

*Measures and Causes of Divergent Productivity
Growth in the Livestock and Crops Sectors:
Manitoba, Saskatchewan and Alberta Provinces
1940-2004*

Bryce Stewart, Terry Veeman, Jim Unterschultz*

Farm Level Policy
APRN Workshop
Chateau Cartier - Aylmer
March 24, 2006

*Graduate Student, Professor Emeritus and Associate Professor Respectively, Department of Rural Economy, University of Alberta



Background to the Study

This work builds on research conducted for the Alberta Agricultural Research Institute (AARI) over a number of years by Terry Veeman, Shiferaw Adilu and Alberto Fantino; respectively, Professor Emeritus and Research Associates with the University of Alberta's Department of Rural Economy.

Outline

1. Description of productivity
2. Trends in Prairie agriculture 1940-2004
3. Productivity estimates
4. Potential causes of the productivity growth
5. Preliminary findings
6. Policy implications & further research

Key Findings

- Productivity growth in Prairie crops has outpaced productivity growth in livestock
- Productivity growth in crops has slowed over the last fifteen years
- Productivity growth in livestock has accelerated over the last fifteen years

Productivity

- What is productivity growth?
 - Productivity growth is the growth in outputs (e.g. heads of cattle or bushels of wheat) not explained by the growth in inputs (e.g. labour, feed, seed).
 - E.g.
 - In period one - a bushel of wheat requires on average 10 units of fertilizer. A ratio of 1:10.
 - In period two – a bushel of wheat requires on average 8 units of fertilizer. A ratio of 1:8.
 - The declining input to output ratio indicates that productivity has improved from period one to period two.

Productivity

- Why is productivity growth important?
 - Majority of growth in agricultural output over the past century is a result of productivity growth *not* an increase in input use.
 - Source of competitive advantage and long run economic sustainability.
- What causes productivity growth?
 - Technology development and adoption (e.g. improved wheat genetics)
 - Increased efficiency in production (e.g. better seed placement)
 - Greater economies of scale in production (e.g. more effective fertilizer spreading over larger areas)

Productivity

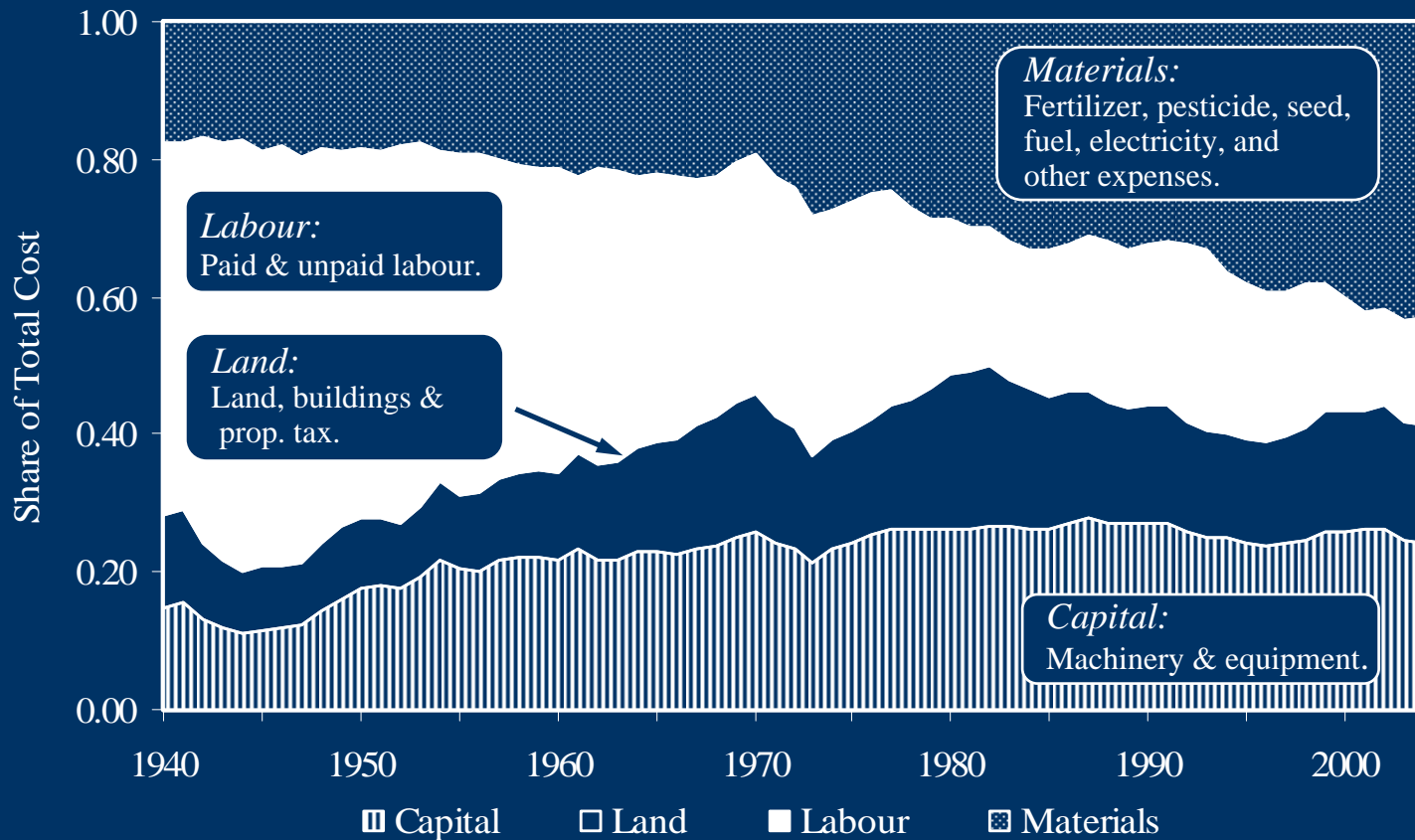
- How is productivity growth measured?
 - The growth of all outputs minus all inputs, i.e. Total Factor Productivity (TFP) or Multifactor Productivity.
 - E.g.
 - output growth = 3 % per annum
 - input growth = 1 % per annum
 - productivity growth = 2 % per annum

Data

- Lengthy data set (1940 to 2004)
 - Detailed information on the evolution of Prairie agriculture.
- Allocation of crops and livestock
 - Allocation of outputs between crops and livestock sectors is straightforward.
 - Allocation of inputs between crops and livestock more complex.
- Aggregate (provincial and Prairie) level of analysis

