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Innovation, Rurality and Human Capital in Food Processing

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The Issue

In the hope of supporting rural economies, some rural planners suggest fostering food processing firms in rural areas. Locating close to the source of necessary agricultural commodities might give the processors an advantage. However, emerging patterns of product innovations, which affect demand, and process innovations, which lower costs, are tied to firm-level capacities in research and development. Communities can become more efficient at supplying services, including research services, to a particular industry. This in turn lowers the costs of that industry, driving up demand for the services and so on. The agglomerations of service firms spin off supporting services, which accommodate yet more firms. Agglomerations of service firms are difficult to support in a rural community. Individual firms in rural areas have trouble meeting their own labour needs, let alone the needs of their service sector.

The two forces of low transportation costs for commodity inputs versus lowered costs from agglomerations can leave the optimal location for a food processing firm unclear. Urban settings will deliver more agglomerations, but rural settings might allow for cheaper commodity inputs.

One of the key factors in a firm's success is the rate of innovation. This study looked at the rate of innovation in food processing firms across western Canada and tested



whether this rate was affected by a firm's location or by the human capital capacities of the firm or the region surrounding it.

Implications and Conclusions

Maintaining a competitive edge in the food processing sector requires continued innovation. Omidvar (2006) explored various factors that might determine innovative activity within food processing firms in Canada. He included data from the Innovation in the Food Processing Industry Survey carried out by Statistics Canada and from a survey of western Canadian food processors that was conducted by the Canadian Agricultural Innovation Research Network. The central theme of the thesis was to study the effects of various local and firm characteristics on the probability of innovation in food processing firms in western Canada. Using several alternative estimations, Omidvar found that firm size and market competition scales had a positive effect on both types of innovation (product and process). Rural firms and firms with lower internal or regional education levels had fewer product innovations, but these firms did not appear to have fewer process innovations.

Background

Human capital, or the levels of education and experience of individual workers, has redefined and reshaped the structure of many industries in advanced countries. Firms can improve profit and the likelihood of future survival in the market if they innovate. Two categories of innovation are explored here: reducing the costs of production and improving the quality of the products. By reducing the costs of production, firms can compete on price. By maintaining or improving the quality of products, they add utility for current customers and/or attract new buyers. There is a strong link between human capital and productivity in any industry. Through education and learning by doing, employees can increase their stock of knowledge and even generate externalities by interacting among each other. This means that human capital in many industries may be seen as part of a continuing cycle of innovation and investment that can generate long-term profitability and growth.

The term *innovation* has a range of different meanings in the literature. In this article we define it as a new or significantly improved product (good or service) or process introduced in the firm. Innovation can occur at any level of a firm or organization, for example, marketing, manufacturing, research, finance or personnel management.

It is in a firm's interest to have an educated labour force because the more highly educated the labour force, the better it is at creating, implementing and adopting new technologies (Benhabib and Spiegel, 1994). In addition, education enhances one's ability to receive, decode, and understand information, and these skills allow firms to generate growth by improving old methods of production or creating new products (Lin, 1991). To

date, there is little research that focuses specifically on the level of education in the regional labour force as a way to understand the rate of innovation in an industry.

Data

This research draws on three main data sources. The first is the Survey of Innovation conducted by the Agricultural Policy Research Network in the winter of 2005. During the survey period, 1200 surveys were mailed to food processing firms in the four western provinces of Canada: British Columbia, Alberta, Saskatchewan and Manitoba. The response rate was 12.5 percent. In the survey, *innovation* was defined as either a product or a process innovation that was new to the business or new to the market.

The second source of data was the Innovation in the Food Processing Industry Survey conducted in the winter of 2004 by the Small Business and Special Surveys Division of Statistics Canada on behalf of Agriculture and Agri-Food Canada. The survey covered about 800 establishments. The objective of this survey was to collect new statistical information on the nature and extent of innovation in the food processing industry, characteristics of organizational change, and restructuring practices in the food supply chain that support innovation processes and facilitate the delivery of innovative products and services. For the purpose of this survey, *innovation* was defined as a firm being the first to introduce and/or develop an entirely new or significantly improved product or process in North America (Statistics Canada, 2006).

