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Innovation in the Canadian Food Processing Industry: Evidence from the Workplace and Employee Survey

Sean Cahill[a], Tabitha Rich[b], and Brian Cozzarin[ⓘc]

[a] *Senior Economist, Agriculture and Agri-Food Canada, Research & Analysis Directorate, Strategic Policy Branch Tower 7-4, 1341 Baseline Road, Ottawa, Ontario, K1A 0C5, Canada*

[b] *Unit Head, Public Sector Statistics, Macroeconomic Accounts Branch, Statistics Canada, 100 Tunney's Pasture Driveway, Ottawa, Ontario K1A 0T6 Canada*

[c] *Associate Professor, Department of Management Sciences, Faculty of Engineering, University of Waterloo 200 University Avenue West, Waterloo, Ontario, Canada N2L 3G1, Canada*

Abstract

The objective of this paper was to examine the link between innovation and profit in the Canadian food processing industry and other Canadian manufacturing industries using firm-level data. We conduct non-parametric tests using a panel of 723 manufacturing firms over eight years (N=5,784). The main finding is that profitability is higher for food processing innovators vs. non-innovators, but product-process innovators have greater profit and profit-margins than firms that have product-only or process-only innovation. Thus, a “one size fits all” policy that simply promotes innovation in manufacturing is not suitable for food processing, where firms that innovate in both product and process spheres is what really matters.

Keywords: innovation, product; process, food processing, profit

ⓘCorresponding author: Tel: + 1.519.888.4587-33291
Email: B. Cozzarin: brian.cozzarin@uwaterloo.ca
S. Cahill: sean.cahill@agr.gc.ca
T. Rich: tabitha.rich@agr.gc.ca

Introduction

The idea that innovating firms are more profitable than non-innovating firms has strong intuitive appeal, yet empirical evidence of this relationship is mixed (Geroski, Machin, and Van Reenen 1993; Cefis and Ciccarelli 2005; Baldwin and Sabourin 2001; Cozzarin 2004). Instead, it is a hypothesis that underpins models of innovation and government programs that aim to stimulate innovation. If innovation does not lead to greater profitability, costly policies and programs may not achieve their objectives. Similarly, analytical frameworks that are based on the assumption that innovation leads to greater profit will be less relevant if this relationship does not hold. In this paper we concern ourselves with the performance of the Canadian agri-food sector. The sector is of major importance, since in 2011, food and beverage production (NAICS 311 and 312) accounted for 1.68% of Canada's national GDP, and 15.93% of total manufacturing GDP (Statistics Canada 2015). Only transportation and equipment manufacturing (NAICS 336) had double-digit importance to manufacturing GDP at 13.32% (and 1.41% in terms of national GDP).

Our firm-level data from the Workplace and Employee Survey (WES) asked four questions regarding four different types regarding innovation. These yes/no (binary) questions asked whether the firm had introduced: (i) new products or services; (ii) improved products or services; (iii) had new processes; and/or (iv) improved processes over the past year. The primary objective of this paper is to examine the linkages between innovation and profit in the Canadian food processing industry and other Canadian manufacturing industries.[1] The analysis uses test statistics to determine whether hypotheses concerning innovation and profit are supported by the data. The central hypothesis is that profit (profit-margin) for innovating firms is different from (greater than) the profit of non-innovating firms. While our main industry of interest is food processing, we included 17 other manufacturing industries. The other industries included will serve as a benchmark for the agri-food sector which is often characterized as not being very innovative.

Related questions about innovation have received considerable attention. These pertain to the choice that firms make between product and process innovation. The second hypothesis tested is that process innovation is more profitable than product innovation. This test is based on an interpretation of the literature, which identifies productivity growth as one potential source of increased profit arising from innovation. The third hypothesis is that a combination of process and product innovation leads to greater profitability than a process or product innovation alone. This test addresses the issue of complementarity, where the combination of the two types of innovation achieve a more effective outcome than if each is introduced independently of the other.

[1] Although our paper deals specifically with innovation and profit, a reviewer has correctly pointed out that there is substantial literature on the persistence of profitability and innovation. There are a number of notable studies such as (Cefis 2003; Cefis and Orsenigo 2001; P. A. Geroski and Machin 1993; Geroski, Machin, and Van Reenen 1993; Gschwandtner 2005; Hawawini, Subramanian, and Verdin 2003; Roberts 1999; Roberts 2001; Slade 2004; Teece 1986).

These tests are useful because they offer a systematic way to examine the impact of innovation on profit. If the tests confirm the intuitive notions, most of all that innovation is profitable, this will reinforce a widely held opinion. Alternatively, if the tests do not support this notion, then there are opportunities for analysis that allow for a wider range of outcomes from innovation. Either outcome could, therefore, lead to a richer understanding of the consequences of firm-level innovation decisions.

The outline of the paper is as follows. Theories underlying the hypothesis tests, previous related empirical research, and more formal statements of the tests are discussed in the next section. A description of the WES data and, particularly, the linked data set, is given next. The section also presents tables summarizing the profitability and innovation data by industry. The hypothesis test results and discussion follow. The last section summarizes the findings and provides some concluding comments.

Theory, Previous Empirical Research, and Hypotheses

The central hypothesis described in the Introduction demands explanation since it seems unlikely that firms would innovate if they knew that this would not lead to a growth in profit. The outcome of an innovation, however, is uncertain, so the firm cannot know in advance what the effect of an innovation will be on profitability. Since the introduction of an innovation typically involves an investment of some sort, models of investment under uncertainty are useful for developing an understanding of the innovation decision. These models posit that the firm will choose the level of investment that maximizes the expected net present value of current and future profit, where uncertainty typically relates only to future prices (Stevens 1974, Craine 1975).

