**Preliminary Draft**



# Innovation of SMEs in the Knowledge-Based Economy

Frank C. Lee
Micro-Economic Policy Analysis Branch
Industry Canada

and

Keith Newton
School of Public Administration
Carleton University

September 11, 2000

## ABSTRACT

In the knowledge-based economy, innovation is the key driver of success. SMEs, with their dynamism, adaptability and flexibility, constitute a central component of the innovative economy. This paper attempts to shed light on the role of SMEs in today's knowledge-based economy by reviewing a number of empirical papers associated with innovation and firm size. The paper addresses sources of innovation as well as the impediments faced by SMEs. Lastly, the paper raises some policy challenges facing SMEs in the new economy.

The authors wish to thank Robert Dunlop for helpful comments. The views expressed in this paper are those of the authors and are not necessarily those of Industry Canada.

## 1. Introduction

Much has been written about the knowledge-based economy (KBE)[1]. The concept is becoming widely familiar and needs little elaboration here. Suffice it to say that countries worldwide are witnessing the evolution of this global knowledge-based economy in which technological advances, particularly in information and communication technologies (ICTs), both facilitate and at the same time reflect the process of knowledge accumulation and diffusion. Most importantly, for present purposes, this process is the means to foster and sustain the rapid and continuous innovation that is crucial for survival and prosperity in the fiercely competitive KBE. Accordingly, for policy and decision makers, in both the public and private sectors, the innovative capacity of national economies, of regions, industries, and individual firms, is of considerable importance. The characteristics and structure of the economy that may affect innovation --market structure, competitive climate, industrial organization, institutional infrastructure, for example-- therefore require close analysis. One of the most important among this array of factors that relate to innovation or "innovativeness" is the question of firm size, and for very good reason.

As table 1 shows, small and medium-sized enterprises (SMEs)[2] account for substantial proportions of economic activity in many advanced economies. The proportion of all firms accounted for by SMEs in practically all OECD countries now stand at over 95 per cent. SMEs' contribution to employment is now generally more than 50 per cent. Contributions to GDP are somewhat smaller, but nevertheless substantial.

[1] See , e.g. OECD (1997c); for Canadian examples: Lee and Has (1996); Gera, Lee-Sing and Newton (2000).
[2] It should be pointed out at the outset that the small firm population is extremely heterogeneous, running the gamut from the hot-dog stand to the would-be "dot com". Thus it is important to bear in mind both industry differences as well as differences in the characteristics of small firms within industries when considering innovative capacity.

**Table 1. The Role of Small and Medium-sized Enterprises (SMEs)[2] in National Economies**

Percentages

| | SMEs as a percentage of enterprises | Employment | SME contribution to GDP |
|---|---|---|---|
| Australia | 96.0 | 45.0[3] | 23.0[3] |
| Belgium | 99.7 | 72.0 | n.a. |
| Canada | 99.8 | 60.0[4] | 57.2[4] |
| Denmark | 98.8 | 77.8 | 56.7 |
| Finland | 99.5 | 52.6 | n.a. |
| France | 99.9 | 69.0 | 61.8[5] |
| Germany | 99.7 | 65.7 | 34.9 |
| Greece | 99.5 | 73.8 | 27.1[6] |
| Ireland | 99.2 | 85.6[3] | 40.0 |
| Italy | 99.7 | 49.0[4] | 40.5 |
| Japan | 99.5 | 73.8[4] | 57.0[5] |
| Netherlands | 99.8 | 57.0 | 50.0 |
| Portugal | 99.0 | 79.0 | 66.0 |
| Spain | 99.5 | 63.7 | 64.3[5] |
| Sweden | 99.8 | 56.0[8] | n.a. |
| Switzerland | 99.0 | 79.3 | n.a. |
| U.K. | 99.9 | 67.2 | 30.3 |
| U.S. | 99.7 | 53.7 | 48.0 |

1. SMEs definition varies across countries but most countries define SMEs as having less than 500 employees. Some countries such as Italy and Sweden define them as having less than 200 employees.
2. All data are for 1991, except Spain, Canada and Ireland (1989), Germany, Greece and Italy (1988), the Netherlands and France (1990).
3. Manufacturing only
4. For Canada, percentage of sector employment and GDP in 1993.
5. Percentage of value added.
6. Percentage of value added in manufacturing.
7. Percentage of sales.
8. Percentage of private sector employment in 1992.

Source: OECD (1997b).

While the evidence suggests that the size distribution of firms has tilted towards the SME end of the spectrum in many countries, one of the more interesting questions concerns the *dynamics* of employment change. Table 2 illustrates, for selected OECD countries and various time periods, the rates of gross job creation and loss, based on longitudinal data bases. The rates for both indicators decline monotonically with firm size, suggesting greater dynamism, as well as turbulence, among SMEs.

With the exception of the U.S. in the period 1973-88 the small firm sector is a superior net creator of jobs.

**Table 2. Job Creation and Loss Rates[1] by Size of Establishment**
Percentages

| | Number of employees | | | | | |
|---|---|---|---|---|---|---|
| | 0-19 | 20-49 | 50-99 | 100-499[2] | 500+[3] | Total |
| **Canada, 1978-92** | | | | | | |
| Gross job creation | 26.7 | 14.9 | 13.0 | 11.1 | 5.9 | 13.4 |
| Gross job losses | 18.6 | 14.6 | 13.8 | 11.9 | 7.1 | 12.1 |
| Net job creation | 8.1 | 0.3 | -0.7 | -0.8 | -1.2 | 1.3 |
| **Denmark, 1985-86** | | | | | | |
| Gross job creation | 30.3 | 15.5 | 13.2 | 12.6 | 7.6 | 17.1 |
| Gross job losses | 18.6 | 11.5 | 11.9 | 10.4 | 11.0 | 12.9 |
| Net job creation | 11.7 | 4.0 | 1.3 | 2.2 | -3.4 | 4.2 |
| **Germany, 1978-93** | | | | | | |
| Gross job creation | 14.7 | 9.0 | 6.6 | 5.5 | 1.7 | |
| Gross job losses | 12.3 | 18.6 | 13.4 | 18.7 | 8.2 | |
| Net job creation | 0.7 | 1.0 | 0.1 | 0.2 | -0.8 | |
| **U.K., 1985-91** | | | | | | |
| Gross job creation | 15.0 | 8.2 | 8.1 | 7.4 | 4.0 | 8.2 |
| Gross job losses | 10.7 | 7.7 | 5.7 | 5.7 | 3.7 | 6.4 |
| Net job creation | 4.7 | 0.6 | 2.6 | 1.7 | 0.3 | 1.9 |
| **U.S., 1973-88** | | | | | | |
| Gross job creation | 18.7 | 13.2 | 12.2 | 9.6 | 5.4 | |
| Gross job losses | 23.3 | 15.3 | 13.5 | 10.7 | 5.6 | |
| Net job creation | -4.5 | -2.1 | -1.3 | -1.1 | -0.2 | |

1. Percent of initial employment.
2. Germany and the U.S., 100-249.
3. Germany and the U.S., 5000+.

Source: Schreyer (1997).

Given the critical importance of innovation in the KBE, and given the very significant contribution of SMEs to the economies of many countries, including Canada, a priority question for policy research is quite simply: just how innovative is that substantial sector of the economy that is made up of SMEs?

There has been a long and lively debate about the version of the "Schumpeterian hypothesis" that maintains that large firms innovate more than small (You, 1995). Thus, for example, it is alleged that larger firms with superior resources can afford to do R&D, access technological information, forge partnerships with universities and governments, and so on. Small firms are said to be more flexible or "nimble" and to have closer relations with customers and suppliers. Drawbacks for large firms might include certain dangers of sclerosis: unwieldiness, hierarchy, rigidity, communication problems, impersonality, etc. Small firms, by contrast, may be less hidebound by tradition and procedure, and have speedier and more personal communication. In any event, for present purposes a convenient point of departure is the observation that "the most notable feature of the considerable body of empirical research on the relationship between firm size and innovation is its inconclusiveness" (Cohen and Levine, 1989 p. 1069).