The third source of data used in this research was the 2001 Census of Population. This census was used to find the education level in each census consolidated subdivision (CCS) region and to link each firm to a CCS code of urban, rural or intermediate. *Urban* and *rural* were two dummy variables used in the models below to determine if the location of the firm plays any part in determining the rate of innovation in the firm. The term *intermediate* refers to the regions that do not meet the definitions for urban or rural locations.

Of the establishments from the Statistics Canada, Innovation in the Food Processing Industry Survey, 52 percent reported that they produced at least one product innovation, and 25 percent reported at least one process innovation.

Thirty-three percent of the establishments reported they employed on average between 50 and 199 workers per year, and 32 percent reported they employed between 20 and 49 workers per year. Only 4 percent of food processing establishments in the sample employed 500 or more workers per year.

For 63 percent of the food processing establishments in the sample, the research group consisted on average of 20 workers or fewer per year from 2001 to 2003.

Fifty-two percent of establishments indicated they invest in product innovation in order to add new products to their existing lines of products. In addition, 58 percent of establishments indicated that increasing their market share is another driving force for investing in product innovation.

Econometric Model

The dependent choice in this study was in all cases the choice to innovate or not. We were looking for firm and regional characteristics that increased the likelihood of innovation. This inquiry required use of one of several types of econometric, discrete-choice model. We chose the probit model.

The probit model can be written as follows: $\Pr(y=1|x) = \Phi(xb)$, where Φ is the standard cumulative normal distribution function and xb is called the probit score or index (Liao, 1994). Since $\Phi(\cdot)$ is a function of the matrix of independent variables x and a vector of coefficients b , the probit can only compute marginal effects by assigning certain values to all of the x 's. Marginal effects measure the effect of a small change in the regressor on the standardized probit index associated with the event.

We used two instances of the probit model in this research. The first model used the data from the Survey of Innovation by the Agricultural Policy Research Network. This model consists of two equations, product innovation and process innovation:

$$\Pr(\text{product innovation} = 1|x) = \Phi(\beta_0 + \beta_1 \text{ budget} + \beta_2 \text{ equipment} + \beta_3 \text{ training} + \beta_4 \text{ bachelor's} + \beta_5 \text{ master's} + \epsilon t) \quad (1)$$

$$\Pr(\text{process innovation} = 1|x) = \Phi(\beta_0 + \beta_1 \text{ budget} + \beta_2 \text{ equipment} + \beta_3 \text{ training} + \beta_4 \text{ bachelor's} + \beta_5 \text{ master's} + \epsilon t) \quad (2)$$

These two equations include five independent variables: *budget*, *equipment*, *training*, *bachelor's* and *master's*. *Budget* is the amount, in dollars, each firm spent on intramural research and development over the three years surveyed. *Equipment* refers to the amount of money, measured in dollars, each firm spent over the past three years in order to acquire advanced machinery, computer software or hardware or generally any equipment that was specifically purchased to produce new or significantly improved products and/or process innovations. *Training* is the amount of dollars each firm spent in the past three years on internal or external training for employees. The purpose of training is to increase the employees' capability to develop or introduce new or significantly improved products and innovations in process. In addition, there are two dummy variables in these two equations: *bachelor's* and *master's*. These variables indicate the answer to the question, "What is the highest level of education among any of the firm's employees?" A high school diploma was the highest education level within 20 percent of the firms. A bachelor's degree was reported as the highest education level for 62 percent of firms. Only 18 percent of firms reported a master's degree as their highest education level. In these two equations, high school education was omitted in order to prevent perfect correlation between the dummy variables. Table 1 shows the variables and the units of measurement.