Profit and Innovation

Although we do not use an economic model of investment under uncertainty in our analysis per se, we instead use the ideas conceptually. Consider first, the firm that makes an innovation investment. It is possible to think of two optimization calculations, one with and one without the innovation investment. For simplicity, suppose that a firm’s decision to make the investment is based simply on a comparison between the expected net present value of a production plan with the innovation and the expected net present value of an alternative plan that does not include the innovation. This is essentially financial cost-benefit analysis under uncertainty (Graham 1981)

There are two types of uncertainty in this framework. The first type is with respect to prices of output and input, while the second type is with respect to the “success” of the innovation, either in its usefulness within the firm (a process) or in market sales (a product). The firm’s decision will also depend, in part, on its risk preferences. If the firm (i.e. its owner) is risk averse, it will make more conservative decisions than if it is risk-neutral.

Irrespective of the issues surrounding uncertainty, the decision to invest in the innovation must be based on ex-ante information. The ex-post profit for the innovating firm cannot be accurately compared with the profit that would have been earned without the innovation. This would require a counter-factual experiment that, even if it were conducted, could only provide hypothetical information (i.e. an estimate of "what might have been") regarding the success of the innovation.

Consider now the firm that doesn't innovate. For simplicity, suppose that this firm is identical in every regard to the innovating firm except that it has different expectations and/or risk preferences. For this firm, the expected net present value of a production plan without the innovation is higher than the expected net present value of a plan that incorporates the innovation. As a result, it will decide not to invest. This firm, too, would have difficulty determining the size of the contribution that the innovation might have made since it would also require a counter-factual experiment.

The preceding line of argument suggests that the relationship between innovation and profit must be tested, but that the test cannot be made with data for one firm alone since this requires a counterfactual experiment. If, however, a sufficiently large sample is used, it should be possible to measure significant differences between the two types of firms. This leads to a more specific statement, namely:

> *H1: Profit for innovators will be significantly different from non-innovators.*

Empirical Literature Related to H1

While there is not a large literature on the subject, there have been several studies that have tested H1 or variants of it with firm-level data. Recently authors (Geroski, Machin, and Van Reenen 1993) used data for 721 U.K. manufacturing firms, including 72 firms in the food, drink, and tobacco industry. They found a positive long-run effect of innovation on profit margins across all firms together, but a negative effect for the food, drink and tobacco industry and two other industries.

Other authors (Cefis and Ciccarelli 2005) sought whether differences in profitability come from innovations themselves or merely from innovative firms having greater competency in business. They divide their sample between innovators and non-innovators, and base their tests on differences in distributions between the two groups. They find a statistically significant difference between the two groups, with innovators being the more profitable of the two. They conclude that innovation seems to have contributed to the observed profit differentials.

There has been previous work that tests the profit-innovation relationship for Canadian manufacturing but nothing specifically for the Canadian food processing industry. In terms of all manufacturing industries, researchers at Statistics Canada assess the impact of technology adoption on profitability (Baldwin and Sabourin 2001). Using the 1998 Survey of Advanced Technology and the Annual Survey of Manufacturers (excluding the food industry), firms are grouped according to whether they are higher or lower than median growth in performance. The differences between the two groups are compared, and plants with the highest growth in profitability are shown to also have higher rates of technology growth.

Another Statistics Canada study used data for growing small-sized and medium-sized firms to test several hypotheses related to innovation (Baldwin and Johnson 1995). The authors test for a significant difference between "general profitability" for innovative and non-innovative firms. They find the difference to be positive, but not significant. No distinction is made between the firms in terms of industry, and so no results are generated that are specific to the Canadian food processing industry.

More recently firm-level data from the 1999 Survey of Innovation linked with data from the Annual Survey of Manufacturing and Logging was used to test the profitability-innovation nexus (Cozzarin 2004). This data, which includes data for firms in most Canadian manufacturing industries including food processing, is used to measure the relationship between innovation and value-added. The estimated coefficients for innovation, which are common across all firms, are positive but have high standard errors. This result suggests that, as in Baldwin and Johnson (1995), innovators seem to have had higher profit than non-innovators on average, but that the levels of profit are not significantly different.

Another author tests the hypothesis that innovation is positively associated with revenue growth using WES data for 1999 and 2000 (Thornhill 2006). The estimated coefficient on innovation is positive and significant. No specific results for the Canadian food processing industry are reported.

The various studies cited here seem to offer a mixed set of results, with some finding clear support for the link between innovation and profitability and others finding only limited support. These latter studies instead report a positive but statistically insignificant relationship between innovation and profitability. This evidence suggests that the relationship between innovation and profitability is not certain and that its statistical significance should be tested.

Profit and Type of Innovation

Where firms do innovate, the question is no longer whether innovators are more profitable than non-innovators, but rather whether certain types of innovation are more profitable than others. One general area of interest in this regard has been in the choice between process and product innovation, with emphasis varying between purely theoretical, applied, and atheoretical approaches. On the theoretical side, there have been a number of contributions. For example, Cohen and Klepper (1996) look at different ways that process and product R&D can affect profitability. In their model, process R&D is assumed to generate increased profit from reductions in average cost. Product R&D, however, is posited to affect product attributes and quality but not cost, so that higher profit comes about from higher prices. The model suggests that the share of process over product R&D increases with firm size.

