

Farm-level analysis in the work on Innovation Systems in Agriculture

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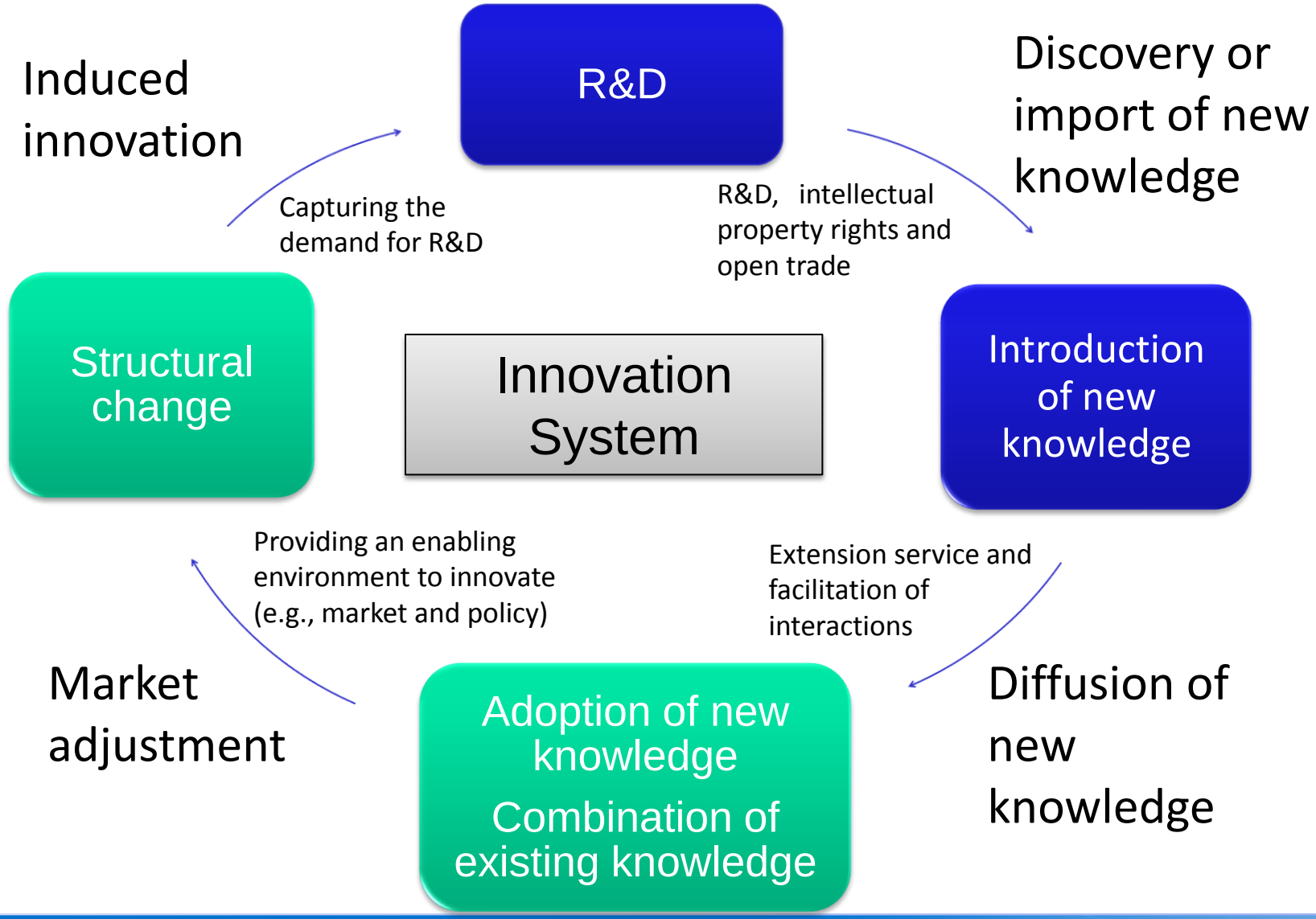
Outline

1. Overview of the planned work on Innovation Systems in 2011-12
2. Potential contribution by OECD Network for Farm-Level Analysis
3. Proposed methodologies of analysis
4. Preliminary analytical results
5. Next Steps