Table 1 Variables Used from the Survey of Innovation

Variable	Dummy variable	Definition	Unit of measurement
budget	no	amount of spending on R&D	dollar
equipment	no	amount of spending to acquire machinery and new technology	dollar
training	no	amount of spending on staff training	dollar
bachelor's	yes	highest education level within the firm	binary
master's	yes	highest education level within the firm	binary

The second probit model in this research used data from Statistics Canada's Innovation in the Food Processing Industry Survey. This model consisted of three equations with three dependent variables: *product innovation*, *process innovation* and *both product and process innovation*. They took the following forms:

$$\Pr(\text{product innovation} = 1|x) = \Phi(\alpha_0 + \alpha_1 \text{size} + \alpha_2 \text{ownership} + \alpha_3 \text{price competition} + \alpha_4 \text{product competition} + \alpha_5 \text{university facility} + \alpha_6 \text{urban} + \alpha_7 \text{rural} + \alpha_8 \text{high school} + \alpha_9 \text{post secondary education} + \epsilon t) \quad (3)$$

$$\Pr(\text{process innovation} = 1|x) = \Phi(\alpha_0 + \alpha_1 \text{size} + \alpha_2 \text{ownership} + \alpha_3 \text{price competition} + \alpha_4 \text{product competition} + \alpha_5 \text{university facility} + \alpha_6 \text{urban} + \alpha_7 \text{rural} + \alpha_8 \text{high school} + \alpha_9 \text{post secondary education} + \epsilon t) \quad (4)$$

$$\Pr(\text{innovation} = 1|x) = \Phi(\alpha_0 + \alpha_1 \text{size} + \alpha_2 \text{ownership} + \alpha_3 \text{price competition} + \alpha_4 \text{product competition} + \alpha_5 \text{university facility} + \alpha_6 \text{urban} + \alpha_7 \text{rural} + \alpha_8 \text{high school} + \alpha_9 \text{post secondary education} + \epsilon t) \quad (5)$$

Size in this model refers to the number of employees working in each establishment. The *ownership* variable will be 1 if majority ownership is Canadian and 0 if the establishment is non Canadian. *Price competition* and *product competition* are two dummy variables used to evaluate the effect of market structure on product and process innovation. *University* in this model is a dummy variable and refers to collaboration between food processing firms and local universities and colleges. *Urban* and *rural* are two dummy variables that check whether the location of the firm plays any part in determining the probability of innovation in the firm. In this study, an intermediate regional designation (neither urban nor rural) was deleted from the data set to prevent perfect collinearity in the model. The last two variables in this model are designed to evaluate the effect of education on the probability of innovation. Table 2 lists the variables and units of measurement used in this model.

Table 2 Variables Used for the Innovation in the Food Processing Industry Survey Model

Variable	Dummy variable	Source of data	Definition	Unit of measurement
size	no	Food Processing Industry Survey	number of employees working in establishment	# of employees
ownership	yes	Food Processing Industry Survey	ownership either Canadian or foreign	binary
price competition	no	Food Processing Industry Survey	intensity of price competition in food processing	scale
product competition	no	Food Processing Industry Survey	intensity of product competition in food processing	scale
university facility	yes	Food Processing Industry Survey	using university or college to produce innovation	binary
urban	yes	CCS region in Census of Pop. 2001	centres with over 100,000 in population along with neighbouring regions where at least 50% of workforce commute to urban core	binary
rural	yes	CCS region in Census of Pop. 2001	regions of 1,000 people or fewer or regions with 400 or fewer people per square km (du Plessis et al., 2001)	binary
population density	no	CCS region in Census of Pop. 2001	number of people living in each square km	# of people
high school	no	CCS region in Census of Pop. 2001	percentage of people with high school education	percentage
post secondary	no	CCS region in Census of Pop. 2001	percentage of people with post-secondary education	percentage

