucine.
[37] Interview with Baroni Daniele (source: www.rai.it, access date: 17/12/2009).

and reproduction of the subsequent benefits through the routinisation of the relevant activities.[38] Throughout this transitional phase, firms started to 'consult' external professionals in order to improve their innovation processes, machinery or to develop profitable collaborations with the suppliers of specific materials or technologies. These professionals would have diverse backgrounds, including architecture, engineering, as well as the recently established industrial design. The motivation behind these stable relationships with client firms was the drive to learn about the client's production strategy and innovation capability, and secure a certain degree of autonomy in their decision-making. Usually, designers interact with members of the product development or R&D unit internal to the firm (the so-called 'ufficio tecnico', i.e., the office of technicians) for a twofold reason: first, the designers have to become familiar with the resources (such as skills, technologies, and production techniques) and the production capabilities of the firm; second, designers play a role in the coordination between the purely engineering-oriented approach of engineers (or technicians) with the aesthetic properties of the new product.[39] Alberto Alessi provides an insightful example of how firms needed to adjust to new technologies and materials. His firm was using the cold presswork technology for steel treatment while innovative and more efficient ways to obtain new products were being discovered (e.g., traditional technology required nearly 100 operations to produce a stainless steel coffee maker, whereas the immersion technology was quicker and even, more suitable for more complex shapes). Given that their traditional specialisation locked the firm into existing technologies, the surrounding dynamics "spontaneously forced" Alessi's opening up to new materials, machinery, and technologies.

In conclusion, the domain was being formalised and change began to take place also at the organisational level. Designers entered organisations "through the back door" as stated by one expert interviewee, meaning that despite the fact that design was not occupying a clear-cut space within organisations, its role became of crucial importance for innovation. As a result, while collaborations with external professionals were still active, firms started to develop design expertise in-house, most often within the domain of the R&D department, and it could comprise a wide range of skills and competencies, "from the painter to the varnisher,

[38] Interview with Baleri Enrico (source: www.rai.it, access date: 17/12/2009).

[39] This statement finds unanimous support across the sample of firms with which primary interviews were conducted.

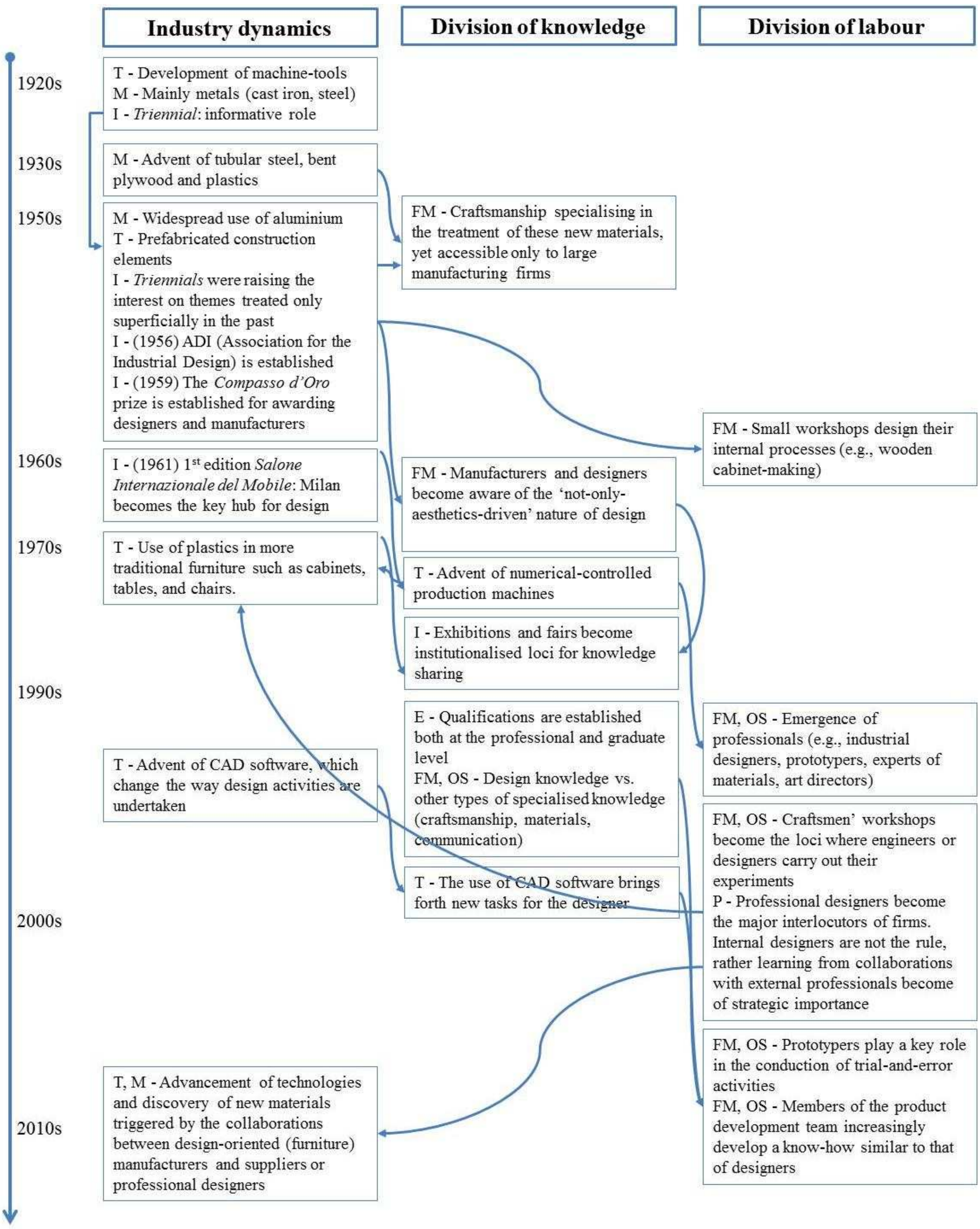
from the expert of polyurethane to that of plastics", as stated by the founder and chairman of B&B Pier Ambrogio Busnelli.

