Catalogue no. 88F0006X, no. 3
ISSN 1921-300X
ISBN 978-1-100-15339-1

Working paper

Business Special Surveys and Technology Statistics Division Working Papers

Characteristics of Canadian Manufacturing Firms That Undertake Design Activities: An Empirical Analysis of Results of the Survey of Advanced Technology, 2007

by Horatio Sam-Aggrey

Business Special Surveys and Technology Statistics Division
7-N, R.H. Coats, Ottawa, K1A 0T6

Telephone: 1-800-263-1136

Statistics Canada Statistique Canada

Canada

How to obtain more information

For information about this product or the wide range of services and data available from Statistics Canada, visit our website at *www.statcan.gc.ca*, e-mail us at *infostats@statcan.gc.ca,* or telephone us, Monday to Friday from 8:30 a.m. to 4:30 p.m., at the following numbers:

Statistics Canada's National Contact Centre

Toll-free telephone (Canada and the United States):	
Inquiries line	1-800-263-1136
National telecommunications device for the hearing impaired	1-800-363-7629
Fax line	1-877-287-4369
Local or international calls:	
Inquiries line	1-613-951-8116
Fax line	1-613-951-0581
Depository Services Program	
Inquiries line	1-800-635-7943
Fax line	1-800-565-7757

To access this product

This product, Catalogue no. 88F0006X, is available free in electronic format. To obtain a single issue, visit our website at *www.statcan.gc.ca* and browse by "Key resource" > "Publications."

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, Statistics Canada has developed *standards of service* that its employees observe. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published on *www.statcan.gc.ca* under "About us" > "Providing services to Canadians."

Statistics Canada
Business Special Surveys and Technology Statistics Division

Characteristics of Canadian Manufacturing Firms That Undertake Design Activities: An Empirical Analysis of Results of the Survey of Advanced Technology, 2007

Published by authority of the Minister responsible for Statistics Canada

May 2010

Catalogue no. 88F0006X, no. 3

ISSN 1921-300X
ISBN 978-1-100-15339-1

Frequency: Occasional

Ottawa

Cette publication est également disponible en français.

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

User information

Symbols

The following standard symbols are used in Statistics Canada publications:

.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0[s]	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
p	preliminary
r	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
E	use with caution
F	too unreliable to be published

Table of contents

Abstract

Design activities are central to firm competitiveness and delivering value-added products. Research has shown that rapidly growing companies attach greater weight to design activities. Through design, firms may improve the user interface and create characteristics that allow them to distinguish their products from those of their competitors. Using the results of the Survey of Advanced Technology 2007, this paper examines the extent of use of design activities among Canadian firms, with a view to explaining factors fostering firms' engagement in design activities. It explores whether design activities are more likely to be carried out in some manufacturing industries than in others. The average size of firms undertaking design activities will also be explored. Characteristics of firms that are likely to spend a greater proportion of their expenditures on in-house design activities versus those who outsource larger percentage of their design work to other firms outside their organizational boundaries will be discussed. This paper will also explore whether firms that have high design intensity are more likely to be innovators. Another area of interest of this paper is the question of whether firms that undertake design activities are more likely to be exporters. Common success factors reported by those firms with high design intensity will also be discussed.

Acknowledgments

I wish to thank Susan Schaan, Frances Anderson, Iddi Alhassan, Eric Turgeon and Heather Berrea for the immense help they offered to me. This paper was first presented at the Statistics Canada Socio-economic Conference in May 2009, with support from Paula Thomson, Director, Business Special Surveys and Technology Statistics Division, Statistics Canada.

Characteristics of Canadian Manufacturing Firms That Undertake Design Activities: An Empirical Analysis of Results of the Survey of Advanced Technology, 2007

1 Introduction

A number of landmark studies of the benefits accruing to firms emanating from investments in design have resulted in a growing consensus in the literature that design has become central to firm competitiveness, customer loyalty and delivering value-added products (Power, 2004; New Zealand Design Taskforce, 2003; Lash and Urry, 1994). Design has been shown to have a positive influence on 'time to market',[1] new product success rate, percentage of revenue from new products, innovation and export levels (Power, 2004; New Zealand Design Taskforce, 2003; United Kingdom (UK) Design Council, 2005). The increasing productivity gap between the United States (US) and Canada is an area of policy interest in Canada and design has been identified as a critical element in achieving better productivity in Canadian firms (Industry Canada, 2010).

In the secondary literature, there is no generally agreed upon definition of design. According to Lawson (2006) design is difficult to define because it can be applied to a wide range of activities including activities that could be called 'engineering' and others that could be called 'art'. Design can be broadly defined as "the purposeful or inventive arrangement of parts or details" (The American Heritage Dictionary, 2000). Design activities may encompass graphical design; industrial design; fashion and textile design, interior design, furniture design; web design; technical design, design planning and management; and experience design (Danish Design Centre, 2003; UK Design Council, 2005). Design within the firm can be implemented during various phases of production. For example, design can be implemented during the research and development phase, the manufacturing phase, during the creation of retail environments phase and in the branding, packaging and marketing of goods (Gertler and Vinodrai, 2006: 6).

Despite the growing importance of design to firm competitiveness, few studies have been conducted on the use of design among Canadian manufacturing firms. Recent studies on design in Canada have concentrated on the characteristics of design professionals and professional design firms (Gertler and Vinodrai, 2004, Gertler and Vinodrai, 2006, Vinodrai, 2006, Design Industry Advisory Committee, 2004). In addition, much of the evidence on the effects of design on firm performance is derived from European data. There is a gap in the literature relating to the use of design by Canadian firms.