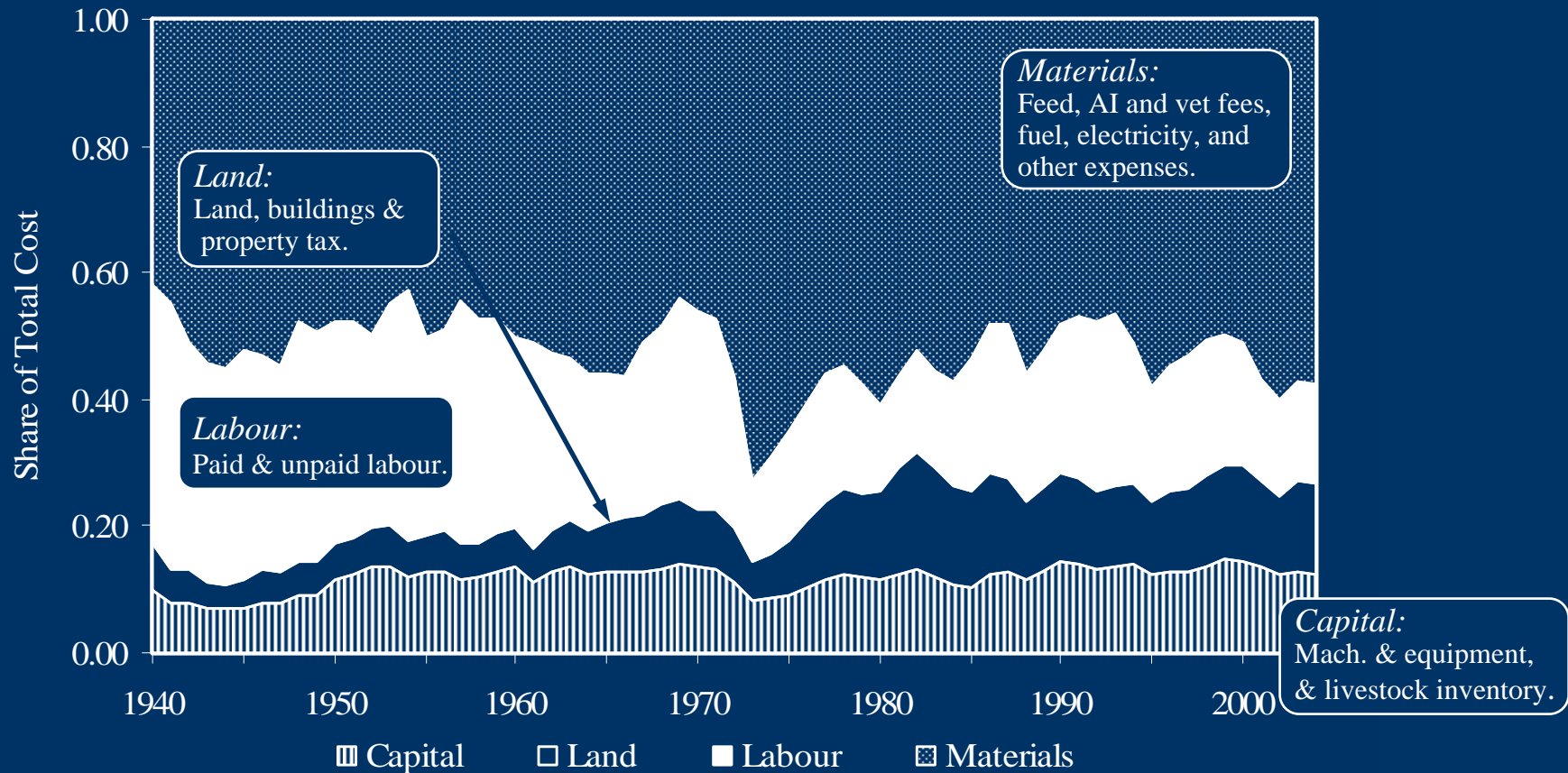
Crops Input Use

Prairie Crop Input Cost Shares: 1940-2004



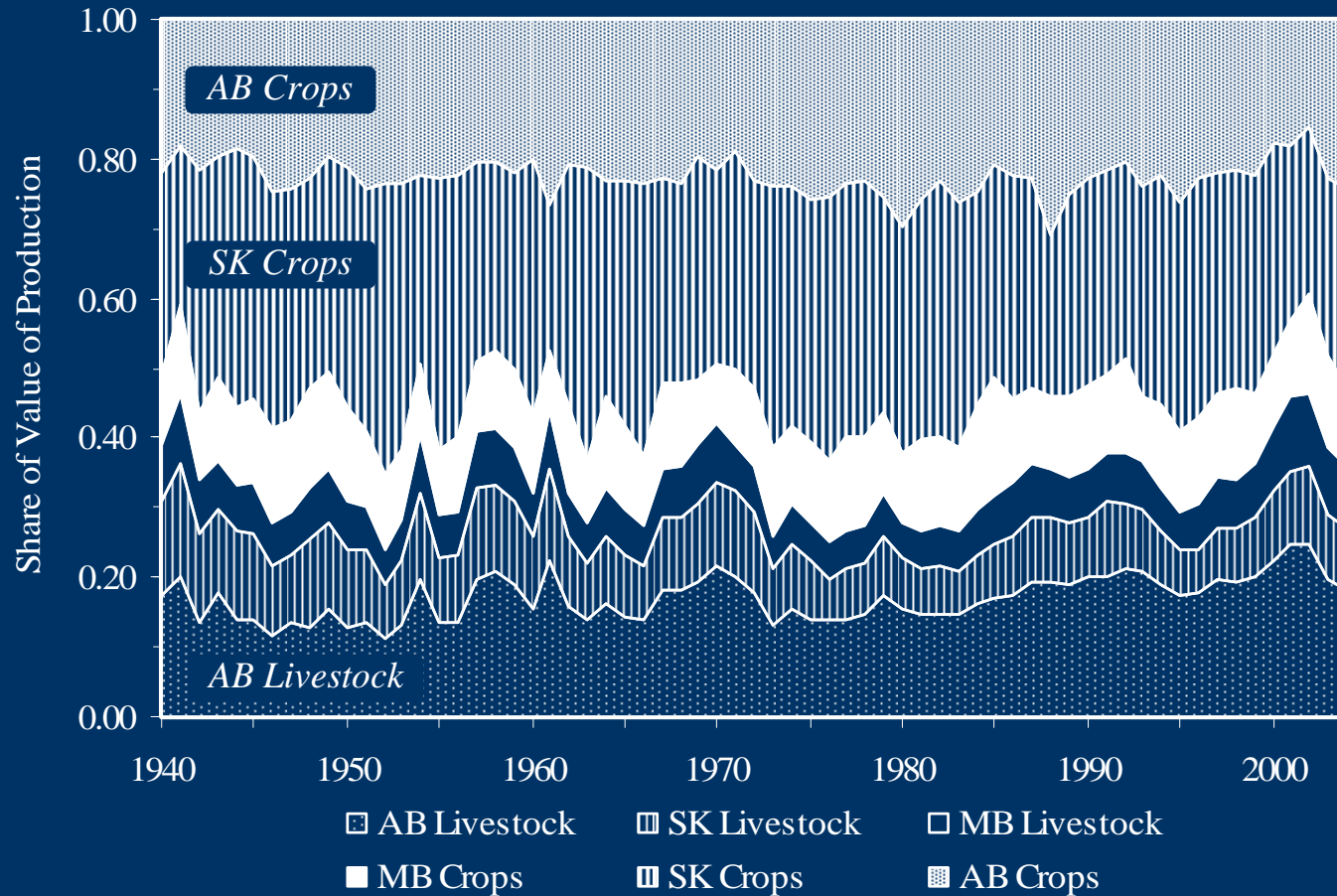
Livestock Input Use

Prairie Livestock Input Cost Shares: 1940-2004



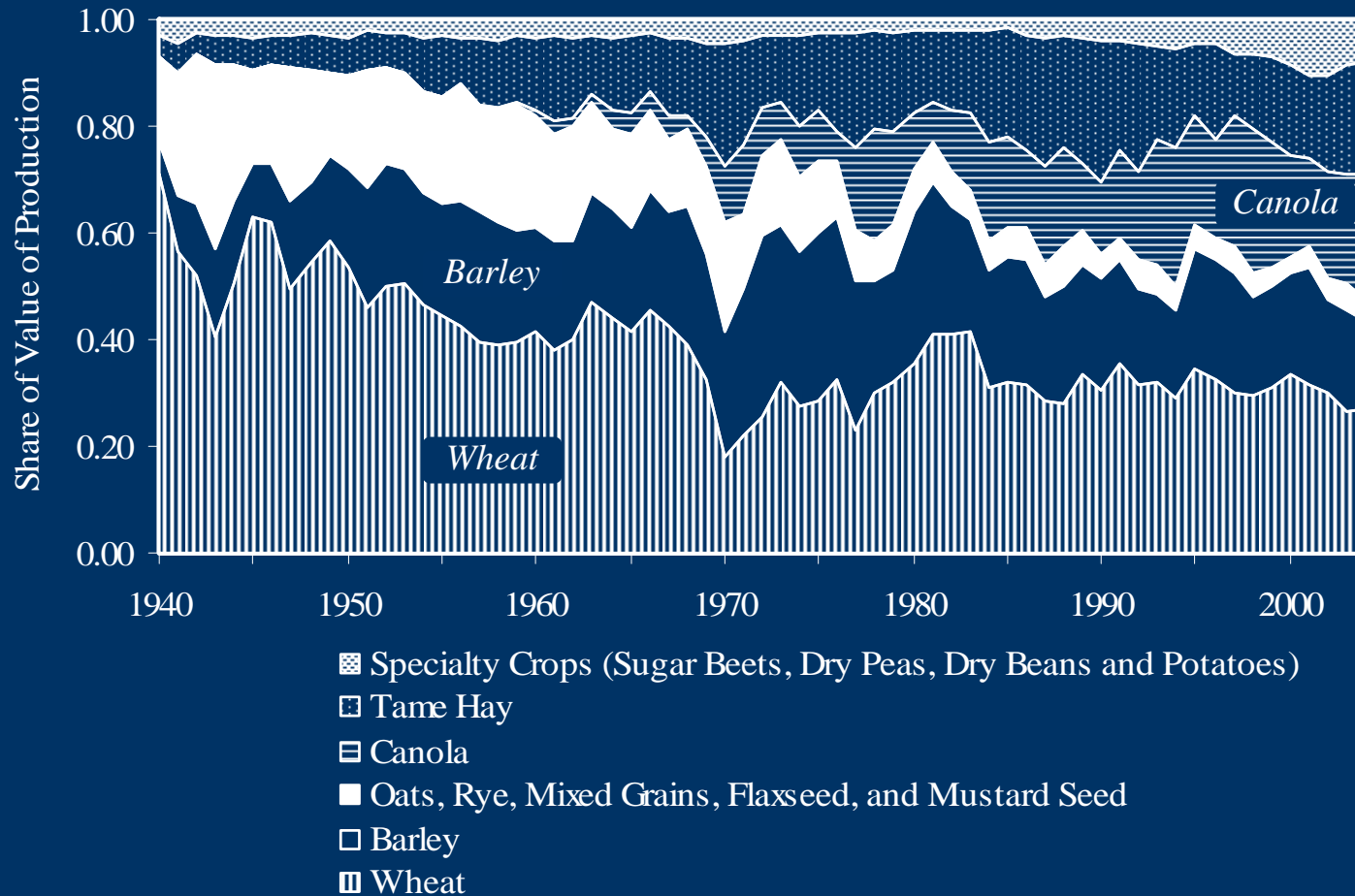