4. Discussion

The technological, organisational and institutional changes observed in the home furnishing sectors shaped firms' patterns of specialisation in several ways. They led to the incorporation of design into the innovation strategy of the firm and the establishment of interactions between formerly unrelated professionals (such as prototypers, designers, art directors, and experts of materials). Also, the organisational boundaries of the firm were redefined. Finally, new cross-institutional connections flourished at the meso level.

The processes discussed in the previous Section did not happen in a single iteration but rather in a cumulative sequence of transformations across industry ecology, knowledge emergence and diffusion and progressive division of labour over an extended timeframe. For instance, the emergence of various organisational roles motivated industry level institutions to organise fairs and events of interest to each particular set of professionals (such as technology fairs for product developers and fairs on materials for experts of materials). Figure 1 below synthesises over a longitudinal dimension the interplay across industry evolution, division of knowledge and division of labour. It highlights interdependent transformations such as: change of technologies (T); of materials (M); of the activities carried out by furniture manufacturers (FM) or other sectors (OS) - such as lighting systems or white appliances, for example; changes in the qualifications provided by education institutions (E); emergence of institutions (I); and finally, emergence of new professional roles (P). Our main argument is that the co-evolution of these elements over time has led to the establishment of (home furnishing) design as an 'industry'.

Figure 1: Technological and institutional changes within the home furnishing industry

