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UNDERSTANDING CREATIVITY AND INNOVATION IN INDUSTRIAL DESIGN: AN HISTORICAL AND EMPIRICAL ASSESSMENT

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Understanding creativity and innovation in industrial design: an historical and empirical assessment

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Abstract In the last decades, industrial design has been increasingly recognized as a sector combining elements of both artistic creativity and economic innovation. Using a unique dataset encompassing information on 326 top designers, 242 firms and 935 products from 1913 to 2000, we investigate the main patterns of the industrial design industry. First, we analyze the worldwide evolution of the creative sector in terms of industry structure, changes in product materials and agglomeration dynamics of both firms and designers. Second, we provide a preliminary quantitative investigation of designers' creativity life-cycles. The paper contributes to the cultural economics literature by shedding light on the relations between creativity and innovation in creative industries.

Keywords: Industrial Design, age, creativity life-cycle

JEL Codes: Z11, O31, R12

1. Introduction

The paper attempts an historic and empirical assessment of industrial design and in particular of the role played by creativity in design-based innovation.

As industrial design refers to the process of combining applied art and applied science to improve the aesthetic quality of a product, in the last decades this economic activity has been increasingly recognized as combining elements of both individual creativity and industrial innovation (Heskett 1980). Like other design-intensive sectors (i.e. Fashion, Architecture) industrial design activities have been included in the creative economy paradigm (UNCTAD, 2008; Bertacchini and Borrione, 2012) as those industries supply goods that commonly carry a strong semiotic and aesthetic content (Lash and Urry, 1994). Further, according to Stoneman (2010), such symbolic content contributes to 'soft innovation', that is innovation in goods and services that primarily impacts upon aesthetic or intellectual appeal rather than functional performance.

Despite its growing recognition, industrial design has been far less thoroughly studied from an economic and social science perspective than innovation. In the economic and social science literature, Pesendorfer (1995) analyzes design innovations, but his focus is limited on modeling how product design and consumers' fashion cycles affect market

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dynamics and competition among firms in design-based industries.

By contrast, Walsh (1996) has provided a more comprehensive attempt by analyzing the industrial design function from economic, sociological and management perspectives. In particular, her work compares design to R&D and technological innovation and then examines the organization and location of design activities in relation to manufacturing firms. Further, Molotch (1992), studying industrial design practices, highlights the role of place and of the cultural milieu in affecting designers' creativity and product style. Likewise, using a qualitative approach with in-depth, semi-structured interviews, Sunley et al. (2008) investigate how firm-designers relations, firm routines and competences are relevant factors to design innovation, even more than inter-firm co-operation or the local cultural environment.

Crucially, this handful of works shows how the analysis of industrial design as a creative sector is only in its infancy and further economic inquiries may be addressed. In particular, the study of industrial design can contribute to the cultural economic literature in several original ways. First, given their aesthetic quality and symbolic significance, cultural economists may deepen the study of design products' cultural value (Throsby, 2001) and its relation with economic values. Second, reproducibility of industrial design objects and other potential differences from original artworks set interesting challenges in studying auction price formation (Ashenfelter and Graddy, 2003). Finally, as for cultural production and the behavior of artists (Bryant and Throsby, 2006), industrial design activities can be analyzed to identify the main economic and social conditions which favor designers' creativity and innovation.

With this perspective, our paper aims to provide a first explorative inquiry on industrial design by investigating the main evolutionary and geographic patterns of such industry.

Our analysis is based on a unique dataset encompassing information on 326 top designers, 242 firms and 935 products from 1913 to 2000. These data allow us to reconstruct the main dynamics of the top industrial design industry. First, we assess the worldwide evolution of this creative sector in terms of industry structure, changes in product design and agglomeration dynamics of both firms and designers. Second, we provide an exploratory quantitative analysis of designers' creativity life-cycles.

The paper is organized as follows: Section 2 presents a concise history of furniture and interior design by focusing on the evolution of this industry according to the most important design communities worldwide; Section 3 discusses the main literature adopted to analyze industrial design dynamics, with particular reference to works on creativity, innovation and economic geography; Section 4 presents the data and the empirical evidence, while Section 5 concludes by suggesting future research developments

2. A short history of industrial design

To present here a summary of a world history of design would be impossible, not only due to the complexity of the topic which involves considerations on the interlacing effects of artistic and cultural movements, industrial development, technological innovation and individual consumption trends, but also because, despite the growing interest of scientific literature for design, the community of design historians is only gradually confronting the question of how a world history of design should be written (Margolin, 2005).

However, it is useful to give some elements of context that may be useful to understand the different evolution that design had in Europe and in the United States.

In the Western mainstream, the history of industrial design covers the entire twentieth century. It is almost as long as the history of industrial production as it is with the raise of modern means of production, with the accelerated availability of new technologies and materials, and with the appearance of a new class of consumer - the bourgeoisie – that the need to define expressive languages congruent with the modern means of production raises.

Crucially, the history of design follows idiosyncratic paths from country to country depending on local creative atmospheres, as well as on the different relationships with traditional craftsmanship, on the patterns of industrial growth and of technological innovation, on the presence of specific raw materials, and on the influences of cultural and artistic movements.

For this reason, industrial design may be deemed as a wide and varied project activity developed gradually and finding its foundations in the anthropological question of human survival in the age of machines (Branzi, 1999). At the very beginning, the idea underlying industrial design may in fact be seen as one of the most important attempts at reunification of conception and execution through the use of machines as a means rather than as an end.

Initially it has been a philosophical/intellectual move, deeply rooted, especially in Europe, in the discussions on the worlds of art and craftsmanship. This bond has been particularly evident in two countries such as the United Kingdom and Germany that had experienced an early industrial and technological evolution and which are considered as the cradles of modern design.