Using the results of Statistics Canada's Survey of Advanced Technology (SAT) 2007, this paper outlines the characteristics of Canadian manufacturing firms that carry out design with a view to explaining factors fostering firms' engagement in design activities. The remainder of the paper is organized as follows. The methodology used to collect and process the data that was used in this paper is outlined in section two. In section three, the characteristics of firms that carry out design activities including industrial and size distribution of firms, percentage of full-time employees engaged in research and development (R&D), adoption of advanced technologies, expenditures on design activities, and exporter status are presented. The relationship between the performance of design and innovation status are explored.

1. Time to market is defined as the time it takes from the conceptualization of a product idea to the time it is ready to be distributed. A faster time to market reflects a better integration of the design, manufacturing and managing processes in a firm (Industry Canada, ND).

The fourth section of the paper focuses on the characteristics of firms that spend a high percentage of their total expenditure on design. Common success factors of high importance reported by high intensity design firms are also discussed.

The fifth section compares the characteristics of firms that spend a large proportion of their expenditures on in-house design activities to those who spend a high percentage of their expenditure on design externally.

The paper concludes with a summary of key findings.

2 Methodology

This paper uses data from the Survey of Advanced Technology (SAT) 2007,[2] a survey that was sent to a stratified random sample of 9,441 manufacturing statistical establishments operating in Canada. Although the collection entity for the survey was the statistical establishment, this paper uses the more familiar term of "firm". The survey used Statistics Canada's Business Register as its frame. In order to be considered for sample selection, the firm had to have at least 20 employees and have at least $250,000 in revenues.

The overall response rate for the SAT 2007 was 72.5% (for manufacturing) for a total of 6,733 completed questionnaires. Response rate is calculated as the total number of completed questionnaires as a percentage of the number of total active, in-scope sample units. This paper will analyse data from the manufacturing sector at the national level or 6,034 completed questionnaires.

The quality of estimates used in this analysis has been assessed based on standard error and imputation rates. Only estimates of publishable quality have been used in this analysis. All comparisons of estimates made within this paper have been evaluated for statistically significant differences. The value of the standard error of each estimate provides a confidence interval of the estimate, the likelihood that the estimate falls within the given range 95 times out of 100. Where confidence intervals for individual estimates overlap, these estimates are said to not be statistically significantly different from each other.

3 Characteristics of manufacturing firms that carry out design activities

The SAT 2007 asked manufacturing firms whether they carried out design activities. The questionnaire specified that design activities may include creative problem solving in the development, engineering, testing and/or communication of designs for products, structures, and/or systems. According to the SAT 2007, Canadian manufacturing firms are more likely than not to carry out design activities. Half (52.0%) of Canadian manufacturing firms indicated they carry out design activities (Table 1).

3.1 Size of manufacturing firms that carry out design activities

Almost half (48.8%) of small firms (20 to 99 employees) indicated they carry out design activities. The probability of a firm carrying out design increases with firm size, from over half (57.6%) among medium-sized firms (100 to 249 employees) to almost two-thirds (64.4%) for large-sized firms (250 and over employees).

2. For detailed information on the methodology of the SAT 2007, please consult *http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SurvId=4223&SurvVer=2&InstaId=14681&InstaVer=4&SDDS=4223&lang=en&db=imdb&adm=8&dis=2.*

Table 1
Percentage of firms indicating they carry out design activities, by size

	Firms that carry out design activities	Firms that do not carry out design activities
	percent	
All firms	**52.0**	**48.0**
Small (20 to 99 employees)	48.8	51.2*
Medium (100 to 249 employees)	57.6	42.4*
Large (250 and over employees)	64.4	35.6*

* Indicates that the two estimates are significantly different at a 95% confidence level
Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

3.2 Industrial distribution of manufacturing firms that carry out design activities

Although design activities are carried out in all industries in the manufacturing sector, the likelihood of a firm to carry out design activities varies from industry to industry. Results from the SAT 2007 show that almost 1 in 3 firms that reported they carry out design activities were either in the fabricated metal product manufacturing (16.0%) or machinery manufacturing (15.1%) industries (Table 2). In these industries, design is an integral part of production processes, owing to the nature of their products. For example, firms in the fabricated metal product manufacturing industry transform metal into semi finished or end products with specific designs, thus in this industry, design plays a pivotal part in the manufacturing process. Common examples of goods produced in this industry are automobile and aircraft parts, metal components used in audio and video devices, aerosol spray cans, silos and prefabricated metal building (Statistics Canada, 2007). Firms in machinery manufacturing industry are primarily engaged in manufacturing industrial and commercial machinery. Many of the firms in the industry specialize in manufacturing machinery for particular applications (Statistics Canada, 2007), thus design considerations are important in their production processes.

Firms in plastics and rubber products manufacturing, transportation equipment manufacturing, furniture and related product manufacturing, wood product manufacturing, and computer and electronic product manufacturing, accounted for over one third (34.2%) of manufacturing firms that indicated they carry out design activities (Table 2). Design is an important activity in automotive, aerospace, wood, furniture, computer and electronic products which generate products than can be used in production processes in these industries.

