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Designers as the Determinants of Aesthetic Innovations

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Abstract

Aesthetic innovations have become increasingly important appropriation mechanisms for firms. Since 2003, the number of design patent applications (to protect aesthetic innovations) has tripled compared to doubling in the numbers of both patent and trademark applications. However, despite the growing interest of firms in aesthetic innovations, knowledge on their determinants is limited. Work on labor mobility within the innovation studies literature focuses mainly on discussion of scientists as crucial for creating technological innovations. This paper adds to work on labor mobility and innovation by examining whether this holds in the case of designers' mobility and aesthetic innovations. Does the hiring of a new designer generate more aesthetic innovations than in a matched firm, which does not hire a designer? What is the importance of prior experience with aesthetic innovation in the receiving firm for the firm's absorptive capacity linked to translating the hiring of a designer into aesthetic innovation? We use a unique dataset containing information on firms, their hiring of designers, and their aesthetic innovation activity measured by design applications (design patents). Our findings show that hiring a designer does increase the likelihood of producing an aesthetic innovation. Hence, designers are a determinant of aesthetic innovations. However, in order to benefit fully from hiring a designer the firm needs prior experience in aesthetic innovation.

Keywords: Designer, aesthetic innovation, design rights, labor mobility

1. Introduction

On June 28th 2007, just 1 day before Apple introduced its legendary first iPhone, it applied for 92 industrial design (ID) patents[1] protecting the design, shape and icons related to the iPhone[2]. Apple had produced a technical innovation whose aesthetics were distinguishable from any other phone on the market. Steve Jobs, Apple's then CEO, pointed out the *"iPhone is a revolutionary and magical product that is literally five years ahead of any other mobile phone"*[3]. The consumers' response was euphoric, and within 3 months Apple sold over 1.4 million iPhones. Apple has been successful in creating devices, which integrate technical and aesthetic innovations. However, it is not alone in emphasizing aesthetic design related aspects to appropriate from innovations. A recent analysis comparing the use globally of IDs and patents as appropriation mechanisms, shows that while technical innovations protected by patents doubled between 2003 and 2013, the use of IDs to appropriate the value from aesthetic innovations, tripled (Alcacer, Beukel et al. 2015). However, despite the enormous industry focus on aesthetic innovations, there is little published research on what underlies innovations with dramatic new aesthetic designs. A very relevant and unexplored question is what type of human capital does the firm require in its knowledge base to enable the creation of aesthetic innovations?

To address this question, we draw on work in innovation studies on human capital, labor mobility and problem-solving. The literature on labor mobility show that the hiring of engineers and scientists can be a driver of technological innovation, and that the mobility of scientists/engineers has implications for both the receiving and departing firms' technological innovation output (Almeida and Kogut 1999, Hoisl 2007, Agarwal, Ganco et al. 2009, Marc Gruber,

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[1] Design patents are known as industrial designs in some countries.
[2] Designview: www.tmdn.org/accessed the 24th February 2015
[3] Apple Press Release: http://www.apple.com/pr/library/2007/01/09Apple-Reinvents-the-Phone-with-iPhone.html

Dietmar Harhoff et al. 2013). Firms can acquire knowledge beneficial for generating new technological innovations, by hiring scientists and engineers (Singh and Agrawal 2011). In this paper, we focus on the type of knowledge base that is the most beneficial for creating aesthetic innovations in terms of the characteristics and value of a typical firm employee who moves between firms. There is a rich stream of literature on problem solving, which provides information on how designers act in the design thinking process. This literature discusses how design thinking leading to aesthetic innovations differs from the innovation processes leading to technical innovations, and emphasizes different skills and methods (e.g. Lawson 1979, Cross 1982, Buchanan 1992, Glen, Suciu et al. 2014). While this literature stream has not been linked to innovation studies or to particular innovation outcomes such as aesthetic innovation, it helps to identify designers as the main drivers of aesthetic innovation, and to explain the mechanisms by which this type of human capital enables firms to create aesthetic innovations.

In this paper we explore whether the hiring of a new designer generates more aesthetic innovations than are produced in a matched firm, which does not hire a designer, and the conditions moderating the effect of hiring a designer. We explore a unique and detailed dataset containing information on firms, their employees, their new hires and their aesthetic innovation activities, measured by design patent applications. We use a matched sample technique to compare firms, which hire a designer versus non-hiring firms. Our findings show that hiring a designer increases the likelihood of aesthetic innovation, and also that firms with prior experience of aesthetic innovation are more likely to apply for design registrations. We also find a positive moderating effect of firms with prior experience of generating aesthetic innovations on the effect of hiring a designer on aesthetic innovation outcomes.

Our contribution to the current literature is two-fold. First, we add to the scarce literature on aesthetic innovation. Although the term has been in use for some time (Christensen 1995), prior studies rely on case study approaches to identify both the nature of the processes leading to aesthetic innovations (Tran 2010) and the network effects of generating aesthetic innovation (Salter and Gann 2003). The determinants of the occurrence of and large N empirical studies on this type of innovation are scarce, with only one study highlighting the differences in occurrences based on industry (Filitz, Henkel et al. 2014). To our knowledge, the present paper is the first to explore the use of design registrations as an output measure for aesthetic innovation and to link it to the hiring of designers. We add to research on labor mobility by empirically investigating the mobility of designers and their importance for aesthetic innovation outcomes.

The remainder of the paper is structured as follows. Section 2 reviews the empirical setting, presents the theory and formulations our hypotheses on labor mobility in relation to prior experience and its moderating effect on hiring designers. Section 3 introduces our unique dataset and the matching process. Section 4 presents our findings and section 5 concludes.

2. Mobility of designers and their contribution to aesthetic innovative output

Hiring is a means used by firms to generate innovation. By hiring a new employee the firm can acquire knowledge. Knowledge is a highly important firm resource (Grant 1996, Kogut and Zander 1996). The new knowledge brought by new recruits is integrated with the firm's existing knowledge (Lippman and Rumelt 1982, Coff 1997). This process of generating new knowledge via hiring has been described as 'learning by hiring' (Singh and Agrawal 2011). In terms of generating technological innovation, prior research shows that firms use hiring to acquire new technological competencies in order to develop capabilities to enter new technological areas (Rosenkopf and

Almeida 2003, Palomeras and Melero 2009, Singh and Agrawal 2011), and introduce new types of products into the market (Rao and Drazin 2002, Dokko and Rosenkopf 2010).