Petsas and Giannikos (2005) use a differentiated product framework to examine the process-product issue. In their model, firms choose an optimal mix of process and product innovation, and this mix depends on firm size. The marginal product of each type of innovation differs, as in the Klepper and Cohen framework, because the level of output affects returns from process but not product R&D. The Petsas and Giannikos model shows that, for a firm that produces several products, product innovation will be more profitable than process innovation up to a threshold number of products, beyond which process innovation will have a larger incremental effect on profit.

Capitanio, Coppola, and Pascucci (2010) estimate a nested logit model to measure the relative importance of various explanatory variables in the choice of process or product innovation.

They look at innovation in food processing specifically. They argue that the food industry has specific innovation patterns, where firms introduce process innovation more often that product innovation and where the latter tend to be incremental. Their study is primarily concerned with the factors leading to the choice of one over the other type of innovation, but their observations regarding the higher frequency of process innovation suggests that these are the more profitable type for food processors. Bertschek (1995) offers a theoretical framework that incorporates the effects of foreign direct investment on innovation. Cost is affected by both process and product innovation while output price is affected only by product innovation. Bertschek estimates this model using a probit procedure. By design, this approach only offers information about the significance of explanatory variables in determining whether product or process innovation is performed. It is not possible, with this type of model, to estimate the effects of the two types of innovation on profit.

Rouvinen (2002) develops a theoretical model that infers relative profitability from the choice that has been made between product and process innovation. The estimation procedure is bivariate probit – this allows for some complementarity but more importantly, is consistent with most of the empirical research in this field in measuring the determinants of the choice of innovation, rather than the impact of the choice of innovation on the level of profitability.

Rosenkranz (2003) provides a purely theoretical approach to the decision between process and product innovation. This model provides ambiguous results, showing that there are a variety of factors that affect a firm's choice between the two types of innovation. Each decision is dependent on firm-specific parameters, so the model does not offer information about the possible outcome of the actual choice that is made.

Hall, Lotti, and Mairesse (2009) estimate a model that uses predicted probabilities of process and product innovation as explanatory variables in an estimated productivity equation. Their estimates show, for a specification that excludes capital, that process innovation has a significant positive effect on productivity and that this effect is larger than the impact of product innovation, which is also positive. The relative contribution of process and product innovation is reversed when capital is included in the equation, but both still have a positive impact on productivity.

From the foregoing, we conclude that the literature does not offer clear guidance regarding the relative impact of process and product innovation on profitability. The common assumption is that process innovation will be cost-reducing (productivity-improving) and that product innovation will tend to raise cost, if anything. This is tested here as:

> *H2: (a) there will be a significant difference between profitability for product-only innovators and process-only innovators and (b) firms introducing process only innovation will have greater profitability than product-only innovators.*

Empirical Literature Related to H2

There is little in the way of previous empirical work that has involved a test of this hypothesis. Of the studies cited above, none examine the effect of process and product innovation on profit directly; instead attempts are made to identify the factors that drive the choice between the two types of innovation, where the latter is usually treated as a binary variable.

There is limited evidence for Canadian manufacturing of the factors leading to the decision of process or product innovation as well as the impact of each type of innovation on profit. Baldwin and Sabourin (1999) estimate logit equations to explain different types of innovation in terms of plant, firm and industry characteristics for a sample of Canadian food processing firms. These results do not, however, give any insight into the relative profitability of the choices made.

Therrien and Hanel (2009) offer evidence of the impact of processing and product innovation on labor productivity but no direct evidence of the impact on profitability. They use data from the 2005 Survey of Innovation and linked to Annual Survey of Manufactures and Logging data. Their estimates show the counterintuitive results that process innovation lowers labor productivity.

Profit and Complementarity

A related issue is whether the two types of innovation are complementary, i.e. whether profitability of innovation is higher if firms introduce both process and product at the same time. There is some theoretical and empirical support for this notion. For example, Mantovani (2006) uses a model that shares some features of both Cohen and Klepper's and Petsas and Giannikos' models in showing how the marginal profitability of two innovations together might exceed that of doing them separately.

Kraft (1990) argues that there are obvious reasons why the two types of innovation might not be independent of each other, for example, where a new process is needed to produce a new product. While not offering a strong theoretical framework, Kraft's estimates, using a probit model, indicate that product innovation has an impact on the adoption of a process innovation but that the reverse does not hold.

It is possible that product innovation will be more profitable if it is accompanied by process innovation, where the latter should be cost-reducing and, therefore, offset some of the (assumed) cost-increasing effects of product innovation referred to in the literature. Similarly, process innovation may be more profitable if it is accompanied by product innovation, providing any increase in cost due to the introduction of new products is offset by increased revenue. So it seems reasonable to suppose that combined process and product innovation would be more profitable than either innovation alone. This leads to the third hypothesis to be tested here, namely:

> *H3: (a) there will be a significant difference between the profitability of product-process innovators versus product-only innovators and process-only innovators (b) firms with product-process innovation with have greater profitability than the other two types of innovators.*

Empirical Literature Related to H3

As in the case of process and product innovation, there has been little work on the issue of process-product innovation complementarity in Canadian manufacturing. In terms of complementarity, Cozzarin and Percival (2006) consider firm strategies while controlling for innovation novelty (world-first, Canada-first, and firm-first) using the 1999 Survey of Innovation. Brewin, Monchuk, and Partridge (2009) appears to be the only example that examines product-process complementarity, although their paper does not address the relative profitability of the innovation types. They estimate a multivariate probit model using a sample of 1200 food processors and conclude that there are complementarities between process and product innovation, particularly when these innovations are developed in-house.