Prairie Livestock and Crops Outputs

Share of Crops and Livestock in Total Value of Production by Province: 1940-2004



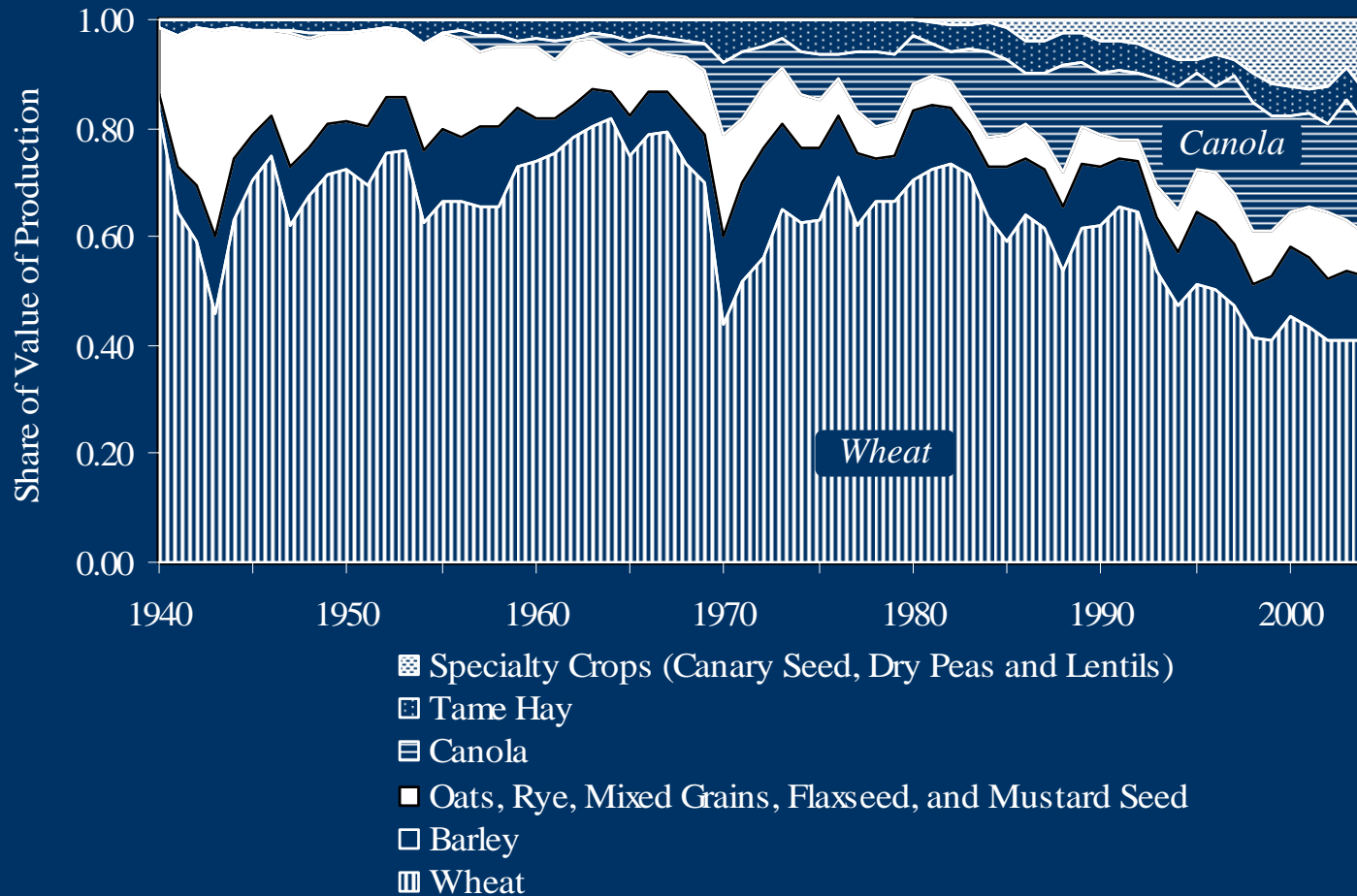
Crops Outputs

Alberta Crops Value of Production Shares: 1940-2004