Several studies show that mobility of scientists and engineers affects the technical innovation output of both the original firm and the hiring firm (see e.g. Almeida and Kogut 1999, Hoisl 2007, Agarwal, Ganco et al. 2009). The knowledge acquired by the scientist/engineer while working for the old employer is transferred to the new employer through the hiring process (Pakes and Nitzan 1983, Kim and Marschke 2005). It provides the hiring firm with access to new knowledge previously unavailable internally. . However, since aesthetic innovation is related to the design not the technical components of a product (Christensen 1995, Sanderson and Uzumeri 1995, Salter and Gann 2003, Eisenman 2013), the hiring of engineers and scientists is unlikely to have an impact on the creation of aesthetic innovations.

In order to understand the human capital needed to allow firms to create aesthetic innovations we draw on work on designers and design thinking. Designers solve the innovation task related problems of shape, context and product forms (Buchanan 1992) through explorative learning involving trial and error to find a solution (Lawson 1979). The literature shows that the problem-solving processes of designers are different from those of scientists (e.g. Lawson 1979, Cross 1982). Lawson (1979) suggests that the scientist's approach to problem solving can be described as the traditional rational problem-solving paradigm, whereas the designer's approach to problem solving is described as design-thinking (Glen, Suciu et al. 2014).

Schön (1983) observed that in the process of design making, learning by doing provides new stimuli which have a positive influence on the aesthetic innovative process, and that designers are able to navigate problems which can be characterized as ill structured. Thus, the cognitive process involved in these two approaches, design-thinking vs. rational problem solving, is fundamentally different. One of the main ways that the work of designers differs from the rational paradigm is that it combines the exploration and exploitation phases. Glen (2014 p.657) describes it as: *"Although the design process may begin with some initial specifications, clients and customers often do not know what they want until they can see what they can get. This reinforces the solution-based, iterative nature of the design process."* Designers differ from scientists also in the development process methodology; designers often rely on observational and ethnographic methodologies (Kelley 2001, Beckman and Barry 2007). Therefore, designers are expected to be able to conduct a different set of innovative activities, using a different approach from that used by scientists in technological innovation.

Aesthetic innovation is another type of innovation which can be viewed as an additional external layer on a technological innovation (e.g. Clark 1985) or as an integrated part of the innovation in which the link between the aesthetic innovation and the technological innovation is central to the generation of a successful new product (Christensen 1995, Sanderson and Uzumeri 1995, Salter and Gann 2003, Eisenman 2013). Eisenman (2013 p. 332) emphasizes the value created by designers as *"visible design attributes, such as color, shape and texture, allow producers to explain what their products do and how best to use them, to excite users in a way that generates sales, and to extend the basic functionalities of their products by highlighting their symbolic meanings"* (), and suggests that the strategic use of aesthetic innovation is a major issue in the commercialization of a technological innovation. The production of a technological innovation with no reference to design, shape, color and texture may reduce the attraction for the consumer/buyer since there is no triggering of affect (Verganti 2006) which has been found to generate higher sales (Bloch 1995, Gemser and Leenders 2001, Hertenstein, Platt et al. 2005).

Therefore, based on the mechanisms related to the mobility of hiring designers, and firms' learning by hiring, we argue that in hiring a designer the firm is employing a type of human capital, namely design capability, which enables it to generate aesthetic innovations. These aesthetic innovations are created based on the problem solving, e.g. the design thinking processes which designers employ. The methods used in a design thinking process are based in ethnography and observation. By hiring a designer the firm is adopting a design knowledge base which has a positive impact on the likelihood of generating aesthetic innovations that are add-ons to a technological innovation or part of a product where the technical and aesthetic are fully integrated. Based on the knowledge based literature, the labor mobility literature and the human capital literature on design thinking we hypothesize that:

H1: *The firm's hiring of a designer is associated with a higher probability that the firm will produce aesthetic innovation output.*

While the process of learning-by-hiring can be used to gain access to new types of knowledge, this knowledge may not be directly applicable by the hiring firm. The literature on organizational learning shows that the firm's ability to acquire and apply new external knowledge is limited by the firm’s own experience and expertise (Nelson and Winter 1982). Learning by doing is a core mechanism for the creation of an internal knowledge base (Argote 1993) which can be exploited by the firm to generate innovation (Levitt and March 1988). The firm essentially follows a learning curve related to improving its ability to develop aesthetic innovation based on prior experience (Argote 1999), which perceives organizational learning as change to the organization's knowledge as a function of experience (Argote and Miron-Spektor 2011). This process of learning from prior experience leads to the generation of new capabilities built on existing capabilities in a process of ‘competence leveraging’ (Miller 2003, Danneels 2007) to create a new capability based on the performance of an activity using patterned behavior (Helfat and Winter 2011). This concept emphasizes learning-by-doing as a core mechanism for the creation of the knowledge required by the firm to generate innovation (Levitt and March 1988, Huber 1991). It is related closely to the concept of absorptive capacity (Cohen and Levinthal 1990) which is required for the firm to implement new knowledge without prior experience and to interpret and understand this new knowledge. A firm with experience of developing aesthetic innovations and registration the associated design rights will be more likely to be able to exploit this new knowledge. Thus, our second hypothesis is that:

H2: The firm's prior experience of aesthetic innovation is associated with a higher probability of producing new aesthetic innovation output.

Engaging in learning-by-hiring to complement the firm's existing knowledge is focused often on the exploration of distant knowledge through broad search to develop new capabilities (Song, Almeida et al. 2003), (Danneels 2002). A firm with no prior experience in aesthetic innovations will engage in more distant search to identify the capabilities necessary to develop aesthetic innovations. Hiring a designer with experience in aesthetic innovation increases the likelihood that the firm will develop aesthetic innovations since the knowledge which diffuses via the learning by hiring process can fill the knowledge gaps in the innovation process (Bessen and Maskin 2009).

Similarly, firms experienced in aesthetic innovation can benefit from learning by hiring. The knowledge and experience required to develop aesthetic innovations can be seen as core firm assets. In this case, the new knowledge brought via the hiring process can be seen as a complementary asset (Teece 1986) which combined with the firm's core assets should create new value.