Planned work on Innovation System in 2011-12

- **Introduction of "innovation system" approach in agriculture**
  - R&D is an important part of innovation, but innovation is more than the scientific discovery. Innovation often occurs as a result of combining existing knowledge
  - Market and policy environment matters to enable innovation
  - Support policies most probably impede the rate at which existing technology is adopted (OECD 1994)
  - "Innovation system" includes whole system of technological diffusion and market adjustments
- **Development of multiple indicators to measure "innovation"**
  - Measuring innovation is a major challenge.
  - A variety of indicators should be pursued for each stage of innovation
- **Analytical framework is applied to assess the innovation system in selected countries**

Preliminary Concept of Innovation System in Agriculture



Indicators to assess the innovation system in agriculture

Example of indicators	Potential Data Sources
Creation or import of new knowledge	
Public and private R&D expenditure in agriculture	OECD R&D Statistics
Number of patent registered in the area of biotechnology	OECD Patent Database
Number of public R&D staffs in agriculture	National Statistics
Adoption of new knowledge	
Public and private expenditure for extension service and agricultural school	OECD PSE database
Number of staffs in extension service, Public and private cost of the service	National Statistics
Contribution of technical change to total factor productivity	**OECD Network for Farm Level Analysis**
Diffusion of knowledge / Combination of existing knowledge	
Contribution of technical efficiency change to total factor productivity	**OECD Network for Farm Level Analysis**
Distribution of farm performance in the sector	**OECD Network for Farm Level Analysis**
Diversification of income sources other than primary agricultural production	**OECD Network for Farm Level Analysis**
Vertical and horizontal integration in the food chain (joint venture farming)	National Statistics
Enabling market and policy environment to innovate	
Correlation of farm support and farm performance	**OECD Network for Farm Level Analysis**
Entry and exit in the agricultural sector	**OECD Network for Farm Level Analysis**
Induction of innovation	
Change in the rate of substitution of inputs	**OECD Network for Farm Level Analysis**
Reflection of R&D demand in public R&D agenda	National Statistics

Contribution of farm-level analysis

Micro-data studies allows us to analyze how innovation translate into the industry-level productivity growth

1. **Distributional analysis of farm performance indicators**
   - Distribution of individual farm performance indicators can infer 1) the characteristics of high performing farms, 2) extent to which existing technology and knowledge is diffused among farms
   - Correlation of farm performance and the amount and type of support received implies the policy and market environment to enable innovation
2. **Decomposition analysis of productivity growth**
   - Decomposing productivity growth into efficiency change and technological change indicate the growth path
   - "technological change" = Shift of productivity frontier
   - "technical efficiency change" = Diffusion of the new knowledge and technologies

Methodologies for distributional analysis on Farm performance and support policies

- **Several methods for the calculation of performance indicators**
  - Value based indicator (profitability) and quantity based indicator (productivity)
  - Conventional index methods – ratio of output and input index
  - Parametric methods – econometric modelling of a production function
  - Non-parametric methods – empirical estimation of production frontier such as data envelope analysis and Malmquist index
- **Several farm performance indicators can be pursued**
  - Single factor (e.g., land, labour and capital) indicators are feasible for most of the participating countries
  - Multifactor indicator could be constructed using available data
  - Single factor indicator can be informative combining with several indices
- **Correlation analysis between farm performance and farm characteristics**
  - Amount of several types of support can be linked to the farm performance indicators

Data requirement for multifactor productivity index

Output and Input Variables	Unit	Deflator or Price
Output		
Crop output	Value	Relevant output price indices
Livestock output	Value	Relevant output price indices
Other on-farm output	Value	Agricultural output price index
Off-farm output (diversified income)	Value	General price index
Input		
Land input		
Utilized Agricultural Area	Quantity	Land value times real interest rate
Capital input		
Depreciation	Value	Relevant input price indices
Maintenance cost of building and machine	Value	Relevant input price indices
Value of fixed asset (excluding land) times real interest rate	Value	Relevant input price indices
Labor input		
Working units (full time eq.)	Quantity	On-farm wage rate
Material input		
Farm cash expense (excluding above)	Value	Relevant input price indices
Payments		
Total payments		
First pillar payments	Value	
Second pillar payments	Value	Excluded from output value
Other payments	Value	
Market price support	Value	