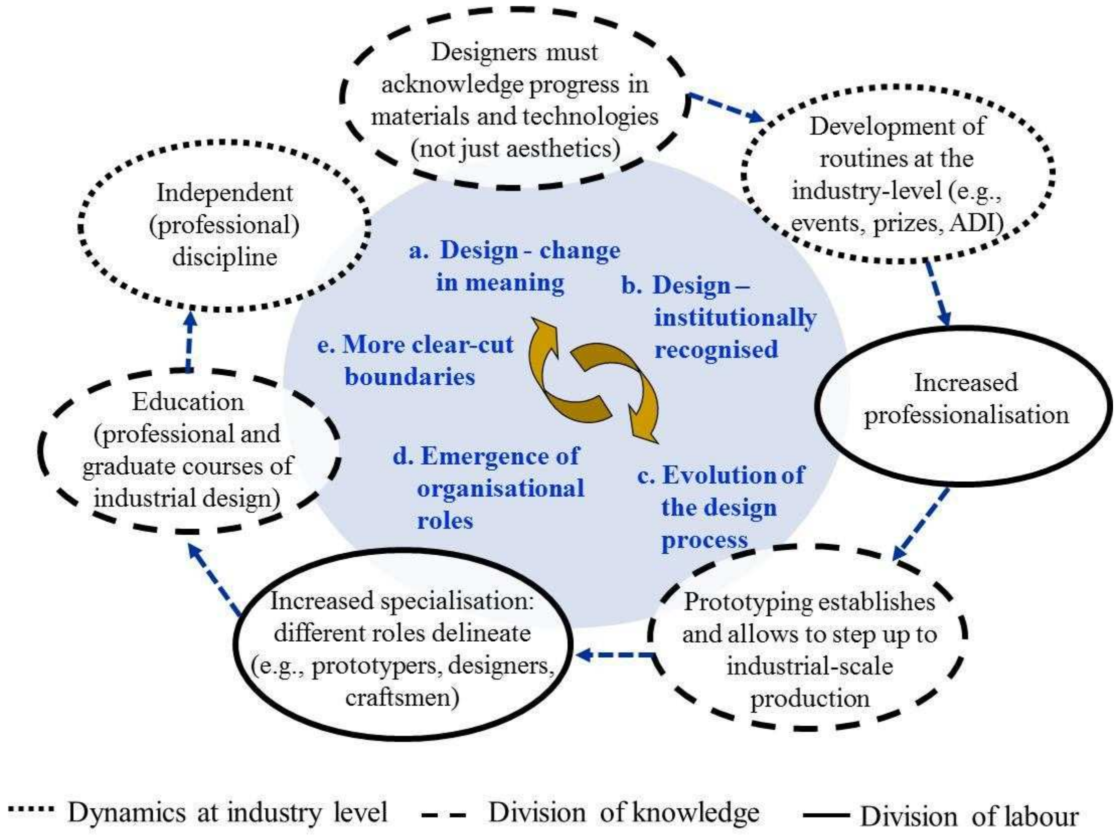


Source: Elaborated by the authors

Existing scholarly work on industry dynamics and firm growth focuses on either division of knowledge or division of labour (Rosenberg, 1963, 1998). The present analysis illustrates the role of industry dynamics in boosting the evolution of the design industry as well as the embeddedness of design-related knowledge within firms. This, we believe, is a meaningful contribution. While organisation studies traditionally concentrate on the internalisation (or externalisation) of new business functions (such as R&D or IT), the case of design presented here highlights the two-fold role of industrial dynamics: first, technological progress was inherently embedded into the growth of the industry (in the dynamics described earlier) and the firms, due to the role of design as booster of their (innovation) strategy; second, firms' decision-making was significantly shaped by routines and practices that have emerged within the industry (e.g., events have influenced firms' approach to design, and gained an increasingly wider audience). These remarks resonate with Nelson´s (1994) view of industry evolution discussed above.

Furthermore, the establishment of design as a discipline provides further insights into the shifting role of designers as their problem-solving skills facilitated the translation of context-specific solutions to other projects and/or business functions (Nightingale, 2000). As a matter of fact, starting with the delivery of a service mainly associated to products' appearance (i.e., during wartime furniture design was targeted mainly to re-furnishing damaged housing), designers became progressively involved with the R&D department and other production experts. High demand shifted the focus of design activities towards a more technological approach in which differentiation through materials or technology acquired relevance (point "a" in Figure 2). This context favoured the regular organisation of events (such as exhibitions and prizes) whereby the meaning of design could reach out towards an increasingly wider audience. The establishment of ADI in 1956 to support knowledge sharing of design amongst manufacturers and practitioners was yet another important hallmark for the institutional recognition of the activity (point "b" in Figure 2). The importance of these events for the identification of technological and other market opportunities has already been stressed (Maskell et al., 2006).

Figure 2: The changes affecting the development of design



Source: Elaborated by the authors

The expertise of craftsmen too gained importance and moved from being a mere alternative to high-volume production to crucial complement of designers in need of a locus for carrying out experiments on prototypes (points “c” and “d” in Figure 2). The organisation of teamwork within workshops fostered a constant interaction between manufacturing firms and production experts, on the one hand, and designers, on the other. Eventually, even education institutions adapted: schools at both professional and graduate level started offering different courses (such as UG degrees in industrial design, training courses on rapid prototyping, and ergonomics) to train the design professionals, rather than relying on engineers or architects (point “e” in Figure 2).

While increased attention of education institutions towards UG and PG design programmes point towards the institutionalisation of the field, it is important to consider the extent to which this may hinder originality and heterodox thinking among design professionals. In relation to this we coincide with Baumol (2005) in highlighting a trade-off between education that focuses on technical competence and mastery of currently available analytic tools, on the one hand, and education which aims to foster creativity and imagination that could stimulate original approaches to problem-solving, on the other. More emphasis on either one of them may hamper rather than facilitate innovation. From our study we can see that practice-based knowledge is essential for designers to encourage innovation within firm product development processes. In so doing, we do not downplay the role of formal education institutions but rather stress the fact that practical knowledge may need to constitute a significant share of design programmes.

A key element in the development of a strong knowledge base stems from designers' progressive engagement with the manufacturing process: only through a 'hands-on' approach designers could understand the language of other specialised professionals, translate it into product characteristics and functionality, and interface with the managerial levels for strategic purposes. In particular, careful selection of materials and craft plants have helped bridge the gap between tradition and innovation and allowed for a transformation in design that enabled the two to converge (Sparke, 1998). Parallel to this, prototyping has developed with different characteristics compared to other fields: while, for example, in aeronautics it was conceived as a methodology (Dreyfuss, 1974; Wilson and Wilson, 1965), in furniture it developed as a stage of the production process essential to assess the feasibility and reaction of a material to certain conditions (such as pressure or temperature, for example).[40]

A major novelty of the dynamics represented in Figure 2 is the counter-intuitive order of institutionalisation of a given body of knowledge. Many of the professions we are familiar with, such as medical doctors or lawyers, gain formal recognition through the establishment of a professional body and the resolution of conflicts and power struggles (Barber, 1963; Etzioni, 1969; Parsons, 1968). The case of design draws attention to a cyclical process according to which certain industry level routines have shaped organisational choices and these, in turn, spread across the industry by influencing the decision-making of institutions. Put differently, industry dynamics triggered an implicit institutionalisation that subsequently spurred initiatives at both the micro- and meso-level by relying on a shared set of specialised skills and competencies (Rosenberg, 1976). The case of design draws attention also to the professionalisation of a body of knowledge that was not characterised by standards to start with. Savage (1994) pointed to the emergence and establishment of a set of routines that led

[40] Needless to highlight that these dynamics have reflected back on the types of specialisations that were emerging across the country: education institutions were establishing courses on specialised subjects (innovation through materials and technologies, for instance).

to the professionalisation of pharmacy, yet this field was relying on a fairly standardised (and codified) domain. The analysis of design shows how, contrary to standardised disciplines, professionalisation may unfold through both internal routines, i.e., demand for newly combined skills and subsequent emergence of a specialised knowledge base, and external routines, i.e., credentialism in the job market and accreditation via curricula development prior to the formalisation of the underlying body of knowledge. Put differently, the professionalisation of design illustrates how the expertise of individual professionals constitutes a potential source of innovation for the firm and, in turn, for the surrounding industry.