Results

Survey of Innovation

Table 3 and table 4 show the means and standard deviations for exogenous variables for product innovations and process innovations, respectively, using data from the Survey of Innovation. Innovation was again measured according to the rate of any innovation in the last three years. Table 3 shows that, on average, innovative firms had higher budgets for research and development than non-innovative firms, as well as more financial resources for training and for acquiring the latest technologies. In addition, the labour force in innovative firms had more individuals with bachelor's degrees than the labour force in non-innovative firms. Three-quarters of innovative firms claimed that the highest education level in their organization was a bachelor's degree, where only one-half of non-innovative firms made the same claim. Furthermore, innovative firms had more workers with post-secondary education than non-innovative firms had: 87 percent of innovative

Table 3 Descriptive Statistics for Product Innovation in Canada, 2004

Dependent	Yes		No	
Product	Observations	30	Observations	16
Independent	Mean	S.D.	Mean	S.D.
budget	257770	571510	91625	168140
equipment	240130	558880	99688	156420
training	27503	45801	17875	62350
high school	0.133	0.346	0.250	0.447
bachelor	0.733	0.450	0.563	0.512
master	0.133	0.346	0.188	0.403

Table 4 Descriptive Statistics for Process Innovation in Canada, 2004

Dependent	Yes		No	
Process	Observations	37	Observations	9
Independent	Mean	S.D.	Mean	S.D.
budget	247660	520500	4000	11630
equipment	227270	509720	43333	63818
training	30003	56186	111.110	333.330
high school	0.162	0.374	0.222	0.441
bachelor	0.676	0.475	0.667	0.500
master	0.162	0.374	0.111	0.333

firms claimed that the highest education level in their organization was post-secondary education where 75 percent of non-innovative firms made the same claim.

Table 4 shows the means and standard deviations for food processing firms with process innovations in the Survey of Innovation. The same patterns were observed here as for product innovations, but the results here are more varied. The table indicates that innovative firms spent the money necessary to carry out new and innovative activities. However, innovative firms did not have an advantage over non-innovative firms when it came to education levels. Innovative and non-innovative firms showed similar percentages of firms where the highest degree was the bachelor's degree.

Tables 5 and 6 show the results of the estimated probit equations for product and process innovation in food processing firms sampled in the survey for Western Canada. The most noteworthy highlight of this output is that all the variables in this equation are insignificant in explaining the probability of innovation at the 0.05 confidence level. However, the *bachelor's* dummy variable in product innovation and the *training expenditures* variable in process innovation are significant at the 0.10 confidence level.

Table 5 Probit Regression for Product Innovation (coded 1) or Not (coded 0) in Western Provinces of Canada, 2004

Variable	Estimated coefficient	T-ratio	Elasticity at means	Weighted aggregate elasticity
budget	8.89E-07	0.895	0.093	4.88E-02
equipment	7.29E-07	0.827	0.073	4.18E-02
training	-1.15E-06	-0.223	-0.015	-1.17E-02
bachelor's	0.741	1.373	0.261	2.53E-01
master's	0.193	0.26	0.015	1.54E-02
constant	-0.345	-0.691	-0.181	-1.76E-01

Table 6 Probit Regression for Process Innovation (coded 1) or Not (coded 0) in Western Provinces of Canada, 2004

Variable	Estimated coefficient	T-ratio	Elasticity at means	Weighted aggregate elasticity
budget	2.03E-05	1.046	0.838	1.89E-02
equipment	-2.51E-06	-1.086	-145.99	-1.56E-02
training	9.46E-04	1.505	0.471	3.34E-02
bachelor's	2.172	0.785	0.302	0.24327
master's	1.614	0.587	0.506	3.83E-02
constant	-2.366	-0.856	-144.49	-0.32595

This implies that having at least one worker with a bachelor's degree (dummy takes on the value of 1) within the firm gives the firm a 0.247 percent increase in the probability of producing a product innovation, holding all else constant. In addition, on average, a one percent increase in the budget devoted to training the staff within the firm gives a 0.0334 percent decrease in the probability of producing a process innovation, holding all else constant.