Preliminary analytical results on mixed farms in Australia

Characteristics of Australia's mixed farm data (constant panel between 2001-07)

	Definition	Number of observation	Mean	Standard dev
Land	Area of land operated (ha)	185	47,917	220,501
Labor	Weeks of labor input	185	157	127
Purchased inputs	Value of cash inputs (AUD)	185	413,393	444,922
Capital	Farm equity (AUD)	185	3,300,000	3,200,000
Crop output	Production value of crop (AUD)	185	125,115	211,464
Livestock output	Production value of livestock (AUD)	185	421,613	657,579
Subsidy	Receipt of all subsidies (AUD)	185	2,383	5,558

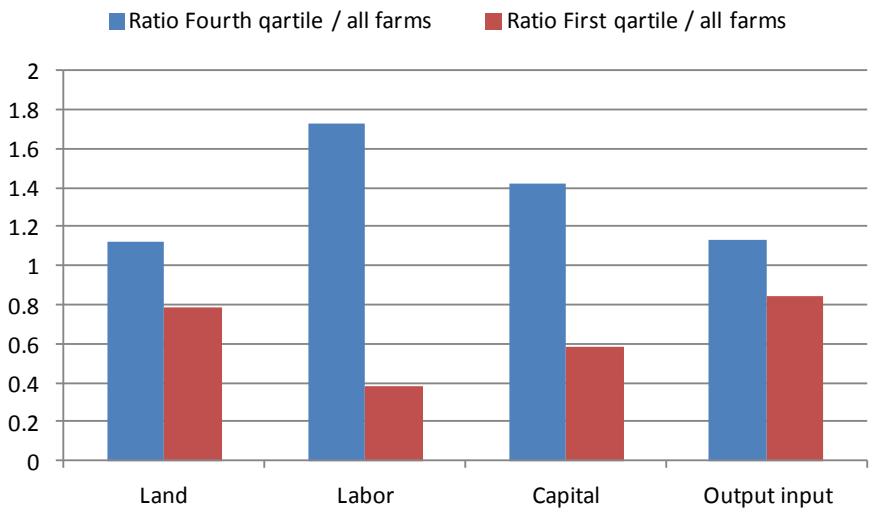
Four partial productivity indicators are constructed with relevant price indices

- **Land productivity (gross agricultural output per hectare of operated land)**
- **Labour productivity (gross agricultural output per week of labour input)**
- **Capital productivity (gross agricultural output per unit of asset)**
- **Input and output ratio (ratio of gross agricultural output and cash input)**

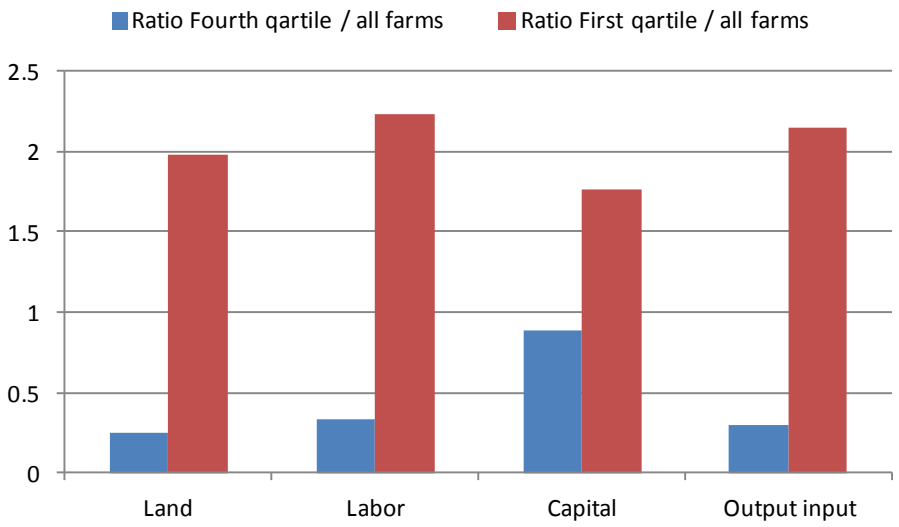
In addition, intensity of support is calculated a share of subsidy in farm receipts