In the second Section we recounted the emergence of chemical engineering (Rosenberg, 1998) as the result of a joint effort by chemists and engineers and the catalysing role of institutions such as MIT in codifying the emergent practices. Furniture design is an example of how industry level technological and institutional dynamics shape firms' organisational boundaries: changes internal to the firm, mainly regarding the knowledge base, stimulated a response in educational and professional institutions. In other words, design acted as cognitive frame whereby practical knowledge developed within home furnishing sectors underwent a process of abstraction, translation and absorption in a different context, and the latter led to a (re)new(ed) industrial domain (Kaplan and Tripsas, 2008).

Design and innovation scholars have argued for years over the relative importance of 'need pull' or 'technology push' for design but, as Bruce and Bessant (2002) argue, this would be missing the point.[41] Both sets of factors are important and they act like "the blades of a pair of scissors" (Bruce and Bessant, 2002:3) - it is their interaction which leads to novel practices and knowledge.

5. Concluding remarks

This paper has analysed the processes that facilitate the development of design routines and their application to more general sets of problems. This cumulative implementation, we argue, stems from interpenetration between scientific knowledge and practical know-how. In fact, the history of design activity recounted here highlights the intersection of multiple

[41] Sometimes the demand may be very clear and what is missing is the particular solution that fits the need – necessity being the mother of invention. And sometimes is the availability of some new knowledge – technology – which needs to find a use. Examples of such 'solutions looking for a problem' include the early days of microelectronics, the current range of biotechnologies, especially genetic engineering, and the growing set of new materials technologies (Bruce and Bessant, 2002).

learning processes at different levels, namely: the contribution of craftsmen expertise to prototyping capabilities; the trial-and-error adoption of novel production criteria; the impact of new technologies on skills throughout the product development process, and the associated emergence of new organisational roles (such as designers, prototypers, and art directors). Our analysis articulates the unfolding of these processes with close attention to the interplay across individual skills, organisational routines and changing firm strategy. Moreover, it illustrates the cyclical process by which certain routines shape organisational choices and these, in turn, spread throughout the industry and encourage broader institutional adjustments.

Conceptually, these findings respond partially to Malerba and Orsenigo's (1996) call for an enlarged perspective in the study of industry evolution, beyond entry/exit of firms and focused also on relations between actors, knowledge bases and technologies. The paper has emphasised the role of institutions and the evolution of skills and routines both at the micro- and meso-level. In so doing, it adds an institutional dimension to the organisational and technological changes observed at firm and industry level. Moreover, the arguments put forth here resonate with the research agenda laid out by Ravasi and Stigliani (2012), who warn design and management scholars about the need to extend our understanding of the broader institutional context within which design activities are carried out.

A final remark concerns the emergence of a (service) industry based on creativity rather than a more technology- or professional-oriented domain. Unlike fields such as pharmacy or law, where the institutionalisation of the fields has undergone the establishment of a professional body or specific education requirements, the design industry has been characterised by events and technological advancements that have shaped the visibility of professionals only indirectly, yet this pulled out the systematisation of the relevant knowledge. To this extent, design is an enlightening example within the service innovation literature since it binds together creativity and professionalisation by focusing on both the specialisation of individual practitioners and firms and the establishment of institutions at the industry level. As illustrated by our findings, design has developed an identity of 'serving' other business units such as product development and strategy, which involved developing 'lateral knowledge' regarding materials, technologies or specialised training, hence establishing a stable set of relationships with the surrounding industry(ies).

Although the main aim of this study was to investigate how the interplay between division of knowledge and division of labour can support a better understanding of industry evolution and the development of firm-level knowledge base, we believe that further effort should be addressed to understanding how changes in individuals' skills have influenced organisational practices and routines. That will be our next project.

Acknowledgements. We are indebted to Stan Metcalfe, Richard Nelson, Ian Miles, Silvia Massini, Jeffrey Butler and Andrea Filippetti for insightful comments on previous versions of the manuscript. Preliminary drafts were presented at the Network of Industrial Economists (NIE) Doctoral Students Colloquium in Nottingham (UK), Summer School in Services in Helsinki (Finland), British Academy of Management Annual Conference in Birmingham (UK) and EAEPE Annual Conference in Vienna (Austria). On those occasions we benefited from comments by George Tsekouras, Giuliana Battisti, Peter Swann, Maria Holmulund-Rytkonen and Tuuli Mattelmaki. BD acknowledges financial support from the Economic and Social Research Council (ES/F022735/1) and the Università Cattolica del Sacro Cuore (Piacenza, Italy). MM acknowledges financial support from the Economic and Social Research Council (RES-189-25-0227). DC acknowledges financial support from the European Community (FP7-PEOPLE-IEF-2008-235278). The opinions expressed in this paper are those of the authors. The usual caveats apply.

References

Ambasz, E., 1972. Italy: the new domestic landscape. Achievements and problems of Italian design. Museum of Modern Art, New York.

Antonelli, C., 2006. The business governance of localized knowledge: an information economics approach for the economics of knowledge. Industry and Innovation 13, 227-261.

Barber, B., 1963. Some problems in the sociology of the professions. Daedalus 92, 669-688.