This paper does not attempt a comprehensive review of the literature relating to innovation and firm size. Rather, it is an attempt to illustrate some of the various empirical approaches to this question and to pull together some of the most recent evidence on this topic. While many of the references are Canadian, the issues are sufficiently generic, and the findings sufficiently representative, as to be of interest to a wider readership. Before turning to the empirical evidence in sections 3 and 4, we briefly take up the meaning of innovation or "innovativeness" and, without offering a single definition, try to emphasize the various dimensions and indicators of the concept. As far as policy implications are concerned we offer two perspectives: section 5 sets out some of the factors that are conducive to, and some that are barriers to, innovation; section 6 alludes to certain generic policy approaches that might usefully be considered by decision makers. Concluding remarks follow.

## 2. Interpreting Innovation

Before turning to the question of the relationship between innovation and firm size we briefly address the concept of innovation itself since it is variously defined, comes in many guises, and is measured in different ways.

Innovation can be broadly defined as "*the ability to manage knowledge creatively in response to market-articulated demands and other social trends*" (OECD, 1999b). In this study, we focus on the economic aspects of innovation. We therefore lean towards a narrower definition suggested by Baldwin and Scott (1987) who follow Schumpeter's definition of innovation as: "*a change in a firm's production function, resulting either from production of a new product or introduction of a new production process or, in less rigorous terms, the economic implementation of knowledge and invention. Innovators are those who first make economic use of ideas or discoveries (inventions) they may or may not have originated. The innovator brings together and organizes a set of inputs to produce a new product and introduce it to the market, or to implement a new production process*".

In considering the concept of innovation, an important distinction is between "hard" technological innovations (robots, lasers, CAD/CAM systems) and "soft", "complementary" innovations (innovations in organizational design, human resource management, etc.). Indeed, with respect to process innovations, there is an extensive literature demonstrating that new machinery, equipment and software require innovative organizational settings, management practices and worker skills if their potential is to be realized (Betcherman, 1996; Newton, 1996). Since knowledge resides in, and is created and diffused by people, the human side of innovation is of paramount importance. Thus innovative concepts such as the high performance workplace, the learning firm, and the development and management of intellectual capital are receiving increasing attention (Newton and Magun, 2000).

If defining innovation is difficult, then measuring it is equally so. Various indicators and proxies can be invoked. R&D and patents, despite well-known drawbacks, continue to be widely used in the empirical literature. Many surveys (e.g. Betcherman and McMullen, 1986) count the proportion of firms using some generic technology (computer-based technologies--CBTs--for example) and/or a set of complementary organizational innovations (such as job redesign; employee involvement; teams; contingent compensation, etc.). Others (e.g. Baldwin and Sabourin, 1998) examine the use of a set of, e.g., advanced manufacturing technologies (AMTs). Attempts to address the people side of innovation might examine the skills and competencies of firms' "knowledge workers" using proxies such as the proportion of the workforce with a degree, or the number of scientists and engineers. In some cases, it is not just the use (or not) of a technology or innovation that is important, but also the *number* of innovations adopted or the *rate* of innovation (per number of employees, for example). Certain qualitative dimensions could also be important. For instance, the novelty of the innovation: is this new just to the firm or industry, or is it a "Canadian first" or even "world first"? Second, speed is of the essence in the innovation process, so one might want to try to measure speed-to-market, frequency of innovation, or the proportion of the firm's products that are new. Third, impact: is the innovation an incremental refinement in a limited area, or a radical, revolutionary breakthrough with myriad pervasive applications?

Finally it is important to view innovation as a *process* involving: various sources; the objectives that the innovation is designed to pursue; impacts on the production process (in the case of process innovations) and/or the market ( in the case of product innovations); the benefits conferred on the innovating firm; and the impediments that hinder innovative activities. A yet-wider context would point to the "systems of innovation" (national, regional, local) within which the innovating firm operates--the various actors in the system, the infrastructure, and the institutional and policy frameworks. These factors all have fundamental implications for the innovative capacity of the individual firm.

## 3. Innovation and Firm Size

### *3.1 R&D, Patents and Firm Size*

There have been many empirical studies investigating the relationship between innovation and firm size. Virtually all past empirical studies relied on a proxy measure of innovation since, as shown above, there is no standard indicator called "innovation". Typically the indicators fall into three broad categories (Acs and Audretsch, 1991; Archibugi and Pianta, 1996). The first category focuses on innovation *inputs*. These include such measures as research and development (R&D) expenditures or the number of researchers. The second category relies on patent statistics to measure an intermediate *output* of innovation. The last category attempts to measure innovative output based on surveys, case studies, expert opinion, etc. Both R&D and patents are proxy measures of innovation and both have conceptual shortcomings. For example, R&D only indicates resources used to produce innovative output, but it may not capture the amount of resulting innovation outcome. It is, in other words, an input of the innovation process, but not an output. R&D is neither a necessary nor sufficient condition for innovation: many innovations stem from sources other than R&D, and much R&D activity does not yield any innovations.

Many researchers have relied on patents as an output indicator of the innovation process. However, patents have their own weaknesses. First, many patents are not commercialized--

suggesting that many of them do not result in innovative output. Second, many commercialized ideas are in fact not patented. Next, there is considerable variation in the economic value of patents. Finally, there are significant differences in the propensity to patent across firms, industries and countries. Nevertheless, despite their weaknesses, patent data are widely used[3] and there have been extensive empirical studies relating R&D and patents to firm size.

Although empirical results are mixed, the overall empirical evidence on R&D and firm size seems to support the Schumpeterian firm size hypothesis in that R&D expenditures appear in many studies to increase at least proportionally with firm size (Acs and Audretsch, 1993; Freeman and Soete, 1997; Symeondis, 1996; Cohen and Levin, 1989; Baldwin and Scott, 1987).

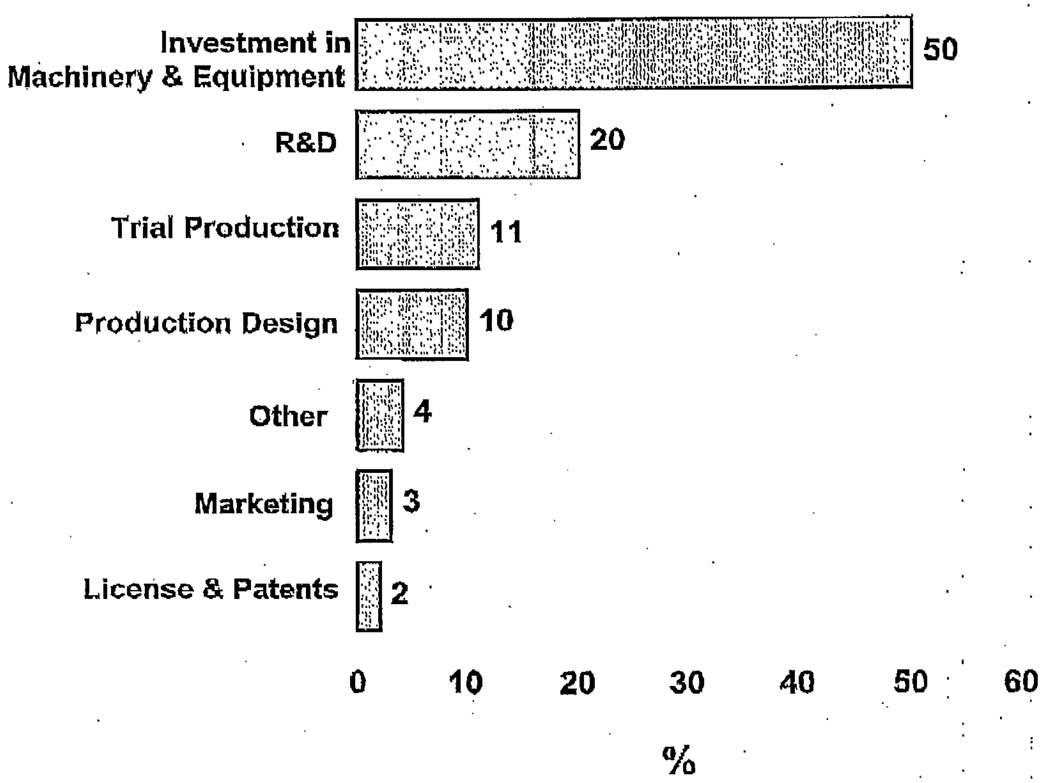
To this conclusion one might add the following proviso, postulated in Freeman and Soete (1997). Of the small firms that do perform R&D, there are two important categories. First, those that have just begun to exploit a new invention and whose sales are therefore low relative to R&D. Second, those with a special, R&D-sustained expertise in a narrow field. In both cases one would observe high R&D-to-sales ratios. Moreover, the authors contend on the basis of the rapid growth of science parks and the number of university spin-offs, that the proportion of small firms in these two categories has grown in recent decades. So one might suppose that the small firm contribution to the innovative capacity of the economy, at least in terms of R&D, has been increasing.[4]

The Schumpeterian size hypothesis seems to have been challenged by empirical studies relating patent activity and firm size. Thus, patent activity appears to increase less than proportionally to firm size (Acs and Audretsch, 1993; Baldwin and Scott, 1987; Cohen and

[3] For a recent example using Canadian and US patent data, see Trajtenberg (2000).
[4] In addition, Almeida (1999) and Audretsch (1999) observe that new small firms turn outside for knowledge to build their innovation capacity. At the same time, they also share knowledge with other local firms thereby playing

Levin, 1989). This apparent paradox was partly explained by Acs and Audretsch (1991) who found that the productivity of R&D (as measured by patents) decreased with firm size --although it should be noted that their findings were based on a sample of high R&D firms with relatively few small firms.