While both experienced and inexperienced firms can benefit from implementing new knowledge in their innovation process, the overall impact differs among firms. Also, for firms with no experience of aesthetic innovation, implementing the new knowledge gained through the hiring process can be problematic. The implementation of new external knowledge is associated with multiple challenges such as a lack of efficient knowledge sharing processes within the firm (Tushman and Scanlan 1981), resistance to change (Ford, Ford et al. 2008) and dissimilarity between the internal and external knowledge bases (Lane and Lubatkin 1998). The new knowledge must be adapted to, and implemented in existing routines and processes (Hoetker and Agarwal 2007). In this process, prior experience helps the firm develop the organizational routines necessary to combine the new external knowledge with its existing internal knowledge (Zahra and George 2002). This prior experience builds organizational memory, resulting in a more positive response within the organization and reducing potential resistance to change (Walsh and Ungson 1991). Thus, firms experienced in aesthetic innovation will be able to apply the new knowledge to re-enforce existing capabilities (Teece 1986), and utilize the external knowledge to provide access to new ideas, prompting development of new products (Grant and Baden-Fuller 2004). For firms with no experience of aesthetic innovation will benefit more from the access to new knowledge acquired through the hiring process, and it can be argued that these firms will benefit more from a larger potential gain in knowledge. However, realizing these benefits requires experience and a level of existing knowledge. Prior research shows the benefit of experience for exploiting external knowledge, described by Inkpen and Pien (2006 p. 781)as: “What can be learned is directly related to what is already known”. First with no prior experience and fewer capabilities will be less able to internalize and apply the new external knowledge. A certain level of absorptive capacity is required to integrate the new knowledge(Cohen and Levinthal 1990). Our third hypothesis is:

H3.Hiring a designer is associated with a higher probability of developing a new aesthetic innovation for firms with experience of aesthetic innovation compared to firms with no experience of aesthetic innovation.

3. Data and Method

Data on design registrations by Danish firms in the period 2000 to 2010 collected from OHIM[4], DKPTO[5] and the German DPMA[6], constitute our core data. We draw on three sources of design registrations since firms operating only in the domestic market tend to register their designs only in Denmark, while firms with a more international focus apply to international patent offices. The data were retrieved from OHIM's Design View database, covering designs registered in the European Union, DKPTO's PVSOnline database, covering designs registered in Denmark, and the German online database DPMA for German designs registered in Germany. These databases use a proprietary internal firm identifier, which is incompatible with the identifier used by Statistics Denmark, the source of our firm and individual-level data; for this reason we conducted a manual merging process based on firm names. In collaboration with DKPTO the registrants of these design rights were identified and a unique firm identifier associated with each registrant using the CVR registry of Danish firms. A total of 10,595 OHIM design registrations, 1,725 Danish design registrations and 521 German design registrations were identified and matched to firm identifiers. After matching the data to the available registry data from Statistics Denmark, we were left with 10,243 OHIM designs, 1,665 Danish designs and 521 German designs, a total of 12,429 designs

[4] Office for Harmonization in the Internal Market
[5] Danish Patent and Trademark Office
[6] National German design registrations (covering only the German jurisdiction)

from 1,457 firms. Individual design registrations with no firm identifier were excluded because they could not be matched to the firm registry.

Data on design registrations were merged with the firm and individual-level data provided by Statistics Denmark. The panel structure data on individuals and firms consist of a combination of employer-employee register data from Statistics Denmark (Integrated Database for r Labour-market Research) from 2000 to 2010. The employee register data include among other information, details of the person's employment (industry, job function, primary job, secondary job, degree of unemployment etc.). The employer data contains information on industry, whether or not the company is an exporter, firm size, geographical location, etc. Most importantly they provide data on end-of-November employment[7]. These are panel data providing annual firm data on revenue, productivity, exports, industry and number of employees as key variables. When merged with individual level data they allow us to track the employment history of each individual within the period of observation. This results in 119,990 observations split across 15,886 unique firms in Denmark in the period 2000 to 2010.

The data show that there is an average 6,026 designers in the Danish workforce per year, and Danish firms on average hire 430 new designers per year. Designers are mostly employed in the manufacturing industries, and the industries registering the highest number of design rights per firm are manufacturing, and trade and transport.

3.1 Variables

Dependent variable:

[7] Statistics Denmark registers individual affiliations annually in November, thus we do not observe mobility within the November to November period.

Our dependent variable is aesthetic innovation which is measured as *Design rights+3* which is a binary variable taking the value 1 if the firm registers a design right three years after hiring a designer. A design is defined as: *"*the appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colors, shape, texture and/or materials of the product itself and/or its ornamentation..."[8] (Article 3 p. 5)

Explanatory variables:

Hire designer is a binary variable, which takes the value 1 if a firm has hired an employee who worked as a designer in his/her previous employment and 0 otherwise. The hiring of designers is measured in November of the given year. The variable is used in the matching procedure and to test hypothesis 1.

Design right registration experience is a binary variable, which takes the value 1 if the firm has prior experience in registering design rights and 0 otherwise. The variable is measured from when the firm is first observed in the data, the first available year being 2000.

Control variables:

The model includes various control variables, which might explain the firm's likelihood to register design rights. We include variables for the firm's combinations of employee job functions, and some firm specific variables. In other words, we control for the share of employees working in a law related job, the share of employees in an engineering job function, the firm's hires of engineers, and the share of new employees other than designers and engineers, the share of designers employed by the firm in the previous year, firm age, firm size, whether the firm is an exporter or not, whether the firm is located in the country capital or not, industry dummies

[8] COUNCIL REGULATION (EC) No 6/2002 of 12 December 2001 on Community designs (available at http://oami.europa.eu/en/design/pdf/reg2002_6.pdf accessed 27th of February 2015).

(manufacturing, construction, trade transport, information and communication technology, financial) and year of matching.

3.2 Method

A potential problem related to econometric analysis is endogeneity. If firms hire designers with the sole purpose of obtaining more design rights, the effect we would observe is the firm's strategy to register design rights, not the effect of having hired a designer. We deal with this selection bias by following Guerzoni and Raiteri (2015) and applying propensity score matching. More specifically, we match firms that have hired designers to other similar firms that have not hired a designer. That is, the dependent variable used in the matching procedure is *hire designer*, with the following explanatory variables: A binary variable for whether the firm registered design rights in the previous year, industry (2 digit industry code), number of designer employees in the previous year, and firm size.

The nature of our data allows us to restrict our sample to firms that did not hire a designer in the previous three years (2000-2003) or the succeeding three years (2008-2010). Thus, the effect we observe is related purely to the hiring of a designer in the time period 2004-2007 and not in either the previous or succeeding three years.

We created separate matched samples for the years 2004, 2005, 2006 and 2007 and pooled them to obtain the final dataset. The regression results for the matched samples for each year, before and after the matched sample procedure, are provided in the appendix.

After creating the matched sample we have a final sample of 1,078 firms allowing us to test whether hiring a designer has a positive effect on the firm's aesthetic innovation (design rights) rate. Table 1 shows the distribution of designer hires in each year; thus, the number of firms is double the number of design hires. The total number of design rights registered in time t+3 is 34.