The Data

Statistical agencies have been conducting innovation surveys for nearly two decades (OECD 2005). Statistics Canada's Survey of Innovation and Advanced Technology (conducted in 1993) is the first Canadian survey that collected comprehensive data on innovation activity. Since then, Statistics Canada has carried out a variety of innovation surveys, the two most recent being the Survey on the Commercialization of Innovation, 2007 and the Survey of Innovation and Business Strategy, 2009. While some innovation surveys have collected economic data (such as the value of investment in innovation), questions regarding revenue, cost of production or profit have been missing, meaning that the data are of limited value for economic analysis.

We use the Workplace and Employee Survey for our analysis, and while it is not an innovation survey, it asked several questions related to innovation activity as well as questions related to input cost, revenue, hires-terminations and employee characteristics. The survey was conducted between 1999 and 2006 by Canada's national statistical agency and, as such, is unique in offering a cross-sectional/time-series data set for analysis of manufacturing firms, including those primarily engaged in food processing. The WES followed a longitudinal, integrated approach to the collection and analysis of data on firms and their employees. These data are, therefore, well-suited for carrying out the types of hypothesis tests described in the previous section.

To capture innovation activity, the WES asked firms whether they had introduced new products/services, improved products/services, new processes or improved processes. The questions were generally consistent with the OECD's Oslo Manual, which defines a product innovation as "the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses" (OECD 2005) and a process innovation as "the implementation of a new or significantly improved production or delivery method" (OECD 2005). Firms were also asked questions about financial information such as gross operating revenue from the sale or rental of all products and services and gross operating expenditure (payroll, non-wage expenses and the purchase of goods). Analysis by detailed industry such as food processing requires access to the micro data. Access to these data was provided by Statistics Canada's Federal Research Data Centre in Ottawa.

Workplace data over the full eight years allows for a maximum sample size of 10,248 manufacturing firms. Linking all eight years for manufacturing industries resulted in some losses in the sample due to 2,308 workplaces being rotated out of the survey frame and 1,348 lost due to bankruptcy, merger, or acquisition. In addition, sixty workplaces were removed from the linked dataset due to anomalies. The resulting sample size was 5,784 observations over eight years or a panel of 723 firms for the manufacturing sector. It is important to note that, by using panel data, both innovating and non-innovating firms in the panel are by definition profitable (or at least break even) on average, since they survive over the whole eight years. This means that only "successful" firms are examined, where each firm's choice to innovate or not innovate has not prevented it from staying in business.

The panel dataset was constructed using a two-stage programming process in SAS. The first stage involved extracting all manufacturing firms as a subset of the data collected in each survey year using the associated North American Industry Classification System (NAICS) coding. Next, the eight sets of firms (one set for each year) were linked across time via another programming module to match a unique firm identifier across years. A backward linkage approach created a panel of firms, grouped by 3-digit NAICS industry.

Profit is defined as the difference between gross operating revenue and gross operating expenditure where data for both variables is collected by two separate questions in the WES questionnaire. Profit can be interpreted either as the cost of capital services from productive capital or as the return to that capital (capital income). The latter interpretation is common, particularly in relation to the National Accounts - see, for example, Diewert, Harrison, and Schreyer (2004) and Statistics Canada (2008). This interpretation suits our analysis well, since the expected net present value of the change in profit due to the innovation investment is the return to that investment. In addition, to deal with scale effects we use a second measure—profit-margin, which is defined as (gross operating revenue – gross operating expenditure)/gross operating revenue.

Profit is commonly used as a measure of firm-level profit in empirical research. For example: Schivardi et al. (2010) use profit data to estimate a profit-margin for retailers in their analysis of the impact of changes in regulations restricting store sizes; Coad, Rao, and Tamagni (2011) investigate the interaction between several variables typically used to assess the degree of firm-level growth, using gross operating revenue minus gross operating expenditure as one of these variables and referring to it as "profit"; and Du Caju, Rycx, and Tojerow (2011) use gross operating revenue minus gross operating expenditure to construct profit-per-worker as an explanatory variable in their wage equations.

To summarize the data, average annual profit and profit-margin for each industry was calculated for 1999-2006. The averages are depicted in Table 1. In spite of the importance of the food processing industry in terms of its share of the manufacturing sector's GDP and employment, average profit of $1,211,222 was lower than the median of $1,574,374 across all manufacturing industries. In terms of profit-margin food processing is in the top seven industries, while the beverage and tobacco product industry is in the top two industries.

Table 1. Average annual profit and profit-margin by manufacturing industry (1999-2006)

NAICS	Industry	Number of Firms in the Panel	Average Annual Profit per Firm ($)	Average Annual Profit-Margin (%)
311	Food Processing	98	1,211,222	14.16
312	Beverage & Tobacco Product	74	12,946,756	27.73
313-314	Textile Mills, Textile Product Mills	20	1,867,192	10.82
315-316	Clothing, Leather & Allied Product	29	554,514	13.58
321	Wood Product	66	2,007,296	13.25
322	Paper	49	11,105,244	13.18
323	Printing & Related Support Activities	52	404,638	14.01
324-325	Petroleum, Coal Product & Chemical	35	5,333,482	11.63
326	Plastics & Rubber Products	44	(333,674)	8.59
327	Non-Metallic Mineral Product	31	1,574,374	12.57
331	Primary Metal Manufacturing	29	5,678,159	15.01
332	Fabricated Metal Product	73	862,861	16.82
333	Machinery	40	1,945,104	28.42
334	Computer & Electronic Product	18	4,193,224	10.35
335	Electrical Equipment, Appliances & Component	14	1,238,703	10.53
336	Transportation Equipment	62	6,191,232	12.38
337	Furniture & Related Product	24	1,033,006	16.22
339	Miscellaneous	30	379,891	19.87

Source. Statistics Canada, Workplace and Employee Survey, Workplace Component, 1999-2006. Data are derived using the linked WES database. Note that some industries were combined due to small sample size (NAICS 313-14, NAICS 315-16, NAICS 324-25).