**Figure 1. Share of Innovation Expenditure (13 European Countries)**




Source: Evangelista, R. *et al.* (1997).

---

an important role in building regional knowledge networks. On the other hand, larger firms perceive themselves to be more self-reliant and do not actively engage in building networks with local organizations.

In any event, innovation involves much more than R&D or patent activity. Figure 1 shows the shares of innovation expenditures[5] based on 13 European countries. It should be noted that firms spend significant amounts on non-R&D related activities. What is interesting, however, is that the evidence of such expenditure patterns shows that the R&D share of innovation expenditure increases with firm size (Evangelista *et al.*, 1997).

### *3.2 Innovation Output and Firm Size*

Over the last twenty years, there have been a number of empirical studies using special survey data to better understand innovation activity. These surveys attempted to directly measure innovative output (or commercialized innovations). An exhaustive review is beyond the scope of this paper, but for illustrative purposes the four surveys mentioned below can be grouped into two stylized sets that may give the reader a flavour of possible approaches. The first group follows the "object" approach in that it is based on the hindsight identification of innovations identified by expert opinion or technical journals. The second group is based on the "subject" approach inasmuch as the identification of innovation relies on the respondents' assessments of their own innovations.[6]

The U.S. Small Business Administration (SBA) constructed a database that uses the number of innovations as the measure of innovative output in each of four-digit SIC U.S. manufacturing industries in 1982 (Acs and Audretsch, 1990). Innovation is here defined as "a process that begins with an invention, proceeds with the development of the invention, and results in the introduction of a new product, process or service to the marketplace" and was identified by examining over 100 technology, engineering and trade journals.[7] In somewhat

[5] Includes expenditures for the following six items: R&D; patents and licenses; production design; trial production and tooling up; marketing; investment in plant, machinery and equipment.
[6] See Archibugi and Pianta (1996) for advantages and disadvantages associated with each approach.
[7] The innovations recorded in 1982 as a result of inventions made, on average 4.3 years earlier.

similar vein, the Science Policy Research Unit (SPRU) at the University of Sussex compiled an innovation database over the period 1945-1983 in which innovations were identified on the basis of technical experts' opinions of successfully commercialized innovation in the U.K. (Pavitt, Robson and Townsend, 1987).

Two other sets of surveys basically follow the "subject" approach. The Centre for Business Research (CBR) at the University of Cambridge conducted three separate surveys on U.K. SMEs since 1990 (Cosh, Hughes and Wood, 1999). Innovations were identified on the respondents' own assessment of innovation. Second, Statistics Canada's 1993 Survey of Innovation and Advanced Technology (SIAT) also relied on self-identification (Baldwin, 1997), as did Statistics Canada's 1989 Survey of Manufacturing Technology and the 1998 Survey of Advanced technology in Canadian Manufacturing (Baldwin, Rama and Sabourin, 1999) as well as the 1996 Survey of Innovation (Gellatly, 1999; Gellatly and Peters, 1999).

From this latter set of survey evidence, Baldwin (1997) compared innovation by firm size for Canadian manufacturing based on the 1993 Survey of Innovation and Advanced Technology (SIAT). He found that the proportion of innovating firms increases with the size of firm as shown in Table 3. In fact, the Table shows that the incidence of innovation increases from 30% for micro-firms to 63% in the large firm group. Furthermore, Baldwin and Sabourin (1998)'s study, based on the 1993 SIAT for Canada and the 1993 Survey of Manufacturing Technology for the US, reveals that SMEs lag behind large establishments in adoption of at least one advanced technology in both Canada and the United States.[8] Moreover, large establishments use multiple technologies more than small establishments.

[8] The results are based on both Canadian and U.S. surveys on manufacturing technology. Advanced technologies include, computer-aided designing and engineering (CAD/CAE); digital representation of CAD output; use of robots; local area networks for technical data; computers used for control in factories, etc.

**Table 3. Percentage of Firms with Product/Process Innovation in Canadian Manufacturing, 1989-91**

| | Number of employees | | | | |
|---|---|---|---|---|---|
| | All firms | 0-19 | 20-99 | 100-499 | 500+ |
| Product or process innovations | 34.2 | 29.9 | 38.9 | 41.2 | 63.1 |

Source: Baldwin (1997).

Baldwin, Rama and Sabourin (1999) use three Statistics Canada surveys of innovation in manufacturing to trace the use of some seventeen advanced manufacturing technologies (AMTs) over the period 1989 to 1998. When the technologies were grouped into seven functional areas and the firms into small (0-49), medium (50-249) and large (250 +) the data revealed that for each of the individual years 1989, 1993 and 1998, and for each of the AMT groups, usage increases monotonically with size. Next, in 1989 the percentage of establishments using the functional technologies was considerably greater in large than in small firms: for most functional technology groups the large firms' proportion outweighed the small by a factor of 5-6, thus indicating a sizeable "innovation gap" between large and small firms. By 1998, while the positive relationship between AMT usage and firm size remains intact across all the functional technology groups, the orders of magnitude of the gap have decreased substantially. The usage percentages for large firms, with a couple of exceptions, now typically outweigh those of small firms by a factor of 2-3. The general tenor of these results is confirmed in Baldwin and Sabourin (2000) which differs slightly in that 15 individual technologies are grouped into 4 functional areas.

The results so far suggest that innovation is positively related to firm size. However, it is misleading to conclude that small firms are not innovative. Table 4, based on Statistics Canada's 1993 SIAT, provides evidence that small firms are indeed innovative. It shows that small firms introduce just as many product innovations per innovator as larger firms, though they lag behind larger firms in process innovations (Baldwin, 1998).

**Table 4. Number of Innovations per Innovator in Canadian Manufacturing, 1989-91**

| | | Number of employees | | |
|---|---|---|---|---|
| Type of innovation | All innovators | 20-99 | 100-499 | 500+ |
| Products | 3.4 | 3.6 | 2.9 | 4.2 |
| Processes | 1.9 | 1.6 | 2.1 | 2.4 |
| Combined products & processes | 2.4 | 3.0 | 1.7 | 2.9 |

Source: Baldwin (1997).

The work of Cosh, Hughes and Wood (1999), using the UK SME data base at Cambridge University's Centre for Business Research points to the important "seed-bed" role that micro and small manufacturing firms play in the process of technological change and innovation. Of particular significance, given our observations that small firms are less likely than their larger counterparts to introduce process innovations, is the finding that the introduction of such process innovations reduces the probability of SME failure. The introduction of product innovations, on the other hand, significantly increases the probability that an SME will be acquired.

Two other data sets mentioned above also testify to the innovativeness of small firms. For example, Acs and Audretsch (1987, 1988, 1990, 1991, 1993) used the U.S. SBA data extensively to analyze innovation and firm size. They focused on the innovation *rate* (number of innovations introduced per 1,000 employees) rather than the incidence of innovation as in Baldwin (1998)[9]. That is, their approach corrects for the size of employment. Acs and Audretsch (1987) found that the average SME innovation rate of 0.322 was higher than the large-

[9] The distinction is important in that it may well alter the interpretation of empirical results.

firm innovation rate of 0.222 in U.S. manufacturing in 1982. However, there is one important qualification. They also found that the innovation rate by firm size varies across industries.