Baumol, W.J., 2005. Education for innovation: entrepreneurial breakthroughs versus corporate incremental improvements. Innovation Policy and the Economy 5, 33-56.

Becker, M.C., Cohendet, P., Llerena, P., 1997. Division of labor and division of knowledge: why the nature of the causality matters for the evolutionary theory of the firm, in: Cantner, U., Malerba, F. (Eds.), Innovation, industrial dynamics and structural transformation. Heidelberg, Berlin, pp. 49-63.

Beltagui, A., Riedel, J., Livesey, F., Demian, P., Moultrie, J., 2008. Briefing note 1: What is design? A review of definitions, DesignScoreboard - A novel approach to measuring the UK's National Design Performance, pp. 1-19.

Bruce, M., Bessant, J.R., 2002. Design in business: strategic innovation through design. Prentice Hall, Essex.

Chiva, R., Alegre, J., 2007. Linking design management skills and design function organization: an empirical study of Spanish and Italian ceramic tile producers. Technovation 27, 616-627.

Chiva, R., Alegre, J., 2009. Investment in design and firm performance: the mediating role of design management. Journal of Product Innovation Management 26, 424-440.

D'Adderio, L., 2001. Crafting the virtual prototype: how firms integrate knowledge and capabilities across organisational boundaries. Research Policy 30, 1409-1424.

Dell'Era, C., Verganti, R., 2010. Collaborative strategies in design-intensive industries: knowledge diversity and innovation. Long Range Planning 43, 123-141.

Dreyfuss, H., 1974. Designing for people. Paragraphic, New York.

Dumas, A., Whitfield, A., 1989. Why design is difficult to manage: a survey of attitudes and practices in British industry. European Management Journal 7, 50-56.

Dyer, W.G., Wilkins, A.L., 1991. Better stories, not better constructs, to generate better theory: a rejoinder to Eisenhardt. Academy of Management Review 16, 613-619.

Etzioni, A., 1969. The semi-professions and their organization: teachers, nurses, social workers. The Free Press, New York.

Falabrino, G.L., 2004. Design speaks Italian. Domus Academy story. Libri Scheiwiller, Milan.

Filippetti, A., 2010. Harnessing the 'essential tension' of design: the complex relationship between the firm and designer consultant. Italian National Research Council, Rome, pp. 1-22.

Gemser, G., Leenders, M.A., 2001. How integrating industrial design in the product development process impacts on company performance. Journal of Product Innovation Management 18, 28-38.

Goffman, E., 1974. Frame analysis: an essay on the organization of experience. Northeastern University Press, Boston.

Hertenstein, J.H., Platt, M.B., Veryzer, R.W., 2005. The impact of industrial design effectiveness on corporate financial performance. Journal of Product Innovation Management 22, 3-21.

Heskett, J., 1980. Industrial design. Thames and Hudson, London.

Kaplan, S., Tripsas, M., 2008. Thinking about technology: applying a cognitive lens to technical change. Research Policy 37, 790-805.

Klepper, S., 2002. The capabilities of new firms and the evolution of the US automobile industry. Industrial and Corporate Change 11, 645-666.

Kotler, P., Rath, G.A., 1984. Design: a powerful but neglected strategic tool. Journal of Business Strategy 5, 16-21.

Kristensen, T., Lojacono, G., 2002. Commissioning design: evidence from the furniture industry. Technology Analysis & Strategic Management 14, 107-121.

Langlois, R.N., 1992. Transaction-cost economics in real time. Industrial and Corporate Change 1, 99-127.

Malerba, F., 2002. Sectoral systems of innovation and production. Research Policy 31, 247-264.

Malerba, F., Orsenigo, L., 1996. The dynamics and evolution of industries. Industrial and Corporate Change 5, 51-87.

Marsili, O., 2001. The anatomy and evolution of industries: technological change and industrial dynamics. Edward Elgar, Cheltenham.

Maskell, P., Bathelt, H., Malmberg, A., 2006. Building global knowledge pipelines: the role of temporary clusters. European Planning Studies 14, 997-1013.

Meredith, J., 1998. Building operations management theory through case and field research. Journal of Operations Management 16, 441-454.

Metcalfe, J.S., 1998. Evolutionary economics and creative destruction. Routledge, London.

Miozzo, M., Grimshaw, D., 2011. Capabilities of large services outsourcing firms: the 'outsourcing plus staff transfer model' in EDS and IBM. Industrial and Corporate Change 20, 909-940.

Nelson, R.R., 1994. The co-evolution of technology, industrial structure and supporting institutions. Industrial and Corporate Change 3, 47-63.

Nelson, R.R., Winter, S.G., 1982. An evolutionary theory of economic change. Belknap Press, London.

Nightingale, P., 2000. The product - process - organisation relationship in complex development projects. Research Policy 29, 913-930.

Olins, W., 1986. The industrial designer in Britain 1946-82, in: Sparke, P. (Ed.), Did Britain Make It? British Design in Context. Design Council, London, pp. 59-67.

Orlikowski, W.J., Gash, D.C., 1994. Technological frames: making sense of information technology in organizations. ACM Transactions on Information Systems 12, 174-207.

Parsons, T., 1968. The professions. International Encyclopedia of the Social Sciences 12, 536-547.