Table 1: Distribution of design hires, firms and design rights in time t+3 in final dataset

	2004	**2005**	**2006**	**2007**	**Total**
No. of design hires	76	118	187	158	**539**
No. of firms	152	236	374	316	**1,078**
No. of design rights in t+3	3	11	16	4	**34**

We use the final dataset for the econometric analysis, which is carried out using logistic regression estimation since the dependent variable, *design right t+3,* is a binary variable. Robust standard errors are applied in all regressions, and both the coefficient estimates and odds ratios are presented in the results table 4.

4. Findings

This section presents the summary statistics, the results of the regression estimations and robustness checks.

4.1 Summary statistics

Table 1 presents the descriptive statistics. The final sample size consists of 1,078 firms half of which employed a designer at time t, and3.2% of which registered a design right in time t+3. Of the 1,078 firms 3.3% have previous experience of aesthetic innovation measured by registration of design rights. On average the share of employees in a designer job function is 1% of the total number of employees, with a maximum of 9.6%.

Table 2: Descriptive statistics

Descriptive statistics (N=1,078)				
Variable	Mean	S.D.	Minimum	Maximum
Design right t+3	0.032	0.175	0	1
Hire designer	0.500	0.500	0	1
Have design right exp.	0.033	0.180	0	1
Share of employees w. law job	0.001	0.007	0	0.176
Share of employees w. engineer job	0.021	0.068	0	0.602
Hire engineer	0.196	0.397	0	1
Other hires	0.949	0.220	0	1
Log firm size	4.362	1.382	0	9.559
Share of designers t-1	0.009	0.037	0	0.440
Design right t-1	0.037	0.189	0	1
Manufacturing	0.397	0.490	0	1
Construction	0.043	0.202	0	1
Trade & transport	0.232	0.422	0	1
Financial	0.178	0.383	0	1
Export firm	0.719	0.450	0	1
Capital area	0.316	0.465	0	1
Matching year	2005	1.017	2004	2007

Table 3 presents the correlations of the dependent, independent and control variables. Both *hire designer* and *have design rights experience* are correlated with registering design rights in time t+3 which is a first indication that the relationships hypothesized are confirmed. The variable *design right t-1* is highly correlated with *have design right experience*, which is as expected since both variables explain the firm's previous design experience. However, it means that *design right t-1* is not included as a control variable in the models, which include the explanatory variable *have design right.*

Table 3: Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Design right t+3	1																
(2) Hire designer	0.0743*	1															
(3) Have design right exp.	0.4096*	0.0723*	1														
(4) Share of employees w. law job	0.0429	0.0273	0.0402	1													
(5) Share of employees w. engineer job	0.0185	0.0520	-0.0133	0.0726*	1												
(6) Hire engineer	0.0447	0.1099*	0.0384	0.0110	0.3086*	1											
(7) Other hires	0.0177	0.0548	0.0431	0.0256	0.0394	0.1144*	1										
(8) Log firm size	0.0481	0.0203	0.0706*	0.0461	-0.0437	0.3262*	0.3420*	1									
(9) Share of designers t-1	-0.0043	0.0124	-0.0163	-0.0194	0.2338*	0.0084	-0.0703*	-0.1136*	1								
(10) Design right t-1	0.3577*	0.0196	0.5098	0.0353	-0.0150	0.0392	-0.0214	0.0302	-0.0035	1							
(11) Manufacturing	0.0705*	0.0000	0.1235	-0.0796*	-0.0442	0.0775*	0.0761*	0.0605*	-0.0600*	0.1316*	1						
(12) Construction	-0.0118	0.0000	-0.0392	-0.0221	-0.0212	0.0462	0.0490	0.0563	0.0040	-0.0414	-0.1713*	1					
(13) Trade & transport	0.0014	0.0000	-0.0043	-0.0525	-0.1352*	-0.1437*	-0.0624*	-0.0310	-0.0632*	-0.0265	-0.4459*	-0.1160	1				
(14) Financial	-0.0146	-0.0000	-0.0595	0.0677*	0.3019*	0.0698*	-0.0463	-0.0595	0.2209*	-0.0401	-0.3777*	-0.0983	-0.2558*	1			
(15) Export firm	0.0774*	-0.0186	0.0933*	-0.0009	-0.0505	0.0484	0.0707*	0.0907*	-0.0783*	0.0791*	0.3218*	-0.2151*	0.0062	-0.2483*	1		
(16) Capital area	-0.0086	0.0658*	-0.0487	0.1269*	0.0542	0.0566	0.0489	0.1428*	-0.0689*	-0.0280	-0.3155*	-0.0153	0.0516	0.1734*	-0.0451	1	
(17) Matching year	-0.0362	0.0000	0.0126	0.0422	-0.0153	0.0203	0.0397	-0.0342	-0.0550	-0.0226	0.0092	-0.0020	-0.0390	0.0141	0.0021	0.0311	1

(*) significant at 5%

4.2 Results

Table 4 presents the results of the logistic regression estimations, and includes both the coefficient estimates and odds ratios. Model (1) contains only the control variables. Model (2) includes the variable for whether the firm hired a designer or not. Model (2) shows that hiring a designer has a significant and positive effect on the likelihood of registering a design right three years later, compared to not hiring a designer. The odds ratio suggests that the firm is 2.6 times more likely to register a design right at time t+3 if the firm hires a designer. Hence, hypothesis 1, that the labor mobility of designers is associated with a higher probability of hiring to produce aesthetic innovations, is supported by the empirical findings.

Model (3) includes the explanatory variable for whether or not the firm has prior experience in registering design rights. The results of model (3) show that having experience of registering design rights has a positive and significant effect on the probability of registering a design right in time t+3 compared to not having experience of registering design rights. The odds ratio suggests that a firm is 37 times more likely to register a design right in time t+3 if it has prior experience of registering design rights. Hence, the results of the logistic regression estimation support hypothesis 2 that that the firm's prior experience of aesthetic innovation is associated with a higher probability that the firm will produce new aesthetic innovation output.

Model (4) shows the results of the logistic regression estimation including the interaction between the two variables for whether the firm hires a designer and whether it has prior experience of registering design rights. Model (4) shows that experience of registering design rights in the absence of hiring a designer has a positive and significant effect on the probability of registering a design right in time t+3 compared to not having experience of registering design rights and not hiring a designer. In addition, if the firm has both experience of registering design rights and hires a designer, the probability of registering a design right in time t+3 is higher compared to not having experience of registering design rights and not hiring a designer. The odds ratio suggests that a firm is 69 times more likely to register a design right in time t+3 if it has both experience in registering designs and hires a designer, compared to not having experience in registering design rights and not hiring a designer. We use a Wald test to test having design rights registration experience only, against having both design rights registration experience and hiring a designer. We cannot reject that the effect of the two variables is the same, that is, we do not find full support for hypothesis 3 that for firms with experience of aesthetic innovation, hiring a designer is associated with a higher probability of developing additional aesthetic innovations when compared to a firm without experience of aesthetic innovation.