**Table 5. Innovation Rates[1] of Large Firms and SMEs by Manufacturing Industry in the U.S., 1982**

| | Large-firm innovation rate (LIR) | SME innovation rate (SIR) | Differences in innovation rate (DIR=LIR-SIR) |
|---|---|---|---|
| Tires | 8.46 | 0.00 | 8.46 |
| Agr. Chem | 2.26 | 0.00 | 2.26 |
| Industrial machinery | 2.20 | 0.39 | 1.81 |
| Food machinery | 2.01 | 0.67 | 1.34 |
| Ammunition | 1.23 | 0.00 | 1.23 |
| Cottonseed oil mills | 1.11 | 0.00 | 1.11 |
| Cheese | 1.13 | 0.09 | 1.04 |
| Wet corn milling | 1.00 | 0.00 | 1.00 |
| Storage batteries | 0.96 | 0.00 | 0.96 |
| Paper products | 0.98 | 0.06 | 0.92 |
| Truck & bus bodies | 0.76 | 0.00 | 0.76 |
| Paper machinery | 0.87 | 0.11 | 0.76 |
| Power handtools | 0.55 | 3.04 | -2.49 |
| Surface agents | 0.54 | 3.45 | -2.91 |
| Industrial controls | 0.35 | 3.54 | -3.18 |
| Primary copper | 0.00 | 3.33 | -3.33 |
| Gum & wood chemicals | 0.25 | 3.75 | -3.50 |
| Measuring devices | 0.14 | 3.91 | -3.77 |
| Scientific instruments | 1.58 | 5.53 | -3.96 |
| Counting devices | 0.44 | 4.55 | -4.11 |
| Synthetic rubber | 0.00 | 6.67 | -6.67 |
| Control instruments | 1.88 | 9.03 | -7.15 |
| Computing equipment | 0.96 | 8.22 | -7.27 |
| Scales and balance | 0.85 | 8.75 | -7.90 |

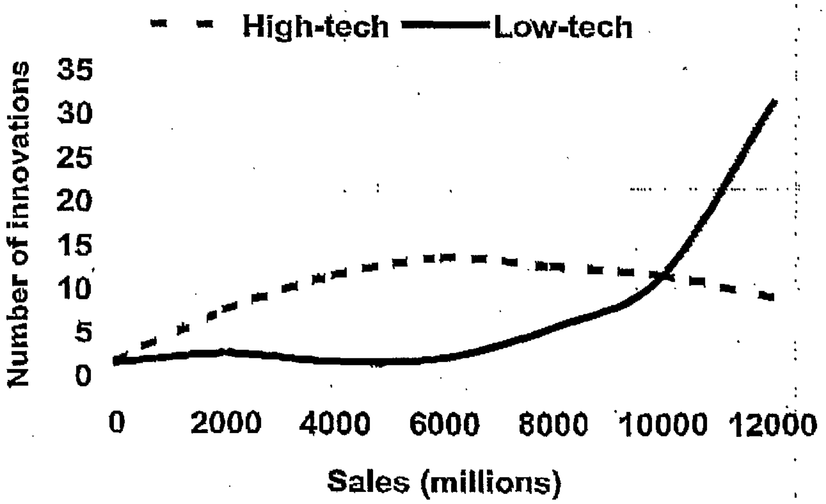
1. Innovation here is defined as "a process that begins with an invention, proceeds with the development of the invention, and results in introduciton of a new product, process or service to the marketplace".

Source: Acs and Audretsch (1987).

Table 5 lists 24 four-digit SIC industries where the largest differences in innovation rates between large firms and SMEs were found. For instance, in the tires industry, the large-firm innovation rate exceeded the SME innovation rate by about eight innovations per thousand employees. The scale and balance industry illustrates the other end of the spectrum where the SME innovation rate exceeded the large-firm innovation rate by about eight innovations per thousand employees. Their analysis also indicated that large firms tended to be more innovative in capital-intensive and concentrated industries whereas SMEs tended to be innovative in industries in the early stages of the life-cycle and where the role of skilled workers is relatively important.

In another study, Acs and Audretsch (1993) demonstrated that the relationship between innovation and firm size differs according to technology intensity. In the low-tech sector, they found the presence of increasing returns to innovation from firm size (Figure 2).

**Figure 2. Firm Size and Innovation in Low and High-Tech Industries in the U.S.**




Source: Acs and Audretsch (1993)

However, in the high-tech sector, they found an inverse U-shaped relationship between innovation and firm size. This difference between high-tech and low-tech sectors suggests the difference in the innovation process between the two sectors. According to Acs and Audretsch (1993), innovation may require a substantial amount of investment in the low-tech sector where large firms tended to have the advantage. On the other hand, in the high-tech sector, there may be a greater scope for innovation with small increments in existing knowledge. Another way to distinguish the innovation process between small and large firms is that small firms tend to be involved in discovery-driven innovation whereas large firms tend to be engaged in design-driven innovation (Carlsson, 1999).

These studies basically took a snapshot of the economy. Pavitt, Robson and Townsend (1987), by contrast, used the SPRU innovation database to analyze innovation rates for U.K. manufacturing between 1956 and 1983. Ten categories of firm ranged from small (<100) to very large (10,000+). Two striking observations emerged from their analysis. The first is that the relationship between innovation and firm size is not simply linear but U-shaped. They found that large-medium firms (2,000-9,999 employees) had below average innovation rates, while very large firms (10,000+ employees) and small firms (100-499 employees) had above average innovation rates[10], especially in the more recent years. Moreover, SMEs became relatively more innovative compared to larger firms over time (Rothwell and Dodgson, 1994).

This section has demonstrated, *inter alia,* that although small firms are less likely to be innovative, they are more innovative than larger firms once their employment size is taken into consideration. However, other methodological refinements may be made. Thus, in a recent article by Tether (1999) the author addresses the body of empirical literature of the late 80s and early 90s which argued that small firms, particularly in manufacturing, were responsible for more innovations than their share of employment might suggest. His own research, for the UK, focusses on the *value* of the innovations, which was found to increase with size.

## 4. Insights from Canadian Evidence

While practically all countries are concerned about their innovative capacity, the issue has had particular poignancy in the Canadian context since the OECD (1995) characterized Canada as having an "innovation gap". Few phrases have so effectively captured the attention of decision-makers and policy researchers in recent years. So a look at innovation in Canada's large SME sector (99.8% of all firms) appears very much in order. Moreover, the Canadian literature itself contains some imaginative contributions to the analysis of SME innovation.

### *4.1 SME Innovation in Canadian Industries*

Turning now to three studies of particular industries, Gellatly and Peters (1999) used Statistics Canada's 1996 Survey of Innovation (SOI) to examine the process of innovation in the dynamic service industries: communications; financial services; and technical business services. Key features of the study are, first, its attention to the sources of, and impediments to, innovation and, secondly, the definition of innovation, which encompasses product, process and organizational innovations and combinations thereof, and is measured by the percentage of businesses that self-identify as innovators. A variety of sources of innovation are discussed including internal factors such as R&D units and other departments of the firm, as well as external factors such as customers, suppliers and competitors. Impediments include the inherent risk and uncertain returns, costs, access to capital, management rigidity, and inadequate skills. The results for all three industries in the sector show that product innovations were by far the most frequent, followed by process innovations, with organizational innovations a distant third.

[10] Number of commercially successful innovations per employee relative to the manufacturing average.

The significance of these findings for the purposes of the present paper can be summed up in the following quotation from Gellatly and Peters (1999):

> "The characteristics outlined above indicate that the service sector innovators studied here have a profile that is generally consistent with the archetypal innovative small firm--one that focuses on quality, flexibility and catering to diverse customer tastes. Early work on innovation, which focused predominantly on large firms, emphasized the importance of business characteristics that often flow from scale economies--sophisticated production processes, research units, financial arrangements and organizational structures. Small firms, often lacking such characteristics, opt for innovation strategies that rely on specialization, customization, product flexibility, all of which result from collaborative interaction with clients, more so than internal sources like R&D (Baldwin *et al.*, 1994)."