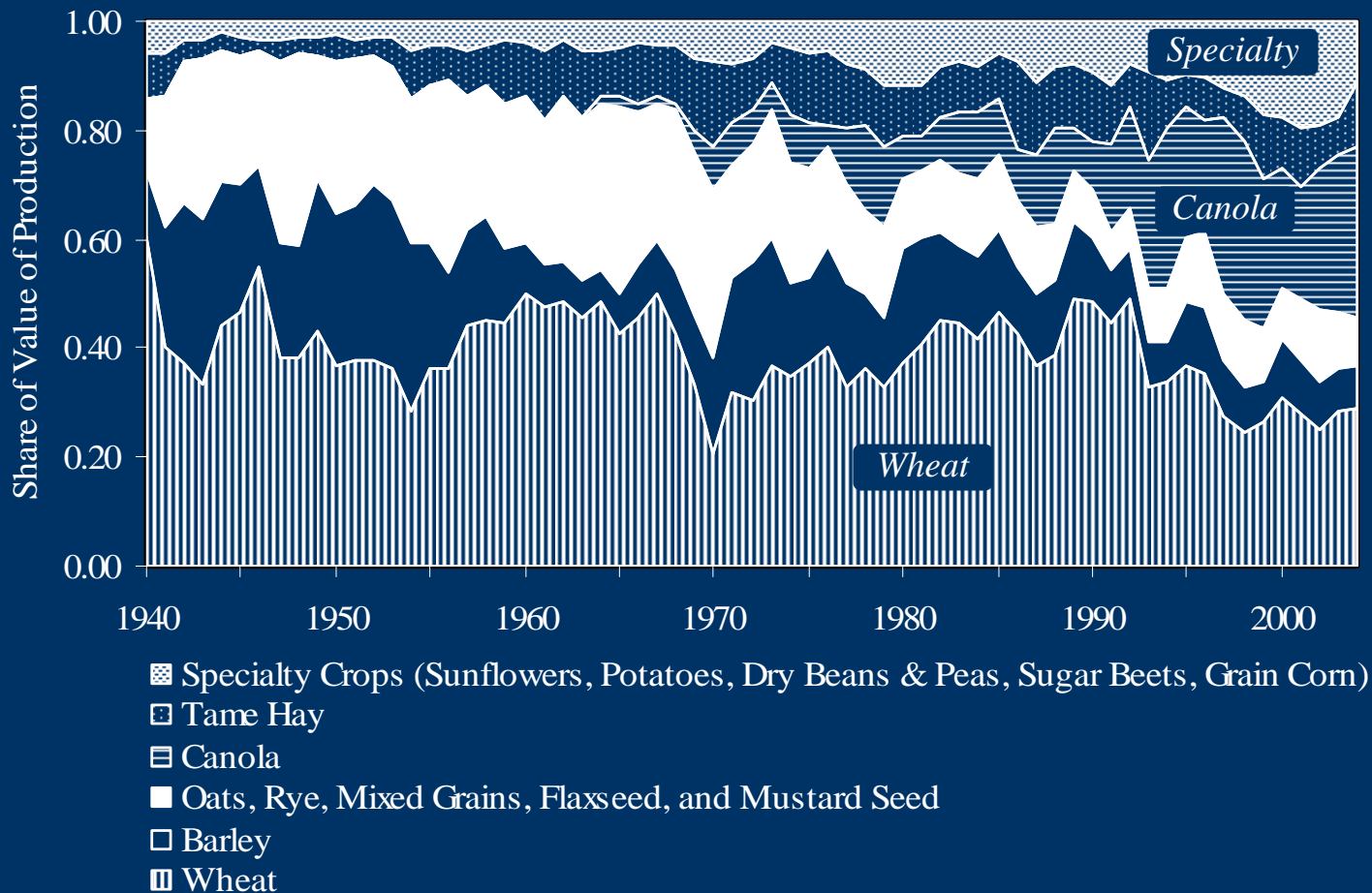
Crops Outputs

Saskatchewan Crops Value of Production Shares: 1940-2004



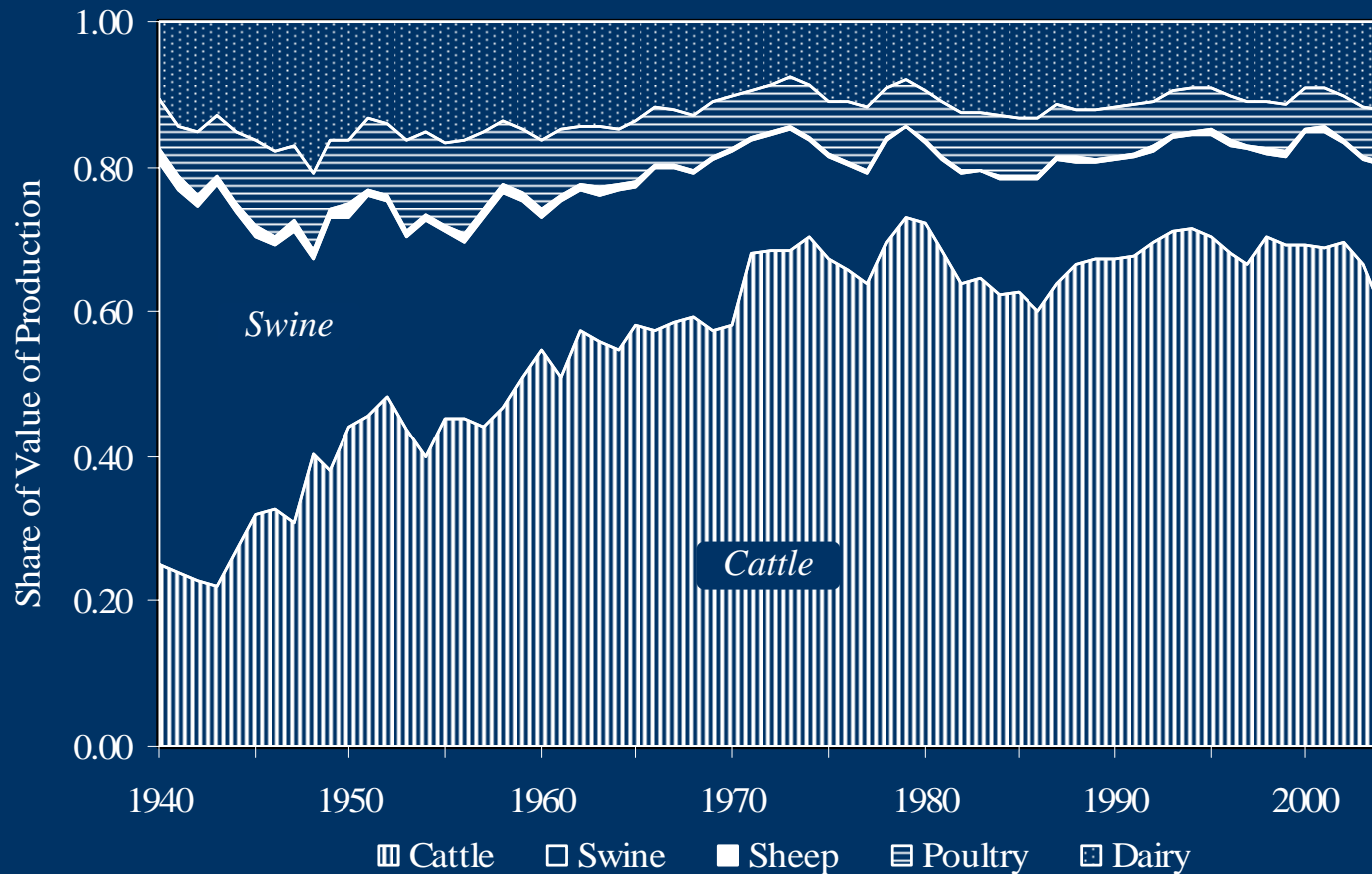
Crops Outputs

Manitoba Crops Value of Production Shares: 1940-2004



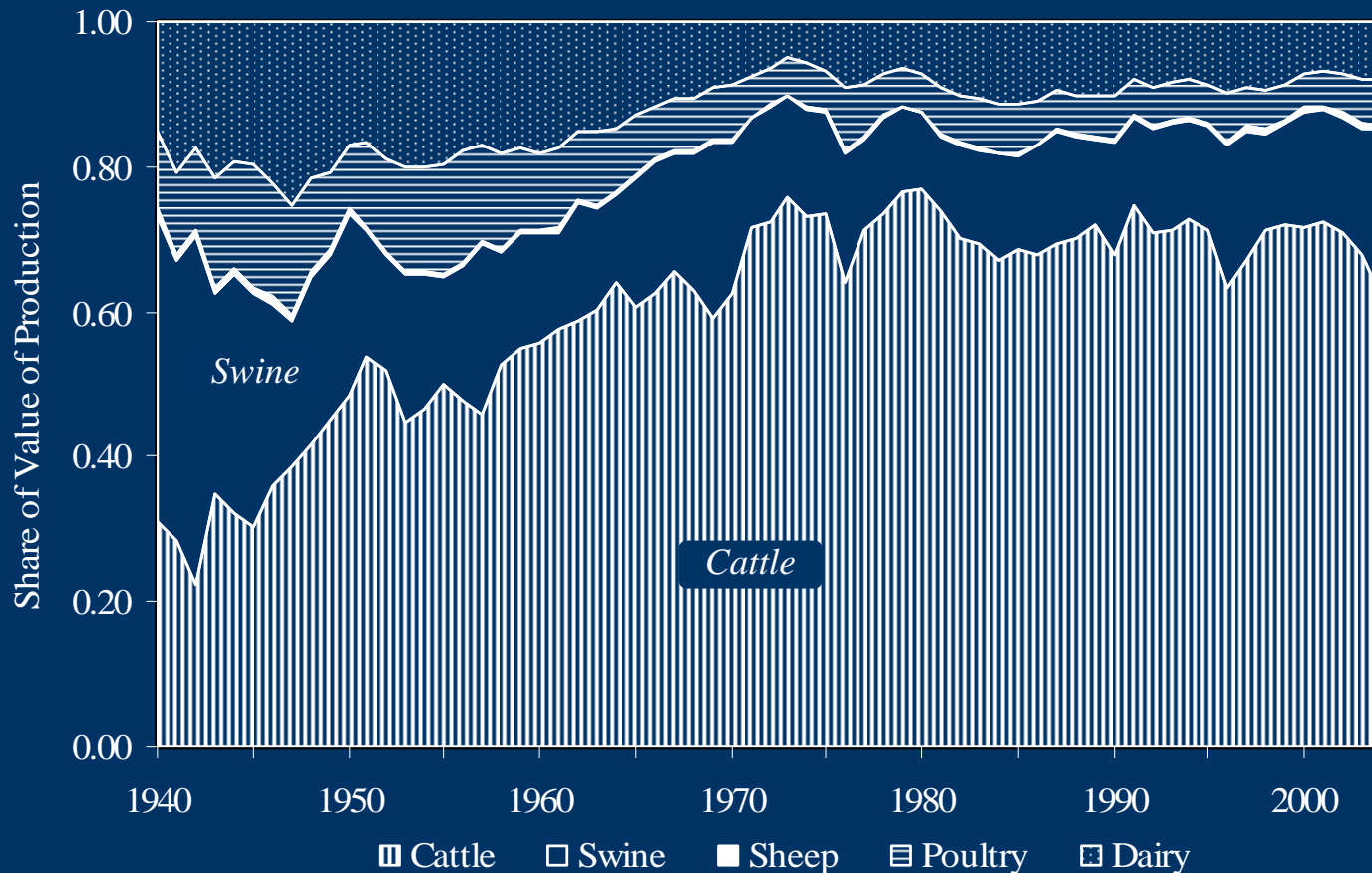