It is important to remember that estimated coefficients do not have a direct economic interpretation. Most economists use marginal effects and elasticities to report their results. The elasticity gives the percentage change in probability of a success in response to a one percent change in the explanatory variable. Since the elasticities vary for every observation, it is desirable to report a summary measure. A convenient summary measure is to evaluate the elasticity at the sample means of the explanatory variables, but it has been suggested that this method is not perfect: since "the elasticities are nonlinear functions of the observed data there is no guarantee that the probit function will pass

through the point defined by the sample average” (Hill, Griffiths and Judge, 2001). Hensher and Johnson (1981) argue that the elasticity-at-means measure tends to over-estimate the probability response to a change in an explanatory variable. These authors recommend evaluating the elasticities at every observation and then constructing a weighted average where the predicted probabilities are the weights. This measure is reported in the output.

It has also been suggested that the marginal effect is a good economic indicator for binary exogenous variables. This suggestion arises from the fact that estimates of the marginal effect are calculated by rescaling the estimated coefficients (Hill, Griffiths and Judge, 2001). This means that the scale factor varies with observed values for explanatory variables. Shazam (2007) suggests that “for reporting purposes, the scale factor can be evaluated at the sample means of the explanatory variables.”

Innovation in the Food Processing Industry Survey

Tables 7, 8 and 9 show the probit estimates for product, process and total innovation for the 685 firms that completed the Innovation in the Food Processing Industry Survey and that could be coordinated geographically with census locations. The results in these tables are based on this sample of 685 firms for which data were complete.

Table 7 shows that size, rurality and the supply of local high school–educated workers are significant at the 0.05 confidence level because their t-values are greater than the critical value of 1.645. The sign of an estimated coefficient gives the direction of the effect of a change in the explanatory variable on the probability of a success. The positive

Table 7 Probit Regression of Firms Reporting Product Innovation (coded 1) or Not (coded 0) in Canada, 2001-2003

Variable	Estimated coefficient	T-ratio	Elasticity at means	Marginal effect	Weighted aggregate elasticity
size (# of employees)	0.274	5.652	0.683	0.109	0.649
ownership (binary)	0.093	0.635	0.083	0.037	7.60E-02
price competition (scale)	0.112	1.39	0.295	0.0446	0.274
product competition (scale)	-0.016	-0.182	-0.035	-0.0063	-3.26E-02
university (binary)	-0.088	-0.517	-0.019	-0.0359	-1.67E-02
urban (binary)	-0.073	-0.493	-0.029	-0.0291	-2.83E-02
rural (binary)	-0.269	-2.015	-0.102	-0.107	-8.54E-02
population density	3.90E-05	1.089	0.042	1.55E-05	4.05E-02
high school (%)	2.278	2.026	0.773	0.9082	0.724
post secondary education (%)	1.232	1.294	0.775	0.4911	0.705
constant	-2.729	-2.697	-2.84	-	-2.607
MCFADDEN (pseudo) R-SQUARE	.5431				

estimated coefficient for size suggests that an increase in the number of employees working in each establishment significantly increases the probability of producing a product innovation. The same can be said about the effect of regional high school education levels. On the other hand, rurality has a reverse effect compared to size and high school.

The high school coefficient can be interpreted, on average, as indicating that a one percent increase in the number of individuals with high school education in each CCS region would lead to a 0.9082 increase in the probability of product innovation. However, this method of reporting has some downfalls. The interpretation of marginal effect is only meaningful when the explanatory variable is continuous (Hill, Griffiths and Judge, 2001). Variables such as the budget devoted to R&D, the budget devoted to acquiring the latest technology or the amount of money spent on staff training are all continuous.