Table 2
Industrial distribution of manufacturing firms that carry out design activities

	percent
Fabricated metal product manufacturing	**16.0**
Machinery manufacturing industry	15.1
Plastics and rubber products manufacturing	7.7
Transportation equipment manufacturing	7.3
Furniture and related product manufacturing	6.5
Wood product manufacturing	6.4
Computer and electronic product manufacturing	6.3
Food manufacturing	5.6
Miscellaneous manufacturing	5.3
Chemical manufacturing	3.5
Electrical equipment, appliance and component manufacturing	3.5
Non-metallic mineral product manufacturing	3.4
Paper manufacturing	3.4
Printing and related support activities	2.6
Clothing manufacturing	2.3
Primary metal manufacturing	2.0
Textile product mills	1.0
Petroleum and coal product manufacturing	0.9
Textile mills	0.7
Beverage and tobacco product manufacturing	0.4
Leather and allied product manufacturing	0.3

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

Firms in computer and electronic product manufacturing firms had the highest propensity to carry out design activities (79.2%), followed by those in machinery manufacturing (75.4%) (Table 3). The nature of production processes in these industries can have a high component of design. The computer and electronics industry is strongly driven by technological innovation and research and development (R&D). The rapid pace of technological advancement in this industry has created the need for the design and manufacture of innovative products. There is a greater emphasis on R&D in this industry than is typical in most manufacturing operations. Among the products in this industry are consumer electronics, memory chips and radars (Statistics Canada, 2007).

Table 3
Percentage of firms that carry out design activities within each manufacturing industry

	percent
Computer and electronic product manufacturing	**79.2**
Machinery manufacturing industry	75.4
Electrical equipment, appliance and component manufacturing	72.8
Transportation equipment manufacturing	68.1
Furniture and related product manufacturing	61.0
Petroleum and coal product manufacturing	60.6
Paper manufacturing	56.7
Plastics and rubber products manufacturing	56.2
Miscellaneous manufacturing	53.9
Fabricated metal product manufacturing	51.6
Primary metal manufacturing	48.8
Clothing manufacturing	47.0
Leather and allied product manufacturing	47.0
Textile product mills	44.8
Chemical manufacturing	41.2
Non-metallic mineral product manufacturing	41.0
Textile mills	40.9
Wood product manufacturing	38.8
Printing and related support activities	28.6
Food manufacturing	28.2
Beverage and tobacco product manufacturing	23.6

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

3.3 R&D activities

The SAT 2007 asked firms to report the percentage of their full-time employees in 2007 that were involved in research and development (R&D). Over three-quarters (77.0%) of Canadian manufacturing firms had from 1% to 10% of their employees engaged in R&D activities in 2007. Based on this distribution, firms can be classified into two groups: low R&D employee intensive firms (firms that had from 1% to 10% of their employees involved in R&D) and high R&D employee intensive firms (firms with more than 10% of their employees involved in R&D).

Manufacturing firms that indicated they carry out design activities were more likely than not to indicate they had some employees involved in R&D in 2007 (78.3% versus 39.0%). Further, 22.9% of manufacturing firms that indicated they carry out design activities were high R&D employee intensive firms in 2007.

3.4 Advanced technology use

The use of advanced technologies is a key contributor to firm success (Baldwin, Diverty and Sabourin, 1995). Results of the SAT 2007 reveal that manufacturing firms that carry out design activities are more likely to use advanced technologies (98.4%) than those that do not carry out design (84.1%) (Table 4). Also, there is consensus that the number of advanced technologies in use in a firm is a measure of that firm's level of technological sophistication (Beede and Young, 1996; and Jensen and Musick, 1996). Results of the SAT 2007 show that firms that carry out design are more likely than those that do not carry out design to use 5 or more advanced technologies (83.0% versus 51.4%).

Table 4
Design activities and advanced technology use in manufacturing firms

	Firms that carry out design activities	Firms that do not carry out design activities
	percent	
Adopt at least one advanced technology	98.4	84.1
Adopt 5 or more advanced technologies	83.0	51.4

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

3.5 Design expenditures

Firms were asked to report the percentage of their total expenditures in 2007 that was spent on design activities. The majority of firms that carry out design activities (62.0%) spent between 1% to 9% of their total expenditures on design (Table 5). Another 28.0% spent between 10% and 24% of total expenditures on design activities (Table 5). On average, Canadian manufacturing firms that indicated they carry out design activities spent about a tenth (9.7%) of their total expenditures on design activities in 2007.

Table 5
Percentage of manufacturing firms that carry out design activities, by percentage of expenditure on design activities in 2007

Percentage of expenditure on design activities	percent
1 to 9 percent	62.0*
10 to 24 percent	28.0*
25 to 49 percent	6.5*
50 to 74 percent	2.2*
75 and greater percent	1.3*

* Indicates that the two estimates are significantly different at a 95% confidence level
Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

3.6 Export activity of firms that carry out design activities[3]

Evidence suggests that design is a key factor in adding value to products and encouraging exports (New Zealand Design Taskforce, 2003; UK Design Council, 2004). Results of the SAT 2007 show that the majority of the firms that carry out design activities are exporters and that firms that carry out design activities are more likely to be exporters than firms that do not. Approximately 8 out of 10 (82.4%) firms that indicated they carry out design also indicated they exported their products, compared to almost 7 out of every 10 (66.8%) firms that indicated they do not carry out design activities but indicated they exported their products.

Firms that indicated they carry out design activities and were exporters in 2007 were found in all manufacturing industries, however firms in machinery manufacturing (16.3%) and fabricated metal product manufacturing (15.8%) accounted for close to a third of all firms that indicated they carry out design activities and were exporters in 2007 (Table 6). The industrial distribution of exporters closely reflects the overall industrial distribution of firms that carry out design.

3. The SAT 2007 asked respondents to provide an estimate of the percentage of their business unit's total revenue in 2007 that came from the sale of products (goods or service) in different geographical markets. If respondents indicated they had any percentage of sales in geographical markets other than Canada they were categorized as exporters.