Note. Profit equals gross operating revenue from the sale or rental of all products and services, less gross operating expenditure (which includes payroll, non-wage expenses and the purchase of goods). Profit margin is simply profit (as defined above) divided by gross operating expenditure.

As stated earlier, the WES survey asked four binary questions regarding four different innovation types introduced by the firm: (i) new products or services; (ii) improved products or services; (iii) new processes; and/or (iv) improved processes over the past year. In any year, a firm could have reported "yes" up to four times, so that, by 2006, a firm could have responded "yes" a maximum of eight times for each of questions (i) to (iv). Thus, cumulatively, any firm could have responded "yes" a maximum of 32 times. Moreover, since each question actually allows for more than one innovation in any given year, a firm could have actually carried out more than 32 innovations over the whole period.

The diversity of possible responses in the panel means that the WES data offer a rich set of possibilities regarding innovation activity. To perform the hypothesis tests, the simplest possible configuration was used. If a firm innovated in at least one out of the eight years, it was included in the innovator group. Similarly, within the innovator group, a firm that carried out only a process innovation in one or more years was included in the set of firms identified as process innovators, etc.

Table 2 summarized the data in terms of innovation type. The second column gives the proportion of total firms in each industry panel that fit into one of three categories of innovation between 1999 and 2006–these are the "innovator" firms.

A firm in the "process innovation" category introduced, in at least one of these years, a new process, an improved process or both, but did not introduce a new or improved product in any year. Similarly, a firm in the "product innovation" category introduced, in at least one year, a new product, an improved product or both, but did not introduce a process innovation in any year. A firm in the "both product and process innovation" category introduced, in at least one year, a new and/or improved process and in the same year or some other year, introduced a new and/or improved product as well. For food processing, 60% of firms introduced at least one innovation over this period. The "any innovation" rate for the food processing panel was higher than the median rate across all industries, which was 53%.

The three other columns in Table 2 illustrate the diversity of innovation both within and across types. The rate of product innovation for firms in the food processing industry was 20%. This is the second highest product innovation rate out of all industry panels. For process innovations, food processing firms were below the median of 5%. The food processing industry introduced both product and process innovation (new and/or improved) at the median rate (36%); this is higher than the rate for process or product innovation alone and was the most common case for all but one industry as well.

What the data show is that, with only one exception, a higher proportion of firms in the industry panels introduced product-only innovations than process-only innovations. For some industries, including food processing, the difference was quite large, with the proportion of firms introducing product-only innovations several times higher than those introducing process innovations only. For the food processing industry panel, the former was almost nine times higher than the latter.

The data also show that, with only one exception, the proportion of firms that introduced both product and process innovation was several times higher than the proportion introducing one or the other type alone. For the food processing industry panel, the proportion introducing both types of innovation was almost twice as high as that for one or the other alone.

Table 2. Rate of Innovation by Type, WES Panel Data by Manufacturing Industry (1999-2006)

	Innovation Type			
	Any innovation	**Process innovation**	**Product innovation**	**Both product & process**
Industry	*(Percent of firms that introduced an innovation of that type in at least one year between 1999-2006)*			
Food Processing	60	4	20	36
Beverage & Tobacco Product	72	2	7	63
Textile Mills, Textile Product Mills	38	4	10	24
Clothing, Leather & Allied Product	49	1	27	21
Wood Product	40	7	9	25
Paper	74	12	14	49
Printing & Related Support Activities	45	8	12	25
Petroleum, Coal Product & Chemical	61	3	13	44
Plastics & Rubber Products	65	13	14	38
Non-Metallic Mineral Product	50	5	10	35
Primary Metal Manufacturing	52	8	7	37
Fabricated Metal Product	39	7	8	25
Machinery	60	4	10	46
Computer & Electronic Product	55	1	4	51
Electrical Equipment, Appliances & Component	51	10	11	30
Transportation Equipment	54	8	13	33
Furniture & Related Product	40	4	15	21
Miscellaneous	59	3	18	38

Note. The WES questionnaire defined innovation as follows: New products or services differ significantly in character or intended use from previously produced goods or services. Improved products or services are those whose performance has been significantly enhanced or upgraded. New processes include the adoption of new methods of goods production or service delivery. Improved processes are those whose performance has been significantly enhanced or upgraded.

Hypothesis Test Results

A test of the effect of innovation on profitability with the WES data needs to take into account the nature of the variables. Test statistics based on the normal, t or F distributions are not appropriate if the profit variable is non-normal. Non-normality of profit was confirmed using several tests: Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling; meaning that standard parametric procedures cannot be used.