Using the weighted aggregate elasticity measure, the output for the first model for product innovation shows that, on average, a one percent increase in the number of employees gives a 0.649 percent increase in the probability of producing a product innovation, holding all else constant. In addition, using the weighted aggregate elasticity measure, a one percent increase in the number of individuals with a high school education in each CCS region gives a 0.724 percent increase in the probability of producing a product innovation, holding all else constant. Using the marginal effect, a firm's location in a rural area would lead to a 0.107 decrease in the probability of product innovation, holding all else constant. Price competition and post secondary education are significant at

Table 8 Probit Regression of Firms Reporting Process Innovation (coded 1) or Not (coded 0) in Canada, 2001-2003

Variable	Estimated coefficient	T-ratio	Elasticity at means	Marginal effect	Weighted aggregate elasticity
size (# of employees)	0.201	3.954	0.657	0.0621	0.6736
ownership (binary)	-0.015	-0.094	-0.017	-0.0046	-0.0164
price competition (scale)	-0.005	-0.055	-0.017	-0.0015	-0.0163
product competition (scale)	0.148	1.551	0.425	0.0457	0.4146
university (binary)	0.211	1.129	0.06	0.0652	0.0573
urban (binary)	0.034	0.211	0.018	0.0105	0.0180
rural (binary)	-0.076	-0.524	-0.038	-0.0235	-0.0334
population density	1.82E-05	0.472	0.026	0	0.0260
high school (%)	0.468	0.39	0.209	0.1446	0.2029
post secondary education (%)	0.116	0.115	0.096	0.0358	0.0913
constant	-1.837	-1.696	-2.51	-	-2.4034
MCFADDEN (pseudo) R-SQUARE	.4825				

Table 9 Probit Regression of Firms Reporting Innovation (coded 1) or Not (coded 0) in Canada, 2001-2003

Variable	Estimated coefficient	T-ratio	Elasticity at means	Marginal effect	Weighted aggregate elasticity
size (# of employees)	0.216	4.049	0.776	0.203	0.8073
ownership (binary)	0.106	0.625	0.137	0.0997	0.1307
price competition (scale)	0.025	0.27	0.095	0.0235	0.0914
product competition (scale)	0.029	0.289	0.093	0.272	0.0892
university (binary)	0.03	0.153	0.009	0.0282	0.0086
urban (binary)	-0.074	-0.438	-0.043	-0.0696	-0.0422
rural (binary)	-0.155	-1.025	-0.085	-0.1458	-0.0724
population density	2.23E-05	0.547	0.034	2.10E-05	0.0346
high school (%)	0.671	0.53	0.328	0.631	0.3199
post secondary education (%)	0.25	0.234	0.227	0.235	0.2136
constant	-2.017	-1.77	-3.028	-	-2.8822
MCFADDEN (pseudo) R-SQUARE	.5063				

the 0.10 confidence level. Using weighted aggregated elasticity, a one percent increase in the price competition score would increase the probability of product innovation by 0.274. In addition, a one percent increase in the number of individuals with a post secondary education in each CCS region gives a 0.705 percent increase in the probability of producing a product innovation, holding all else constant.

Table 8 shows that size is significant at the 0.05 confidence level and product competition is significant at the 0.10 confidence level. Using the weighted aggregate elasticity measure, this result can be interpreted as indicating that, on average, a one percent increase in the size of the firm gives a 0.674 percent increase in the probability of producing a process innovation. Holding all else constant, a one percent increase in the measure of product competition intensity would, on average, increase the probability of product innovation by 0.4146.

Table 9 shows that size is once again significant at the 0.05 confidence level. This implies that a one percent increase in the size of the firm gives a 0.807 percent increase in the probability of producing an innovation, holding all else constant.

In summary, using several alternative probit estimations, this investigation found that firm size and market competition scales had a positive effect on innovation. Rural firms and firms with lower internal or regional education levels had fewer product innovations, but there was no evidence that these firms had fewer process innovations.

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