Next, Baldwin and Sabourin (1999) used a special 1998 industry specific survey of advanced technology to focus specifically on the firm size dimension of the Schumpeterian hypothesis in a study of the Canadian food processing sector. Innovation was defined as product-only, process-only and a combination of the two. The study determined the importance of a variety of characteristics, including R&D activity, business and engineering practices, ownership, and degree of competition, that are conducive to innovation. As for size, the probability of a plant introducing a process-only innovation rises monotonically from 18% (10-19 employees) through 36% (50-99) to 49% (250+). Product-only innovations were most likely in the medium (50-99) size class, while for combined product-process innovations it was the largest size class that was most likely (66%) to innovate.

A third sector-specific study by Gellatly (1999) examined the incidence of innovation within small (<50) business service establishments, using a sub-sample from the 1996 SOI. This sector is important inasmuch as it provides core business inputs to the dynamism of other sectors of the economy. As such, the author contends, one might be tempted to conclude that all firms in this sector would be committed to innovation. In the event, only a minority (40%) innovate. Among those that do, 81% report product innovation, 46% process innovation, and 33% organizational innovation. Among the innovating group much more importance was attached to financial management, access to capital, workforce skills, and incentive compensation. One interesting insight is that while, when considering various impediments, one might expect non-innovators to assign them greater importance than innovators, in fact this was not so. The author suggests that this reflects a kind of "learning by doing": it is precisely through the experience of innovating that these small firms become more sharply aware of the barriers that must be surmounted.

### *4.2 The "Softer" Side of Innovation*

We conclude this section with a few observations about the "softer", or "people", side of innovation. First, Baldwin and Johnson (1996) confirm the close connection between training, labour skill, and innovation in SMEs. Using the Growing Small and Medium-Sized Enterprise (GSME) survey they invoke yet another taxonomy of different innovator types--comprehensive innovators, who rely on both inside and outside sources for their innovations, those focusing on R&D, and those relying on outsiders for innovation. When comprehensive innovators are divided into quartiles on the basis of their innovativeness, some 80% of firms in the top quartile are found to have a training program compared to only 36% in the bottom quartile. Training is also positively related to the emphasis that a firm gives to total quality management. Finally, the probability that training occurs increases with the size of firm.

Baldwin (1999) points to an apparent paradox in the findings of the GSME survey. Firms placed considerable emphasis on the human factor as a determinant of growth: management and skilled labour were ranked first and second in order of importance, with technology development and R&D strategies further down the list. (Only 10% of firms reported having an R&D unit or investment in R&D). In contrast to these self-assessments, however, statistical analysis relating measures of success to various input factors show technological innovation to be the crucial factor. Perhaps the appropriate interpretation has to do with complementarity: neither human resources nor R&D, alone, is a sufficient condition for successful performance. Indeed, Baldwin (1999) concludes that what distinguishes faster from slower growing firms is innovation; and that innovators manifest greater attention to a wide range of competencies, of which human resources are an important component.

The Working With Technology Survey (WWTS) developed at the Economic Council of Canada by Betcherman and McMullen (1986) examined the adoption of computer-based technologies (CBTs) and organizational changes (such as job rotation, enlargement or enrichment; employee participation; and contingent compensation) in about one thousand Canadian firms. The incidence of both hard and soft innovations was found to increase with firm size.

On the training front, Ekos Research Associates (1996) surveyed over two thousand establishments to assess the extent of formal training (defined as having set objectives and a defined curriculum). They found that the incidence was more than twice as high in larger (100+) firms (55%) than in smaller (<20) firms, for which the incidence was 26%. The authors identify three main impediments. First, cost: the survey found training costs per employee to be twice as high in small firms. The high fixed expenses of training can be spread to achieve scale economies in the larger firms. Second, the disruptive effects of having key employees absent is relatively greater for small firms. Third, small firms have inferior information about training opportunities and resources or to work with other firms or educational institutions.

Finally, some interesting preliminary data from Statistics Canada's new Workplace and Employee Survey (WES)[11] pertains to organizational innovation (Ekos Research Associates, 1998). For the establishment size categories <20, 20-99, 100-499, and 500+, the following selected results were obtained with respect to the percentage of firms adopting organizational change. For functional flexibility (which includes job rotation, multiskilling and total quality management (TQM), the incidence increases monotonically with size (21%, 50%, 65% and 77%, respectively); for delayering, the proportions are 5%, 21%, 43% and 72%; and for interfirm collaboration, they are 11%, 26%, 46%, and 40% respectively. Fully 46 per cent of the smallest firms introduced no changes compared to only 4 per cent in the largest category.

**5. Sources of, and Impediments to, Innovation**

Various factors conducive to, or detracting from innovativeness were alluded to in the preceding sections. However, some of the empirical work on firm size takes innovation sources and barriers as a principal focus and a brief sampling of findings is presented here.

Some notable differences between large and small firms are reflected in the sources of ideas for innovation identified in the 1993 Survey of Innovation and Advanced Technology by Statistics Canada. Baldwin (1997) summarized the results as listed in Table 6. Small firms rely less on R&D as a source of innovation compared to large firms (34% versus 62%), and are less likely to

[11] See Statistics Canada and Human Resources Development Canada (1999) for a description of WES and preliminary findings.

be tied to an external network of related firms. Only 12% of small firms identified related firms as a source of ideas whereas 25% of large firms perceived them to be an important source of ideas. Small firms rely to a much greater extent on customers than do large firms, and get more of their ideas from trade fairs. Large firms stress the importance of specialized R&D capabilities either through internal R&D facilities or interfirm transfers. Smaller firms, however, are more likely to depend on managers as a source of innovation, which may reflect greater organizational flexibility and internal communication. Further, Acs, Audretsch and Feldman (1994) found that the innovation output of small firms benefits from R&D spillovers from universities and to a lesser degree from R&D centers in their larger counterparts.

**Table 6. Sources of Ideas for Innovations**
% of Firms

| | | Number of employees | | |
|---|---|---|---|---|
| Sources | All firms | 20-99 | 100-499 | 500+ |
| Management | 52.6 | 53.8 | 54.8 | 39.5 |
| R&D | 43.5 | 33.7 | 51.8 | 62.4 |
| Sales/marketing | 42.9 | 43.3 | 47.3 | 37.2 |
| Production | 35.9 | 36.1 | 45.5 | 26.6 |
| Suppliers | 28.3 | 24.3 | 34.5 | 25.4 |
| Customers | 46.1 | 50.1 | 45.7 | 39.5 |
| Related firms | 15.2 | 11.9 | 16.7 | 25.0 |
| Trade fairs | 17.4 | 18.0 | 16.7 | 14.2 |

Source: Baldwin (1997).

The particular contribution of Pavitt and Patel (1995) is to show that, in addition to size, the characteristics of the various industries affect firms' innovation sources. Thus, for example, the typically small firms in agriculture, private services and traditional manufacturing draw more heavily on suppliers as the source of innovations. Small firms in instruments and software rely on design and development.

As for large firms, not unexpectedly, those in science-based industries such as chemicals and electronics, rely on basic research through corporate R&D, while those in finance and retailing are information-intensive and derive much of their innovation from in-house software development and systems engineering.

A close corollary of the finding that firms of different sizes in different industries rely on different innovation sources is that they also encounter different impediments to innovation. Table 7 summarizes the innovation impediments faced by Canadian firms as identified in the SIAT (Baldwin, 1997). Firms of all sizes identified a lack of skilled personnel as the most important impediment to innovation. This is not surprising since the knowledge-based economy prizes knowledge as its most important factor of production. For all other factors, a larger proportion of smaller than of larger firms consider them to be impediments to innovation. Both a lack of information on technologies and markets and a lack of technical services are more frequently indicated to be impediments by SMEs than by large firms, and SMEs also regard interfirm cooperation to be a problem more frequently than large firms.

**Table 7. Impediments to Innovation**
% of Firms

| | | Number of employees | | | |
|---|---|---|---|---|---|
| Category | All firms | 0-19 | 20-99 | 100-499 | 500+ |
| Lack of skilled personnel | 45.9 | 44.1 | 49.2 | 48.3 | 43.4 |
| Lack of information on technologies | 30.5 | 30.8 | 30.9 | 33.5 | 20.4 |
| Lack of information on markets | 37.2 | 42.7 | 29.8 | 31.5 | 30.0 |
| Lack of external technical services | 20.0 | 21.1 | 21.2 | 14.3 | 12.7 |
| Barriers to interfirm cooperation | 18.9 | 21.8 | 17.2 | 14.3 | 6.1 |
| Barriers to university cooperation | 7.6 | 9.3 | 5.2 | 5.5 | 7.1 |
| Government standards | 30.6 | 34.0 | 26.8 | 21.7 | 31.0 |

Source: Baldwin (1997).