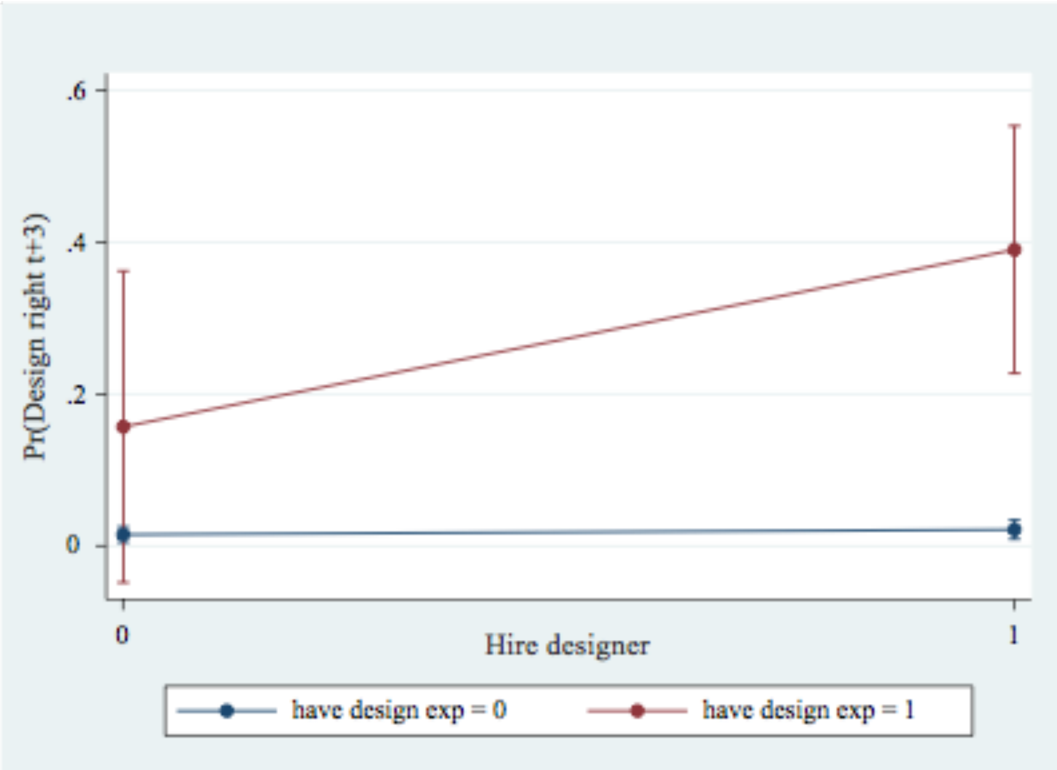
Table 4: Results of logistic regression models and odds ratios

Regression estimation results								
Dependent variable: *design right t+3*	Model (1)		Model (2)		Model (3)		Model (4)	
	a. Logit	b. Odds ratio	a. Logit	b. Odds ratio	a. Logit	b. Odds ratio	a. Logit	b. Odds ratio
Hire designer			0.870**	2.387*				
			(0.38)	(0.914)				
Have design right exp.					3.703***	40.57***		
					(0.50)	(20.11)		
No hire designer x have design right exp.							2.945***	19.01**
							(1.05)	(19.97)
Hire designer x no have design right exp.							0.373	1.453
							(0.48)	(0.692)
Hire designer x have design right exp.							4.189***	65.98***
							(0.62)	(40.80)
Share of employees w. law job	63.987***	6.15292e+27***	61.216***	3.85395e+26**	38.698***	6.40266e+16**	36.831**	9.89877e+15*
	(18.82)	(1.15927e+29)	(18.84)	(7.25929e+27)	(14.97)	(9.5854e+17)	(14.81)	(1,46579e+17)
Share of employees w. engineer job	1.241	3.458	0.946	2.575	2.018	7.524	2.131	8.420
	(2.22)	(7.664)	(2.20)	(5.656)	(2.06)	(15.49)	(2.06)	(17.31)
Hire engineer	0.145	1.156	0.012	1.013	0.195	1.216	0.006	1.006
	(0.48)	(0.554)	(0.48)	(0.481)	(0.57)	(0.690)	(0.58)	(0.588)
Other hires	-0.653	0.520	-0.767	0.464	-0.850	0.428	-0.911	0.402
	(0.87)	(0.451)	(0.85)	(0.397)	(0.92)	(0.393)	(0.91)	(0.365)
Log firm size	0.141	1.152	0.155	1.168	-0.046	0.955	-0.028	0.972
	(0.17)	(0.191)	(0.17)	(0.193)	(0.22)	(0.207)	(0.21)	(0.209)
Share of designers t-1	-0.418	0.658	-0.451	0.637	-1.517	0.219	-1.856	0.156
	(3.09)	(2.032)	(3.36)	(2.141)	(3.55)	(0.779)	(3.80)	(0.595)
Manufacturing	20.088***	529,891,444.7***	21.410***	1.98716e+09***	16.950***	229,801,32.9***	16.277***	117,254,17.8***
	(3.42)	(1.81126e+09)	(3.41)	(6.78348e+09)	(2.87)	(658,736,96.8)	(2.79)	(327,721,16.4)
Construction	20.118***	545,686,128.8***	21.433***	2.03277e+09***	17.739***	505,878,38.7***	17.067***	258,180,86.4***
	(3.76)	(2.05334e+09)	(3.74)	(7.60892e+09)	(3.29)	(166,249,818.5)	(3.21)	(829,214,55.2)
Trade & transport	19.946***	459,469,179.4***	21.231***	1.66141e+09***	16.875***	213,262,69.7***	16.137***	101,875,55.2***
	(3.48)	(1.59748e+09)	(3.46)	(5.75537e+09)	(2.91)	(620,577,49.1)	(2.85)	(290,342,35.0)
Financial	19.643***	339,602,822.7***	21.069***	1.41349e+09***	17.109***	269,471,13.5***	16.448***	139,122,98.5***
	(3.31)	(1.12346e+09)	(3.32)	(4.68753e+09)	(2.76)	(745,036,93.3)	(2.73)	(379,874,92.0)
Export firm	1.637**	5.140*	1.662**	5.272*	1.569*	4.802	1.623**	5.066*
	(0.73)	(3.777)	(0.74)	(3.925)	(0.80)	(3.845)	(0.80)	(4.037)
Capital area	0.042	1.042	-0.006	0.994	0.119	1.126	0.104	1.110
	(0.45)	(0.469)	(0.46)	(0.457)	(0.51)	(0.576)	(0.52)	(0.579)
Matching year = 2005	0.791	2.205	0.802	2.231	0.682	1.979	0,5375	2.168
	(0.67)	(1.474)	(0.67)	(1.488)	(0.65)	(1.287)	(0.66)	(1.427)
Matching year = 2006	0.840	2.315	0.844	2.325	0.905	2.472	0.956	2.601
	(0.66)	(1.530)	(0.66)	(1-540)	(0.61)	(1.513)	(0.62)	(1.624)
Matching year = 2007	-0.537	0,40625	-0.541	0.582	-0.777	0.460	-0.725	0.484
	(0.83)	(0.485)	(0.82)	(0.476)	(0.84)	(0.384)	(0.84)	(0.407)
Constant	-25.229***		-27.005***		-21.701***		-21.292***	
	(3.87)		(3.86)		(3.39)		(3.29)	
Observations	1,078	1,078	1,078	1,078	1,078	1,078	1,078	1,078
χ2 -test	χ2(15) = 127	χ2(15) = 127	χ2(16) = 166	χ2(16) = 166	χ2(16) =311	χ2(16) =311	χ2(18) =245	χ2(18) =245
R2	0.12	0.13	0.14	0.15	0.30	0.31	0.31	0.32