Perks, H., Cooper, R., Jones, C., 2005. Characterizing the role of design in new product development: an empirically derived taxonomy. Journal of Product Innovation Management 22, 111-127.

Politi, M., 2000. Economia del design - Sintesi della ricerca. Centro Studi Industria Leggera (CSIL), Milan, pp. 1-48.

Potter, S., Roy, R., Capon, C.H., Bruce, M., Walsh, V., Lewis, J., 1991. The benefits and costs of investment in design: using professional design expertise in product engineering and graphics projects. The Open University and UMIST, Milton Keynes.

Ravasi, D., Lojacono, G., 2005. Managing design and designers for strategic renewal. Long Range Planning 38, 51-77.

Ravasi, D., Stigliani, I., 2012. Product design: a review and research agenda for management studies. International Journal of Management Reviews Forthcoming, 1-25.

Richardson, G.B., 1972. The organisation of industry. The Economic Journal 82, 883-896.

Rosenberg, N., 1963. Technological change in the machine tool industry. The Journal of Economic History 23, 414-443.

Rosenberg, N., 1976. Technological change in the machine tool industry, 1840-1910, in: Rosenberg, N. (Ed.), Perspectives on Technology. M. E. Sharpe, New York, pp. 9-31.

Rosenberg, N., 1982. Inside the black box: technology and economics. Cambridge University Press, Cambridge.

Rosenberg, N., 1998. Chemical engineering as a general purpose technology, in: Helpman, E. (Ed.), General purpose technologies and economic growth. MIT Press, London.

Rothwell, R., Gardiner, P., 1983. The role of design in product and process change. Design Studies 4, 161-169.

Roy, R., Walsh, V., Salaman, G., 1986. Design based innovation in manufacturing industry: principles and practices for successful design and production, in: DIG-02, R. (Ed.), DIG no 2. The Open University and UMIST, Milton Keynes.

Roy, R., Wield, D., 1986. Product design and technological innovation: a reader. Open University Press, Milton Keynes.

Savage, D.A., 1994. The professions in theory and history: the case of pharmacy. Business and Economic History 23, 129-160.

Sparke, P., 1983. Consultant design. The history and practice of the designer in industry. Pembridge Press, London.

Sparke, P., 1986. Did Britain make it? British design in context 1946-86. Design Council, London.

Sparke, P., 1998. The straw donkey: tourist kitsch or proto-design? Craft and design in Italy, 1945-1960. Journal of Design History 11, 59-69.

Stigler, G.J., 1991. Charles Babbage (1791 + 200 = 1991). Journal of Economic Literature 29, 1149-1152.

Utterback, U., Vedin, B.A., Alvarez, E., Ekman, S., Sanderson, S.W., Tether, B.S., Verganti, R., 2007. Design-inspired innovation. World Scientific Publishing, Singapore.

Verganti, R., 2003. Design as brokering of languages: innovation strategies in Italian firms. Design Management Journal 14, 34-42.

Verganti, R., 2008. Design, meanings, and radical innovation: a metamodel and a research agenda. Journal of Product Innovation Management 25, 436-456.

Verganti, R., 2009. Design-driven innovation - Changing the rules of competition by radically innovating what things mean. Harvard Business Press, Boston.

Vincenti, W.G., 1990. What engineers know and how they know it. Analytical studies from aeronautical history. The John Hopkins University Press, London.

von Stamm, B., 2008. Managing innovation, design and creativity. John Wiley & Sons, Chichester.

Vona, F., Consoli, D., 2011. Innovation and skill dynamics: a life-cycle approach, Documents de Travail 2011-26, Observatoire Français des Conjonctures Economiques (OFCE).

Walsh, V., 1996. Design, innovation and the boundaries of the firm. Research Policy 25, 509-529.

Walsh, V., Roy, R., 1983. Plastic products: good design, innovation and business success, in: DIG-01, R. (Ed.), DIG no 1. The Open University and UMIST, Milton Keynes.

Walsh, V., Roy, R., Bruce, M., 1988. Competitive by design. Journal of Marketing Management 4, 201-216.

Walsh, V., Roy, R., Bruce, M., Potter, S., 1992. Winning by design: technology, product design and international competitiveness. Blackwell Publishers, Oxford.

Wilson, I.G., Wilson, M.E., 1965. Information, computers, and system design. Wiley, London.

Wulfing, K.W., 2003. Compasso d'Oro and changes in the Italian domestic landscape, College of Architecture and Urban Studies. Virginia Polytechnic Institute and State University, Virginia, pp. 1-89.

Yin, R., 2009. Case study research: design and methods, 4th ed. Thousand Oaks - 4th Edition, California.

Appendix A.