Finally, as a conceptual summary of the advantages and disadvantages facing small and large firms in the process of innovation, one may profitably refer to the comprehensive treatment of Rothwell and Dodgson (1994) set out, with additions by the present authors, in Table 8. This shows the relative potential (dis) advantage of small and large firms for a wide range of factors (twelve) that are crucial to the process of innovation. One's overall impression is of power and resources versus flexibility, nimbleness and opportunism. Bo Hedberg's (1984) delightful metaphor about "palaces" and "tents" (albeit in the context of organizational culture) comes to mind. The denizens of the palaces are rich, powerful and tradition-steeped. The occupants of the tents, by contrast, carry little baggage and are ready to move to a new opportunity.

**Table 8. Advantages and Disadvantages of Small and Large Firms in Innovation**

| Small Firms | | Large Firms | |
|---|---|---|---|
| **Advantages** | **Disadvantages** | **Advantages** | **Disadvantages** |
| Management | | | |
| Little bureaucracy; entrepreneurial management; rapid decision-making; risk-taking; organic style | Entrepreneurial managers often lack formal management skills. | Professional managers able to control complex organizations and establish corporate technology strategies. | Often controlled by risk-averse accountants; managers become bureaucrats and lack dynamism. |
| Communication | | | |
| Rapid and effective internal communication; informal networks. | Lack of time and resources to forge suitable external S&T networks. | Able to establish comprehensive external science and technology networks. | Internal communication can be cumbersome; long decision chains result in slow reaction times. |
| Marketing | | | |
| Fast reaction to changing market requirements; can dominate narrow market niches. | Market start-up abroad can be prohibitively costly. | Comprehensive distribution and servicing facilities, high market power with existing products. | Can ignore emerging market niches with growth potential; see new technology as a threat to existing products and not as an opportunity in the marketplace. |
| Technical manpower | | | |
| Technical personnel well plugged in to other departments. | Often lack high-level technical skills. Full-time R&D can be too costly. (Need technical specialists for external links.) Can suffer diseconomies of | Able to attract highly skilled specialists; can support the establishment of a large R&D laboratory; | Technical manpower can become isolated from other corporate functions. |

| | | | |
|---|---|---|---|
| | scope in R&D. | economies of scale and scope in R&D. | |
| Finance<br>Innovation can be less costly in SMEs; SMEs can be more "R&D efficient". | Innovation represents a large financial risk; inability to spread risk; accessing external capital for innovation can be a problem. Cost of capital can be relatively high. | Able to borrow; can spread risk over a portfolio of products; better able to fund diversification. | Shareholder pressure can force a focus on short-term profits. Can access external capital on favourable terms. |
| Growth<br>Potential for growth through 'niche strategy' techno/market leadership. | Problems in accessing external capital for growth; entrepreneurs often unable to manage growth. | Able to obtain scale and learning curve economies through investment in production; can fund growth via acquisition, can gain price leadership. | |
| Regulations<br>Regulations sometimes applied less stringently to SMEs. | Often cannot cope with complex regulations; unit costs of compliance can be high; often unable to cope with patenting system; high opportunity costs in defending patents. | Able to cope with government regulations; can fund R&D necessary for compliance; able to defend patents. | Regulations often applied more stringently to large companies. |
| Government schemes<br>Many schemes have been established to assist innovation in SMEs. | Accessing government schemes can be difficult; high opportunity costs. Lack of awareness of available schemes. Difficulty in coping with collaborative schemes. | Can employ specialists to assist in accessing government schemes. Able to manage collaborative schemes. | Increasingly, government innovation support has focused on SMEs. |
| Learning ability<br>Capable of 'fast learning', and adapting routines and strategies. If new, no 'unlearning' problems. | May lack resources for systematic and continuous technological scanning | Have resources to do scanning for benchmarking and identification of best practices | Slow to learn; often locked in to well-established practices and routines. |
| Organization<br>Generally simple and focused. 'Organic' form. | May simply be too small to implement some innovative organizational forms (such as cross-functional teams) | Potential synergies across divisions. | Generally complex; multidivisional, and increasingly multinational. Mechanistic organization. Danger of sclerosis, rigidity, unwieldiness, institutional inertia. |
| Joint ventures/strategic alliance<br>Can prove attractive partner if technological leader. | Little management experinece; power imbalance if collaborating with large firms. | Possess strategic managerial resources to enable the selection of appropriate partners and the proper management of collaboration. | |

| | | | |
|---|---|---|---|
| Supplier relations | | | |
| May enjoy closer personal relations with suppliers. | Can exert little control over suppliers. | Can encourage innovative suppliers. May be big and powerful enough to impose standards (such as JIT, e.g.). | May be too big and too distant to enjoy the personal relations that may be conducive to innovation |

Source: Based on Rothwell and Dodgson (1994).

## 6. Concluding Comments and Policy Implications

While there may be substantial differences, smaller firms tend to pay lower wages, have lower labour productivity and do not survive long. However, successful entrants which are typically small are vital to the strength of the economy since they are carriers of new ideas and agents of change (Acs, 1999a; Carlsson, 1999; Schreyer, 1999). They often bring radical innovations that are spread over the economy. In fact, new entrants are estimated to contribute between 15 to 25 per cent of productivity growth in Canada and the U.S. (Baldwin and Johnson, 1999; Hartiwanger, 1997). Bianchi (1999) argues that SMEs can be competitive only if they are successful in substituting static economies of scale typically enjoyed by large firms with dynamic economies of scale. That is, their innovative activities and entrepreneurship allow them to grow over time.

This paper has looked at the nature of the process of innovation in SMEs. Different concepts, types and measures of innovation were considered in the context of firm size. However, small firms face barriers that have general policy implications. That cost would be a barrier to small firms is almost axiomatic and various governments have used a wide variety of instruments over the years --tax credits, subsidies, loans, etc.--to try to alleviate this problem. But the findings also point to a role for government in its newer, less interventionist guise as facilitator, catalyst and provider and disseminator of strategic information.

Thus, for example, one common finding about impediments has to do with the relative information deficit of small firms. This suggests the appropriateness of government initiatives to provide and disseminate strategic information. The OECD (1995) describes the dozens of advisory, consultancy and extension services to assist SMEs in various countries by providing specialized advice and expertise. A well-known Canadian example is the National Research Council's Industrial Research Assistance Program (IRAP) which has a network of technology experts across the country to help SMEs with everything from the acquisition of and/or application of technology, acquisition of skills, preparation of a business plan, etc.

The more general question of provision and dissemination of strategic industrial, market and technological intelligence is currently being addressed by the enormous --and popular-- Industry Canada electronic database known as *Strategis*. A subsector of this program is directed at SMEs and is known as Contact! The policy challenge will be to continuously enrich, update and extend the usage and application of such programs to promote SME innovation and growth.

The other common impediment to SME innovation is the difficulty in forging links for joint development of technologies, knowledge-sharing, etc. Here again is a potential role for government--i.e. as the broker or facilitator of partnership arrangements. Clearly there is growing and widespread acknowledgement of the importance of this role, as the ubiquitous presence of the word "partnership" in government documents, and the titles, guidelines and criteria of government programs attests. We confine ourselves to two sets of comments.

The first relates to the question of mechanisms to forge closer links between SMEs and the universities. Many of the latter now have offices to promote the commercial application of university-spawned ideas and inventions--"spin-offs". But links with academia for established SMEs are also important. In this connection we simply observe that the experience of a British initiative--The Teaching Company Scheme (TCS)--warrants close monitoring in this regard[12]. The scheme was set up by the UK government some 25 years ago to enable firms to access ideas, inventions and innovations from universities and help the professors refresh their knowledge of industry. As Robson (1996) reports, a recent development has been a systematic effort to involve small firms through the establishment in 1994 of a network of TCS Centres for Small Firms.

Another promising institutional arrangement to overcome SMEs' information deficit and encourage innovation is networks to share information on means to stimulate technological advance, innovation, productivity and competitiveness. In some variants retired business professionals with many years of experience and expertise may play a valuable mentoring role. Such programs merit, in our view, close monitoring and assessment. Given the crucial role of innovation in the KBE, the importance of SMEs in so many economies, and the special innovation impediments encountered by small firms (especially with respect to information) such initiatives should be a target for policy research.

