

Measures and Causes of Divergent Productivity Growth in the Livestock and Crops Sectors: Prairie Provinces 1940-2004

Bryce Stewart (Graduate Student), Terry Veeman (Professor Emeritus), and Jim Unterschultz (Associate Professor) Department of Rural Economy, University of Alberta.

1.0 Background

Productivity growth is responsible for sixty-four percent of the considerable growth in Prairie agricultural output from 1940 to 2004 (increases in input use are responsible for the remaining thirty-six percent). This study focuses on measuring the productivity growth that has occurred in Prairie agriculture from 1940 to 2004, and the policy implications of these results.

1.1 Changes in Prairie Agriculture Over the Past 65 Years

The measurement of productivity growth in Prairie agriculture requires the construction of a comprehensive data set of agricultural inputs and outputs. Beyond its use in measuring productivity growth, the data set also shows trends in Prairie agricultural production.

In terms of input use, Prairie agriculture has been strongly labour saving and materials using (Figure 1). This is a reflection of the rapid mechanization of agriculture, gains in labour productivity, and the increasing use of pesticide, fertilizer, and energy inputs. Agricultural outputs have also changed substantially over time. The Prairie crops sector typically produces in excess of sixty percent of the total value of Prairie agricultural production; although the livestock sector has increased its share of total agricultural production from the 1980's onward (Figure 2). Figure 3 shows a decline in the share of traditional crops being produced (e.g. wheat, flaxseed and rye). In contrast, canola and specialty crop production (e.g. lentils, sugar beets) has expanded considerably.

Figure 1: Input cost as share of total input cost: Prairie Agriculture 1940-2004

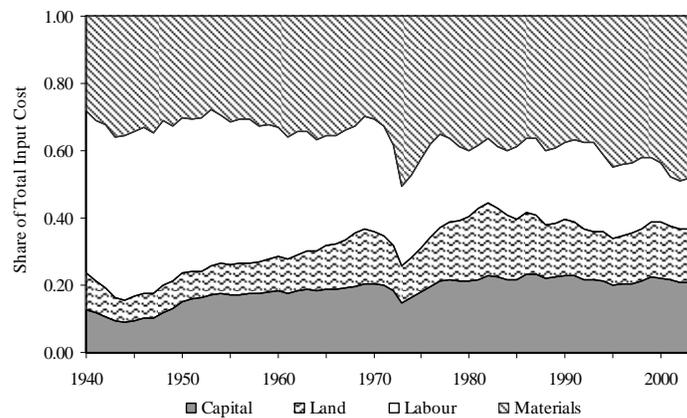


Figure 2: Share of total Prairie agricultural output, by province and sector 1940-2004