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

To further investigate the effect of the interaction term on the probability of registering a design right in time t+3, we plotted the marginal effects. Figure 1 shows the predicted marginal effects of the interaction term. The effect of hiring a designer without having design registration experience is positive but not significant. However, for firms with experience of registering design rights the effect of hiring a designer is associated with a significantly higher probability of registering design rights in time t+3.

Figure 1: Predictive marginal effects



4.3 Robustness checks

As a robustness check we introduce *design right t+1* and *design right t+2* as dependent variables, and conduct negative binomial regression using *number of design rights t+1, number of design rights t+2* and *number of design rights t+3* respectively as the dependent variable. The findings hold for the negative binomial model with *number of design rights t+3* as the dependent variable. The results hold also if we include design *right t+1* as the dependent variable and *design right t+2* as the dependent variable in a logistic regression model. The results are also the same for the negative binomial model. The results of the robustness checks are presented in the appendix.

6. Conclusion

In this paper we explored whether hiring a designer affects the likelihood that the firm would develop aesthetic innovations, exploiting unique data on labor mobility of designers and firms' design registrations. Unlike the relation between scientists' mobility and technological innovation, there are very few studies that investigate the determinants of aesthetic innovation. Specifically, the sources of aesthetic innovation, which we identified and tested empirically, are limited, and the properties of the aesthetic innovation process different from the process of technological innovation. Existing work uses industry or firm case studies , which limits the generalizability of the results (i.e. Salter and Gann 2003, Tran 2010).

Our results show a positive relation between hiring a designer and the likelihood that the firm will develop new aesthetic innovations. This suggests that firms seeking to develop aesthetic innovations to enhance an existing product or create a new product, can acquire the necessary capabilities through recruitment. Our results suggest also that firms that hire designers exploit their skills to develop innovations shown by the direct effect of employing a designer. We find that the development of aesthetic innovation is dependent on prior experience. Firms already conducting aesthetic innovation developments are more likely to produce further aesthetic innovations in the future. While this points to a competence leveraging effect, it does not explain how the firm develops its first aesthetic innovation. Future research should look more closely at how the initial development of aesthetic innovation takes place in both new and established firms.

We find that in order for the firm to benefit most from hiring a designer, measured by a higher probability of registering design rights, it needs prior experience of innovation and registering design rights. That is, without the necessary absorptive capacity, the firm will be unable to exploit the designer's full potential, and therefore the probability of registering design rights will not increase. While recruiting a designer to the firm can have a positive effect on aesthetic innovation, this effect is contingent on the firm's having the necessary knowledge in place. This could be a problem for firms seeking to develop aesthetic innovation activity. Our results suggest that it is not sufficient to acquire the necessary capabilities through the process of learning-by-hiring but that the firm needs to certain capabilities before the benefits of hiring designers can be realized.

As discussed above, our results do not provide sufficient insight into what determines the firm's ability to develop the first aesthetic innovation, which presents an opportunity for future research. The possible determinants of aesthetic innovation may be heterogeneous distribution of formal skills within the firm among designers, engineers and scientists, which allow novel recombinations of skills and broader search, or the involvement of designers in the product development process.

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7. Appendix

A1. Results before and after the matching procedure for the years 2004, 2005, 2006 and 2007.

	Model 1	Model 2	Model 3	Model 4
	Before matching	After matching	Before matching	After matching
Log firm size	0.720***	0.058	0.747***	0.009
	(0.08)	(0.12)	(0.07)	(0.10)
Share of designers t-1	5.132***	-5.392	4.805***	-1.819
	(1.91)	(4.19)	(1.72)	(3.85)
Design right t-1	0.926	1.072	1.894***	0.721
	(0.63)	(1.17)	(0.41)	(0.63)
Constant	-7.494***	-0.208	-7.204***	-0.058
	(0.37)	(0.56)	(0.31)	(0.47)
Observations	9,067	152	9,050	236
$\chi2$ -test	$\chi2(3)$ =86	$\chi2(3)$ = 4	$\chi2(3)$ =150	$\chi2(3)$ =2
R2	0.10	0.02	0.12	0.01

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

	2006		2007	
	Model 5	Model 6	Model 7	Model 8
	Before matching	After matching	Before matching	After matching
Log firm size	0.674***	0.034	0.689***	0.016
	(0.05)	(0.08)	(0.06)	(0.08)
Share of designers t-1	5.778***	7.465*	6.667***	4.647
	(1.10)	(4.26)	(1.47)	(3.91)
Design right t-1	1.118**	-0.456	0.975**	0.517
	(0.44)	(0.54)	(0.49)	(0.74)
Constant	-6.412***	-0.189	-6.643***	-0.115
	(0.24)	(0.35)	(0.27)	(0.36)
Observations	9,240	374	9,173	316
$\chi2$ -test	$\chi2(3)$ =172	$\chi2(3)$ =5	$\chi2(3)$ =150	$\chi2(3)$ =2
R2	0.09	0.01	0.09	0.005