Livestock Outputs

Alberta Livestock Value of Production Shares: 1940-2004



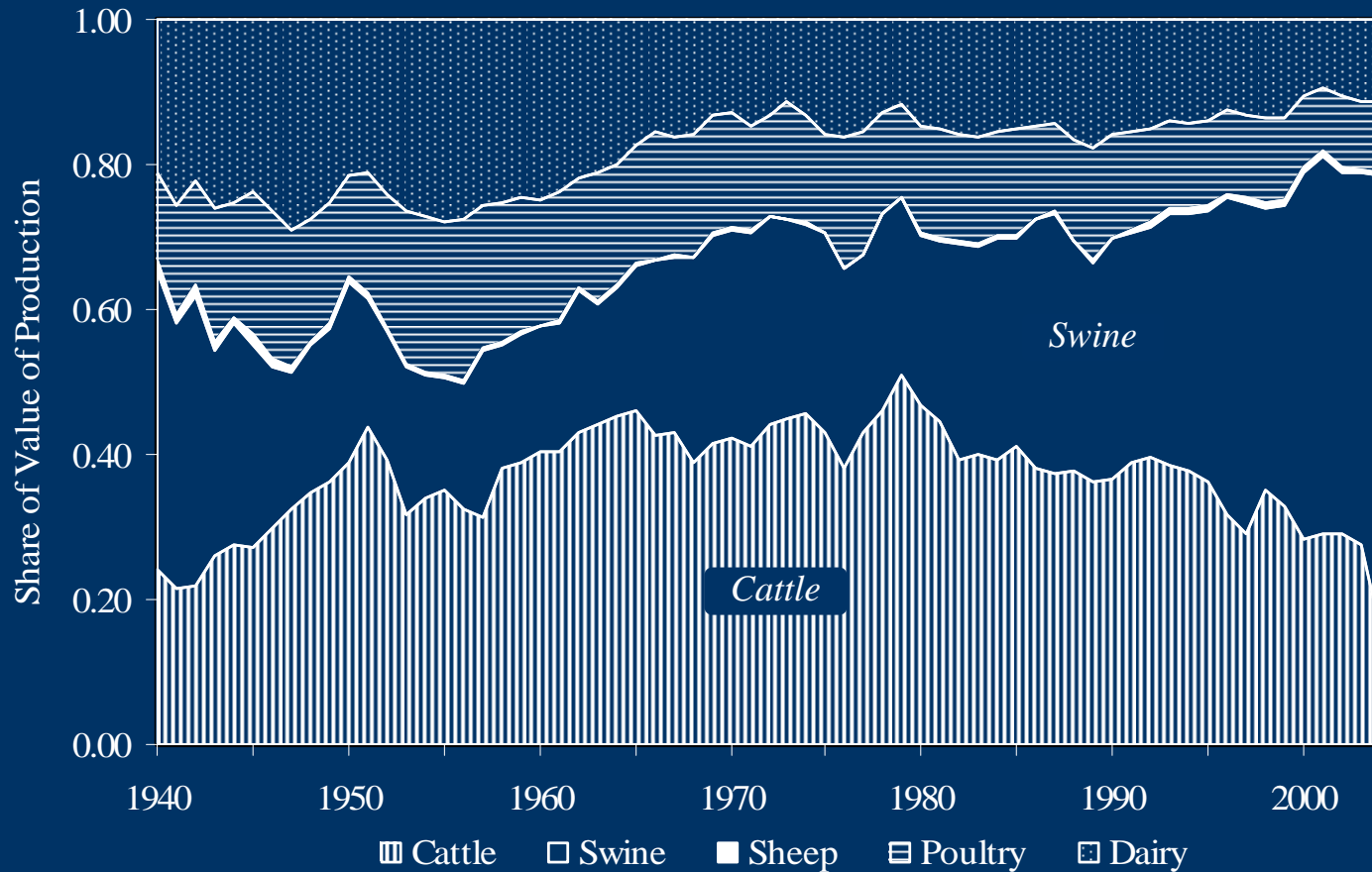
Livestock Outputs

Saskatchewan Livestock Value of Production Shares: 1940-2004



Livestock Outputs

Manitoba Livestock Value of Production Shares: 1940-2004



Productivity Methodology

- Total Factor Productivity (TFP) growth measured using Törnqvist-Theil indexing procedure:
 - Implies an underlying translog production function.
 - Flexible cost and revenue shares.

