Canadian and Prairie Agricultural Productivity: Measurement, Causes, and Policy Implications

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The Implications for Agricultural Research Policy
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Outline

2. Overview of agricultural productivity in Canada and nearby Great Plains states.
3. Roles of technical change and scale impacts in productivity growth.
4. Assessment of probable causal factors underpinning productivity growth.
Theory: Bare Bones

1. Törnqvist-Theil procedure used in compiling indexes of Total Factor Productivity (TFP).

2. Productivity decomposition accomplished using translog cost functions.

3. Causal assessment of productivity growth using panel data and a three equation SUR model (following Huffman and Evenson).
Data and Estimation

Lengthy data set (1940 to 2004)
• Output and input P’s and Q’s—Y, X, TFP, TT, R/C

Allocation of crops and livestock
• Outputs rel. easy, inputs complex: use census data

Aggregate level of analysis
• By Prairie & province (Alberta, Saskatchewan & Manitoba)
Crops Input Use

Materials:
Fertilizer, pesticide, seed, fuel, electricity, and other expenses.

Labour:
Paid & unpaid labour.

Land:
Land, buildings & prop. tax.

Capital:
Machinery & equipment.
Livestock Input Use

Prairie Livestock Input Cost Shares: 1940-2004

Materials: Feed, AI and vet fees, fuel, electricity, and other expenses.

Land: Land, buildings & property tax.

Labour: Paid & unpaid labour

Capital: Mach. & equipment, & livestock inventory.
Productivity Growth Estimates
Aggregate Prairie Agriculture Compound Annual % Productivity, Input and Output Growth Rates

<table>
<thead>
<tr>
<th></th>
<th>1940-2004</th>
<th>1990-2004</th>
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</thead>
<tbody>
<tr>
<td>Productivity Growth</td>
<td>1.56</td>
<td>0.59</td>
</tr>
<tr>
<td>Input Growth</td>
<td>0.86</td>
<td>-1.12</td>
</tr>
<tr>
<td>Output Growth</td>
<td>2.43</td>
<td>-0.53</td>
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</table>

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

Prairie Crops and Livestock Productivity: 1940-2004

Index (1940=1.0)

Crops Total Factor Productivity

Livestock Total Factor Productivity
# Prairie Productivity Growth Results

Provincial Livestock and Crops Annual Compound % Productivity Growth Rates

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Alberta</td>
<td>1.65</td>
<td>-0.05</td>
<td>0.54</td>
<td>0.90</td>
</tr>
<tr>
<td>Sask.</td>
<td>1.76</td>
<td>0.40</td>
<td>0.59</td>
<td>3.61</td>
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<tr>
<td>Manitoba</td>
<td>2.12</td>
<td>1.75</td>
<td>0.97</td>
<td>4.21</td>
</tr>
<tr>
<td>Prairies</td>
<td>1.77</td>
<td>0.51</td>
<td>0.65</td>
<td>2.27</td>
</tr>
</tbody>
</table>
Key Productivity Findings

• Productivity growth in Prairie crops has outpaced productivity growth in livestock

• Manitoba has highest productivity growth

• Productivity growth in crops has slowed over the last fifteen years

• Productivity growth in livestock has accelerated over the last fifteen years
Ag. Productivity Growth Comparisons

- Prairie: 1940-2004, 1.56%
- Prairie: 1980-2004, 1.80%
- U.S.: 1948-2004, 1.77%
- Great Plains: 1960-1999, 1.53%
- Aust. Broadacre: 1953-2004, 2.50%
- Cdn StatCan: 1981-2000, 3.40%
## Components of Productivity Growth

1940 to 2004: Roles of Technical Change and Scale

<table>
<thead>
<tr>
<th></th>
<th>Crops</th>
<th></th>
<th>Livestock</th>
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<tbody>
<tr>
<td></td>
<td>Technical Change</td>
<td>Scale of Production</td>
<td>Technical Change</td>
<td>Scale of Production</td>
</tr>
<tr>
<td>Alberta</td>
<td>94.7 %</td>
<td>4.9 %</td>
<td>37.3 %</td>
<td>51.0 %</td>
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<tr>
<td>Saskatchewan</td>
<td>84.5 %</td>
<td>16.9 %</td>
<td>57.4 %</td>
<td>62.4 %</td>
</tr>
<tr>
<td>Manitoba</td>
<td>80.4 %</td>
<td>16.5 %</td>
<td>53.2 %</td>
<td>36.0 %</td>
</tr>
</tbody>
</table>

- Productivity decomposed using translog cost functions.
- Crops prod. growth is composed largely of technical change.
- Livestock productivity growth more evenly split.
- Critical role of marginal cost pricing assumption.
Causes of Productivity Growth: R&D

1. Research and Development (R&D)

Prairie Private and Public R&D Expenditure Stocks (20 Year Lag in 1972 Dollars), 1940-2004
Causes of Prod. Growth: Terms of Trade

2. Terms of Trade
   - Definition: growth in output prices minus growth in input prices.
   - Cochrane’s treadmill theory of agriculture (1958) - producers adopt technological innovations to respond to cost-price pressures

Terms of Trade in Prairie Agriculture: 1940-2004

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<th></th>
<th>Crops</th>
<th>Livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prairies</td>
<td>-2.57 % per annum</td>
<td>-0.29 % per annum</td>
</tr>
</tbody>
</table>
Causes of Prod. Growth: Other

3. Geoclimatic Conditions
4. Inherent Productivity Differences
5. Structural Change
6. Education and Extension
7. Regional Economic Conditions
8. Government Policy
Modeling the Causes of Productivity Growth

• Following Huffman and Evenson (1993 & 2001) methodology.