Preliminary analytical results on mixed farms in Australia

Farm size and farm productivity



Farm productivity and intensity of support



- Farm size is defined according to the size of gross output value
- Farm performance indicators are averaged across the years
- Large farmer has higher performance compared to average farmers in particular labour and capital productivity
- Low performer receives support more intensively than average and high performing farms

Preliminary analytical results on the distribution of efficiency scores in Australia, Canada and UK

Characteristics of Canada's crop farm data (constant panel between 2003-07)

	Definition	Number of observation	Mean	Standard dev
Input				
Land	Area of crop land	457	448	346
Purchased inputs	Value of variable inputs	457	75,492	70,901
Capital	Value of fixed inputs	457	39,975	28,947
Output				
Crop output	Production value of crop	457	93,334	77,973
Livestock output	Production value of livestock	457	23,930	47,090
Others				
Crop insurance	Receipts of crop insurance indemnity	457	7,016	10,204
CAIS	Receipt of CAIS payments	457	10,980	10,976

Characteristics of UK's cereal farm data (constant panel between 1999-07)

	Definition	Number of observation	Mean	Standard dev
Input				
Land	UAA	97	233	190
Labor	AWU	97	2.3	1.5
Input	Fixed and variable costs	97	191,575	159,317
Output				
Agricultural output	Production value of crop and livestock	97	178,037	149,127
Non-agricultural output	Off-farm revenue	97	161,122	137,626
Others				
Subsidy	Receipt of all subsidies	97	52,257	42,096

Preliminary analytical results on the distribution of efficiency scores in Australia, Canada and UK

- Non-parametric approach (Data Envelopment Analysis) is taken to estimate the efficiency score of individual farm for each year
- Efficiency score of 1 means that the farmer is on the productivity frontier

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Australia									
Mean			0.61	0.57	0.49	0.60	0.53	0.63	0.46
Standard dev			0.23	0.22	0.26	0.24	0.26	0.23	0.23
Median			0.56	0.53	0.45	0.58	0.48	0.61	0.42
Minimum			0.06	0.14	0.00	0.11	0.04	0.10	0.05
Maximum			1	1	1	1	1	1	1
Canada									
Mean					0.48	0.53	0.55	0.55	0.41
Standard dev					0.20	0.20	0.20	0.20	0.18
Median					0.46	0.49	0.52	0.53	0.37
Minimum					0.24	0.09	0.11	0.06	0.05
Maximum					1	1	1	1	1
United Kingdom									
Mean	0.74	0.80	0.68	0.73	0.71	0.73	0.73	0.73	0.76
Standard dev	0.18	0.15	0.19	0.18	0.18	0.17	0.14	0.14	0.16
Median	0.73	0.80	0.67	0.72	0.71	0.71	0.72	0.73	0.76
Minimum	0.39	0.39	0.30	0.32	0.29	0.31	0.40	0.38	0.31
Maximum	1	1	1	1	1	1	1	1	1

Preliminary analytical results on the distribution of efficiency scores in Australia, Canada and UK

- Panel data allows how individual farmer performance evolved across years
- Three tiers of efficiency score are created each year and the movement of individual farm performance across the tiers is tracked
- Cereal farms in UK looks more stable than other two countries where more than half of the farms often moves to the different tiers each year

Stability analysis of the individual farm performance (% of farms)

	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Australia								
Remain unchanged			**57.7**	**43.6**	**44.3**	**49.0**	**51.7**	**49.0**
Moved to lower tier			21.5	29.5	26.8	25.5	25.5	24.8
Moved to higher tier			20.8	26.8	28.9	25.5	22.8	26.2
Canada								
Remain unchanged					**50.1**	**50.1**	**49.9**	**49.0**
Moved to lower tier					25.4	25.4	25.2	25.6
Moved to higher tier					24.5	24.5	24.9	25.4
United Kingdom								
Remain unchanged	**50.0**	**42.7**	**61.5**	**64.6**	**71.9**	**50.0**	**67.7**	**59.4**
Moved to lower tier	27.1	29.2	18.8	17.7	13.5	26.0	16.7	18.8
Moved to higher tier	22.9	28.1	19.8	17.7	14.6	24.0	15.6	21.9