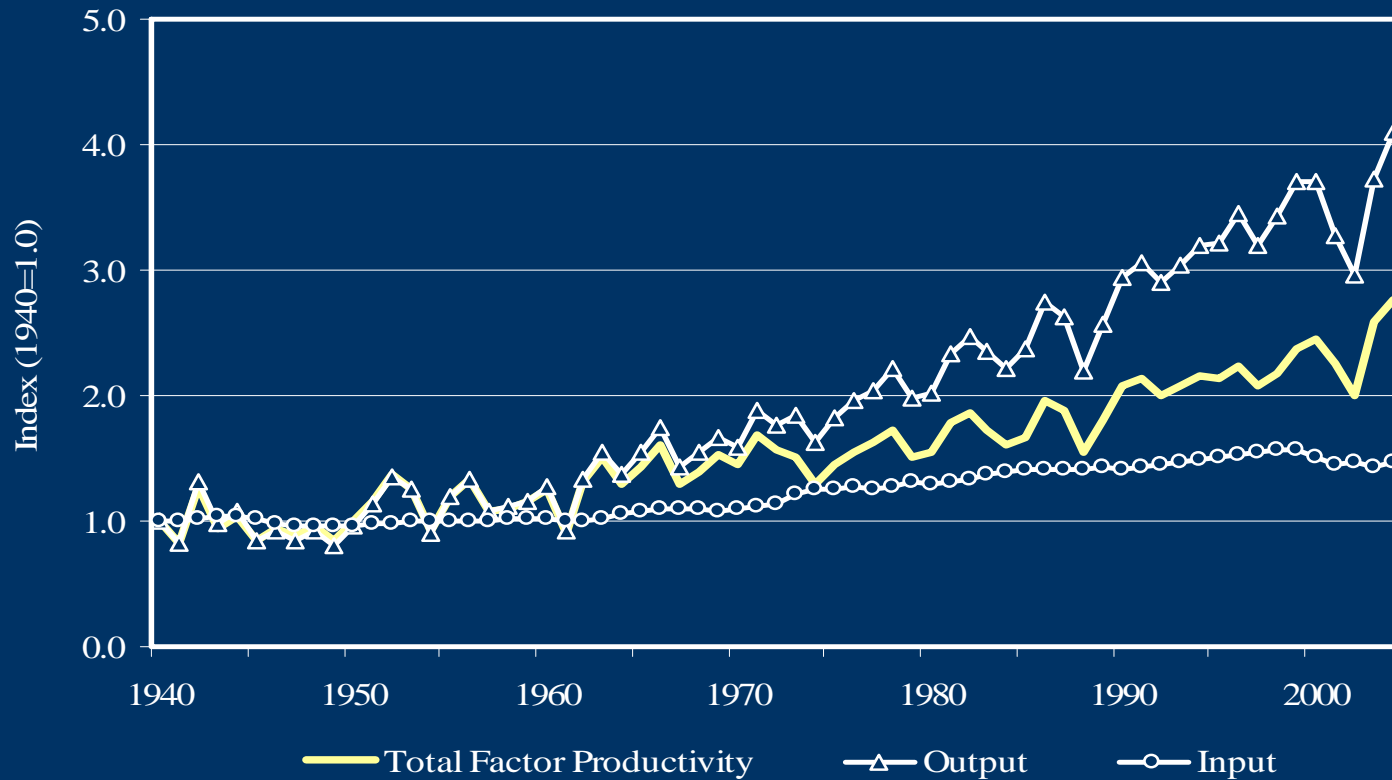
$$(1) \quad \dot{TFP} = \dot{Q} - \dot{X}$$

$$(2) \quad \dot{X} = \sum_{i=1}^n \left(\frac{s_{i,t} + s_{i,t-1}}{2} \right) [\ln x_{i,t} - \ln x_{i,t-1}]$$

$$(3) \quad \dot{Q} = \sum_{j=1}^m \left(\frac{r_{j,t} + r_{j,t-1}}{2} \right) [\ln q_{j,t} - \ln q_{j,t-1}]$$

Total Inputs, Outputs and Productivity

Prairie Aggregate Agriculture Input, Output and Productivity:
1940-2004



Total Productivity Estimates

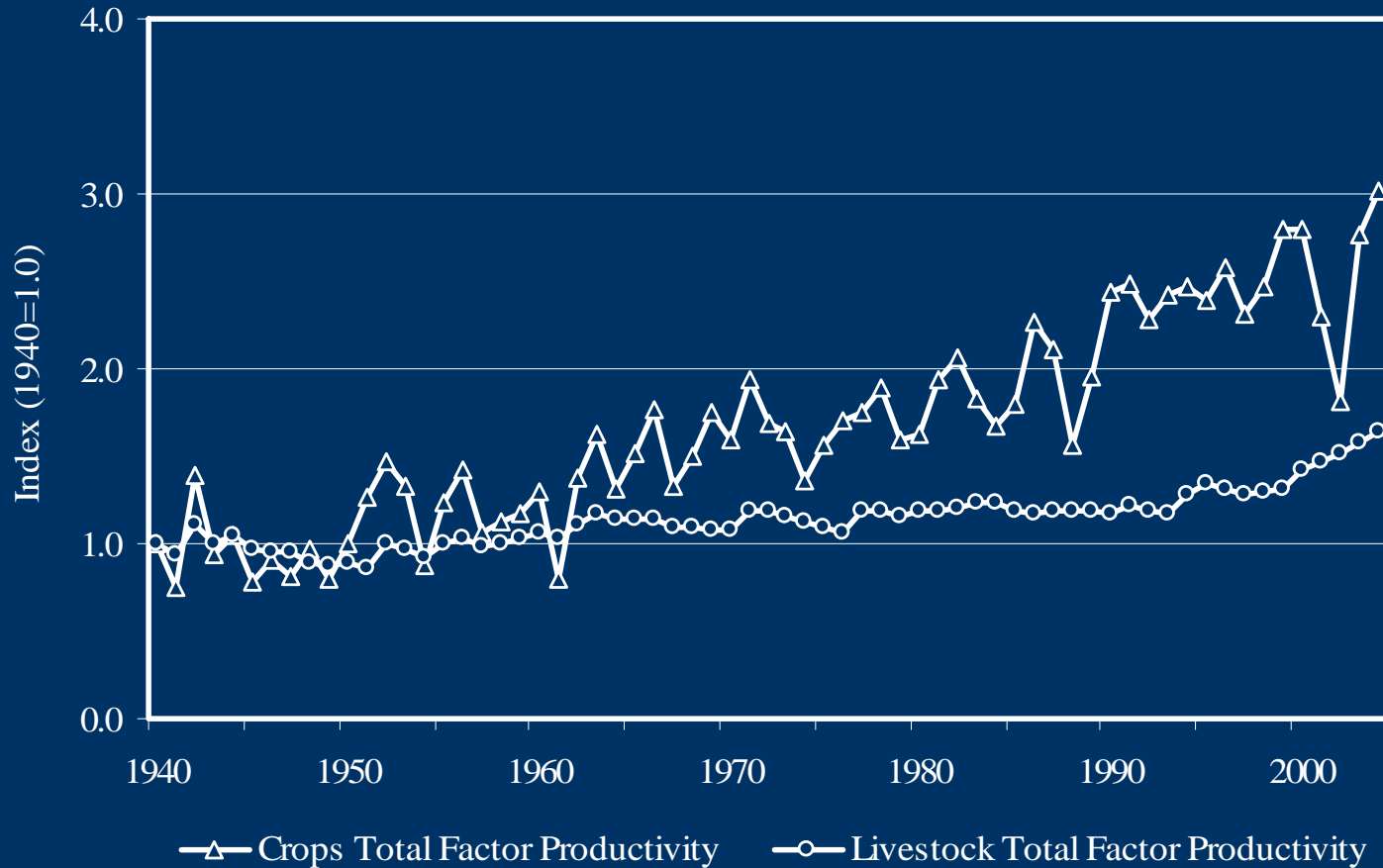
Aggregate Prairie Agriculture Compound Annual % Productivity, Input and Output Growth Rates

	1940-2004	1940-1959	1960-1979	1980-2004	1990-2004
Productivity Growth	1.56	1.25	1.48	1.80	0.59
Input Growth	0.86	-0.03	1.45	0.57	-1.12
Output Growth	2.43	1.22	2.95	2.38	-0.53

- Relatively strong overall Prairie productivity growth (1940-2004).
- Productivity growth accounts for 64% of output growth (1940-2004).
- Productivity slowdown over the 1990-2004 period.