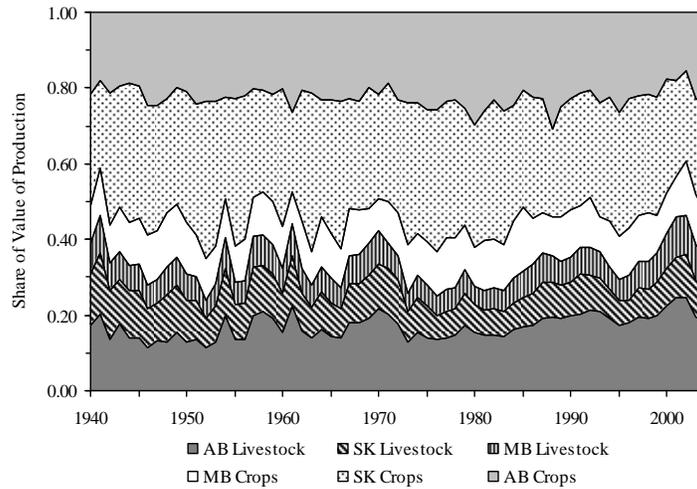


Figure 3: Shares of Prairie crop outputs 1940-2004

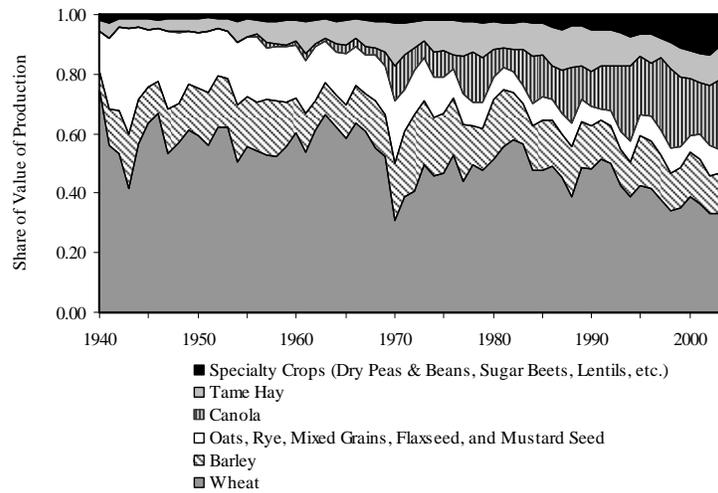
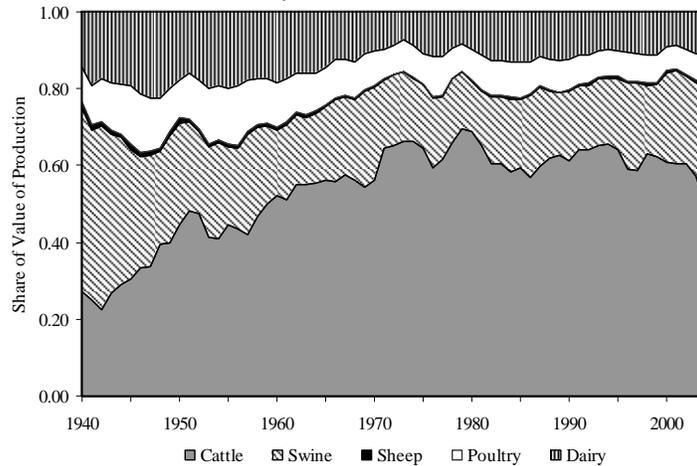


Figure 4: Shares of Prairie livestock outputs 1940-2004



The expansion of cattle's share in total Prairie livestock production from 1940 to 1980 can be seen in Figure 4. By 1980 cattle's share begins to stabilize and then declines somewhat as swine production expands (principally in Manitoba).

2.0 Productivity Growth and its Measurement

Productivity growth is the growth in outputs (e.g. heads of cattle or bushels of wheat) not explained by a growth in inputs (e.g. labour, feed or seed). Prairie agriculture displays strong overall productivity and output growth of 1.56 and 2.43 percent per annum respectively over the 1940 to 2004 period (Table 1). Input growth is more modest at only 0.86 percent a year. However, growth rates measured over the sub periods indicate substantial variation over time.

Table 1: Average annual compound percentage growth rates for Prairie aggregate agricultural inputs, outputs and productivity: 1940-2004

	1940-2004	1940-1959	1960-1979	1980-2004	1990-2004
Productivity Growth	1.56	1.25	1.48	1.80	1.46
Inputs Growth	0.86	-0.03	1.45	0.57	0.21
Outputs Growth	2.43	1.22	2.95	2.38	1.67

To assess the aggregate productivity growth measures in more detail estimates are also obtained at the provincial and sectoral (i.e. crops and livestock) levels. A number of noteworthy trends can be discerned from Table 2. First, productivity growth in the crops sector is substantially higher than in the livestock sector. Second, productivity growth in Manitoba agriculture is considerably higher than in Alberta or Saskatchewan. Third, while crops productivity growth declines over the final fifteen years of the study, livestock productivity growth accelerates over this period (particularly in Manitoba and Saskatchewan).

Table 2: Average annual compound productivity percentage growth rates for Prairie provinces by crops and livestock sectors

	Crops		Livestock	
	1940-2004	1990-2004	1940-2004	1990-2004
Alberta	1.65	-0.05	0.54	0.90
Saskatchewan	1.76	0.40	0.59	3.61
Manitoba	2.12	1.75	0.97	4.21

3.0 How Productivity Growth Happens

Causal explanations for productivity growth can be grouped into one of the three categories: technology development and adoption (e.g. improved genetics), increases in the degree of technical efficiency in production (e.g. better seed placement), and greater economies of scale in production (e.g. more effective use of capital in larger farms).

Productivity growth can be decomposed to reveal the respective roles of technology and economies of scale in productivity growth. Efficiency changes are grouped with measurement errors (i.e. residual). For Alberta, Saskatchewan, and Manitoba respectively, 94.7, 84.5 and 80.4 percent of the recorded crop productivity growth is generated by technology (Table 3). In contrast, the livestock sector has been more effective in generating increasing returns to scale over time. The recent slowdown in crops productivity growth may be largely attributed to limited technological advances in this sector. The accelerating livestock productivity growth may be

attributed in part to technological gains accruing to the sector, but more importantly to the economies of scale realized from the rapid increase in livestock output over the final fifteen years.