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

A2. Robustness check – hypothesis 1, logistic regression model

	Model (1)	Model (2)	Model (2)
	Dep. var.: *design right t+1*	Dep. var.: *design right t+2*	Dep. var.: *design right t+3*
Hire designer	1.275***	0.502	0.870**
	(0.42)	(0.37)	(0.38)
Share of employees w. law job	51.512***	26.589	61.216***
	(19.21)	(17.23)	(18.84)
Share of employees w. engineer jol	-0.409	-0.463	0.946
	(2.28)	(2.44)	(2.20)
Hire engineer	0.450	0.613	0.012
	(0.42)	(0.47)	(0.48)
Other hires	-0.171	-0.115	-0.767
	(1.13)	(1.09)	(0.85)
Log firm size	0.161	0.168	0.155
	(0.16)	(0.17)	(0.17)
Share of designers t-1	0.527	2.920	-0.451
	(4.07)	(3.44)	(3.36)
Manufacturing	21.423***	1.979	21.410***
	(3.49)	(1.62)	(3.41)
Construction			21.433***
			(3.74)
Trade & transport	20.736***	2.190	21.231***
	(3.55)	(1.69)	(3.46)
Financial	20.748***	1.386	21.069***
	(3.28)	(1.85)	(3.32)
Export firm	1.349**	1.425*	1.662**
	(0.64)	(0.73)	(0.74)
Capital area	-0.197	-0.255	-0.006
	(0.52)	(0.50)	(0.46)
Matching year = 2005	0.300	0.270	0.802
	(0.53)	(0.62)	(0.67)
Matching year = 2006	-1.083*	-0.037	0.844
	(0.60)	(0.61)	(0.66)
Matching year = 2007	-0.468	-0.078	-0.541
	(0.56)	(0.63)	(0.82)
Constant	-26.645***	-7.619***	-27.005***
	(4.02)	(2.45)	(3.86)
Observations	1,031	1,031	1,078
$\chi2$ -test	.	$\chi2(15) = 27$	$\chi2(16) = 166$
R2	0.17	0.09	0.14

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

A3. Robustness check – hypothesis 1, negative binomial model

	Model (1)	Model (2)	Model (2)
	Dep. var.: *no. design right t+1*	Dep. var.: *no. design right t+2*	Dep. var.: *no. design right t+3*
Hire designer	2.488***	1.139**	2.064***
	(0.70)	(0.45)	(0.46)
Share of employees w. law job	24.393	100.801***	90.019***
	(21.65)	(25.28)	(17.16)
Share of employees w. engineer job	-1.387	3.407	6.374*
	(3.91)	(4.09)	(3.75)
Hire engineer	0.399	-0.361	-1.864***
	(0.63)	(0.51)	(0.64)
Other hires	-0.276	-1.386	-3.379**
	(1.06)	(1.04)	(1.35)
Log firm size	0.547***	0.299	0.391***
	(0.17)	(0.22)	(0.15)
Share of designers t-1	1.826	1.518	12.020
	(8.04)	(6.51)	(10.95)
Manufacturing		2.332	32.235***
		(1.67)	(3.17)
Construction	-19.872***	-18.075***	29.114***
	(0.80)	(1.79)	(2.62)
Trade & transport	-0.488	2.571	32.091***
	(0.65)	(1.91)	(2.75)
Financial	-0.021	-0.200	30.514***
	(0.85)	(2.20)	(3.07)
Export firm	2.477***	2.897**	3.213***
	(0.69)	(1.42)	(0.56)
Capital area	-1.276*	-0.561	0.522
	(0.69)	(0.61)	(0.54)
Matching year = 2005	1.188	-0.251	-0.428
	(1.55)	(0.71)	(0.77)
Matching year = 2006	-1.694	-1.712***	-1.046
	(1.18)	(0.65)	(0.76)
Matching year = 2007	-1.936*	-1.089*	-3.220***
	(1.14)	(0.66)	(0.94)
Constant	-6.803***	-6.502*	-34.914***
	(2.57)	(3.50)	(3.52)
Observations	1,077	1,077	1,078
$\chi2$ -test	$\chi2(15)$ = 1,035	$\chi2(16)$ = 1,818	.

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

A4. Robustness check – hypothesis 2, logistic regression model

	Model (1)	Model (2)	Model (2)
	Dep. var.: *design right t+1*	Dep. var.: *design right t+2*	Dep. var.: *design right t+3*
Have design right exp.	4.480***	4.132***	3.703***
	(0.56)	(0.48)	(0.50)
Share of employees w. law job	18.525	18.910*	38.698***
	(17.91)	(10.97)	(14.97)
Share of employees w. engineer job	0.861	-0.850	2.018
	(2.01)	(3.02)	(2.06)
Hire engineer	0.754	0.928*	0.195
	(0.63)	(0.54)	(0.57)
Other hires	-0.234	-0.319	-0.850
	(1.22)	(1.17)	(0.92)
Log firm size	-0.079	-0.051	-0.046
	(0.22)	(0.18)	(0.22)
Share of designers t-1	-2.101	3.297	-1.517
	(5.07)	(3.90)	(3.55)
Manufacturing	14.165***	0.573	16.950***
	(0.71)	(1.12)	(2.87)
Construction			17.739***
			(3.29)
Trade & transport	13.670***	1.200	16.875***
	(0.80)	(1.15)	(2.91)
Financial	14.141***	0.691	17.109***
	(0.60)	(1.45)	(2.76)
Export firm	1.137*	1.499	1.569*
	(0.64)	(0.93)	(0.80)
Capital area	-0.033	-0.222	0.119
	(0.71)	(0.64)	(0.51)
Matching year = 2005	0.091	0.156	0.682
	(0.67)	(0.72)	(0.65)
Matching year = 2006	-1.591*	-0.052	0.905
	(0.82)	(0.67)	(0.61)
Matching year = 2007	-0.998	-0.223	-0.777
	(0.78)	(0.73)	(0.84)
Constant	-17.973***	-5.866**	-21.701***
	(1.67)	(2.30)	(3.39)
Observations	1,031	1,031	1,078
χ^2 -test	$\chi^2(15) = 3{,}107$	$\chi^2(15) = 102$	$\chi^2(16) = 311$
R2	0.40	0.34	0.30