Table 6
Industrial distribution of firms that carry out design and export their products in 2007

	percent
Machinery manufacturing industry	**16.3**
Fabricated metal product manufacturing	15.8
Plastics and rubber products manufacturing	8.4
Transportation equipment manufacturing	7.8
Computer and electronic product manufacturing	7.4
Wood product manufacturing	5.6
Furniture and related product manufacturing	5.5
Miscellaneous manufacturing	4.9
Food manufacturing	4.7
Electrical equipment, appliance and component manufacturing	3.9
Chemical manufacturing	3.7
Paper manufacturing	3.6
Non-metallic mineral product manufacturing	2.7
Primary metal manufacturing	2.4
Printing and related support activities	2.2
Clothing manufacturing	2.2
Textile product mills	0.9
Textile mills	0.8
Petroleum and coal product manufacturing	0.7
Leather and allied product manufacturing	0.4
Beverage and tobacco product manufacturing	0.3

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

Firms in the textile mills (96.3%), computer and electronic product manufacturing (94.6%), leather and allied product manufacturing (94.2%) and primary metal manufacturing (94.1%) industries that indicated they carry out design activities have the highest propensities to export their products (Table 7).

Table 7
Percentage of manufacturing firms that carry out design activities that indicated they exported their products in 2007, by industry

	percent
Textile Mills	**96.3**
Computer and electronic product manufacturing	94.6
Leather and allied product manufacturing	94.2
Primary metal manufacturing	94.1
Electrical equipment, appliance and component manufacturing	88.0
Plastics and rubber products manufacturing	86.4
Machinery manufacturing industry	85.8
Transportation equipment manufacturing	85.4
Chemical manufacturing	85.4
Paper manufacturing	85.0
Fabricated metal product manufacturing	79.0
Clothing manufacturing	77.4
Miscellaneous manufacturing	74.6
Wood product manufacturing	70.3
Textile product mills	70.2
Printing and related support activities	67.7
Furniture and related product manufacturing	67.4
Food manufacturing	66.7
Non-metallic mineral product manufacturing	64.5
Beverage and tobacco product manufacturing	60.7
Petroleum and coal product manufacturing	60.0

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

3.7 Innovation and design

Innovation status is an important factor influencing export decision (Danish Design Centre, 2003; UK Design Council, 2004). Product (goods or service) design and innovation,[4] are increasingly seen as interdependent on one another (Gertler and Vinodrai, 2006). Firms worldwide are responding to changes in market forces and rapid technological changes by trying to introduce new products into the market as quickly as possible.

According to the results of the SAT 2007, about 9 out of every 10 firms (88.0%) that indicated they carry out design activities were innovative during the period 2005 to 2007 (Table 8).

Table 8
Selected characteristics of manufacturing firms that carry out design activities by innovation status during the three years 2005 to 2007

	Design performing innovators	Design performing non innovators
	percent	
All firms	**88.0**	**12.0**
Small (20 to 99 employees)	66.9	82.0*
Medium (100 to 249 employees)	22.6	13.4*
Large (250 and over employees)	10.5	4.6*
Employees engaged in R&D and exporter status		
High percentage of employees engaged in R&D	24.5	11.1*
Exporter	82.4	61.7*
Use of advanced technology		
Percentage of firms using at least one advanced technology	98.8	95.6*
Percentage of plants using 5 or more advanced technologies	85.4	65.3*

* Indicates that the two estimates are significantly different at a 95% confidence level
Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

According to the results of the SAT 2007, almost 6 out of every 10 firms (60.2%) that were innovative during the period 2005 to 2007[5] indicated they carry out design activities. It is understandable that not all design activities would necessarily lead to innovation, however, innovation in the absence of design activities is more difficult to reconcile. It is theoretically and practically possible to be innovative without having to carry out design activities. Not all innovation requires design. Also, design may be carried out as “silent design,” that is, design that is undertaken by people who are not professional designers or by people who are not aware that they are designing (Gorb and Dumas, 1987). Finally, corporate accounts may not be sufficiently disaggregated to separate design from R&D, production engineering or development because design activities occur at different stages of production and do not always start or finish at easily quantifiable periods (MacPherson and Vanchan, 2009). These factors can help explain the almost 4 out of 10 innovators (39.8%) who did not report that they perform design.

One quarter (25.4%) of non innovators indicated they carry out design activities. These non innovators that carry out design may be engaged in design for aesthetic purposes, may not have considered the change to be a significant improvement to their product or ultimately did not introduce the changed product to the marketplace.

Firms that indicated they carry out design activities and were non innovative during the period 2005 to 2007 are more likely than their innovative counterparts to be small (82.0% versus 66.9%), less likely to have a high percentage of full time employees engaged in R&D[6] (11.1% versus 24.5%), less likely to be exporters (61.7% versus 82.4%) and less likely to use at least one advanced technology (95.6% versus 98.8%) or use 5 or more advanced technologies (65.3% versus 85.4%) (Table 8).

4. According to the Oslo manual (OECD/Eurostat, 2005:46) innovation is the implementation of a new or significantly improved product (goods or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.
5. These findings must be taken with caution as respondents were not given a time frame within which they performed design activities but they were asked about their innovation status from 2005 to 2007.
6. In this paper, those firms with more than 10% of their employees involved in R&D are referred to as high R&D employee intensive firms.

4 Characteristics of firms with high intensity design

Design activities of firms differ with respect to their intensity, orientation, and use of external knowledge. In this paper, firms spending more than 20% of their total expenditures in 2007 on design are described as firms with high intensity design while those spending between 1% to 20% of their expenditures are considered as firms with low intensity design. According to results of the SAT 2007, only 10.2% of manufacturing firms can be described as firms with high intensity design.