Table 3: Components of productivity growth over the 1940 to 2004 period by Prairie province

	Crops (1940-2004)			Livestock (1940-2004)		
	Technology	Scale	Residual	Technology	Scale	Residual
Alberta	94.7 %	4.9 %	0.4 %	37.3 %	51.0 %	11.7 %
Saskatchewan	84.5 %	16.9 %	-1.5 %	57.4 %	62.4 %	-19.8 %
Manitoba	80.4 %	16.5 %	3.1 %	53.2 %	36.0 %	10.8 %

4.0 Testing Causal Explanations for Productivity Growth

In addition to the three general categories of causes (technological, scale, and efficiency) of productivity growth, specific explanations for productivity growth and its variability can be advanced. The following list briefly summarizes a number of explanations applicable to Prairie agriculture: Geoclimatic Differences; Research and Development (R&D) Expenditures; Productivity Differences Inherent in the Biology and/or Production Processes of Specific Outputs; Economic Pressures and Producer Support; Education and Extension; Structural Change.

It is desirable to assess empirically the causal explanations of productivity growth. A number of variables are tested including: domestic R&D, terms-of-trade, farm specialization, farm size, education, extension, off-farm labour, farm/manufacturing wage ratio, and support payments.

For both livestock and crops, Canadian research and development displays the largest positive impact on productivity growth. This finding points to the positive fundamental role that past domestic research and development investments play in productivity growth in both the crops and livestock sectors. Terms-of-trade (growth in output prices minus growth in input prices) is a measure of cost price pressures with a negative number indicating that input costs have increased at a faster rate than output prices. The crop sector and the livestock sector terms-of-trade were -2.57 and -0.29 respectively over the 1940-2004 period. The crops sector in particular and livestock sectors have faced consistently declining (negative) terms-of-trade, an indication of the cost price squeeze faced by Prairie agriculture. The results indicate producers have responded to the cost-price pressures by increasing productivity growth through increased technological adoption. Farm size, as measured by output quantity produced per farm, has increased in both the crops and livestock sectors. Structural change, in terms of increasing farm size, plays an important role in generating positive productivity growth in the livestock sector. Finally, product specialization in swine has been more productive than beef. This result may explain the higher livestock productivity growth in Manitoba over the past fifteen years; a province characterized by rapidly expanding swine production.

5.0 Policy implications

The exact causes of variation in productivity growth between the livestock and crops remain an open question. However, the foregoing results do provide a starting point for assessing the likely causes of Prairie productivity growth and point to a number of policy implications.

First, domestic public and private research and development plays an important role in productivity growth. Consequently, the productivity growth slowdown in crops may be mitigated by long term investments in research and development. The long term nature of the investments is critical due to the long time lags typically involved between research investments and their productivity payoffs. Research and development expenditures are also important for the livestock

sector. Although much of the livestock sector's past productivity gains can be attributed to its swine and cattle output expansion, it is not clear that it can continue to expand in the future at past rates, thus future productivity growth in livestock will likely need to come increasingly from technology, rather than scale of production.

Second, cost price pressures encourage productivity growth in Prairie agriculture. This suggests that producers in both the crops and livestock sectors respond to increasingly competitive economic conditions by increasing productivity. Policy that contributes to producers' flexibility in adopting novel technologies, business structures and management strategies should help ensure productivity growth in the future. This study was not able to directly assess the impact of institutions and regulations on Prairie agriculture productivity growth.

Third, farm size is an important determinant of productivity growth in the livestock sector. Consequently, policy that promotes smaller livestock farm size (e.g. for niche livestock products or rural development policies may involve a trade-off with higher productivity growth.

Fourth, some outputs appear inherently more productive than others (e.g. swine); in this context, increased industry specialization may be desirable. It may also be desirable to focus R&D expenditures on these inherently more productive agricultural outputs. Conversely, to pursue a more diversified productivity strategy, R&D could be earmarked for less productive outputs.

Acknowledgements

Farm Level Policy briefs are summaries of studies funded by the FLP. As such, the briefs omit many of the details and references contained in the longer reports. This brief is based on research work by Bryce Stewart at the University of Alberta. Funding for this project was provided by the FLP and the Alberta Agricultural Research Institute. FLP is funded by Agriculture and Agri-Food Canada. The views expressed in this paper are those of the authors and should not be attributed to the funding agencies.



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