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant

A5. Robustness check – hypothesis 2, negative binomial model

	Model (1)	Model (2)	Model (2)
	Dep. var.: *no. design right t+1*	Dep. var.: *no. design right t+2*	Dep. var.: *no. design right t+3*
Have design right exp.	5.760***	5.027***	5.684***
	(0.45)	(0.46)	(0.87)
Share of employees w. law job	-6.277	22.944	-1.820
	(12.52)	(19.41)	(13.84)
Share of employees w. engineer job	1.632	1.080	8.522**
	(2.26)	(2.65)	(3.92)
Hire engineer	0.746	-0.167	-0.126
	(0.54)	(0.67)	(0.69)
Other hires	-1.253	-1.927*	-4.063***
	(1.62)	(1.04)	(1.09)
Log firm size	0.061	0.047	-0.005
	(0.17)	(0.20)	(0.17)
Share of designers t-1	-8.477	4.048	-3.504
	(7.29)	(6.00)	(6.46)
Manufacturing	16.114***	1.383	16.830***
	(0.62)	(1.19)	(0.90)
Construction		-17.022***	15.313***
		(1.28)	(1.02)
Trade & transport	15.520***	2.065	16.674***
	(0.60)	(1.26)	(0.92)
Financial	15.552***	1.105	15.480***
	(0.56)	(1.44)	(0.68)
Export firm	1.971***	2.424**	1.825***
	(0.58)	(1.10)	(0.52)
Capital area	0.877*	0.480	1.432***
	(0.52)	(0.50)	(0.51)
Matching year = 2005	-0.496	0.577	1.526*
	(0.75)	(0.59)	(0.79)
Matching year = 2006	-2.596***	0.132	0.740
	(0.87)	(0.77)	(0.69)
Matching year = 2007	-2.372***	-0.444	-2.579***
	(0.87)	(0.53)	(0.72)
Constant	-19.061***	-5.745**	-17.751***
	(1.65)	(2.38)	(1.25)
Observations	1,077	1,077	1,078
$\chi2$ -test	$\chi2(15) = 6,012$	$\chi2(16) = 4,214$	$\chi2(16) = 1627$

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

A6. Robustness check – hypothesis 3, logistic regression model

	Model (1)	Model (2)	Model (2)
	Dep. var.: *design right t+1*	Dep. var.: *design right t+2*	Dep. var.: *design right t+3*
No hire designer x have design right exp.	3.900***	3.625***	2.945***
	(0.86)	(0.95)	(1.05)
Hire designer x no have design right exp.	0.856	-0.378	0.373
	(0.58)	(0.54)	(0.48)
Hire designer x have design right exp.	5.364***	4.046***	4.189***
	(0.76)	(0.60)	(0.62)
Share of employees w. law job	16.757	19.338*	36.831**
	(18.04)	(11.34)	(14.81)
Share of employees w. engineer job	0.836	-0.743	2.131
	(2.01)	(3.08)	(2.06)
Hire engineer	0.516	0.516	0.006
	(0.66)	(0.55)	(0.58)
Other hires	-0.405	-0.268	-0.911
	(1.25)	(1.16)	(0.91)
Log firm size	-0.051	-0.055	-0.028
	(0.22)	(0.18)	(0.21)
Share of designers t-1	-1.899	3.222	-1.856
	(5.51)	(3.91)	(3.80)
Manufacturing	14.962***	0.566	16.277***
	(0.96)	(1.10)	(2.79)
Construction			17.067***
			(3.21)
Trade & transport	14.325***	1.192	16.137***
	(1.07)	(1.14)	(2.85)
Financial	14.942***	0.642	16.448***
	(0.90)	(1.44)	(2.73)
Export firm	1.277*	1.529	1.623**
	(0.69)	(0.93)	(0.80)
Capital area	-0.055	-0.220	0.104
	(0.74)	(0.65)	(0.52)
Matching year = 2005	0.146	0.206	0.774
	(0.70)	(0.75)	(0.66)
Matching year = 2006	-1.657*	-0.019	0.956
	(0.87)	(0.70)	(0.62)
Matching year = 2007	-0.957	-0.178	-0.725
	(0.78)	(0.75)	(0.84)
Constant	-19.283***	-5.764**	-21.292***
	(1.94)	(2.27)	(3.29)
Observations	1,031	1,031	1,078
$\chi2$ -test	$\chi2(17) = 1,591$	$\chi2(17) = 108$	$\chi2(18) = 245$
R2	0.42	0.34	0.31

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%

A7. Robustness check – hypothesis 3, negative binomial model

	Model (1)	Model (2)	Model (2)
	Dep. var.: *no. design right t+1*	Dep. var.: *no. design right t+2*	Dep. var.: *no. design right t+3*
No hire designer x have design right exp.	4.432***	3.443***	4.231***
	(0.87)	(0.82)	(1.10)
Hire designer x no have design right exp.	0.945*	-1.062**	0.605
	(0.53)	(0.47)	(0.41)
Hire designer x have design right exp.	6.678***	5.073***	6.413***
	(0.64)	(0.48)	(1.05)
Share of employees w. law job	-9.407		-2.318
	(13.66)		(14.52)
Share of employees w. engineer job	1.254	1.134	7.873**
	(2.23)	(2.89)	(3.69)
Hire engineer	0.494	0.148	-0.225
	(0.53)	(0.59)	(0.69)
Other hires	-1.241	-1.555*	-4.208***
	(1.41)	(0.91)	(1.10)
Log firm size	0.084	-0.025	0.007
	(0.17)	(0.17)	(0.17)
Share of designers t-1	-7.268	3.584	-2.885
	(7.87)	(5.99)	(6.27)
Manufacturing	16.392***	1.296	16.894***
	(0.63)	(1.02)	(0.77)
Construction	-12.992***		15.024***
	(0.61)		(0.88)
Trade & transport	15.847***	2.029*	16.428***
	(0.68)	(1.13)	(0.75)
Financial	15.703***	1.416	15.420***
	(0.52)	(1.46)	(0.57)
Export firm	2.018***	2.284***	1.889***
	(0.61)	(0.88)	(0.50)
Capital area	1.022*	0.459	1.434***
	(0.56)	(0.46)	(0.52)
Matching year = 2005	-0.216	0.597	1.383*
	(0.69)	(0.64)	(0.75)
Matching year = 2006	-2.521***	0.125	0.922
	(0.81)	(0.78)	(0.71)
Matching year = 2007	-2.294***	-0.489	-2.282***
	(0.84)	(0.63)	(0.79)
Constant	-20.202***	-5.284***	-18.030***
	(1.49)	(1.96)	(1.20)
Observations	1,077	1,077	1,078
$\chi2$ -test	.	$\chi2(16) = 254$	$\chi2(18) = 2,613$

Robust standard errors in square brackets ; (*) significant at 10%; (**) significant at 5%; (***) significant at 1%