Table A.1: Secondary source interview data: list of interviewees[42]

Informant[43]	Affiliation	Relevance for the Italian design
1. Albricci Alberto	Entrepreneur (economics graduate)	Amongst the patrons of Italian design, he was invited by Ernesto Gismondi to manage *Memphis*.[44]
2. Alessi Alberto (1946)	Entrepreneur (law graduate)	Partner and CEO of his family's business, *Alessi*. Remembered for the radical innovations introduced, such as the use of metal in kitchenware (e.g., Espresso kettle, designed by Richard Sapper).
3. Amadori Carlo	Architect (architecture graduate)	Founding partner of *Studio Immagini Alternative* (*Studio for Alternative Images*). General manager and co-founder (since 1986) of the event *Abitare il tempo*, innovative because it reunited manufacturers from different sectors.
4. Bellini Mario (1935)	Architect/Designer (architecture graduate)	He covered different roles: President of ADI (1969-71); director of *Domus Magazine*; design director of *Olivetti*. Awarded four *Compasso d'Oro*; twenty-five of his projects are exhibited in the Museum of Modern Art (MoMA). He collaborated with *Gruppo La Rinascente*, *B&B*, *Cassina*, *Artemide*, and *Flos*.
5. Branzi Andrea (1938)	Architect/Designer (architecture graduate)	Well-known as a design critic, he is amongst the protagonists of the radical modern design through exhibitions and founding member of the *Archizoom Association* (with Alberto Branzi, Gilberto Corretti, Paolo Deganello and Massimo Morozzi) and *Domus Academy*. Awarded a *Compasso d'Oro* in 1987. Designer for *Alessi*, *Cassina*, *Vitra* and *Zanotta*.
6. Busnelli Piero Ambrogio (1921)	Founder of *B&B*	Successful entrepreneur, his company attracted well-known designers, such as De Pas, D'Urbino, Lomazzi, Castiglioni, Mario Bellini, Richard Sapper. Awarded the *Compasso d'Oro* on many occasions, one in recognition of his career (1989).
7. Castelli Giulio (1920-2006)	Founder of *Kartell* (engineering graduate)	Amongst the members of the committee promoting the foundation of ADI, his company is known worldwide for manufacturing furniture objects in plastics and attracted well-known designers such as the Castiglioni Brothers, Gae Aulenti, Joe Colombo, Marco Zanuso, and Richard Sapper.

[42] Interview data publicly available on the RAI Italian state owned public service broadcaster RAI Radiotelevisione Italiana S.p.A. (www.educational.rai.it).
[43] Dates of birth and/or death of the interviewees are included where available. This information provides additional insight on the timing of the establishment of design as a professional practice.
[44] *Memphis* is a research laboratory focus on design. It was founded by Ernesto Gismondi in 1981, and represents one of the most prominent exhibitions within the home furnishing sectors.

Table A.1 ***(Continued)***

Informant	Affiliation	Relevance for the Italian design
8. Castiglioni Achille (1918-2002)	Architect/Designer (architecture graduate)	He is the author of many product successes, with a focus on light systems, chairs, tables and desks.
9. Cibic Aldo (1955)	Architect/Designer (architecture graduate)	Founding member of *Sottsass Associati* (with Ettore Sottsass, Marco Zanini and Matteo Thun). He contributes actively to the management of *Memphis* and teaches at *Domus Academy*.
10. Colombari Rossella	Art dealer and collector	Known as the expert of the design produced by Carlo Mollino, she has organised series of events around his work.
11. Colombo Joe (1914-1978)	Architect/Designer and entrepreneur (architecture graduate)	Well-known designer who collaborated with Luigi Fontana and Sebastian Matta, he joined the *Movimento di Arte Concreta* (*Movement of Applied Art*). He designed renowned products such as *Universal* chair (one of *Kartell*'s best sellers), *Ragno* light (awarded a *Compasso d'Oro*) and *O-Luce* lamp.
12. De Lucchi Michele (1951)	Architect and designer (architecture graduate)	Co-founder of the artistic group *Cavart*, he designed different products for *Alchimia* and *Memphis*. He collaborates with different firms such as *Acerbis, Artemide, Arflex, Biefeplast, Moroso* and *Vitra*. Awarded a *Compasso d'Oro* in 1989.
13. Gavina Dino (1922-2007)	Entrepreneur	Founder of the homonymous company, he was active in reproducing famous collector's items. His 'revolution' started with *Flos*, where he worked on light systems, and continued with *Simon International*, where he explored the serial and modular production techniques.
14. Giovannoni Stefano (1954)	Architect/Designer (architecture graduate)	Academic and designer, he is known for his collaboration with G. Venturini in the *King Kong* experience (focusing on design as a means of communication) and *Alessi*.
15. Gismondi Ernesto (1931)	Entrepreneur and designer (engineering graduate)	Founder of *Artemide* and co-founder of *Memphis*. He has also held administrative roles within ADI and the board of directors of the *Triennial*.
16. Magistretti Vico (1920-2006)	Architect/Designer	His talent has been recognised worldwide through different prizes (*Compasso d'Oro, Triennial's Golden Medal*) and exhibitions to his honour. He collaborated with firms such as *Acerbis, Artemide, Cassina, Flou, Kartell* and *O-Luce*.
17. Mari Enzo (1932)	Artist/Designer	He co-organised many important events, such as the *Biennale* in Zagreb, the *Triennials* in Milan and the *Biennales* in Venice. He has collaborated with a wide range of companies.
18. Marzano Stefano (1950)	Architect/Designer (architecture graduate)	He is the design manager of *Philips*. His objects were presented in a special exhibition at the *Salone Internazionale del Mobile 1999*.