Manufacturing firms with high intensity design are most likely to be found in the fabricated metal manufacturing, machinery manufacturing, and computer and electronic product manufacturing industries. Together, these industries account for over half (53.4%) of the manufacturing firms with high intensity design (Table 9).

Table 9
Percent distribution of manufacturing firms with high intensity design by industry

	percent
Machinery manufacturing industry	21.5
Computer and electronic product manufacturing	18.2
Fabricated metal product manufacturing	13.4
Wood product manufacturing	7.2
Miscellaneous manufacturing	7.2
Plastics and rubber products manufacturing	6.3
Transportation equipment manufacturing	4.9
Electrical equipment, appliance and component manufacturing	4.6
Furniture and related product manufacturing	3.7
Food manufacturing	2.7
Chemical manufacturing	2.2
Clothing manufacturing	2.1
Primary metal manufacturing	2.1
Non-metallic mineral product manufacturing	1.8
Petroleum and coal product manufacturing	1.1
Paper manufacturing	0.4
Textile product mills	0.2
Printing and related support activities	0.2
Textile mills	0.2
Leather and allied product manufacturing	0
Beverage and tobacco product manufacturing	0

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

4.1 Design intensity and R&D intensity

According to the SAT 2007, firms with high intensity design (61.2%) are more likely than firms with low intensity design (25.0%) to be R&D employee intensive firms, that is, they had more than 10% of their employees involved in R&D activities in 2007. This finding is not surprising, given the importance of R&D to design (MacPherson and Vanchan, 2009). It would be interesting to examine the relationship between R&D and design in more detail than is within the scope of this paper.

4.2 Success factors for firms with high design intensity

What a firm considers as a success factor can play an important role in its decision to undertake activities, including design, and therefore can influence the level of firm investment in these activities. Results from SAT 2007 show important differences between low intensity design firms and high intensity design firms with respect to the factors they considered highly important[7] for their firms' success.

7. The SAT 2007 asked respondents to rate the importance of twenty one specified success factors as having a high, medium, or low importance or if the specified success factor was not relevant.

Firms with high design intensity are more likely than low design intensity firms to rate reducing cycle time for new product development and market introduction (55.5% versus 35.4%) as a success factor of high importance (Table 10). This may partly explain their high level of expenditure on design activities. Also, high design intensity firms are more likely than low design intensity firms to rate 'developing new products' (67.9% versus 52.7%), 'recruiting new talents (51.8% versus 39.3%), using teams (cross functional, quality improvement)' (44.2% versus 32.3%), and 'entering new markets' (59.1% versus 48.5%), as success factors of high importance to them.

Table 10
Percentage of manufacturing firms with high and low design intensity indicating high importance of selected success factors

	High design intensity	Low design intensity
	percent	
Reducing cycle time for new product development and market introduction	55.5	35.4*
Developing new products (goods or services)	67.9	52.7*
Recruiting talent	51.8	39.3*
Using teams (cross functional, quality improvement)	44.2	32.3*
Carrying out ongoing technical training	36.3	25.3*
Entering new markets	59.1	48.5*
Securing government support funding	23.2	13.2*
Developing new manufacturing technologies	40.3	30.7*
Developing new methods of manufacturing or producing products	48.0	38.6*
Improving existing products (goods or services)	67.9	58.5*
Reducing manufacturing cost	73.9	74.1
Improving existing methods of manufacturing or producing products	58.3	57.6
Introducing new logistics, delivery or distribution methods for their inputs or products (goods or services)	23.0	18.5
Introducing significantly improved logistics, delivery or distribution methods for firms inputs or products (goods or services)	22.5	19.1

* Indicates that the two estimates are significantly different at a 95% confidence level
Source(s): Statistics Canada, Survey of Advance Technology, 2007.

5 In-house design and externally acquired design expenditures

Firms can perform design through a variety of means: having their own in-house design department, employing designers to work in various departments within their businesses, hiring contractors to work on the design components of specific projects, purchasing the services of an outside design consultancy or using some combination of the various means stated above (Gertler and Vinodrai, 2006).

Studies show that there is a growing trend among industrial firms to hire external sources of technical expertise to support new product design and development (Cofey and Drolet, 1996; Beeseley and Rothwell, 1987). For example, Apple hired external designers to design the Ipod (Economist, 2007). Researchers have concluded that the motivations for externalization of firm activities are to access external expertise that complements the core activities[8] of firms, and lower transaction cost (Cofey and Drolet, 1996; Vanchan, 2006; MacPherson and Vanchan, 2009).

While the outsourcing of some of the non core aspects of the production process of firms is nothing new, recent evidence suggests that some firms are increasingly subcontracting substantial parts of the knowledge component of their complete products to independent business service companies (Bryson et al., 2004, Harrigan, 2006, Pritchard, 2006). For example, Bombardier contracted out some of the R&D and design-related work for its new C-Series regional jet to some European Aerospace companies (Pritchard, 2006). Boeing also outsourced parts of the design of its 787 aircraft (MacPherson and Pritchard, 2007). In all of the above-mentioned cases, substantial parts of the knowledge content of the production processes of firms are being outsourced to high wage nations,

8. Core activities are deemed to be those that underpin the ability of the organization to outperform the competition (McIvor, 2000).

thus the resource-based perspective which states that firms outsource some services in order to access expertise outside of their organizational boundaries offers a more potent explanation for this practice (Harrigan, 2006, Pritchard, 2006), however, for other firms, the decision to outsource design could reflect a mix of cost and resource availability factors.