But this connection is also present in the Scandinavian countries, which together with the UK, Germany, France, Italy and the US represent one of the most important western design communities, and where design experienced a much softer relationship between

craft and industry, not having taken mechanization as a reference.

Actually, the case of Scandinavian design is particularly relevant due to a number of factors that differentiate it from other European experiences (De Fusco, 2002). These are mainly the absence of a fracture between craft and industry, the desire not to deny tradition but rather to continue it; to have claimed a privileged place for the design of domestic objects; the prevalent use of certain raw materials including glass, porcelain, and especially wood, a resource which the Nordic countries had in abundance and were able to process using innovative techniques such as the cold bending of plywood sheets and veneer.

Starting from the forties, Scandinavian designers such as Alvar Aalto, Tapio Wirkkala, Arne Jacobsen and Finnish and Danish companies such as Fritz Hansen and Artek dominated the international design arena. In 1954, with the travelling exhibition "Design in Scandinavia", their works arrived in the United States conquering them with an innovative and economic style.

While in Europe the discussion focused mainly on the relationship between applied and industrial arts, in U.S. mechanization had taken command (Giedion, 1948). For instance, the term "industrial design" was coined in the Thirties in the US and the profession of designer went affirming also due to a transfer of culture and skills from designers escaped from Nazi Germany and coming from Scandinavia (as in the case of Eero Sarinen.). Furthermore, although the automotive and household appliances had been an important first application field for design, also the national furniture sector appeared particularly significant. In it converged the national Streamline tradition, the German Bauhaus legacy, the lesson of Alvar Aalto and of the Scandinavians, the French model of Le Corbusier, the technological expertise gained during the World Wars, and the indigenous culture.

The first American furniture designer to gain an international reputation was Charles Eames (1907-1978), while U.S. furniture design can be well represented by two leader companies: Herman Miller, founded in 1923 and Knoll International Furniture Company, founded in 1938 by Hans G. Knoll, a German immigrant, son of one of the pioneers of the German production of modern furniture.

These companies not only gave birth to the products of the most prominent American designers, from Charles Eames to Gerorge Nelson, but also to the ones of many European masters such as Verner Panton or Alvar Aalto, contributing to the success of the Scandinavian design overseas.

Finally, to enrich and profoundly change the international design scene, the Italian design emerged starting from the sixties. Actually, since the late fifties, the Italian furniture design had fully developed by the work of the great masters of that period: Achille

Castiglioni, Vico Magistretti, Marco Zanuso, Franco Albini, among others, and some small, innovative companies such as Kartell, Zanotta and Artemide and others.
Except for Olivetti, the identity of Italian design has not been defined in a special relationship between design and big industry but rather in the meshes of a network of small and medium-sized companies.
"The Italian design emerged as a phenomenon deeply rooted in the contradictions of a country that had never been the protagonist of modernity, a design that could not be defined in a style [...], without a unified methodology, consisting of opposing trends, personalities and policies, and produced by a weak but rampant industry; data that together that defined not only its originality and relevance, but also its substantial strategic unity. [...]" (Branzi, 1999).
During the sixties, Italy and Milan increasingly gained an international leadership and a new generation of designers emerged together with new models of organic collaboration with the industry as in the case of Sottsass with Olivetti.
In the late seventies this transformation culminated with a deep criticism of the mainstream design which manifests itself in particular with the activities of Studio Alchimia but especially with the birth of Memphis then (1981). Even the design firms began to look at the post-modern as new road and to work in this way also through marketing. Emblematic of this new course of Italian design is the collaboration between Alessi and Alessandro Mendini (since 1983). During the eighties an increasing internationalization of Italian design creative milieu also took place, with the arrival in Milan of designers like Philippe Starck, Ron Arad and others.
The Italian experience is particularly significant as it was fully developed on the field, within the context of a country which, on paper, was the least suitable for the success of this discipline due to the lack of large industries able to program an advanced commodity research and of political alliances with the government parties for a real modernization (Branzi 1999). From these difficult conditions, Italian design came out by developing its own operational model based on the ability to interact spontaneously with small and medium firms, satisfying their demand for innovation and then transferring it directly to the industry. In other words, Italian design has transformed the lack of a unified project methodology in a great diversity of languages and internal trends which, in the end, favored its constant regeneration over time (Branzi, 1999). Perhaps in a most effective way than German design, based on a strong industrial culture, or than Scandinavian design.

Two missing countries from this panorama are France and the UK. To put it very

concisely, after the explosion of Art Decò in France, and despite the presence of driving personalities like Le Corbusier, the subsequent evolutions of French design concentrated very little on furnishing and more on the production of building components and on large industries such as the automobile sector. While then, another part of French research in the design field focused on the plastic arts.

Worthy of a special mention is the French designer, Philippe Starck, as he is an interpreter of a contemporary trend on a global scale, one that is not linked to the tradition of one specific country. After gaining his first product experiences with Italian companies such as Driade from1975 to 1985, today, in fact, he is a designer who belongs to the world.

How design is evolving today? Design in the last two decades has been overlooking a growing number of research areas in innovative ways, greatly expanding its range of action, from communication design, to food design, the city design, only to name a few. Also due to this evolution, design is now increasingly conceived as a means of economic repositioning and it seems to have taken a proactive role in the application and synthesis of new and powerful technology tools at the forefront into new forms of industrial production.

Design is nowadays considered a key element in place branding and place identity strategies (Kalandides, 2007) finding new and frequent connections with the tourism sector both for the creation of tourism products and services, and a as tourism product itself.

Design is also changing its geographic boundaries due, on the one side to the emergence of new design hubs, on the other to an increasing international mobility of designers. There are now many design centers all around the world which they are not necessarily determined by the presence of production facilities or of specific communication bodies anymore (Antonelli, 2011). There are also new markets, for example in Russia and in the Middle East, to which firms are turning

Moreover, in the design sector we also find the signs of the profound changes that have transformed the global economy, production systems and the labor market.