Table A.1 ***(Continued)***

Informant	Affiliation	Relevance for the Italian design
19. Mendini Alessandro (1931)	Architect/Designer (architecture graduate)	He has worked as an architect, designer and journalist for many years. At a certain point in his career, he starts developing an intellectual debate around the world of design and founds and directs the magazines *Casabella*, *Modo* and *Domus*.
20. Mollino Carlo (1905-1973)	Photograph, graphic engineer, set designer	He is defined as the 'Designer without the industry'. Critics believe he developed his talent for design through the wide range of professional activities he undertook. His furniture production incorporated many innovations in terms of production techniques and materials (e.g., cold bending plywood).
21. Morello Augusto (1928)	Art dealer (chemical engineering graduate)	General director of *Olivetti* and *La Rinascente*, he has actively promoted the Italian design. He has directed the *Compasso d'Oro* and is amongst the founders of *ADI*. He was also an academic at the Faculty of Architecture (Polytechnic of Milan).
22. Noorda Bob (1927-2010)	Designer industrial design graduate)	Born and grown up in The Netherlands, he moved to Italy in the 1960s and participated actively to the graphic development of the country. He designed the underground signposting in Milan (*Compasso d'Oro* award) and in other cities. He collaborated with *Pirelli* and *La Rinascente*.
23. Pesce Gaetano (1939)	Architect/Designer (architecture graduate)	Founder of the *N Group*, and protagonist of many inter-cultural events and movements within the international scene. Amongst the founders of *Bracciodiferro* with the mission of producing experimental objects and the contributors to the famous MoMA's exhibition "Italy: the new domestic landscape".
24. Pininfarina Sergio (1926)	Entrepreneur (aeronautical engineering graduate)	President of the eponymous company founded by his father. With the support of Alberto Morelli, Pininfarina undertakes his studies and develops a series of products with success from the post-war period onwards. He collaborates with *Ferrari*, *Alfa Romeo*, *Lancia* and *Peugeot*.
25. Ponti Gio (1891-1979)	Architect/Designer (architecture graduate)	He was a designer (*Fontana Arte*, *Cassina*), an architect (*Pirelli* skyscraper in Milan), a promoter of the Italian design (*Triennials*, *Biennales*, *Compasso d'Oro*, *ADI*), an intellectual (author of important books, and teacher at the Faculty of Architecture in Milan).
26. Santachiara Denis (1950)	Designer/Artist	Self-taught expert of designer, he starts off his career in the automobile industry and, since 1975, he tackles themes of neo-design. He collaborates with many firms such as *Luceplan*, *Artemide*, *Vitra*, *Campeggi* and *Magis*. He has been awarded different prizes (e.g., *Design World 2000*).

Table A.1 ***(Continued)***

Informant	Affiliation	Relevance for the Italian design
27. Sapper Richard (1932)	Designer/Graphic (economics graduate)	He started his career at *Mercedes*; he then moves to Italy and collaborates with designers such as Gio Ponti, Alberto Rosselli and Marco Zanuso. After a period of consultancy, he becomes the world product design manager of *IBM*. He has been awarded ten *Compasso d'Oro* and many of his objects are exhibited at the MoMA.
28. Sarfatti Riccardo (1940-2010)	Architect (architecture graduate)	Academic at the Faculty of Architecture and Design in Milan and Venice. Founder of *Luceplan* with Paolo Rizzato and Sandra Severi, he is the first to apply the LED technology to lighting systems.
29. Sottsass Ettore (1917-2007)	Architect/Designer (architecture graduate)	Director of the Computer business unit in *Olivetti* and awarded a *Compasso d'Oro*. He contributed to the coordination of many *Triennials* (Milan) and *Biennales* (Venice). He is co-founder of *Memphis*, active promoter of the *Global Tools* movement, and founder of the *Studio Sottsass Associati* in 1980.
30. Terragni Emilio	Architect (architecture graduate)	Amongst the pioneers of the modern movement in Italy, his activity can be featured by the continuous search for new and innovative materials, either in architecture or building construction.
31. Thun Matteo (1952)	Architect/Designer (architecture graduate)	Co-founder of *Studio Sottsass Associati* and *Memphis*, he collaborated with *Alessi*, *Tiffany*, *Campari* and *Swatch*. He has been awarded three *Compasso d'Oro*.
32. Valle Gino (1923-2003)	Architect/Designer	Trainee of Carlo Scarpa and Giuseppe Samonà, he started his career in his father's company (*Valle*, in Udine); he collaborated with *Solari* (awarded three *Compasso d'Oro*) and *Zanussi*. He also taught at the University of Venice.
33. Wilson Bob	Artist and set designer	Not originally from Italy or based in Italy, he has acted as a critic of the evolution of design in Italy. One of the highlights of his career has been to organise and coordinate the *Seventies angels* event for celebrating the 70^{th} birthday of *Domus* (magazine).
34. Zanuso Marco (1916-2001)	Architect/Designer (architecture graduate)	Architect and urban designer, he was co-director of *Domus Magazine* and copy editor of the magazine *Casabella* as well as lecturer at the Faculty of Architecture (Polytechnic of Milan). He was honoured three times at the *Triennials* and five times at the *Compasso d'Oro*.
35. Zorzi Renzo (1921-2010)	Intellectual and copy editor	He was the copy editor of the national journal *L'Arena*. He was called by *Olivetti* to coordinate the cultural activities of the firm, and when its CEO died, Zorzi became the firm's art director.