The non-parametric Kruskal-Wallis test is used to test the hypotheses. This test does not rely on the assumption of a normal distribution. Instead, the data are transformed into ranks (scores). The test uses the scores and not the original observations, and comparisons of mean scores are compared across groups (e.g. innovating firms and non-innovating firms). The Kruskal-Wallis statistic follows a chi-squared distribution. The null hypothesis (of no difference between groups) is tested by comparing the value of the statistic with critical values.

The first hypothesis test is that innovator firms were more profitable than non-innovators. The Kruskal-Wallis test results reported in Table 3 show that equality of profit between the two groups is rejected for the food processing industry panel as well as for nine other manufacturing industry panels.

Table 3. Results by Industry for Hypothesis 1: Firms that innovate are more profitable than firms that do not innovate

	Kruskal-Wallis Test for difference in means between the two groups			**Kruskal-Wallis Test for difference in means between the two groups**		
		(profit)			*(profit-margin)*	
Industry	Chi-square	Pr> Chi-square	Results	Chi-square	Pr> Chi-square	Results
Food Processing	8.106	0.004	reject H0	0.487	0.486	cannot reject
Beverage & Tobacco Product	0.019	0.890	cannot reject	2.904	0.088	reject H0
Textile Mills, Textile Product Mills	6.537	0.011	reject H0	0.066	0.798	cannot reject
Clothing, Leather & Allied Product	0.203	0.652	cannot reject	0.082	0.775	cannot reject
Wood Product	7.133	0.008	reject H0	0.899	0.343	cannot reject
Paper	1.634	0.201	cannot reject	9.442	0.002	reject H0
Printing & Related Support Activities	7.392	0.007	reject H0	0.000	0.991	cannot reject
Petroleum, Coal Product & Chemical	1.505	0.220	cannot reject	2.893	0.089	reject H0
Plastics & Rubber Products	7.792	0.005	reject H0	2.912	0.088	reject H0
Non-Metallic Mineral Product	2.587	0.108	cannot reject	1.158	0.282	cannot reject
Primary Metal Manufacturing	0.683	0.409	cannot reject	1.512	0.219	cannot reject
Fabricated Metal Product	11.643	0.001	reject H0	0.009	0.926	cannot reject
Machinery	9.936	0.002	reject H0	0.063	0.802	cannot reject
Computer & Electronic Product	2.133	0.144	cannot reject	0.959	0.328	cannot reject
Electrical Equipment, Appliances & Component	0.913	0.339	cannot reject	0.273	0.601	cannot reject
Transportation Equipment	8.776	0.003	reject H0	2.198	0.138	cannot reject
Furniture & Related Product	16.173	<0.0001	reject H0	0.139	0.709	cannot reject
Miscellaneous	11.785	0.006	reject H0	3.380	0.066	cannot reject

[1]The formal expression of H1 is: Given two groups of firms with non-negative profits, where the first group of firms innovates and the second group of firms does not innovate then (a) there will be a significant difference between the level of these profits and (b) innovating firms will have a higher level of profit than the non-innovating firms. Part (a) is tested using the Kruskall-Wallis test and (b) is tested using the Rank Sum test.
[2]The critical values for the Kruskall-Wallis test with (k-1) where k is number of groups degrees of freedom (α=0.05) is 3.841 and (α=0.10) is 2.706.

Moreover, for these industries, the rank sum test results (Appendix 2) support the hypothesis that innovator profit was greater than non-innovators. It is evident, from results for the eight industries where equality could not be rejected, that the innovation-profitability link was not universal. For the price-cost margin test results (column 7), we see that in food-processing we cannot say that innovating firms have a different margin than non-innovators, but we can say that for beverage & tobacco product manufacturing. Only four out of 18 industry test results show that innovators have different profit margins than non-innovators. In summary, if we do not consider scale effects in food processing—innovators have greater profits, but if we do, then the advantage goes away. Clearly, just having an innovation in the previous year does not confer profitability to the firm. Profitability is a more complex outcome than just being innovative.

Hypothesis H2 is tested by comparing the profit for process innovators (firms that introduced at least one new process or one improved process between 1999 and 2006) with the profit for product innovators (which are defined similarly); firms with neither are excluded. Results presented in Table 4a show that, for the innovators in the food processing industry panel, the profit was not significantly different between process and product innovators. This was the case for every other manufacturing industry panel of innovating firms, with the exception of the machinery industry, where higher profit for process innovations could not be rejected. Table 4b shows the test results for H2 by comparing food processing with all other manufacturing. We see a positive result only for all other manufacturing; for profit margin we see no effect. Thus in most cases, if the previous year's innovative activity has an effect on profit, it either impacts both process and product innovators in the same fashion, or not at all.

Table 4a. Results by Industry for Hypothesis 2: Process innovations are more profitable than product innovations