In many countries, industrial design is more and more a mass profession supported by a powerful education system: the latest available data describe a population of 300,000 design students in India, over 200,000 in the U.S. and 50,000 in Europe (Gallico, 2005).

In addition we are gradually witnessing to the consolidation of a generation of micro-designers and the rise of what has been called "buzz design" or a "uncontrollable swarm of micro-projects and environmental sub-systems that penetrate into the interstices of the built world and in the most microscopic domestic environments" (Branzi, 2010, p.61).

3. Literature

The analysis of industrial design links up closely to various topics of research. However, being mainly interested in the evolutionary patterns of such a creative sector, this section briefly addresses the main strains of literature related to these specific phenomena. First, literature on creativity life cycles is particularly suited for analyzing designers' creative patterns. Second, works on cultural industries may add insights into the evolution and spatial organization of the creative and innovative systems of industrial design worldwide.

3.1 Creativity life cycles

The idea that creativity is of vital importance to innovation and economic competitiveness has been part of accepted wisdom for a very long time. However, the concept of creativity as an economic factor has not played an important role historically in economics. Rather than creativity, economic models have mainly identified technological change as a key engine of economic dynamics (Bryant and Throsby, 2006). In cultural economics literature some attempts have been made to incorporate individual creativity, but mainly as an input in artistic production functions where artists face a trade-off between economic and artistic rewards from their activity (Cowen and Tabarrock, 2000; Throsby, 2006; Bryant and Throsby, 2006).

With few exceptions (Levin and Stephan 1991; Oster and Hamermesh 1998; Van Dalen 1999), economists have paid even less attention to empirically study how creativity – in terms of individual productivity – is expressed over an individual's life span or is affected by time and space. Conversely, psychologists have been more active by investigating how personal age is connected to individual achievements and outstanding accomplishment (Simonton, 1988). The several works in this field, mainly focusing in scientific productivity and artistic expressions, have identified age peaks of creative output and a U-reversed relationship between age and individual performance. The emerging evidence has been mainly used to support theories concerning how individuals' developmental changes or the social context directly affect achievement behaviors (Simonton, 1997).

These works have generally focused on differences across disciplines in peak ages of creativity by aggregating practitioners by discipline. As a result, differences across disciplines have been attributed to the nature of the disciplines themselves.

Conversely, some recent studies have started viewing life cycle creativity as an individual

and not a disciplinary phenomenon. For example, using data on Nobel Prize winners and great inventors, Jones (2005) finds that the mean age at which noted innovations are produced has increased over the 20th Century. This result suggests that peak ages for individuals' great achievements may change over time due to factors and conditions not necessarily specific to the discipline. In a similar vein, Galenson (2000) and Galenson and Weiberg (2000) have shown that creativity peak periods for American modern painters have changed over time. In this case, a substantial decline occurred over time in the age at which these artists produced their most valuable work and, according to the authors, was caused by a shift in the nature of the demand for modern art during the 1950s. Extending this approach to other fields, such as Nobel laureates in Economics, great painters, Architects and modern novelists, Galenson finds evidence that there are two distinct life cycles of individual creativity, with peaks at very different stages within a single discipline (Galenson, 2004; 2005; 2008; Weinberg and Galenson, 2005). Experimental innovators work inductively, accumulating knowledge from experience. Conceptual innovators work deductively, applying abstract principles and do their most important work earlier in their careers than experimental innovations.

3.2 Evolution and spatial organization of creative and innovative systems

While literature on creativity life cycles focuses on individual patterns, the evolution and spatial organization of creative and innovative systems help identifying the characteristics and conditions of environments where creativity and innovation emerge as collective phenomena.

Starting at least from the work of Alfred Marshall (1890), the analysis of economic processes has emphasized the spatial function of 'clusters' and 'districts' in terms of industrial atmosphere, local knowledge spillovers and external economies on firms' localization and agglomeration. Economic geographers have also contributed to this research agenda by developing the concept of milieu, namely the cultural, economic and social context in which agents are embedded. With this perspective, creative output and innovation is recognized to arise in clusters in both time and space (Santagata, 2010). From the Pericles' Athens to the Renaissance Florence until the today Silicon Valley or Shanghai, the creative milieu and atmosphere is the result of an intense flow of ideas and information within a community on products, styles, art forms, consumer needs, technological innovation and business models. The prominent observers of creative places, such as Hall (2000), Scott (2000) and Törnqvist (2012), have all emphasized how the creative milieu and atmosphere of a place tends to manifest itself through three basic

factors: the intense exchange of information between people, the accumulation of knowledge, skills and know-how in specific activities and, finally, the capacity of individuals and organizations to creatively use and recombine the two above factors.
However, not only the physical proximity and the geography of places matter in defining the evolution and spatial organization of creative and innovative systems. As noted by many scholars, knowledge creation and creative processes may be the result of the organizational ecology and network relations connecting individuals and economic organizations, which not necessarily require physical proximity. For example, Bathelt et al. (2004) suggest that the co-existence of high levels of buzz and global pipelines of economic transactions may favor outward-looking and lively clusters. Studying the genealogical structure of parent-spinoff relationship in the fashion design industry over the period 1858–2005, Wenting (2008) analyze the effects of routine replication on firm success. His findings show that fashion designers who have worked in different cities tend to outperform immobile fashion designers, suggesting that local knowledge spillovers matter if this knowledge is applied in a new geographical context.

4. Empirical Evidence

In this section we provide preliminary empirical evidence on some relevant patterns of industrial design as a creative industry. First, we present the dataset highlighting the pros and cons for using the information collected in the analysis of the phenomenon. Second, we quantitatively describe the worldwide evolution of the creative sector in terms of industry structure, changes in product design and agglomeration dynamics of both firms and designers. Third, we provide a preliminary exploration on designers' creativity life-cycles.

