Technical Efficiency and Factor Substitution in the Canadian Food Manufacturing Industry

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Abstract: The purpose of the note is to estimate the input elasticity of substitutions and technical efficiency in the Canadian and U.S. food manufacturing industries. First, we find that capital and labour are technical substitutes, whereas capital and energy are technical complements. Second, the mean technical efficiency of the Canadian food manufacturing industry is 87.5%. Lastly, we find no correlation between elasticity of substitutions and technical efficiency.

1 What Is the Issue?

Food processing is among Canada's leading manufacturing employer and accounts for 236,000 jobs. The food processing industry is also the second-largest manufacturing industry overall by revenue. However, the industry has recently experienced a considerable change in terms of the policy governing the food processing sector, as there has been a rise in energy costs and minimum wages. Both these factors might impact the orientation of the industry and in turn, have a bearing on the efficiency and ease of substitution between the factors of production. Rising input costs may influence the competitiveness of the Canadian food manufacturing sector. The extent to which this may happen will depend on the ability of various industries within the sector to substitute from higher-cost inputs to lower-cost inputs, and its ability to maintain or improve production efficiency in the process. Whether or not the industry can substitute between inputs is at the heart of this study. The purpose of the note is to estimate the input elasticity of substitutions and technical efficiency in the Canadian and U.S. food manufacturing industries.

Canada's food and beverage manufacturing sector (NAICS 311 and 312) accounts for 1.68% of national GDP and 15.93% of total manufacturing GDP. The food processing sector is Canada's second-largest manufacturing industry in terms of shipments having a valuation of about CAN$105.5 billion in 2014. The sector employs about 246,000 Canadians and supplies 75% of processed food products in Canada (AAFC, 2014). There are about 6,500 food processing establishments in Canada. Ninety percent of these firms have fewer than 100 workers, while nine percent have between 100 and 500 workers, and only one percent have more than 500 workers. Ontario and Quebec account for about 65% of food processing sector sales, followed by British Columbia and Alberta accounting 21%, while the remaining provinces have a smaller combined share of 14% (AAFC, 2014).

In 2017, the Government of Ontario passed legislation to increase the minimum wage from CAN$11.60 per hour to CAN$14 per hour, and it is tipped to stay at this level for the forthcoming year as well. This rise has represented as one of the steepest rises in the minimum wage in the history of wage hikes for the province. Resultantly, it may also impact the wages across sectors and especially the food manufacturing industry. Hence, it is of utmost importance for firms to track the rising costs in the face of the apparent wage hikes, to be sustainable and profitable at the same time. The recent hike in Ontario's electricity prices can be primarily attributed to the "Global Adjustment Fees", as on average, residential customers and small businesses in Ontario paid about 7.9 cents per kilowatt-hour in Global Adjustment fees last year. This fee stems from the Ontario Green Energy Act. This act was put into motion in 2009, and it intended to expand the province's use of renewables to promote conservation of energy and is billed to all hydro customers in the province (Jackson et al., 2017). As a result, a rise in the energy cost structures may also impact the efficiency of the firms, as Ontario historically used to be a jurisdiction with low electricity costs. It was a competitive advantage in attracting businesses into the province. Recently, Ontario electricity prices have soared, threatening industrial competitiveness, and primarily that of the manufacturing sector for which electricity is a significant input cost. Ontario's manufacturing sector accounts for almost 40% of Canada's exports, and between 2005 and 2015, Ontario's manufacturing output declined by 18% and employment by 28% (Mckitrick and Aliakbari, 2017).

2. What Did the Study Find?

The elasticity of substitution: We find that capital and labour are technical substitutes, whereas capital and energy are technical complements. The elasticity of substitution between, for example, capital and energy, is crucial for policies aimed at reducing energy consumption and the concentration of polluting emissions. Rising energy prices and emission reduction policies such as cap and trade can induce changes in the composition of input and the effect of these behavioural changes depends on the level of substitutability. These results have important implications for investment behaviour and long-term input demand. For example, the results suggest that a rise in energy price may results in a decline in the demand for energy and demand for new capital, leading to a negative effect on capital investment. The complementarity between capital and energy may discourage investment in energy-efficient (saving) technology. The substitutability between capital and labour encourages investment in labour-saving technologies or automation.