Finally, Lerner (1999) points out the importance of care in formulating intellectual protection policies. Stringent intellectual property policy (e.g. strong patent protection) which is intended to protect intellectual property may in fact drive up litigation costs. These costs may divert valuable financial resources away from innovative activities to cover to these costs. In this case, these costs may put small firms at a significant disadvantage.

To sum up, small firms in many countries account for substantial proportions of output and employment. Since innovation is the quintessential characteristic of the KBE, the innovativeness of the SME sector is a vital policy concern. The empirical literature reveals

[12] Basically, the TCS involves promising graduates ("Associates") in demanding projects jointly supervised by representatives of the firm and the university.

considerable evidence attesting to the innovativeness of SMEs. From the policy point of view, however, it is important to identify the particular types of advantages --and most particularly, the impediments-- that distinguish small firms from large in the process of innovation.

## References


Acs, Zoltan J., 1999a, "The American Evolution", in Acs, Zoltan ed., *Are Small Firms Important? Their Role and Impact*, 1-20, Boston: Kluwer Academic Publishers.

_____, 1999b, "Public Policies to Support New Technology-Based Firms (NTBFs)", *Science and Public Policy* 26, 247-257.

Acs, Zoltan J. and David B. Audretsch, 1993, "Innovation and Firm Size: the New Learning", *International Journal of Technology Management, Special Publication on Small Firms and Innovation*, 23-35.

_____, 1991, "R&D, Firm Size and Innovative Activity", in Acs, Zoltan J. and David B. Audretsch, eds., 1991, *Innovation and Technological Change: An International Comparison*, 39-59, Ann Arbor, Michigan: University of Michigan Press.

_____, 1990, *Innovation and Small Firms*, Cambridge, M.A.: MIT Press.

_____, 1988, "Innovation in Large and Small Firms: An Empirical Analysis", *American Economic Review* 78, 678-690.

_____, 1987, "Innovation, Market Structure, and Firm Size", *Review of Economics and Statistics* 69, 567-690.

Acs, Zoltan J., David B. Audretsch and Maryann P. Feldman, 1994, "R&D Spillovers and Recipient Firm Size", *Review of Economics and Statistics* 76, 336-340.

Acs, Zoltan J., Randall Morck and Bernard Yeung, 1999, "Productivity Growth and Firm Size Distribution", in Zoltan J. Acs , Bo Carlsson and Charlie Karlsson, eds., *Entrepreneurship, Small and Medium-Sized Enterprises and the Macroeconomy*, 367-396, Cambridge, U.K.: Cambridge.

Acs, Zoltan J., Randall Morck, J. Myles Shaver and Bernard Yeung, 1997, "The Internationalization of Small and Medium-Sized Enterprises", in Zoltan J. Acs and Bernard Yeung, eds., *Small and Medium-Sized Enterprises in the Global Economy*, 367-396, Ann Arbor, Michigan: University of Michigan Press.

Almeida, Paul, 1999, "Semiconductor Startups and the Exploration of New Technological Territory", in Acs, Zoltan ed., *Are Small Firms Important? Their Role and Impact*, 39-50, Boston, M.A.: Kluwer Academic Publishers.

Archibugi, Daniele and Mario Pianta, 1996, "Innovation Surveys and Patents as Technology Indicators: The State of the Art", in OECD, *Innovation, Patents and Technological Strategies*, 17-56, Paris: OECD.

Audretsch, David B., 1999, "Small Firms and Efficiency", in Acs, Zoltan ed., *Are Small Firms Important? Their Role and Impact*, 21-37, Boston, M.A.: Kluwer Academic Publishers.

Baldwin, John and David Sabourin, 2000, "Advanced Technology Use in Manufacturing During the 1990s", *Canadian Economic Observer*, March, 3.1-3.11.

Baldwin, John, 1999a, "Innovation, Training and Success", Statistics Canada Analytical Studies Branch Research Paper No. 137, Ottawa: Statistics Canada.

______, 1999b, "Strategic Capabilities in Innovative Business", Statistics Canada, mimeo.

______, 1998, "Were Small Producers the Engines of Growth in the Canadian Manufacturing Sector in the 1980s?", *Small Business Economics* 10, 349-364.

______, 1997, "The Importance of Research and Development for Innovation in Small and Large Canadian Manufacturing Firms", Statistics Canada Analytical Studies Branch Research Paper Series No. 107, Ottawa: Statistics Canada.

______, 1995a, "Productivity Growth, Plant Turnover and Restructuring in the Canadian Manufacturing Sector", Statistics Canada Analytical Studies Branch Research Paper Series No. 87, Ottawa: Statistics Canada.

______, 1995b, "Innovation: The Key to Success in Small Firms", Statistics Canada Analytical Studies Branch Research Paper Series No. 76, Ottawa: Statistics Canada.

Baldwin, John, Petr Hanel and David Sabourin, 2000, "Determinants of Innovative Activity in Canadian Manufacturing Firms: The Role of Intellectual Property Rights", Statistics Canada Analytical Studies Branch Research Paper No. 122, Ottawa: Statistics Canada.

Baldwin John and Joanne Johnson, 1999, "Entry, Innovation and Firm Growth", in Acs, Zoltan ed., *Are Small Firms Important? Their Role and Impact*, 51-77, Boston, M.A.: Kluwer Academic Publishers.

______, 1998, "Different Types of Innovators", in Eliasson, Gunnar, Chris Green and Charles McCann ,eds., *Microfoundations of Economic Growth: A Schumpeterian Perspective*, 227-253, Ann Arbour, Michigan: Univ. of Michigan Press.

______, 1996, "Business Strategies in More- and Less-innovative Firms in Canada", *Research Policy* 25, 785-804.

Baldwin, John and Garnett Picot, 1995, "Employment Generation by Small Products in the Canadian Manufacturing Sector", *Small Business Economics* 7, 317-331.

Baldwin, John, Ed Rama and David Sabourin, 1999, "Growth and Advanced Technology Use in Canadian Manufacturing During the 1990s", Statistics Canada Analytical Studies Branch Research Paper No. 105, Ottawa: Statistics Canada.

Baldwin, John and David Sabourin, 1999, "Innovative Activity in Canadian Food Processing Establishments: the Importance of Engineering Practices", Statistics Canada Analytical Studies

Branch Research Paper No. 101, Ottawa: Statistics Canada, (forthcoming in *International Journal of Technology Management).*

______, 1998, "Technology Adoption: A Comparison Between Canada and the United States", Statistics Canada Analytical Studies Branch Research Paper Series No. 119, Ottawa: Statistics Canada.

Baldwin, William L. and John T. Scott, 1987, *Market Structure and Technological Change*, London and New York: hardwood Academic Publishers.

Betcherman, Gordon, 1996, *Changing Workplace Strategies*, Ottawa: Government of Canada.

Betcherman, Gordon and Kathryn McMullen, 1986, *Working With Technology*, Ottawa: Economic Council of Canada.

Bianchi, Patrizio, 1999, "Policies for Small and Medium-Sized Enterprises (SMEs)", in Elsner, Wolfram and John Groenewegen, eds, *Industrial Policies After 2000*, 285-319, Boston, M.A.: Kluwer Academic Publishers.

Carlsson, Bo, 1999, "Small Business, Entrepreneurship, and Industry Dynamics", in Acs, Zoltan ed., *Are Small Firms Important? Their Role and Impact*, 99-110, Boston, M.A., Kluwer Academic Publishers.

Cohen, Wesley M. and Richard C. Levin, 1989, "Empirical Studies of Innovation and Market Structure", in Richard Schmalensee and Robert Willig, eds., *Handbook of Industrial Organization, Vol. II*, 1059-1107, Amsterdam: North-Holland.

Cosh, Andy, Alan Hughes and Eric Wood, 1999, "Innovation in U.K. SMEs: Causes and Consequences for Firm Failure and Acquisition", in Zoltan J. Acs , Bo Carlsson and Charlie Karlsson, eds., *Entrepreneurship, Small and Medium-Sized Enterprises and the Macroeconomy*, 329-366, Cambridge, U.K.: Cambridge University Press.