Preliminary analytical results on the distribution of efficiency scores in Australia, Canada and UK

- Simple OLS regression is performed on the average efficiency score across the sample years against inputs and amount of support received.
- Amount of subsidy received is negatively correlated with the average efficiency scores in Australia and UK after controlling land size and labour input

OLS regression on the average efficiency scores between sample years

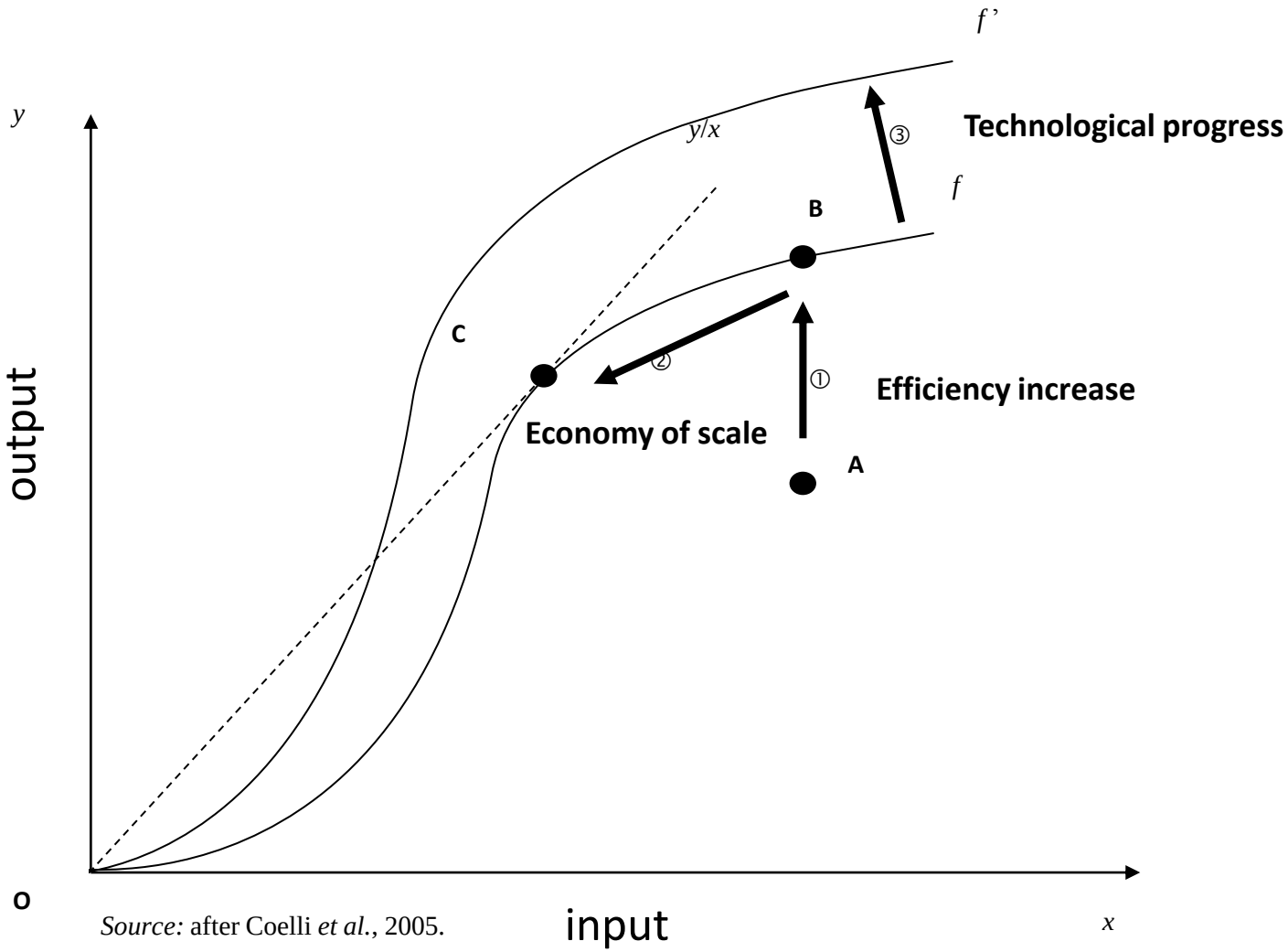
	Coefficient sign	t value	P>|t|
Land size			
Australia	–	-0.55	0.582
Canada	–	3.99***	0.000
UK	+	5.10***	0.000
Labour input			
Australia	+	1.41	0.162
Canada	**n.a.**	n.a.	n.a.
UK	–	-6.57***	0.000
The amout of subsidy received			
Australia	–	-3.37***	0.001
Canada	+	0.95	0.342
UK	–	-3.57***	0.001