Technical Efficiency: the mean technical efficiency of the Canadian food manufacturing industry is 87.5%, and 86.42% for the U.S. We also find considerable heterogeneity in technical efficiency for both Canada and the U.S. (Figure). Technical efficiency ranges between 36.05% and 97.62% for Canada, and 18.24% to 96.67% for the U.S. Dispersion in technical efficiency has an important implication for business dynamics and economic growth. For example, for efficient firms are more likely to grow and less likely to exit the industry. Dispersion in technical efficiency also suggests that technology and management practices of frontier firms – i.e., more efficient firms – can be adapted by less efficient firms. The policy implication of this result is that growth can be achieved through innovative activities by frontier firms or from the adoption of the frontier firms' behaviour by the non-frontier firms (Acemoglu et al. 2006; Bartelsman et al. 2015).

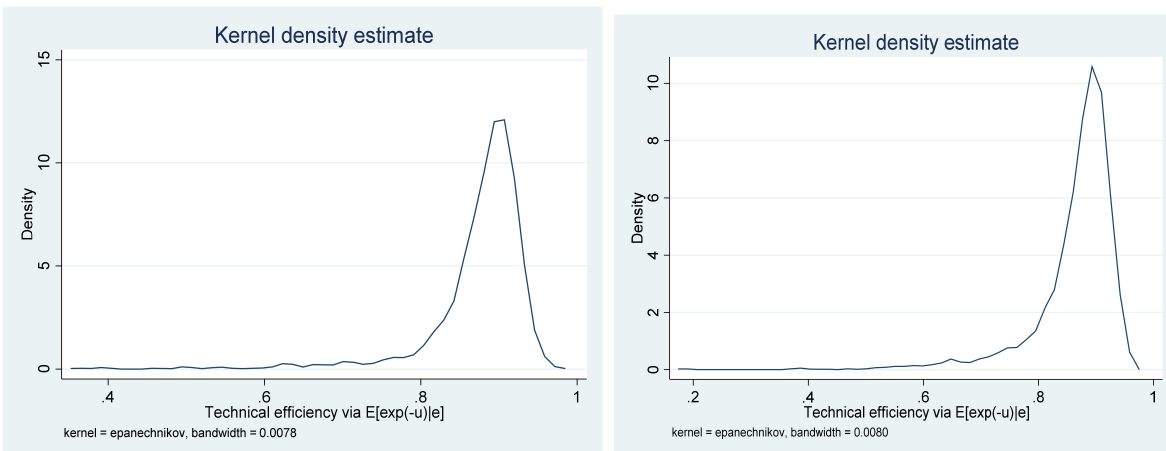

Figure 1. Distribution of Technical efficiency for Canadian and U.S food processing Sectors

3 How was the Study Conducted?

We use annual aggregate data from Statistics Canada over the period 1990 and 2013 at the provincial level and NAICS-4 level. The data are sourced from the Annual Survey of Manufactures and Logging (ASML) and the Fixed Capital Flows and Stocks program. The ASML is an annual survey program and covers detailed industrial statistics for the Canadian manufacturing and logging industries. The Fixed Capital Flows and Stocks program comprises information for all businesses and provides annual estimates of fixed capital stock information. For this study, one aggregate output (manufacturing value-added) and four aggregate inputs (capital, labour, energy, and materials) are defined for our empirical model for Canadian data. The data for the US food manufacturing industry for the duration 2005-2011 are retrieved from the United States Census Bureau for one aggregate output (manufacturing value-added) and three aggregate inputs (capital, labour, and materials). The US data had all the variables similar to the Canadian data, but it did not have any values for the energy cost.

We estimate translog stochastic production frontier to estimate production efficiency and elasticity of substitution. We use the Hicks elasticity of complementarity and the Morishima elasticity of complementarity to measure the elasticity of substitution.

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