	Kruskal-Wallis Test for difference in means between the two groups *(profit)*			**Rank Sum Test for which group has greater mean profit** *(profit)*		
Industry	Chi-square	Pr>Chi-square	Results	Z	One-Sided Pr<Z	Results
Food Processing	2.175	0.140	cannot reject	-1.475	0.070	cannot reject
Beverage & Tobacco Product	1.901	0.168	cannot reject	1.365	0.086	cannot reject
Textile Mills, Textile Product Mills	0.357	0.550	cannot reject	0.594	0.276	cannot reject
Clothing, Leather & Allied Product	3.050	0.081	cannot reject	1.744	0.041	reject H0
Wood Product	2.971	0.085	cannot reject	-1.722	0.043	reject H0
Paper	0.123	0.726	cannot reject	-0.350	0.363	cannot reject
Printing & Related Support Activities	1.438	0.230	cannot reject	-1.198	0.116	cannot reject
Petroleum, Coal Product & Chemical	0.308	0.579	cannot reject	-0.554	0.290	cannot reject
Plastics & Rubber Products	0.565	0.452	cannot reject	-0.750	0.227	cannot reject
Non-Metallic Mineral Product	0.039	0.843	cannot reject	0.194	0.423	cannot reject
Primary Metal Manufacturing	1.619	0.203	cannot reject	-1.270	0.102	cannot reject
Fabricated Metal Product	0.916	0.339	cannot reject	-0.956	0.170	cannot reject
Machinery	6.747	0.009	reject H0	-2.596	0.005	reject H0
Computer & Electronic Product	0.669	0.413	cannot reject	0.814	0.208	cannot reject
Electrical Equipment, Appliances & Component	0.235	0.627	cannot reject	-0.478	0.316	cannot reject
Transportation Equipment	2.295	0.130	cannot reject	-1.514	0.065	reject H0
Furniture & Related Product	1.352	0.245	cannot reject	-1.159	0.123	cannot reject
Miscellaneous	0.372	0.542	cannot reject	-0.608	0.272	cannot reject

Table 4b. Results for Hypothesis 2: Process innovations are more profitable than product innovations

	Kruskal-Wallis Test for difference in means between the two groups			Kruskal-Wallis Test for difference in means between the two groups		
	(profit)			*(profit-margin)*		
Industry	Chi-square	Pr>Chi-square	Results	Chi-square	Pr>Chi-square	Results
311	0.6607	0.4163	cannot reject	1.657	0.198	cannot reject
All other manufacturing (excluding 311)	18.94	<0.0001	reject H0	2.3291	0.127	cannot reject

Hypothesis H3 is tested by comparing the profit for process-product innovators to the profit for firms that are only product innovators or only process innovators. Non-innovating firms are excluded from the test. Results presented in Table 5a show that, for the innovators in the food processing industry panel, the profit was significantly different between process-product and only process or only product innovators (rank sum test results were suppressed). The same result holds true for furniture and related products, however, in all other industries the null hypothesis (of no difference in means) cannot be rejected. Table 5b shows that "more intensive" food processing innovators are more profitable (in terms of profit and profit-margin). By more intensive we mean, firms that do both product and process innovation. For the "all other manufacturing" group of firms, the results indicate that more intensive innovators have greater profit, but not greater price-cost margins.

Table 5a. Results by Industry for Hypothesis 3: Combined Product-Process innovations are more profitable than product innovations alone or process innovations alone

	Kruskal-Wallis Test for difference in means between the two groups			Rank Sum Test for which group has greater mean profit		
		(profit)			*(profit)*	
Industry	Chi-square	Pr>Chi-square	Results	Z	One-Sided Pr<Z	Results
Food Processing	8.866	0.012	reject H0	-- results suppressed --		
Beverage & Tobacco Product	2.534	0.282	cannot reject	-- results suppressed --		
Textile Mills, Textile Product Mills	1.498	0.473	cannot reject	-- results suppressed --		
Clothing, Leather & Allied Product	3.753	0.153	cannot reject	-- results suppressed --		
Wood Product	3.510	0.173	cannot reject	-- results suppressed --		
Paper	0.457	0.796	cannot reject	-- results suppressed --		
Printing & Related Support Activities	5.086	0.079	cannot reject	-- results suppressed --		
Petroleum, Coal Product & Chemical	1.811	0.404	cannot reject	-- results suppressed --		
Plastics & Rubber Products	3.075	0.215	cannot reject	-- results suppressed --		
Non-Metallic Mineral Product	0.595	0.742	cannot reject	-- results suppressed --		
Primary Metal Manufacturing	3.489	0.174	cannot reject	-- results suppressed --		
Fabricated Metal Product	0.779	0.677	cannot reject	-- results suppressed --		
Machinery	1.259	0.532	cannot reject	-- results suppressed --		
Computer & Electronic Product	0.153	0.927	cannot reject	-- results suppressed --		
Electrical Equipment, Appliances & Component	0.640	0.726	cannot reject	-- results suppressed --		
Transportation Equipment	3.537	0.170	cannot reject	-- results suppressed --		
Furniture & Related Product	10.682	0.005	reject H0	-- results suppressed --		
Miscellaneous	2.687	0.261	cannot reject	-- results suppressed --		

Table 5b. Combined Product-Process innovations are more profitable than product innovations alone or process innovations alone

	Kruskal-Wallis Test for difference in means between the two groups			**Kruskal-Wallis Test for difference in means between the two groups**		
		(profit)			*(profit-margin)*	
Industry	Chi-square	Pr>Chi-square	Results	Chi-square	Pr>Chi-square	Results
311	9.3261	0.0094	reject H0	4.8384	0.089	reject H0
All other manufacturing (excluding 311)	34.5183	<0.0001	reject H0	2.4192	0.2983	cannot reject

Conclusion

The objective of this paper was to examine the link between innovation and profit in the Canadian food processing industry and other Canadian manufacturing industries using firm-level data. Test statistics determined whether hypotheses about innovation and profit (measured as profit, or profit-margin) were supported by the data. The first, and central, hypothesis was that the level of profit for innovating firms was different from (and greater than) the profit for non-innovating firms. We found support for the hypothesis related to profit in food processing and nine out of the seventeen other manufacturing industries in the sample. In terms of profit-margin there was no difference between innovators and non-innovators in food processing. In fact, in only three industries did profit-margins differ between innovators and non-innovators. The mixed results across manufacturing industries is in contrast to Geroski, Machin, and Van Reenen (1993), who found a positive long-run effect for all UK industries except for food processing. These results are also different from those reported by Cefis and Ciccarelli (2005), who found that innovators were more profitable than non-innovators and concluded that innovation seemed to have contributed to the observed profit differentials.