Productivity Estimates

Prairie Crops and Livestock Productivity: 1940-2004



Productivity Estimates

Provincial Livestock and Crops Compound Annual % Productivity Growth Rates

	Crops		Livestock	
	1940-2004	1990-2004	1940-2004	1990-2004
Alberta	1.65	-0.33	0.54	0.58
Saskatchewan	1.76	0.39	0.59	4.28
Manitoba	2.12	2.70	0.97	5.33

Productivity growth estimates vary:

1. Over time
2. Between livestock and crops sectors
3. Between provinces

Productivity and Cost Pressures

Prairie Agriculture Compound Annual % Productivity, Input and Output Price, Terms-of-Trade, and Returns-to-Cost Growth Rates: 1940-2004

	TFP	Output Prices	Input Prices	Terms-of-Trade	Returns-to-Cost
Crops	1.77	5.13	2.43	-2.57	-0.85
Livestock	0.65	3.73	4.04	-0.29	0.36
Aggregate Agriculture	1.56	2.74	4.76	-1.93	-0.40

- Livestock has been the relatively more profitable sector (1940-2004).
- The crops sector has traditionally faced greater cost price pressures.

Definitions

Terms-of-trade: growth in output prices minus growth in input prices. Declining (negative) terms-of-trade indicate that input prices are rising faster than output prices. The terms-of-trade provide a measure of cost-price pressures.

Returns-to-cost: the sum of productivity growth and terms-of-trade. Returns-to-cost provide a crude measure of overall profitability.

Productivity Estimate Key Points

1. The crops sector has traditionally recorded higher productivity growth than the livestock sector.
2. Productivity growth in Manitoba livestock and crops is considerably higher than in Alberta and Saskatchewan.
3. Saskatchewan has somewhat higher productivity growth in livestock and crops than Alberta.
4. Productivity growth in livestock has increased rapidly over the past fifteen years.
5. Productivity growth in Alberta and Saskatchewan crops has slowed over the past fifteen years.

Questions

- What accounts for provincial differences in productivity growth?
- What accounts for differences in productivity growth between the crops and livestock sectors?
- Why has productivity growth in the crops sector slowed over the last fifteen years?
- Why has productivity growth in the livestock sector accelerated over the last fifteen years (1990 to 2004)?

Components of Productivity Growth

Components of Productivity Growth Over the 1940 to 2004 Period

	Crops		Livestock	
	Technology	Scale of Production	Technology	Scale of Production
Alberta	94.7 %	4.9 %	37.3 %	51.0 %
Saskatchewan	84.5 %	16.9 %	57.4 %	62.4 %
Manitoba	80.4 %	16.5 %	53.2 %	36.0 %

- The crops sector appears to be better able to take advantage of technological advances.
- The livestock sector has been more effective in generating increasing returns to scale over time.
- Productivity decomposed using a translog cost function

Potential Causes of Productivity Growth Differences

1. Geoclimatic differences between provinces
2. Differential research and development expenditures between provinces and agricultural outputs
3. Education and extension expenditures
4. Productivity differences inherent in the production processes and biology of different outputs

Potential Causes of Productivity Growth Differences

5. Impacts of different regional economic conditions and financial pressures
6. Levels of producer support
7. Structural change: increasing farm sizes, specialization, and off-farm labour rates
8. Economies of scale and scope in production

Modeling the Causes of Productivity Growth

- Following Huffman and Evenson (1993 & 2001) methodology.
- Three equation SUR model using cross-sectional data.
- Provincial TFP measures for aggregate agriculture, livestock, and crops as dependent variables.
- Independent variables include domestic and foreign research and development, terms-of-trade, farm specialization, farm size, education, extension, off-farm labour, farm/manufacturing wage ratio, and support payments.

References:

Huffman, W.E. and R.E. Evenson. *Science for Agriculture*. Ames: Iowa State University Press, 1993.

Huffman, W.E. and R.E. Evenson. "Structural and Productivity Change in US Agriculture, 1950-1982." *Agricultural Economics* 24(2001):127-147.

SUR Model: Selected Results

Estimated Coefficients for SUR Three Equation Model

	Crops	Livestock
Canadian R & D	0.6445**	0.5699**
Terms-of-Trade	-0.3865**	-0.1948**
Farm Size	0.2521*	0.3542**
Product specialization	-0.0209*	0.0977**

** and * denote statistical significance at the one and ten percent level respectively

- Log-log model – reported coefficients are elasticities
- R&D is a stock of past investments. Twenty year total lag structure – seven years rising, six years constant, seven years declining.

Preliminary Findings

1. Domestic research and development expenditures are the most important single factor underpinning the productivity growth of both crops and livestock sectors.
2. Cost price pressures are positively correlated with productivity growth.
3. Increased farm size is positively correlated with productivity growth in livestock and crops.
4. The share of swine in the livestock output is positively correlated with productivity growth.
5. The share of canola and specialty crops production in total crop production does not play an economically significant role in productivity growth.

Policy Implications

1. Public and private research and development expenditures play a significant role in agricultural productivity growth.
2. Financial cost-price pressures encourage productivity growth.
3. Some outputs appear to be inherently more productive than others (e.g. swine). Increased industry specialization may be desirable.
4. Structural change (i.e. increased farm size) serves to promote productivity growth, particularly in the livestock sector.

Further Work

- Future work should focus further on the determinants of agricultural productivity growth.
 - More detailed estimates of research and development expenditures.
 - More detail regarding the role(s) of structural change.
 - Further refinements and testing of the econometric model.
- Extensions to British Columbia, Ontario, Quebec and the Maritimes.

I would like to acknowledge the financial support of the Farm Level Policy Network, AAFC, APRN, and the past support of the Alberta Agricultural Research Institute.

Thank you.

Bryce Stewart – bryces@ualberta.ca