*** indicates significance at one percent level

Methodologies for decomposition analysis on productivity growth

- **Decomposition analysis of productivity growth requires longitudinal panel data**
  - Both parametric and non-parametric approach exists to decompose the productivity growth to “technical efficiency change” and “technological change”
  - While “technological change” indicates the shift of productivity frontier, “technical efficiency change” implies to which extent the new knowledge and technologies are diffused to other farmers.

Pathways of productivity growth



Source: after Coelli *et al.*, 2005.

Preliminary analytical results on the decomposition of productivity growth in Australia, Canada and UK

- Non-parametric approach (Malmquist Index Estimation) is taken to estimate the TFP growth, technical efficiency change and technical change
- Input and output values are deflated to construct an implicit quantity index using the relevant price index statistics in each country

Annual percentage growth rate

	Malmquist TFP Index	Efficiency change	Technical change
Australia			
Mean	-0.9	3.4	-4.1
Standard dev	9.4	9.9	3.3
Median	-1.1	3.2	-4.9
Maximum	34.8	36.3	3.3
Mlnimum	-34.6	-29.4	-7.5
Canada			
Mean	3.1	-7.9	11.9
Standard dev	14.0	12.4	3.7
Median	1.1	-9.8	12.3
Maximum	73.6	57.1	57.7
Mlnimum	-29.2	-36.2	-1.8
United Kingdom			
Mean	4.2	0.2	4.0
Standard dev	3.6	3.2	2.9
Median	4.6	0.2	4.9
Maximum	11.2	10.4	7.5
Mlnimum	-6.0	-8.4	-4.3

Next Steps

- **Two concrete projects are proposed: 1) distribution analysis of farm performance and 2) decomposition analysis of productivity growth**
  - The first project could depend on the previous data used in the distribution of support project, while panel data is necessary for the second project. Countries are invited to participate in either or both projects depending on the availability of data and their interests.
  - Output will be shared among the participants and it is expected to be a part of OECD work on innovation systems in 2011-12
- **Terms of reference is developed based on the received feedback**
  - Project proposal is discussed as a part of innovation system study at the Working Party of Agricultural Policy and Markets in late May.

Steps of distribution analysis of farm performance

STEP 1. Construction of the data set

Years of coverage (2004, 2006, 2007 and 2008)

Definition of farm type (field crops / green house, nursery and floriculture / fruits and vegetable / dairy / pigs / poultry and eggs)

STEP 2. Calculation of performance indicators

Starting from profitability indicators

- gross output value (and net operating income) per land, labour and capital input
- ratio of gross output value and total input (with and without imputed cost of own land, capital and labour)
- partial and multifactor productivity indices

Reporting quartile information in total and by farm type on farm performance indicators and farm characteristics (farm size, types of support received and production practice etc..)

Steps of decomposition analysis of productivity growth

STEP 1. Construction of the data set

The project could benefit from the existing panel data on crop farms analyzed for risk management projects with supplementary data on input (labour and capital)

Years of coverage (approximately 10 years of panel data)

Definition of farm type (crop farm, dairy farm, etc..)

STEP 2. Analysis of productivity pathways

Secretariat develops a software to perform non-parametric Malmquist TFP decomposition methods. Analysis could be done either by Secretariat or participating countries

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