Crépon, Bruno and Emmanuel Duguet and Jacques Mairesse, Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level, NBER Working Paper No. 6696, (Cambridge, M.A.).

Ekos Research Associates, Inc., 1998, "Using the WES Data to Study Organizational Change", Report to Statistics Canada Business and Labour Market Analysis Division, Ottawa.

______, 1996, "Developing Skills in the Canadian Workplace: Results of the Workplace Training Survey", Report to Human Resources Development Canada, Ottawa.

Evangelista, Rinaldo, Tore Sandven, Giorgio Sirilli and Keith Smith, 1997, "Innovation Expenditures in European Industry", STEP Rapport/Report 5/97, Studies in Technology, Innovation, and Economic Policy, Oslo, Norway: STEP.

Freeman, Chris and Luc Soete, 1997, *The Economics of Industrial Innovation*, Third Edition, Cambridge, M.A.: MIT Press.

Gellatly, Guy, 1999, "Differences in Innovator and Non-Innovator Profiles: Small Establishments in Business Services", Statistics Canada Analytical Studies Branch Research Paper No. 143, Ottawa: Statistics Canada.

Gellatly, Guy and Valerie Peters, 1999, "Understanding the Innovation Process: Innovation in the Dynamic Service Industries", Statistics Canada Analytical Studies Branch Research Paper No. 127, Ottawa: Statistics Canada.

Gera, Surendra, Clifton Lee-Sing and Keith Newton, 2000, "The Emerging Global Knowledge-Based Economy", mimeo, Ottawa: Industry Canada and forthcoming in Louis Lefebvre, Elizabeth Lefebvre and Pierre Mohnen, eds., *Doing Business in the Knowledge-Based Economy*, Boston: M.A., Kluwer Academic Publishers.

Griliches, Zvi, 1990, "Patent Statistics as Economic Indicators: A Survey", *Journal of Economic Literature* 28, 1661-1707.

Hartiwanger, John, 1997, "Measuring and Analyzing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence, " *Federal Reserve Bank of St. Louis Economic Review* 79, No. 3, 55-77.

Hedberg, Bo. "Career Dynamics in a Steelworks of the Future", *Journal of Occupational Behaviour* 5, 1984, 53-69.

Kaminski, Philippe, 1996, "How Can Very Small Technology Firms be Helped?", in OECD, *Innovation, Patents and Technological Strategies*, 125-137, Paris, OECD.

Lee, Frank C. and Handan Has, 1996, "A Quantitative Assessment of High-Knowledge Industries Versus Low-Knowledge Industries", Howitt, Peter, ed., *The Implications of Knowledge-Based Growth for Micro-Economic Policies*, 39-81, Calgary: Calgary University Press.

Lerner, Joshua, 1999, "Small Business, Innovation, and Public Policy", in Acs, Zoltan ed., *Are Small Firms Important? Their Role and Impact*, 159-168, Boston, M.A.:, Kluwer Academic Publishers.

Lhuillery, Stephane, 1996, "Innovation in French Manufacturing Industry: A Review of the Findings of the Community Innovation Survey", in OECD, *Innovation, Patents and Technological Strategies*, 89-124, Paris: OECD.

National Research Council, 1999, *Funding a Revolution: Government Support for Computing Research*, Washington D.C.: National Academy Press.

Newton, Keith, 1996, "The Human Factor in Firms' Performance", Industry Canada Occasional Paper No. 14, Ottawa: Industry Canada.

Newton, Keith and Sunder Magun, 2000, "Organizational Learning and Intellectual Capital", Mimeo, forthcoming in Lefebvre, Louis, Elizabeth Lefebvre and Pierre Mohnen, eds., *Doing Business in the Knowledge-Based Economy*, Cambridge, M.A.:: Kluwer Academic Publishers.

O'Doherty, Dermot, 1998, "Increasing Participation by Small and Medium-Sized enterprises in International Technology Co-operation: The Role of Public Policy", in OECD, *Facilitating International Technology Co-operation: Proceedings of the Seoul Conference*, 168-185, Paris: OECD.

OECD, 1999b, *Managing National Innovation Systems*, Paris: OECD.

_____, 1998a, *Fostering Entrepreneurship*, Paris: OECD.

_____, 1998b, *Technology, Productivity and Job Creation: Best Policy Practices*, Paris: OECD.

_____, 1997a, *Globalization and Small and Medium Enterprises (SMEs) Vol. 1: Synthesis Report*, Paris: OECD.

_____, 1997b, *Globalization and Small and Medium Enterprises (SMEs) Vol. 2: Country Studies*, Paris: OECD.

_____, 1997c, *OSLO MANUAL*, Paris, OECD.

_____, 1996a, *SMEs: Employment, Innovation and Growth*, Paris, OECD.

Pavitt, Keith and Pari Patel, 1995, "Corporate Technology Strategies and National Systems of Innovation", in Allouche, José and Gérard Pogorel, eds., *Technology Management and Corporate Strategies: A Tricontinental Perspective*, 313-340, Amsterdam, the Netherlands: Elsevier.

Pavitt, Keith, Michael Robson and Joe Townsend, 1987, "The Size Distribution of Innovating Firms in the U.K.: 1945-1983", *Journal of Industrial Economics* 35, 297-316.

Rafiquzzaman, Mohammed and Lori Whewell, 1998, "Recent Jumps in Patenting Activities: Comparative Innovative Performance of Major Industrial Countries, Patterns and Explanations", Industry Canada Working Paper No. 27, Ottawa: Industry Canada.

Rothwell, Roy and Mark Dodgson, 1994, "Innovation and Size of Firm", in Dodgson, Mark and Roy Rothwell, eds., *The Handbook of Industrial Innovation*, 310-324, Hants, England: Edward Elgar Publishing.

_____, 1993, "Technology-based SMEs: their Role in Industrial and Economic Change", *International Journal of Technology Management, Special Publication on Small Firms and Innovation*, 23-35.

Roy, Philippe, 1999, "Business Networks, Business Growth", Mimeo, Ottawa: Industry Canada.

Sabourin, David and Desmond Beckstead, 1999, "Technology Adoption in Canadian Manufacturing: Survy of Advanced Technology in Canadian Manufacturing 1998", Statistics Canada Catalogue Number 88F0006XPB No. 5, Ottawa: Statistics Canada.

Schreyer, Paul, 1999, "Small and Medium-Sized Enterprises (SMEs); Employment Creation and Industrial Policy", in Elsner, Wolfram and John Groenewegen, eds, *Industrial Policies After 2000*, 285-319, Boston, M.A.: Kluwer Academic Publishers.

_____, 1996, "SMEs and Employment Creation: Overview of Selected Quantitative Studies in OECD Member Countries", OECD STI Working Papers 1996/4, Paris: OECD.

Schumpeter, Jospeh A., 1942, *Capitalism, Socialism and Democracy*, New York: Harper.

Statistics Canada and Human Resources Development Canada, 1998, *The Evolving Workplace: Findings from the Pilot Workplace and Employee Survey*, Statistics Canada catalogue No. 71-583-XPE, Ottawa: Statistics Canada.

Soete, Luc, 1979, "Firm Size and Inventive Activity: the Evidence Reconsidered", *European Economic Review* 12, 319-340.

Sterlacchini, Alessandro, 1999, "Do Innovative Activities Matter to Small Firms in non-R&D intensive Industries? An Application to Export Performance", *Research Policy* 28, 819-832.

Symeonidis, George, 1996, "Innovation, Firm Size and Market Structure: Schumpeterian Hypotheses and Some New Themes", OECD Economic Department Working Paper No. 161, Paris: OECD.

Tether, Bruce S., 1999, "Small Firms, innovation and employment creation in Britain and Europe: A question of expectations" *Technovation* 20, 109-113.

Trajtenberg, Manuel, 2000, "Is Canada Missing the "Technology Boat"? Evidence from Patent Data", Industry Canada Discussion Paper No. 9, Ottawa: Industry Canada.

Wallsten, Scott J., 1998, "Rethinking the Small Business Innovation Research Program", in Branscomb, Lewis M. and James H. Keller, eds., *Investing in Innovation*, 194-220, Cambridge: M.A.: MIT Press.

You, Jong-Il, 1995, "Small Firms in Economic Theory", *Cambridge Journal of Economics* 19, 441-462.

0 96809 24058 7

**DATE DUE**
DATE DE RETOUR

| | |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |