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

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Outline

1. Prairie productivity growth estimates: aggregate, crops & livestock, 1940-2004.
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

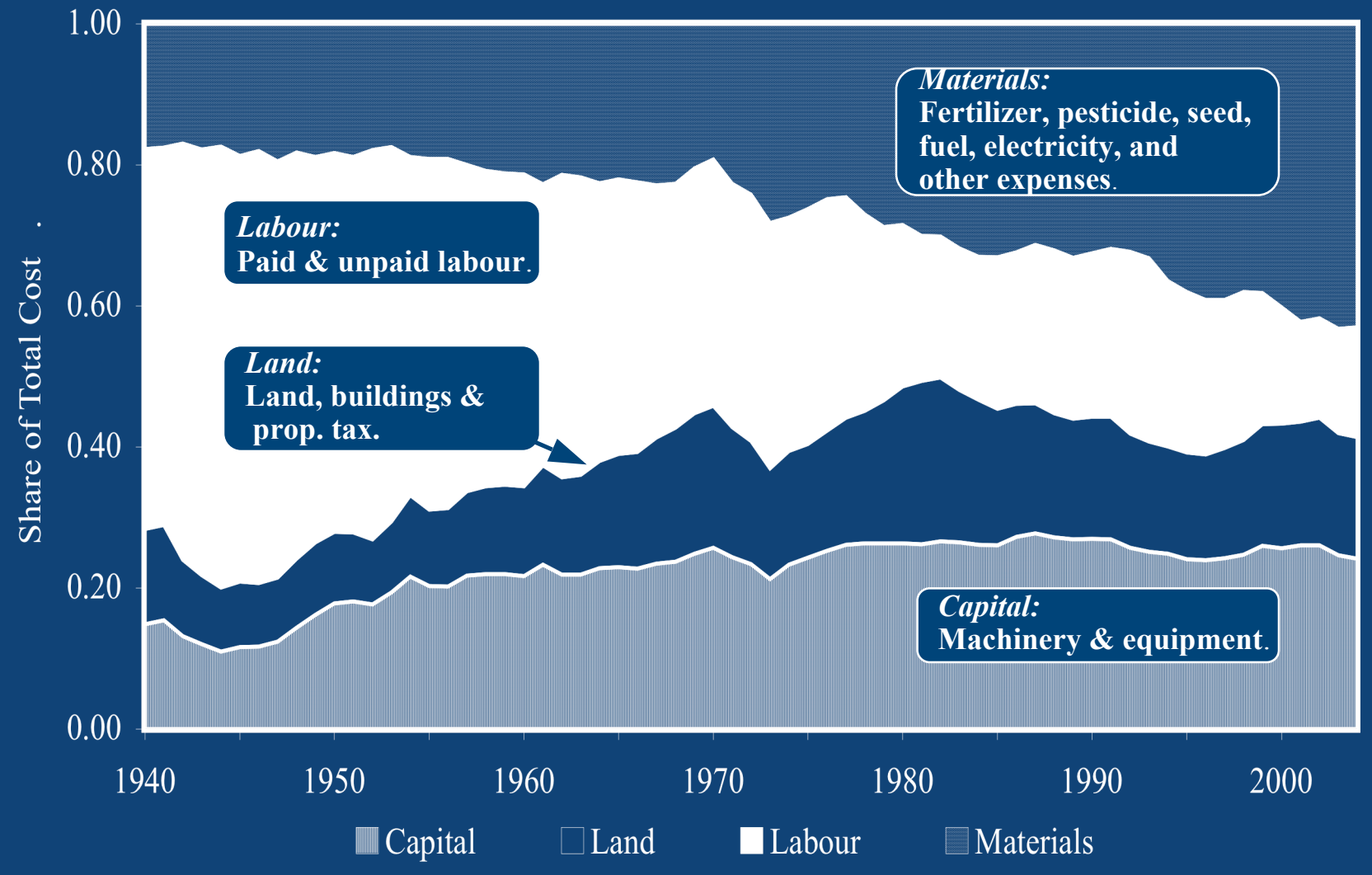
Allocation of crops and livestock

- Outputs rel. easy, inputs complex: use census data

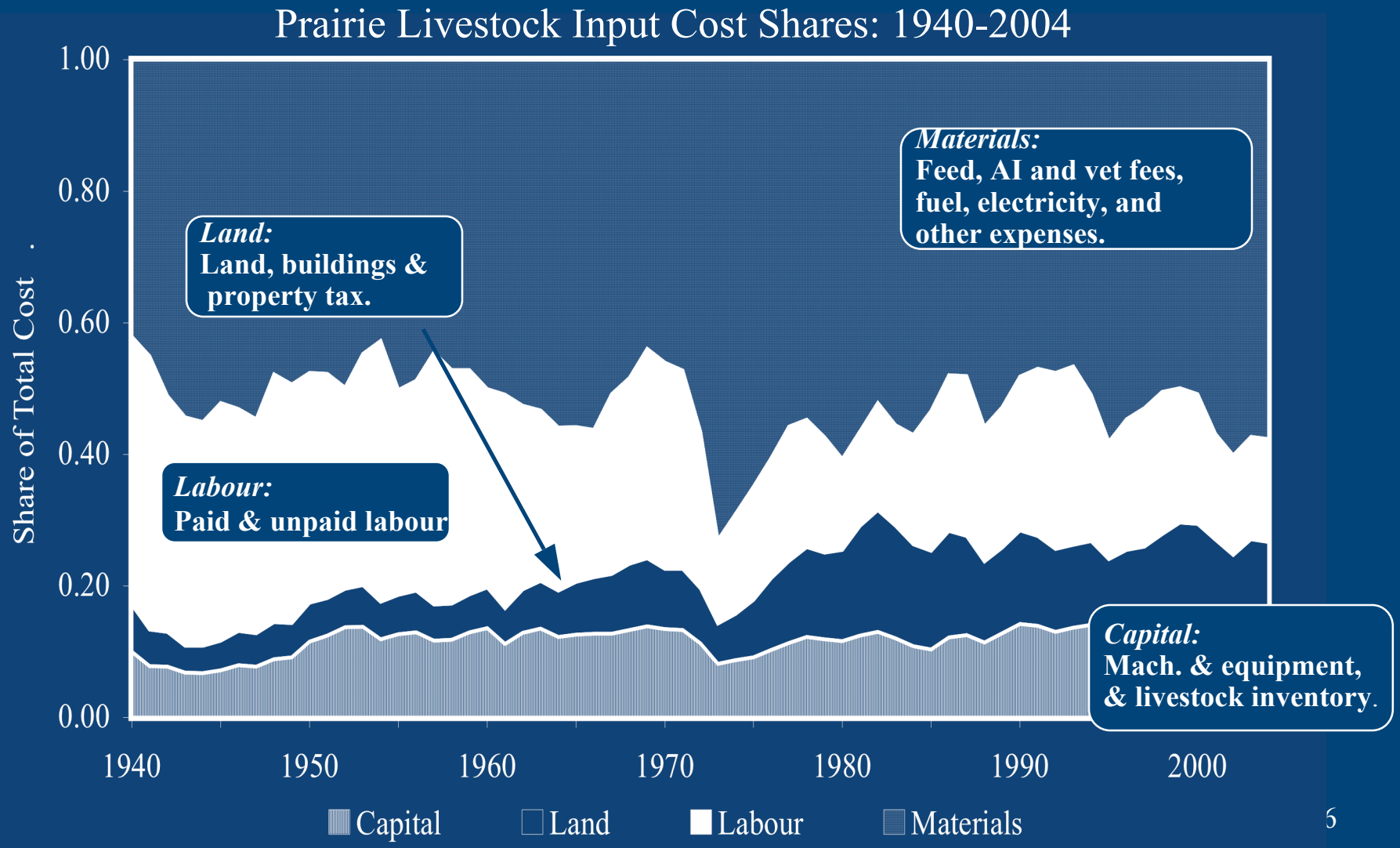
Aggregate level of analysis

- By Prairie & province (Alberta, Saskatchewan & Manitoba)

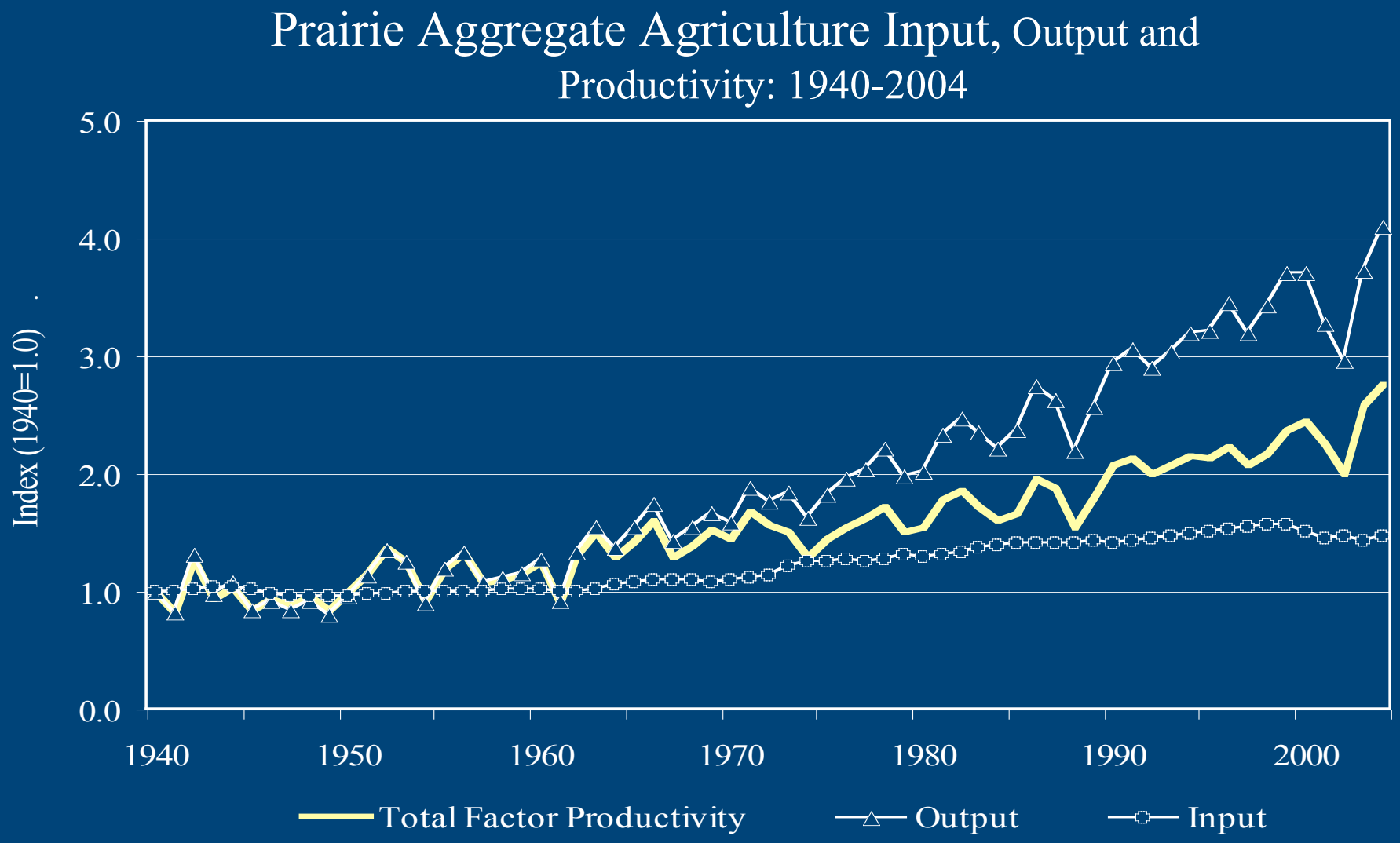
Crops Input Use



Livestock Input Use



Total Inputs, Outputs and Productivity



Productivity Growth Estimates

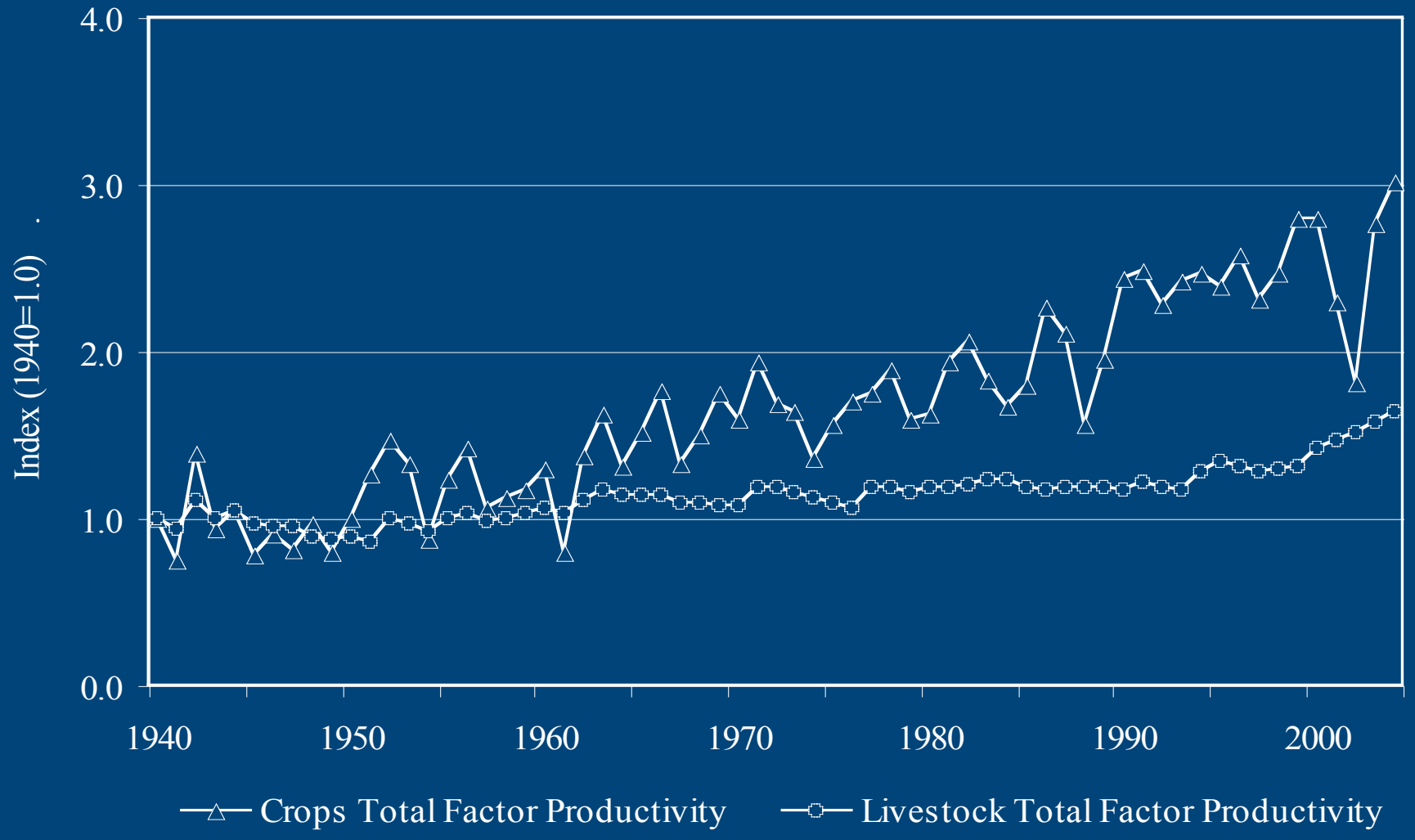
Aggregate Prairie Agriculture Compound Annual % Productivity, Input and Output Growth Rates

	1940-2004	1990-2004
Productivity Growth	1.56	0.59
Input Growth	0.86	-1.12
Output Growth	2.43	-0.53

- 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



Prairie Productivity Growth Results

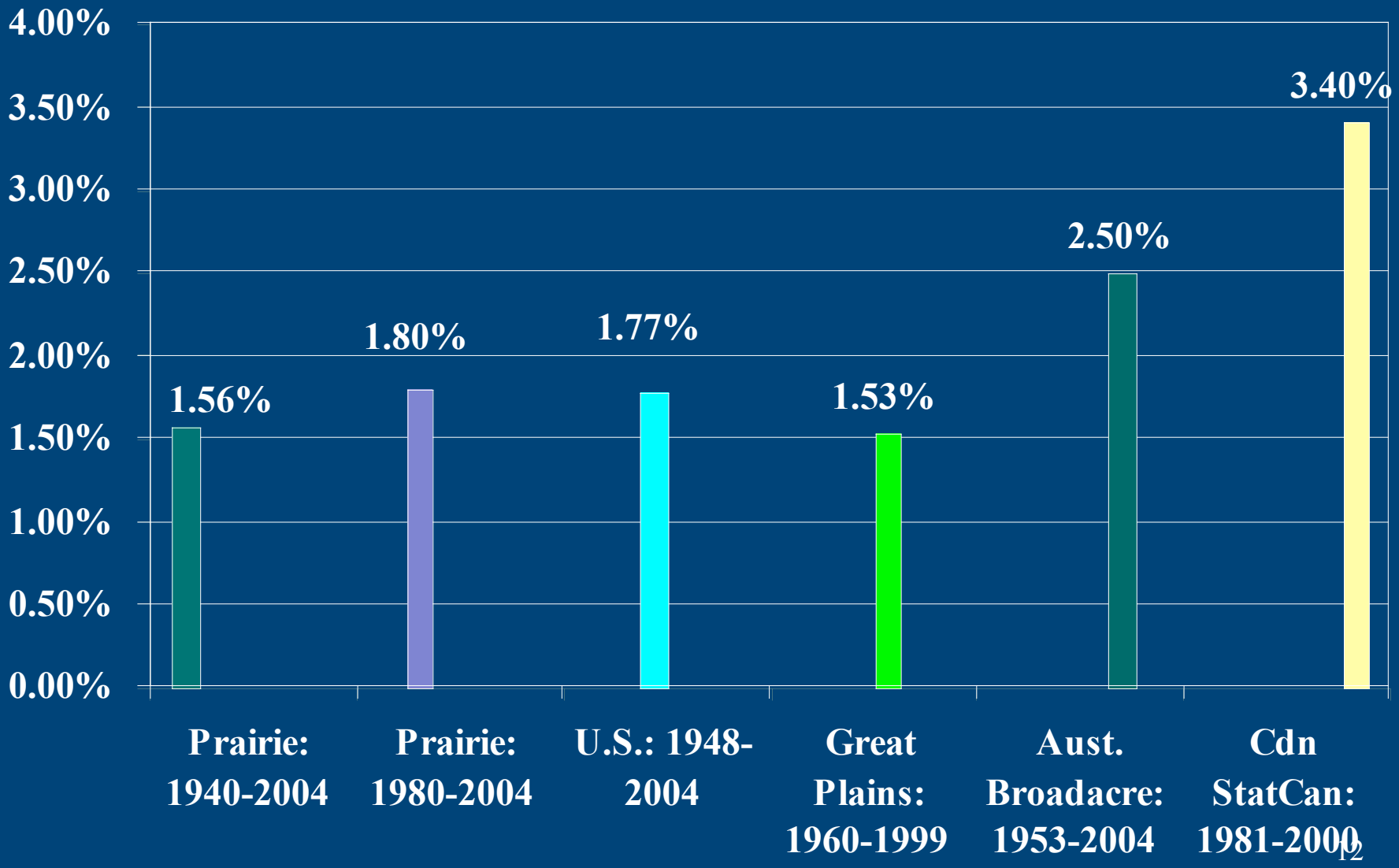
Provincial Livestock and Crops Annual Compound % Productivity Growth Rates

	Crops		**Livestock**	
	1940-2004	1990-2004	**1940-2004**	1990-2004
Alberta	**1.65**	-0.05	**0.54**	0.90
Sask.	**1.76**	0.40	**0.59**	3.61
Manitoba	**2.12**	1.75	**0.97**	4.21
Prairies	**1.77**	0.51	**0.65**	2.27

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



Components of Productivity Growth

1940 to 2004: Roles of Technical Change and Scale

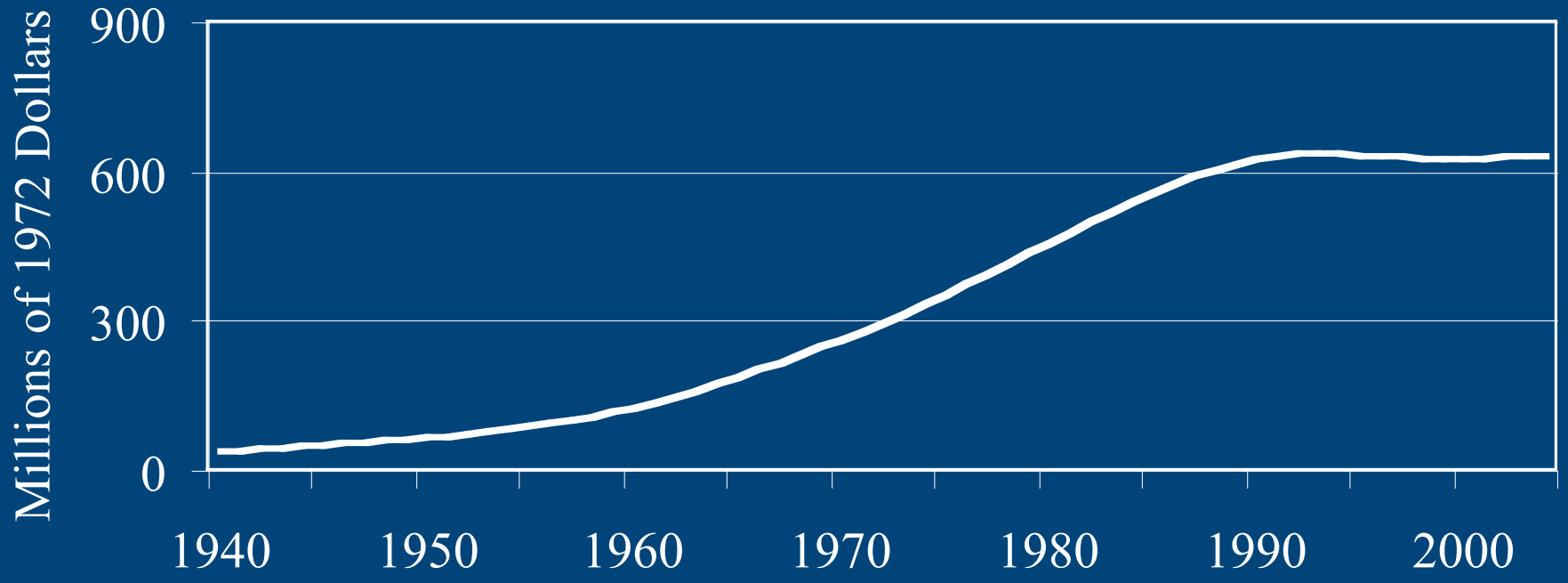
	Crops		Livestock	
	Technical Change	Scale of Production	Technical Change	**Scale of Production**
Alberta	**94.7 %**	4.9 %	37.3 %	**51.0 %**
Saskatchewan	**84.5 %**	16.9 %	57.4 %	**62.4 %**
Manitoba	**80.4 %**	16.5 %	53.2 %	**36.0 %**

- 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

	Crops	Livestock
Prairies	**-2.57 % per annum**	**-0.29 % per annum**

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

	Crops	Livestock
Domestic R & D	**0.57***	**0.61***
Terms of Trade	**-0.34***	**-0.18***
Farm Size	0.02	**0.38***
Productive Outputs	-0.03	**0.10***

* 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 (eg., 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.

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

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Further Productivity Results

		1940-2004	1940-1959	1960-1979	1980-2004	**1990-2004**
Crops	Alberta	**1.65**	1.36	1.62	1.04	**-0.33**
	Saskatchewan	**1.76**	1.97	2.00	2.11	**0.39**
	Manitoba	**2.12**	0.90	2.67	2.47	**2.70**
Live-stock	Alberta	**0.54**	0.24	0.19	0.34	**0.58**
	Saskatchewan	**0.59**	-0.39	0.19	1.86	**4.28**
	Manitoba	**0.97**	0.04	0.78	2.13	**5.33**

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

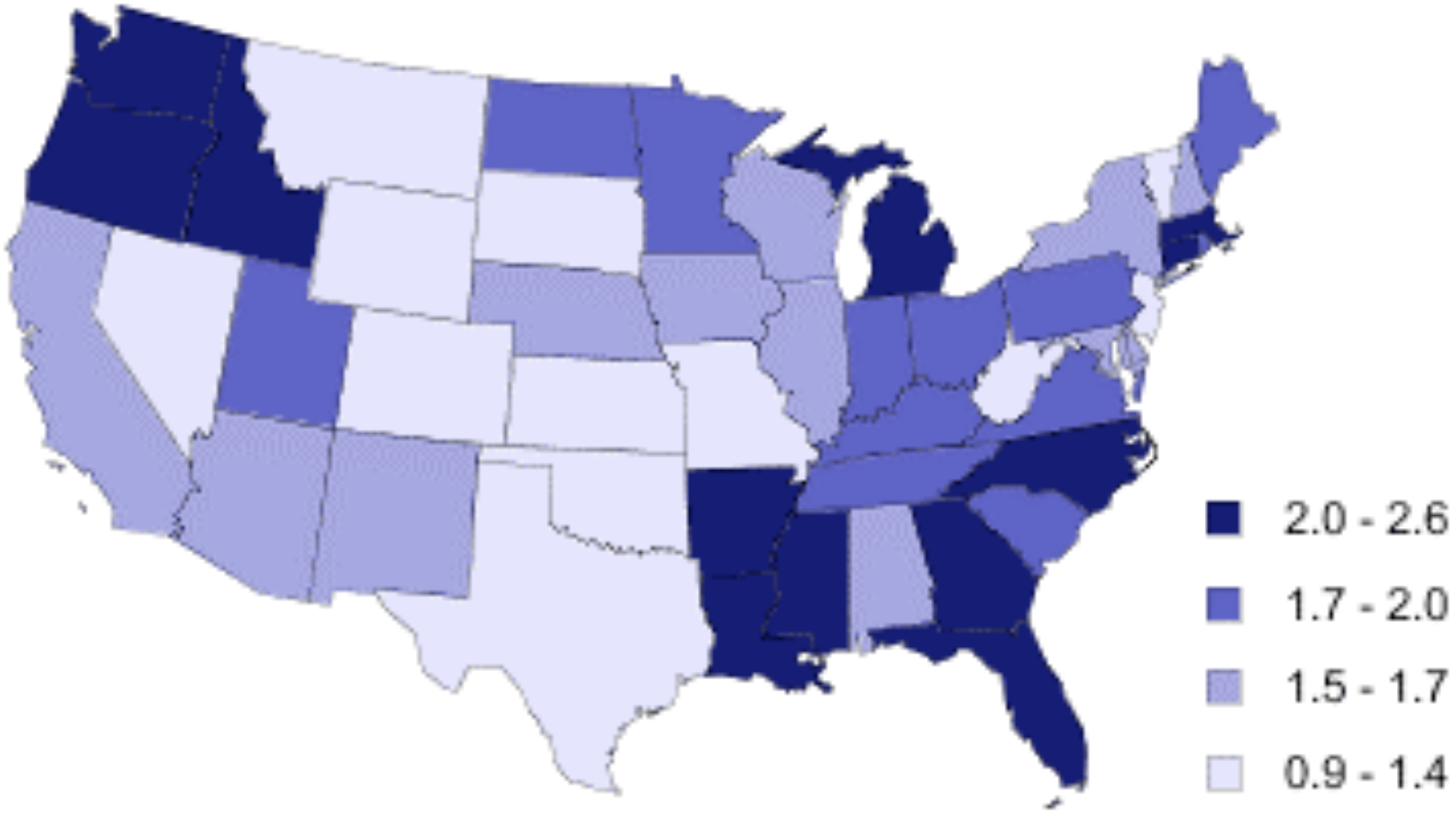
SUR Model: Estimates

	Crops	Livestock
Domestic R & D	**0.5650****	**0.6133****
Terms-of-Trade	**-0.3366****	**-0.1813****
Farm Size	0.0235	**0.3819****
Productive Outputs	**-0.0209***	**0.0977****
Support Payments	0.0106	0.0066
Off-Farm Employment	-0.1610	-0.0722
Manf. / Farm Wage Ratio	0.3544	0.0541
Farm Specialization	-0.3653	-0.0410
Schooling	0.2578	0.5047
Extension	-0.1800	-0.0731
Time Trend	-0.0261	-0.0607**
Quadratic Time Trend	0.2705	0.0005**

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

Average annual growth of productivity, by State, 1960-99

Percent



Source: ERS data product, Agricultural Productivity in the United States.

USDA ERS http://www.ers.usda.gov/Data/AgProductivity/ Accessed April 27, 2007.