4.1 Data

We collected a unique dataset comprising information on 326 world top designers, 242 firms and 935 products from 1913 to 2000. The data were collected starting from products, which are classified according to functionalities and materials (See Annex for a description). Most of information about products and their relative designers and producers comes from one main Internet source, the database DesignIndex[1], which

[1] http://www.designaddict.com/design_index/index.cfm, Last access: November, 2011

presents records of the most important products in the history of industrial design based on experts' evaluation. This was partly supplemented by consulting more detailed biographies of specific designers to include additional data, such as the year of birth and the professional activity in architecture.

As will be shown below, the dataset is detailed and reflects the qualitative accounts on the industry's history in terms of historical location and production patterns. However, it cannot be considered complete. In fact, the product, designers and firms on whom we have collected data represent a mere fraction of the total number throughout the industrial design's history. As a result, although our dataset offers a unique opportunity to quantitatively analyze the structure, dynamics and the conditions leading to great achievements in industrial design, it also suffers from a bias to the more successful firms and designers.

Because this represents the first attempt to quantitatively assess such a creative sector, additional sources may improve the information available in the dataset.

First, in our dataset the observations of firms and designers are strictly associated to the products and the year on which those were created. Conversely, the use of more detailed biographical information on designers and firms, such as in Wenting (2008), may expand the number of products in the dataset and help understanding how designers-firms relations affect the development of the most valuable products.

Second, while the dataset includes only the most relevant products in the history of design, each product has the same weight in terms of its historical prominence. This approach may limit our analysis in the study of great achievements in this creative sector as compared to the studies using the number of citations of scientific works (Weinberg and Galenson, 2005) or the records of auction prices and the number of illustrations in art history books for paintings (Galenson and Weinberg, 2000)

4.2 Structure and Evolution of the Industrial Design Sector

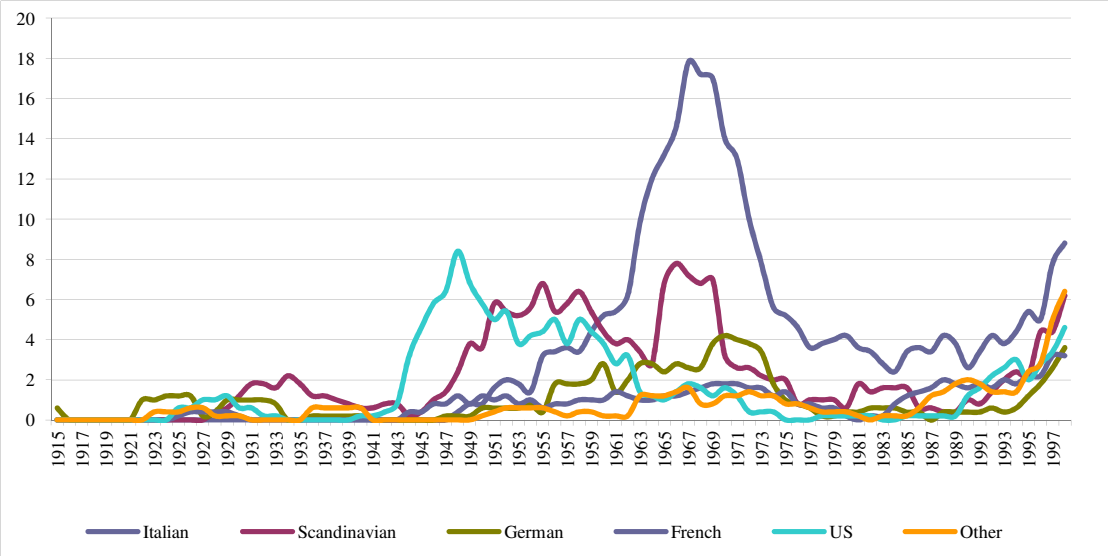
Notwithstanding the above limitations, the data allows us to provide a first quantitative account of the structure and evolution of the Industrial Design sector.

A first evidence emerges when analyzing the number of products by nationality of designers from 1913 to 2000. Figure 1 show the presence of a number of peaks: during the Forties and the early Fifties in the United States, all over the Sixties for Italy, and a double peak for Scandinavian design during the Fifties and again in the late sixties.

Even when considering the relative low number of observations for each period, the peaks are largely illustrative of the golden ages of national designs. This is particularly

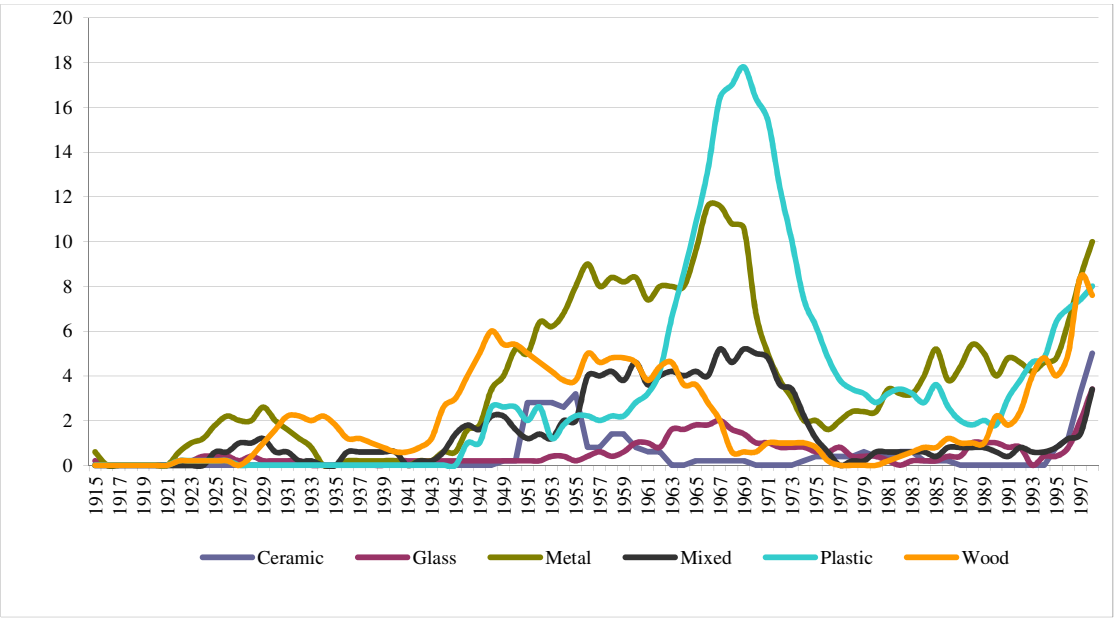
evident for Italy, whose design went affirming between the mid 50's and 60's.