Results from SAT 2007 reveal that 62.1% of manufacturing firms that carry out design activities carry out these activities inhouse only. On the other hand, only 2% of manufacturing firms that carry out design activities reported that they outsource all of their design activities. The results from this survey also show that 9 out of every 10 (90.2%) Canadian manufacturing firms that carry out design activities spent a greater proportion of their expenditures on design in-house.[9] The remaining 9.8% spent an equal or larger percentage of their design expenditures on externally acquired design services (outsourced). Some firms may not consider some of their design activities sacrosanct and may decide to outsource all or a significant proportion of their design activities.

Firms in fabricated metal manufacturing (16.4%), machinery manufacturing (16.2%), plastics and rubber products manufacturing (7.8%), transportation equipment manufacturing (7.3%), and computer and electronic product manufacturing (6.5%) account for over half (54.2%) of the firms that had a larger proportion of design activity expenses in-house than externally (Table 11). It could be argued that for such industries, design is such an intrinsic part of their production process that it could not be outsourced.

Table 11
Industrial distribution of manufacturing firms with a greater percentage of their expenditures on design activities in-house than were outsourced

	percent
Fabricated metal product manufacturing	**16.4**
Machinery manufacturing industry	16.2
Plastics and rubber products manufacturing	7.8
Transportation equipment manufacturing	7.3
Computer and electronic product manufacturing	6.5
Furniture and related product manufacturing	6.2
Wood product manufacturing	6.2
Food manufacturing	5.4
Miscellaneous manufacturing	5.4
Electrical equipment, appliance and component manufacturing	3.4
Chemical manufacturing	3.2
Paper manufacturing	3.1
Non-metallic mineral product manufacturing	2.7
Printing and related support activities	2.7
Clothing manufacturing	2.4
Primary metal manufacturing	1.8
Textile product mills	1.1
Petroleum and coal product manufacturing	0.7
Textile mills	0.7
Beverage and tobacco product manufacturing	0.3
Leather and allied product manufacturing	0.3
Total	100

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

Firms in the textile product mills manufacturing (98.5%), machinery manufacturing (96.7%), clothing manufacturing (95.7%) and electrical equipment, appliance and component manufacturing (95.0%) had the highest propensities to have a greater percentage of their design expenditures in-house (Table 12). This result is not surprising given the importance that design can have in these industries. For example, textile product mills process fiber into fabric and fabric into clothing and other textile products. In firms where design activities are carried out, designers can play a significant role in the production processes in this industry.

9. The SAT 2007 asked manufacturing firms that had indicated they carry out design activities to indicate the proportion of their expenditures on design in 2007 in three areas: those that were in-house (in the enterprise); by other enterprise or operations of their larger firm; and the proportion that was for externally acquired design services not carried out by other enterprise or operations of their larger firm. Firms with “in-house” expenditures refer to those with any expenditures on design in either of the first two areas.

Table 12
Percentage of firms with a greater percentage of their design expenditures that were in-house than were outsourced, by industry

	percent
Textile product mills	98.5
Machinery manufacturing	96.7
Clothing manufacturing	95.7
Electrical equipment, appliance and component manufacturing	95.0
Printing and related support activities	94.3
Miscellaneous manufacturing	93.7
Textile mills	93.4
Computer and electronic product manufacturing	93.1
Fabricated metal product manufacturing	92.6
Transportation equipment manufacturing	91.0
Plastics and rubber products manufacturing	90.7
Leather and allied product manufacturing	88.0
Wood product manufacturing	87.4
Furniture and related product manufacturing	87.2
Food manufacturing	86.6
Chemical manufacturing	82.3
Primary metal manufacturing	81.9
Paper manufacturing	80.9
Beverage and tobacco product manufacturing	79.5
Non-metallic mineral product manufacturing	72.3
Petroleum and coal products manufacturing	68.6
Total	100

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

5.1 Expenditures on outsourced design services

Firms in fabricated metal manufacturing industries (12.2%) non-metallic mineral product manufacturing (9.7%), furniture and related product manufacturing (8.6%) and wood product manufacturing (8.3%) were the most likely among manufacturing firms that carry out design activities to spend an equal or higher proportion of their design expenditure on externally acquired sources of design services (Table 13). Firms in these industries may outsource design activities in order to concentrate on their core activities or to access to specialized design services not available within their firm.

Table 13
Industrial distribution of manufacturing firms with expenditures on design in 2007 with an equal or greater percentage of their design expenditures on externally acquired design services than in-house

	percent
Fabricated metal product manufacturing	**12.2**
Non-metallic mineral product manufacturing	9.7
Furniture and related product manufacturing	8.6
Wood product manufacturing	8.3
Food manufacturing	7.8
Plastics and rubber products manufacturing	7.5
Paper manufacturing	6.8
Transportation equipment manufacturing	6.8
Chemical manufacturing	6.4
Machinery manufacturing industry	5.2
Computer and electronic product manufacturing	4.5
Primary metal manufacturing	3.8
Miscellaneous manufacturing	3.4
Petroleum and coal product manufacturing	3.0
Electrical equipment, appliance and component manufacturing	1.8
Printing and related support activities	1.5
Clothing manufacturing	1.0
Beverage and tobacco product manufacturing	0.8
Textile mills	0.5
Leather and allied product manufacturing	0.4
Textile product mills	0.2
Total	100

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

Firms in the petroleum and coal products manufacturing (31.5%), non metallic mineral product manufacturing (27.7%) and beverage and tobacco product manufacturing industries (20.5%) had the highest propensities to spend an equal or greater percentage of their design expenditures on externally acquired design services (Table 14).