The second hypothesis concerns the profit of process-only innovators versus product-only innovators. We found that for the innovators in the food processing industry, profit and profit-margin were not significantly different between process and product innovators. This was the case for every other manufacturing industry panel of innovating firms, with the exception of machinery, where higher profit for process innovations could not be rejected.

The third hypothesis stated that for three groups of innovating firms, where the first group introduces both process and product innovation; the second group introduces process innovation alone; the third group introduces product innovation alone, then (a) there will be a significant difference between profitability and (b) firms introducing both process and product innovation will have greater profits than firms in the two other groups. We found that the innovators in food processing had significantly different profit between process-product and process-only and product-only innovation. The same result holds true for furniture and related products, however, in all other industries the null hypothesis (of no difference in means) could not be rejected.

In more general terms, the results suggest that it is not a foregone conclusion that innovation is profitable or that one type of innovation will lead to higher profits than another. If this is so, it means that both the analysis of innovation and the development of innovation policy needs to allow for the possibility that innovation will fail to live up to its promise. Over the period 1999-

2006 the Canadian food processing industry had a rather high rate of innovation (60%) relative to lower performing industries. Low performing industries include: textile mills (38% of firms report an innovation), fabricated metal (39%), wood product (40%), furniture (40%), printing (45%), clothing (49%), non-metallic minerals (50%), electrical equipment (51%), primary metal (52%), transport equipment (54%), computer and electronic (55%) and miscellaneous (59%). Another way to look at innovation is that of the 18 NAICS industries in this study, food processing ranked 5th. This finding alone should dispel the myth that food manufacturing is a lackluster innovator.

However, the main finding of the paper is that profitability is higher for food processing innovators vs. non-innovators and that product-process innovators have greater profit and profit-margins than firms that have product-only or process-only innovation. Relative to the remaining manufacturing industries in the sample, we see that nine out of 17 industries demonstrated that profit was greater for innovators vs. non-innovators; for the case of profit-margin, the results fell to only four out of 17 industries. Only 3 out of 17 other industries had greater profit for process-only innovators vs. product-only innovators (profit-margin results had zero out of 17). Perhaps the most telling result was that none of the 17 remaining industries showed that product-process innovators had greater profits and profit-margins than product-only or process-only firms. Thus, firms that innovate in both product and process domains in food processing are more profitable. We should note that this does not mean that firm have to have simultaneous product-process innovation, but instead that they undertake both types. So rather than government promoting an agri-food policy simply to “innovate”, this unique result warrants further investigation.

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Appendix 1

Table A1. Variables and Transformations of Data from the Linked WES Database

Variable Type/Name/Source	Variable Description	Units
Economic Variables: WES Raw Data		
Gross operating revenue (R)	Revenue from the sale of all products and services	$
Gross operating expenditure (C)	Sum of payroll and non-wage expenses and the purchase of goods	$
Economic Variables: Derived		
Profit	R - C	$
Innovation Variables: WES Raw Data		
New product innovation (new_prd)	"Yes" to: has this workplace introduced new products or services?	binary
Improved product innovation (impv_prd)	"Yes" to: has this workplace introduced improved products or services?	binary
New process innovation (new_prc)	"Yes" to: has this workplace introduced new processes?	binary
Improved process innovation (impv_prc)	"Yes" to: has this workplace introduced improved processes?	binary
Innovation Variables: Derived		
Any innovation	"Yes" to any of new_prd, new_prc, impv_prd, impv_prc	binary
No innovation	"No" to all of new_prd, new_prc, impv_prd, impv_prc	binary
Process innovation	"Yes" to either new_prc or impv_prcx or both	binary
Product innovation	"Yes" to either new_prd or impv_prd or boht	binary
Both product & process innovation	"Yes" to (new_prc or impv_prc or both) and (new_prd or impv_prd or both)	binary

Appendix 2

Table A2. Rank sum test for greater profit of innovators vs. non-innovators

	Rank Sum Test *(profit)*		
Industry	Z	One-sided Pr<Z	Results
Food Processing	-2.847	0.002	reject H0
Beverage & Tobacco Product	-0.132	0.448	cannot reject
Textile Mills, Textile Product Mills	-2.555	0.005	reject H0
Clothing, Leather & Allied Product	-0.449	0.327	cannot reject
Wood Product	2.671	0.004	reject H0
Paper	-1.278	0.101	cannot reject
Printing & Related Support Activities	-2.718	0.003	reject H0
Petroleum, Coal Product & Chemical	-1.226	0.110	cannot reject
Plastics & Rubber Products	-2.791	0.003	reject H0
Non-Metallic Mineral Product	1.607	0.054	cannot reject
Primary Metal Manufacturing	-0.825	0.205	cannot reject
Fabricated Metal Product	3.412	0.000	reject H0
Machinery	-3.152	0.001	reject H0
Computer & Electronic Product	-1.458	0.072	cannot reject
Electrical Equipment, Appliances & Component	-0.953	0.170	cannot reject
Transportation Equipment	-2.962	0.002	reject H0
Furniture & Related Product	-4.020	<0.0001	reject H0
Miscellaneous	-3.432	0.000	reject H0