Figure 1 – Number of products per country of designers, 5 years moving average



With regard to the evolution of materials used in the development of industrial design products, Figure 2 highlights also some interesting historical patterns and in particular the rise in the use of plastic starting from the sixties. This occurs with the acceleration during the fifties in the research and development of plastic materials culminated in 1963 with the assignment of the Nobel Prize for Chemistry to the German chemist Karl Ziegler and to the Italian chemist Giulio Natta in recognition of their studies on polymers. The other reasons in the evolution of plastic design objects is strictly linked with the history of Italian design and, in particular, with the success of the Italian company named Kartell (1949), the first company to print pieces of furniture in nylon, to make lamps in Acrylonitrile Butadiene Styrene (ABS) and to produce chairs entirely made of plastic.
The productive specialization of this company and its international success help in explaining the partial overlapping of the Italian design evolution of Figure1 with the evolution in the use of plastic described by Figure 2.

Fig. 2 – Number of products per material used, 5 years moving average



Finally, Table 1 offers a synthesis of the main characteristics of national designs communities according to the data collected. Italian design is the most represented with 319 products from Italian designers, followed by the Scandinavian (207) and US (151). This result is similar if consider the distribution of products according to the nationality of firms. Notably, there exist relevant differences among national communities as to their structure and as to the way they contributed with their most valuable products to the industrial design. On average, each US designer and firm have contributed with more products as compared to designers and firms in other national communities. For instance, in US, the average number of products per designer is 4,1 and 6,9 products per firm. On the contrary, german designers and firms have the lowest individual average contribution in terms of products. This trend reflects also in the distribution of top design products among designers and firms within the national communities. In this case, we measure the concentration of products in a community using a normalized Herfindahl index[2]. Also in this case, US score among the highest values suggesting that few firms and designers have contributed most to the development of American industrial design.

[2] In our setting the Herfindhal index captures the unequal distribution of products by designers and firms. The index is computed as follow

$$H = \sum_{i=1}^{n} s_i^2$$

where s_i is the share of products developed by a designer or a firm over the total number of products of the national design community.

Table 1 – Summary statistics on national design communities

Design Communities	Number of Products by Designers	Number of Products by Firms	Number of Designers	Number of Firms	Products/ Designers	Products/ Firms	Products concentration per Desingers (H-Index)	Products concentration per Firms (H-Index)	Designers' Function Specialization (Spec. Index>1,3)	Designers' Material Specialization (Spec. Index>1,3)
Italian	319	333	111	77	2,9	4,3	0,0211	0,0299	Lighting Acessories	Glass Plastic
Scandinavian	207	172	63	55	3,3	3,1	0,0214	0,0302	Tableware	Ceramic Wood
German	98	109	55	45	1,8	2,4	0,0105	0,0272	Appliances Lighting	Glass Plastic
French	78	51	33	32	2,4	1,6	0,0803	0,0138	Accessories	-
US	151	193	37	28	4,1	6,9	0,0705	0,1771	Appliances Furniture Miscellaneous	Mixed Wood
Other	76	36	46	22	1,7	1,6	0,0157	0,0377	Miscellaneous	Ceramic

Interesting is also to observe the specialization among national communities of design production by function. By using a specialization index[3], it clearly emerges a privileged relationship between Italian design and lighting, American design and furniture, and between Scandinavian design and tableware. For these specific functions the national communities present a specialization index well above 1,5. A lower but significant specialization (>1.3) is also evident for Italy and France in accessories as well as for Germany and the U.S. in appliances and again for Germany in lighting.

4.3 Designers' creativity life cycle

To analyze creativity life-cycles we explore different aspects concerning the relation between age and creative output by designers. As noted before, our unit of analysis is made of records of the most important products in the history of industrial design based

[3] As specialization index we adapt a measure of location quotient, which is computed as follow

$$LQ = \frac{p_i / p}{P_i / P}$$

where p_i is the number of products per country of functional typology *i*, *p* is the total number of products per country, P_i is the total number of products of functional typology *i* and *P* is the total number of products. A LQ>1 indicates relative specialization for a given functional typology of products.

on experts' evaluation. For each observation we know the age at which the designer created the product.

First, we analyze whether differences across national communities or the typology of products affect the age of designers when those made their most relevant products. Table 2 presents measures on the age of designers for all the products in the dataset across national groups and product functionalities. On average, the most important products in the history of design have been created at 42,1 years old, with a minimum of 19 to a maximum of 88 years old. Average age does significantly (testing for difference between means) but barely differ across nationalities, with German (37,11) and French (40,32) designers being below, while Italians (45,2) above the total mean. Conversely, if we observe the age of designers grouped according to the product functionality, there is no significant difference in the mean age across groups.

Table 2 – Age characteristics across groups

		Products	**Age**		
		Observations	***Minimum***	***Maximum***	***Mean***
Nationality	*Italian*	288	19	83	45,2
	Scandinavian	193	22	74	41,63
	German	84	24	62	37,11
	French	60	25	70	40,32
	US	136	27	66	42,71
	Other	68	22	88	36,91
	*p-value for equality across groups**				*0,001*
Functionality	*Accessories*	114	26	83	43,72
	Appliances	61	26	64	41,3
	Furniture	408	19	82	41,12
	Lighting	103	23	73	41,17
	Miscellaneous	22	29	62	45
	Tableware	121	24	88	44,59
	*p-value for equality across groups**				*0,037*
	Total	***829***	***19***	***88***	***42,1***

*: Use of Welch's Test for equality of means

A second point is to explore age trends among designers regarding their most important products in the history of industrial design. This is useful to detect shifts in the age distribution over time. We consider the following regression:

$$y_i = \alpha + \beta x_i + \gamma X + \varepsilon_i$$

where y_i is the age of designer i at the time of the product designed and recorded in the dataset as great achievements. X are fixed effects for the country of the designer's birth and for the typology of products. Results of this regression are presented in Table 1. Interestingly, the coefficient is significant and positive, meaning that the average age at great achievement in the history of design is trending upward.

Table 3 – Age Trends among Designers

Dependent Variable: Age at great achievements

	(1)	(2)	(3)
Year of great achievements	0,129*** (0,020)	0,146*** (0,020)	0,139*** (0,021)
Country of Birth Fixed Effects	No	Yes	Yes
Product Typology Fixed Effect	No	No	Yes
Number of Observations	829	829	829
Time Spam	1913-2000	1913-2000	1913-2000
R^2	0,047	0,119	0.129

Notes: Coefficient on year of great achievement gives age trend in years per century. Standard errors are given in parentheses. For Product Typology see Data Appendix A1.

*** Indicates significance at a 99% confidence level.

However, in order to clearly interpret these results it is important to notice that the data used for this analysis do not take into account only one peak age for each designer, By contrast, several designers contribute with more than one product at different time and so the age recorded for each achievement is likely to increase along their professional career.

To have a deeper understanding of designers' life-cycle creativity, following Galenson's approach, we consider a subsample of designers, namely those born before 1950 and with at least 5 products in the dataset. This allows us to select the most important designers based on critical judgments and to have quite reasonable time-span to study their careers.

Table 4 presents information on the selected designers, namely nationality, year of birth, peak age at which the designer did his most valuable works and the peak year.

The peak age is computed as the median of the observed ages at which the designers did their most important products included in the dataset along their professional career[4].

From this table we can draw some preliminary interesting insights on the industrial designers creativity life-cycles.

First, although there has been a whole generation that before the IIWW had already passed his thirties, there is hardly any great designers' peak before the war, with the only exception of Alvar Aalto, with a peak year on 1933. This is also confirmed in his biography: in 1927 he begins to experiment on wooden furniture and in 1935 he founds Artek. In 1938 his works are exhibited at the MoMA in New York.

Conversely, for all the other designers in the sample, their most relevant contributions occur after the conflict. For instance, the first generation of Americans reach their peak from the early to the mid '50, (Charles Eames, Ray Eames, Harry Bertoia, Kaj Franck, George Nelson, Eero Saarinen, Irving Harper), with a peak age ranging from 38 (Ray Eames) to 48 (Nelson). The same occurs with Italian designers who reach their most important production in the 60s.

Table 4 – *Selected Designers' Careers*

Designer	Nationality	Number of products	Year Birth	Peak Age (Median)	Year at Peak Age
Alvar Aalto	Finland	14	1898	35	1933
Jean Prouvé	France	5	1901	47	1948
Arne Jacobsen	Denmark	21	1902	65	1967
Franco Albini	Italy	6	1905	53	1958
Charles Eames	US	29	1907	43	1950
George Nelson	US	15	1908	48	1956
Eero Saarinen	Finland/US	6	1910	46	1956
Kaj Franck	Finland	11	1911	42	1953
Riki Watanabe	Japan	5	1911	54	1965
Ray Eames	US	29	1912	38	1950
Pier Giacomo Castiglioni	Italy	13	1913	49	1962
Hans J. Wegner	Denmark	15	1914	36	1950
Harry Bertoia	US	6	1915	37	1952
Tapio Wirkkala	Finland	9	1915	58	1973
Irving Harper	US	12	1916	40,5	1956
Marco Zanuso	Italy	5	1916	49	1965

[4] See the Table A1 in the Appendix for a detailed presentation of the distribution of products by age of designers.

Florence Knoll Basset	US	5	1917	44	1961
Achille Castiglioni	Italy	14	1918	44	1962
Anna Castelli Ferrieri	Italy	8	1920	56,5	1976
Vico Magistretti	Italy	10	1920	47	1967
Ulla Procopé	Finland	7	1921	36	1957
Verner Panton	Denmark	8	1926	39,5	1966
Pierre Paulin	France	15	1927	36	1963
Frank Gehry	Canada	6	1929	63	1992
Poul Kjaerholm	Denmark	6	1929	26,5	1956
Joe Colombo	Italy	32	1930	35,5	1966
Carlo Bartoli	Italy	13	1931	61	1992
Massimo Vignelli	Italy	7	1931	44	1975
Dieter Rams	Germany	5	1932	36	1968
Eero Aarnio	Finland	6	1932	37	1969
Enzo Mari	Italy	16	1932	37	1969
Louis Weisdorf	Denmark	6	1932	34,5	1967
Richard Sapper	Germany	8	1932	41	1973
Reinhold Weiss	Germany	5	1934	33	1967
Mario Bellini	Italy	8	1935	38	1973
Koen De Winter	Belgium	10	1943	44	1987
Torsten Thorup	Denmark	6	1944	49,5	1994
Paolo Pedrizzetti	Italy	7	1947	41	1988
Philippe Starck	France	13	1949	44	1993

Arguably, this seems to indicate that individual creativity life cycle is influenced by geographical and historical conditions, such as the world conflict and the period in which industrialization and mass production took off in a given country or region. Differences in life-cycle creativity can be further highlighted if we subdivide the sample according to year of birth.

Table 5 shows the difference in peak age between designers born before and after 1920. Interestingly, the mean peak age of designers in the first cohort is 46,6 years old, remarkably higher than that of designers in the second cohort, which is 40,9 years old.

Table 5 – Designers' peak age and year across cohorts

	All		Pre-1920 Cohort*		Post-1920 Cohort	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Year of birth	1925	13,1	1911	6,3	1933	7,3
Peak age	44	8,8	46,6	7,9	40,9	9,0
Year at peak age	1966	13,8	1958	9,8	1974,3	12,6
Number of Designers	39		20		19	

* 1920 included

Such a pattern can be confirmed also by looking in more detail at the difference in the peak ages between first and second generation in designers' national communities. For example, Italian designers born in the 1910s such as Albini, Zanuso and the Castiglioni brothers become more productive in their forties while designer of a later generation such as Colombo, Mari and Bellini, experience an earlier productivity (see Table A1 for details).

Finally, while historical and exogenous conditions may have affected designers' life cycle creativity, individual characteristics should be better analyzed in order to understand whether also in the industrial design field may exist both conceptual and experimental innovators. For example, if we consider Eero Sarinen, who is in the same cohort of Charles and Ray Eames, we find that his productivity peak later in the mid-fifties, that is in 1956, the year of his celebrated "Tulip" series.

5. Conclusion

The paper has provided a historical and quantitative assessment of industrial design. Although industrial design has been increasingly recognized as a creative sector for the development of goods and services embedded with symbolic and aesthetic values, cultural economics has barely paid attention to this industry and to its relevant characteristic of combining both individual creativity and industrial innovation. To fill

this gap, using a unique dataset encompassing information on 326 top designers, 242 firms and 935 products from 1913 to 2000, we have explored the main patterns of the industrial design industry. First, we have analyzed the worldwide evolution of the creative sector in terms of industry structure, changes in product materials and agglomeration dynamics of both firms and designers. In this case, as many other creative industries, industrial design is historically characterized in different historical periods by creative hotspots where communities of designers and producers tend to emerge developing the most important products.

Second, we have provided a preliminary quantitative investigation of designers' creativity life-cycles. The evidence collected suggests individual designers' creativity life cycle is influenced by geographical and historical conditions, which have in turn influenced the age at which different generations of designers have been more creative.

As this work represents a first attempt to quantitatively analyze industrial design dynamics, more research is needed to better understanding of the factors and conditions affecting designers' creativity and firm-based innovation. In particular, the most promising research paths refer to studying auction price formation for industrial design products and to deepening the analysis of designers' creativity life cycle by expanding the dataset with additional sources of experts' and market evaluation to measure designers' creative output. Finally, the use of more detailed biographical information on designers and firms may help understanding how designers-firms relations affect the development of the most valuable products in industrial design.

Bibliography

Antonelli P. (2011), "The Elastic Mind of Young Design" interview in *Design Industriale*, N.50-51, pp.163-167.

Ashenfelter, O. and K. Graddy (2003), Auctions and the price of art, Journal of Economic Literature XLI, 763-787.

Bathelt, H., Malmberg, A. and Maskell, P., (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28: 31-56.

Bertacchini, E.E., Borrione, P. (2012), The geography of the Italian creative economy: the special role of the design and craft-based industries, Regional Studies, DOI: 10.1080/00343404.2011.628625.

Branzi, A. (1999), *Introduzione al design italiano*, Milano, Baldini&Castoldi.

Branzi, A. (2010), "Design come professione di massa" in *Disegno Industriale*, anno VII, n. 42/43.

Bryant, W. and Throsby, D. (2006). Creativity and the Behavior of Artists, in: Victor Ginsburgh and David Throsby (eds). *Handbook of the Economics of Art and Culture*. Amsterdam: North Holland: 507–28.

Cowen T. and Tabarrock A. (2000). An Economic Theory of Avant-Garde and Popular Art, or High and Low Culture', *Southern Economic Journal. 67, 2: 232–53*.

De Fusco (2002), *Storia del Design*, Bari, Editori Laterza.

Galenson D. (2000). "The Careers of Modern Artists," Journal of Cultural Economics, Springer, vol. 24(2), pages 87-112

Galenson, D. and Bruce A. Weinberg (2000). "Age and the Quality of Work: The Case of Modern American Painters.", *Journal of Political Economy*, Vol. 108 (4), pp. 761-777.

Galenson, D. (2004). "A Portrait of the Artist as a Young or Old Innovator: Measuring the Careers of Modern Novelists." NBER Working Paper, 10213.

Galenson, D. (2005). Old Masters and Young Geniuses: Two Life Cycles of Artistic Activity. Princeton, NJ: Princeton University Press.

Galenson, D. (2008) "The Greatest Architects of the Twentieth Century," NBER Working Paper 14182.

Gallico, D. (2005), *Design In-Formazione*, Milano, Franco Angeli.

Giedion, S. (1948), *Mechanization Takes Command*, Oxford, Oxford University Press.

Hall P. 2000. "Creative Cities and Economic Development." Urban Studies, 37: 639.

Heskett, J. (1980). *Industrial Design*. Thames and Hudson, London

Jones, B., (2005). Age and great invention. NBER Working Paper # 11359.

Lash S. and Urry J. (1994) *Economies of Signs and Space*. Sage, London.

Levin S. and Stephan P. (1991). "Research Productivity Over the Life Cycle: Evidence from American Scientists." *American Economic Review* 81(1): 114-132.

Margolin, V. (2005), "A World History of Design and the History of the World", *Journal of Design History*, Vol.18, N.3, pp.235-243.

Marshall A. (1890) *Principles of Economics.* London: MacMillan

Molotch, H. (2002) Place in product, *International Journal of Urban and Regional Research*, 26:665–688.

Oster, S. M. and D. S. Hamermesh (1998). "Aging and Productivity Among Economists.", *The Review of Economics and Statistics,* Vol. 80, No. 1, pp. 154-156.

Pesendorfer, W. (1995) Design Innovation and Fashion Cycles. American Economic Review 85(4), pp. 771-792.

Scott A. J. (2000) *The Cultural Economy of Cities*. Sage, London.

Simonton, D. K. (1988). Age and outstanding achievement: What do we know after a century of research? Psychological Bulletin, 104, 251-267.

Simonton D.K. (1997) Genius and creativity. New York, NY: Ablex Publishing.

Santagata W. 2010. The Culture Factory: Creativity and the Production of Culture. Springer-Verlag

Stoneman, P., (2010), *Soft Innovation: economics, product aesthetics and the creative industries*, Oxford University Press, Oxford.

Sunley P., Pinch S., Reimer S. And Macmillen J. (2008) Innovation in a creative production system: the case of design, Journal of Economic Geography 8(5), 675–698.

Throsby, D. (2001), *Economics and Culture*, Cambridge University Press, Cambridge

Throsby, D. (2006). An Artistic Production Function: Theory and an Application to Australian Visual Artists, *Journal of Cultural Economics. 30: 1–14.*

Törnqvist G. (2012). *The Geography of Creativity.* Edward Elgar Publishing

UNCTAD (2008) *Creative Economy Report 2008. The challenge of assessing the creative economy towards informed policy-making*. http://www.unctad.org/en/docs/ditc20082cer_en.pdf.

Van Dalen H.P. (1999) "The Golden Age of Nobel Economists." *American Economist* 43 (2): 19-35.

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

Weinberg B.A. and Galenson D. (2005), "Creative Careers: The Life Cycle of Nobel Laureates in Economics" NBER Working Paper No. 11799.

Wenting R. (2008), "Spinoff dynamics and the spatial formation of the fashion design industry, 1858–2005". *Journal of Economic Geography Vol. 8: 593-614*

United Nations Conference On Trade And Development (UNCTAD) (2008) *Creative Economy Report 2008*. United Nations Development Programme (UNDP), Geneva and UNCTAD, New York, NY.

Appendix

A1. Data

The dataset comprise information on 326 world top designers, 242 firms and 935 products from 1913 to 2000. The data were collected starting from products, which are classified according to functionalities and materials. Most of information about products and their relative designers and producers comes from one main Internet source, the database DesignIndex[5].

The products are classified according to their functionality and materials used.
Functionalities include: accessories (i.e. home accessories such as vases, ashtrays, pencil holders, magazine racks etc.); appliances (which include all those device and instruments for household use such as televisions, phones, table clocks and similar); furniture (which comprise all kinds of furniture from tables, to armchairs, chairs, drawers and so on); lighting (in this category are desk lamps, floor lamps, hanging lamps etc.); tableware (which includes articles such as dishes, plates, knives, forks); miscellaneous. This last category contains mainly rugs and fabrics such as, an example, those designed by Arne Jacobsen. It also includes various products not elsewhere classified such as door handles, fire extinguisher and others.

With regards to products' materials, these are classified in: ceramic (vases, bowls, cups etc.); glass (vases, bowls, lamps etc.); metal (desks, lamps, chairs etc.); plastic (bowls, chairs, tables etc.); wood (tables, sideboards, chairs etc.); and mixed media which includes all those products not specifically referable to a single, specific material.

Finally, as regards the geographical classification of designers and firms, these have been divided in five main category - French, German, Italian, Scandinavian and U.S. design – and in a sixth class named "Other". Belgium is classified in the "French" group. Scandinavian design includes products from Denmark, Finland and Sweden. The category "German", includes also Switzerland, the Netherland and the Czech Republic while "U.S." includes Canada.
The category "Other" comprises all those products coming from countries less represented in the database such as Australia, Argentina, Brazil, Japan and the UK.

[5] http://www.designaddict.com/design_index/index.cfm, Last access: November, 2011

A.2 Creativity life-cycles

Table A.1 - Distribution of products by age of designer

Designer	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Alvar Aalto				5	9										
Jean Prouvé			1				2	2							
Arne Jacobsen							2	2	4	1	11				
Franco Albini							2	2		2					
Charles Eames					6	12	4	3	1	3					
George Nelson					1	3	7	4							
Eero Saarinen					2		4								
Kaj Franck						10		1							
Riki Watanabe						1		3							1
Ray Eames				6	12	4	3	1	3						
Pier Giacomo Castiglioni						2	6	5							
Hans J. Wegner				2	8		2	2				1			
Harry Bertoia					5		1								
Tapio Wirkkala					1		1		3	1	3				
Irving Harper				3	1	8									
Marco Zanuso							3	1	1						
Florence Knoll Basset					1	4									
Achille Castiglioni					2	6	5	1							
Anna Castelli Ferrieri							2	2	1	2	1				
Vico Magistretti							9	1							
Ulla Procopé				2	5										
Verner Panton				1	3	3	1								
Pierre Paulin		2	1	3	5	4									
Frank Gehry						2				4					
Poul Kjaerholm		1	3	1	2										
Joe Colombo				12	14	6									

Carlo Bartoli				1	1	2		2		6	1				
Massimo Vignelli				1	2	1	2			1					
Dieter Rams			1	1	2			1							
Eero Aarnio				2	2	1					1				
Enzo Mari				1	10	2			1		2				
Louis Weisdorf				3	1	1	1								
Richard Sapper				3		3	2								
Reinhold Weiss			2	1	1	1									
Mario Bellini				2	5					1					
Koen De Winter				2	1	3	1	3							
Torsten Thorup		1			1		1	1	2						
Paolo Pedrizzetti				2	1	2		2							
Philippe Starck					1	7	3	2							