Table 14
Percentage of manufacturing firms with expenditures on design in 2007 that had an equal or greater percentage of design expenditures on externally acquired services, by industry

	percent
Petroleum and coal products manufacturing	31.5
Non-metallic mineral product manufacturing	27.7
Beverage and tobacco product manufacturing	20.5
Paper manufacturing	19.1
Primary metal manufacturing	18.1
Chemical manufacturing	17.7
Food manufacturing	13.4
Furniture and related product manufacturing	12.9
Wood product manufacturing	12.6
Leather and allied product manufacturing	12.1
Plastics and rubber products manufacturing	9.3
Transportation equipment manufacturing	9.0
Fabricated metal product manufacturing	7.4
Computer and electronic product manufacturing	6.9
Textile mills	6.6
Miscellaneous manufacturing	6.3
Printing and related support activities	5.7
Electrical equipment, appliance and component manufacturing	5.0
Clothing manufacturing	4.3
Machinery manufacturing	3.3
Textile product mills	1.5

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

5.2 Firm size and location of design activities

Firm size does not appear to be a factor in whether design expenditures are in-house or acquired externally (Table 15). There are no significant differences among small, medium and large firms that spend a higher percentage of their design expenditure in 2007 in-house and those that spend an equal or higher percentage of their design expenditures in 2007 on externally acquired design services.

Table 15
Size distribution of firms that carry out design by level of expenditure on design that is spent in-house and externally

	Firms that spend an equal or greater percentage of their design expenditures on externally acquired design services	Firms that spend a greater percentage of their expenditures on design in-house
	percent	
Small (20 to 99 employees)	63.8	69.2
Medium (100 to 249 employees)	22.1	21.4
Large (250 and over employees)	14.2	9.3

Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

5.3 R&D activities and location of design activities

Results of the SAT 2007 show that the decision to carry out design activities within the firm or to outsource design services is related to the percentage of full-time employees within the firm that are involved in R&D activities. Firms that spend the majority of their design expenditure in-house in 2007 are more likely to have a high percentage (over 10%) of their full-time employees involved in R&D in 2007.[10] About 1 in 10 firms (12.7%) that outsourced an equal or greater percentage of their design activities were high R&D employee intensive firms, compared to about a quarter (24.0%) of firms that spent greater percentage of their design expenditure in-house (Table 16).

Table 16
Percentage of firms with design expenditures in 2007 by concentration of employees involved in R&D activities

	Equal or greater percentage of design expenditures from externally acquired design services	Majority of design expenditures spent in-house
	percent	
High R&D employee intensive firms	12.7	24.0*
Low R&D employee intensive firms	87.3	76.0*

* Indicates that the two estimates are significantly different at a 95% confidence level
Source(s): Statistics Canada, Survey of Advanced Technology, 2007.

This finding is not surprising because firms with a high percentage of employees involved in R&D activities could have the resources to perform design in house and would not need to acquire design services externally. While this outcome agrees with the resource-based theory of outsourcing (Harrigan, 2006; Pritchard, 2006), it also opens up the debate about the nature of the relationship between R&D and design.

10. Respondents to the SAT 2007 were asked to provide their best estimate of the percentage of full-time employees in their enterprise in 2007 who were involved in R&D activities.

6 Summary and next steps

The results of the SAT 2007 show that Canadian manufacturing firms are more likely than not to carry out design activities. It also shows that about a third of firms that carry out design activities are in the fabricated metal product manufacturing and machinery manufacturing industries.

Among industries, firms engaged in computer and electronic product manufacturing and those in machinery manufacturing had the highest propensities to perform design. It could be argued that these are industries who supply technologically sophisticated goods, which require considerable design intensity.

Firms that carry out design activities were found to be more likely to be exporters than firms that do not carry out design activities.

Size is an important factor in the likelihood of a firm performing design activities. Larger firms are more likely than smaller ones to engage in design activities.

The results of the survey also show that firms that carry out design activities are more likely to be innovators during the period 2005 to 2007 than those that do not carry out design. About 9 out of every 10 firms that perform design were found to be innovators during the period 2005 to 2007. The main differences between design performing firms that are innovators compared to the non innovators are that the firms in the latter group are more likely to be small firms, less likely to be exporters, less likely to be using advanced technologies and less likely to have a high percentage of their employees involved in R&D activities.

Not all innovators carry out design activities. Results of the survey have found that about 6 out of every 10 innovators carry out design. This is an interesting finding as it would be expected that innovation involves some element of design. Is it the case that those firms who are innovators but do not perform design are process, organizational or marketing innovators and not product innovators? On the other hand, is it a case that firms do not necessarily recognize the role of “silent design”? It would be interesting to explore the relationship between innovation and design further.

Firms with high design intensity are more likely than firms with low design intensity to emphasize success factors such as reducing cycle time for new product development and market introduction, developing new products, recruiting new talents, entering new markets, and developing new manufacturing technologies.

The results of the survey also show that firms that spent an equal or greater percentage of their design expenditures on externally acquired design services are likely to be firms that do not have a high percentage of their full-time employees involved in R&D activities.

This paper has presented some findings on the relationship between design and innovation, firm size, industrial distribution, exporter status. It has confirmed some previous findings on the relationship between outsourcing of work and availability of in-house expertise; however, it has also provided opportunities for further research on the relationship between design and R&D, and design and innovation. Another area of interest is the financial performance of high design intensity firms. Do these firms show better results than low design intensity firms? Do firms that carry out design activities perform better than those that do not? These questions could be explored by linking survey results to financial data.