• Three equation SUR model using panel data.

• Total Factor Productivity (TFP) indexes of aggregate agriculture, livestock, and crops as dependent variables.

• Independent variables include domestic R&D, terms-of-trade, farm specialization, farm size, education, extension, off-farm labour, farm/manufacturing wage ratio, and support payments.
## Modeling the Causes of Productivity Growth

### Selected Estimates SUR Model

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<thead>
<tr>
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<th>Crops</th>
<th>Livestock</th>
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</thead>
<tbody>
<tr>
<td>Domestic R &amp; D</td>
<td>0.57*</td>
<td>0.61*</td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>-0.34*</td>
<td>-0.18*</td>
</tr>
<tr>
<td>Farm Size</td>
<td>0.02</td>
<td>0.38*</td>
</tr>
<tr>
<td>Productive Outputs</td>
<td>-0.03</td>
<td>0.10*</td>
</tr>
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</table>

* denotes statistical significance at the one percent level
Policy Implications

1. R&D is a key to long run productivity growth.

2. *Treadmill* theory points to importance of adaptability and flexibility of producers regarding emerging technologies.

3. Livestock farm size contributes to productivity growth.

4. Some agricultural outputs appear inherently more productive (e.g., hogs).
Take Home Messages

• Merit in comprehensive study over 65 years.
• Productivity growth is important.
• Crops productivity growth has outpaced that of livestock historically (but not in last 15 years).
• Can decompose estimated productivity growth.
• R&D and terms of trade — 2 key explanators.
• Stagnant R&D stock since 1990—-a concern.
We would like to acknowledge the financial support of the Farm Level Policy Network, the Department of Rural Economy, the Alberta Agricultural Research Institute, and the SFM Network

Thank you.

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References:
## Further Productivity Results

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<tr>
<td><strong>Crops</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alberta</td>
<td><strong>1.65</strong></td>
<td>1.36</td>
<td>1.62</td>
<td>1.04</td>
<td><strong>-0.33</strong></td>
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<tr>
<td>Saskatchewan</td>
<td><strong>1.76</strong></td>
<td>1.97</td>
<td>2.00</td>
<td>2.11</td>
<td><strong>0.39</strong></td>
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<tr>
<td>Manitoba</td>
<td><strong>2.12</strong></td>
<td>0.90</td>
<td>2.67</td>
<td>2.47</td>
<td><strong>2.70</strong></td>
</tr>
<tr>
<td><strong>Livestock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Alberta</td>
<td>0.54</td>
<td>0.24</td>
<td>0.19</td>
<td>0.34</td>
<td><strong>0.58</strong></td>
</tr>
<tr>
<td>Saskatchewan</td>
<td><strong>0.59</strong></td>
<td>-0.39</td>
<td>0.19</td>
<td>1.86</td>
<td><strong>4.28</strong></td>
</tr>
<tr>
<td>Manitoba</td>
<td><strong>0.97</strong></td>
<td>0.04</td>
<td>0.78</td>
<td>2.13</td>
<td><strong>5.33</strong></td>
</tr>
</tbody>
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Environmentally-Adjusted TFP

• Important to assess productivity performance in social, and not merely private, terms

• Several adjustment techniques—each with varying merits (Hailu and Veeman, 2001)

• Key problem—lack of appropriate data on environmental “goods” and “bads”
  – Pulp and paper sector in Canada—good data on BOD, TSS
  – Agriculture and logging sectors—much more problematic
  – Little or no work on positive environmental services
## SUR Model: Estimates

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<thead>
<tr>
<th></th>
<th>Crops</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Domestic R &amp; D</td>
<td>0.5650**</td>
<td>0.6133**</td>
</tr>
<tr>
<td>Terms-of-Trade</td>
<td>-0.3366**</td>
<td>-0.1813**</td>
</tr>
<tr>
<td>Farm Size</td>
<td>0.0235</td>
<td>0.3819**</td>
</tr>
<tr>
<td>Productive Outputs</td>
<td>-0.0209*</td>
<td>0.0977**</td>
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<tr>
<td>Support Payments</td>
<td>0.0106</td>
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<tr>
<td>Off-Farm Employment</td>
<td>-0.1610</td>
<td>-0.0722</td>
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<tr>
<td>Manf. / Farm Wage Ratio</td>
<td>0.3544</td>
<td>0.0541</td>
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<tr>
<td>Farm Specialization</td>
<td>-0.3653</td>
<td>-0.0410</td>
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<tr>
<td>Schooling</td>
<td>0.2578</td>
<td>0.5047</td>
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<tr>
<td>Extension</td>
<td>-0.1800</td>
<td>-0.0731</td>
</tr>
<tr>
<td>Time Trend</td>
<td>-0.0261</td>
<td>-0.0607**</td>
</tr>
<tr>
<td>Quadratic Time Trend</td>
<td>0.2705</td>
<td>0.0005**</td>
</tr>
</tbody>
</table>

** and * denote statistical significance at the one and five percent level respectively.
Average annual growth of productivity, by State, 1960-99

Percent