7 References

Baldwin, J., B. Diverty and D. Sabourin. 1995. *Technology Use and Industrial transformation: Empirical Perspectives*. Analytical Studies Research paper no. 75. Ottawa: Statistics Canada.

Beede D.N. and K.H. Young. 1996. Patterns of Advanced Technology Adoption and Manufacturing Performance: Employment Growth, Labor Productivity, and Employee Earnings. Economics and Statistics Administration, ESA OPD, 96-1, February 1996.

Beesley, N. and R. Rothwell. 1987. Small firm linkages in the United Kingdom. In Rothwell, R. and Bessant, J. (ed). Innovation, Adaptation and Growth (Elsevier, Amsterdam).

Bryson, J.R., P.W. Daniels and G. Rusten. 2004. Design workshops of the world: the production and integration of industrial design expertise into the product development and manufacturing process in Norway and the United Kingdom. Working Paper no. 53/04. Design Norwegian Competitiveness, Institute for Research in Economics and Business Administration.

Coffey, W.J. and R. Drolet. 1996. Make or Buy: internalization and externalization of producer service inputs in the Montreal metropolitan area. *Canadian Journal of Regional Science* 19 (1): 25-48.

Danish Design Centre. 2003. 'The economic effects of design. Published by the National Agency for Enterprise and Housing, Denmark, September, 2003. Available at: *www.ebst.dk/file/1924/the_economic_effects_of_design.pdf*.

Design Industry Advisory Committee. 2004. What can 40,000 designers do for Ontario? Design matters. Toronto: Design Industry Advisory Committee.

Gertler, M.S. and T. Vinodrai. 2005. "Anchors of Creativity: how do public universities create competitive and cohesive communities?" In *taking public universities seriously.* Frank Iacobucci and Carolyn Tuohy. Toronto: University of Toronto Press.

Gertler, M.S. and T. Vinodrai. 2006. *Better by Design? Capturing the Role of Design in Innovation*, in OECD (2006a).

Gertler, M.S. and T. Vinodrai. 2004. 'Designing the Economy: A profile of Ontario's Design Workforce', Prepared for the Design Industry Advisory Committee, University of Toronto.

Gorb, P. and A. Dumas. 1987. Silent Design. *Design Studies*, 8, pp. 150-156.

Harrigan, F. 2006. Integrating theories of boundary choice: a case of the global aircraft industry. UCD School of Business, University College Dublin: *http://www.eaa2006.com/pdf/EAA2006_0794_paper.pdf* (last accessed February 10, 2009).

Industry Canada. State of design: The Canadian Report 2010. Industry Canada Publications: Ottawa.

Jensen B.J. and N. Musick. 1996. Trade, Technology, and Plant Performance. Working Papers on Industrial and Economic Performance, Office of Policy Development, Economics and Statistics Administration, US Department of Commerce.

Lash S. and J. Urry. 1994. The Economies of Signs and Space. Sage.

Lawson, B. 2006. *How Designers Think*. Boston: Elsevier.

MacPherson, A. and V. Vanchan. 2009. The Outsourcing of Industrial Design Services by Large US Manufacturing Companies. *International Regional Science Review*.

MacPherson, A. and D. Pritchard. 2006. Outsourcing innovation: the case of the Boeing 787. In press, Journal of Labor Research.

McIvor, R. 2000. A Practical Framework for Understanding the Outsourcing process (2000), Supply Chain Management, Vol 5, number 1, pp. 22-36.

New Zealand Design Taskforce. 2003. Success in design. A report and strategic plan from the design taskforce, in partnership with the New Zealand government in support of the growth and innovation framework. New Zealand.

New Zealand Design Taskforce. 2003. Success by design: A report and Strategic Plan. A report prepared in collaboration with the New Zealand government. (accessed on 11th march 2009). Available at *http://www.nzte.govt.nz/common/files/design-strategy.pdf*.

Organisation for Economic Co-operation and Development (OECD)/EUROSTAT. 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd edition, OECD, Paris.

OECD. 1992. Technology and the Economy: The key relationships, OECD Publications, Paris.

Power, D. 2004. The future in design: The Competitiveness and industrial dynamics of the Nordic design industry. Uppsala Sweden: Centre for research into innovation and industrial dynamics.

Pritchard, D.J. 2006. The launch process for the Bombardier C-Series regional jet: Implications for Canadian Trade and Employment. Canada-United States Trade Center Department of Geography State University of New York Buffalo, New York.

Saxenian, A. 1994. *Regional Advantage, Culture and Competition in Silicon Valley and Route 128*, Harvard University Press, Cambridge, Massachusetts.

Statistics Canada. 2007. North American Industry Classification System (NAICS) Canada Catalogue no. 12-501-XIE Statistics Canada Publications: Ottawa.

The American Heritage Dictionary. 2000. The American Heritage Dictionary of the English Language, Fourth Edition, Houghton Mifflin Company, United States.

The Economist. 2007. Lessons from Apple. June 7 [*http://www.economist.com*], Quoted from MacPherson, A. and V. Vanchan. 2009. The Outsourcing of Industrial Design Services by Large US Manufacturing Companies. *International Regional Science Review,* 2009.

UK Design Council. 2004. Design in Britain 2004-2005. Available at *http:www.design council.org.uk.*

Vanchan, V. 2006. Communication and relationships between industrial design companies and their customers. The Industrial Geographer, Volume 4, issue 2, p. 28-46.

Vinodrai, T. 2006. Reproducing Toronto's design ecology: Career paths, intermediaries, and local labour markets. Economic Geography 82(3): 237-263.