Capital in Agriculture: A Panel Dataset

Rita Butzer
Yair Mundlak
Donald F. Larson

Global Agricultural Productivity Conference, May 11-12, 2010

2000.
Donald F. Larson, Rita Butzer, Yair Mundlak, and Al Crego
A Cross-Country Database for Sector Investment and Capital.
World Bank Economic Review 14, 371-391.

2008.
Yair Mundlak, Rita Butzer, and Donald F. Larson
Heterogeneous Technology and Panel Data:
The Case of the Agricultural Production Function.
World Bank Policy Research Working Paper 4536.

Motivation for Construction of Dataset on Agricultural Capital Stocks

- Underlying process of agricultural growth is universal
- Pace of growth varies over time and across countries
- How to account for this variability?

- What accounts for output growth?
  - a change in resources (total factors)
  - the efficiency of their use (total factor productivity – TFP)

- Identify
  - constraints that prevent countries from operating on the frontier
  - determinants that control the pace of convergence to the frontier

- Hypothesis
  - More advanced techniques are more capital intensive,
    thus capital scarcity determines the pace of implementation of new techniques

Motivation, continued

- Adequate measures of capital stocks in agriculture comparable across countries are necessary to address these issues

- No satisfactory datasets existed with coverage beyond the OECD countries

- Lack of appropriate agricultural capital data inhibited studies on important topics
  - the role of capital in agricultural production
  - total factor productivity in agriculture

- Thus we embarked upon constructing our own measures
  - Fixed capital
  - Livestock
  - Treestock

Construction of Agricultural Capital Series

Fixed Capital

- Modified Perpetual Inventory Method
- Based on National Accounts data
- Generate lengthier time series of investment
  rather than seeding initial value of capital stock

Livestock

- Quantity of Animal Stocks valued at Export Prices

Treestock

- Present value is discounted stream of future net revenues
- Net revenue is imputed forward in time, with discounting by the
  real interest rate for the lifetime of each treecrop

Country Coverage of Capital Dataset

Region	Number of countries	
	Initial dataset 1967-1992	
East Asia & Pacific	3	
Europe & Central Asia	3	
Latin America & Caribbean	13	
Middle East & Northern Africa	6	
South Asia	3	
Sub-Saharan Africa	7	
High Income OECD	18	
High Income -- Other	4	
Total	**57**	

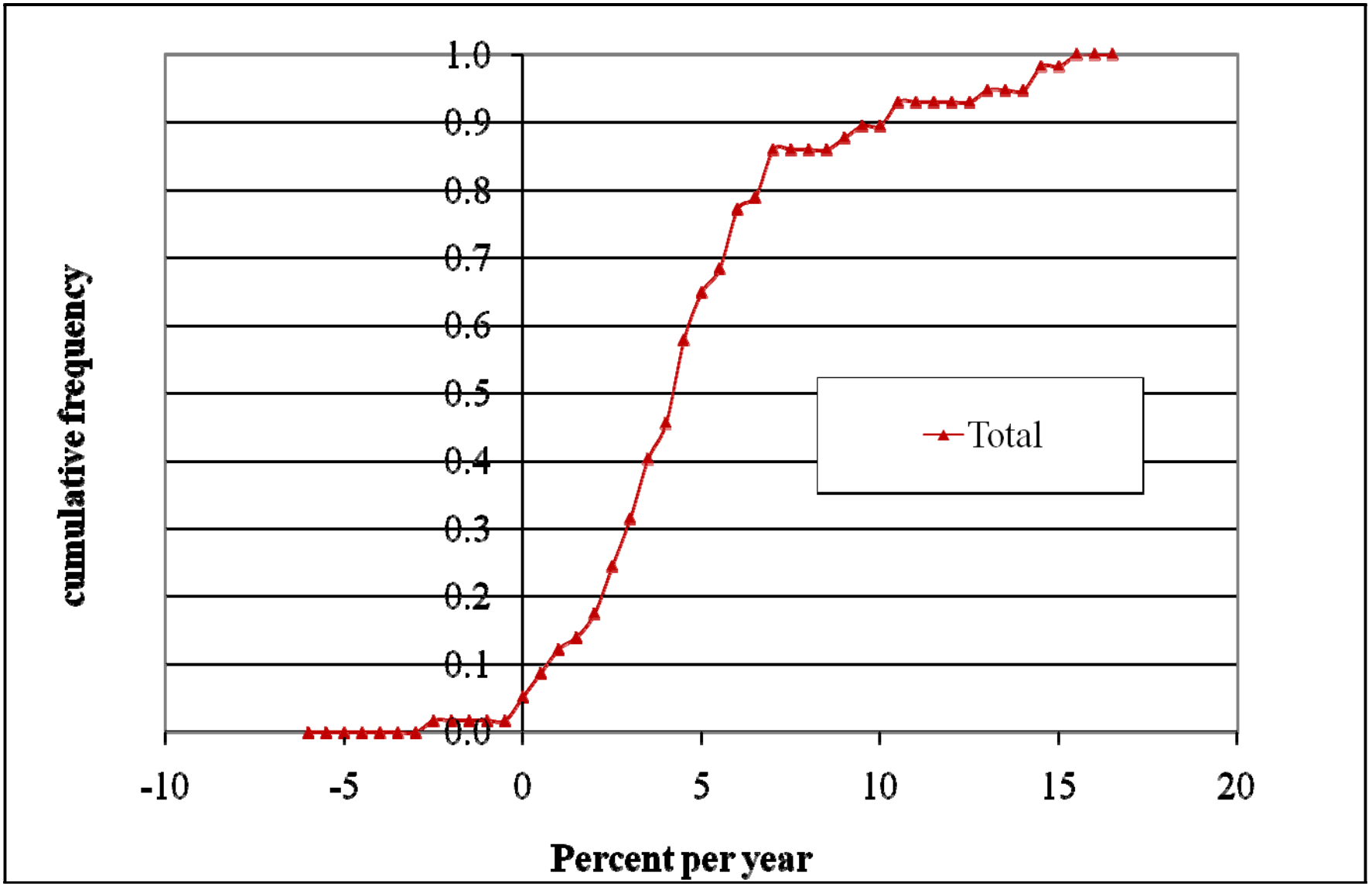
Country Coverage of Capital Dataset

Region	Number of countries	
	Initial dataset 1967-1992	**Updated dataset 1970-2000**
East Asia & Pacific	3	3
Europe & Central Asia	3	1
Latin America & Caribbean	13	2
Middle East & Northern Africa	6	3
South Asia	3	3
Sub-Saharan Africa	7	4
High Income OECD	18	13
High Income -- Other	4	1
Total	**57**	**30**

Country Coverage of Capital Dataset

Income Category	Number of countries	
	Initial dataset 1967-1992	**Updated dataset 1970-2000**
Low Income	9	6
Lower Middle Income	16	6
Upper Middle Income	10	4
High Income	22	14
Total	**57**	**30**

Growth of Fixed Capital Stocks, 1967-1992



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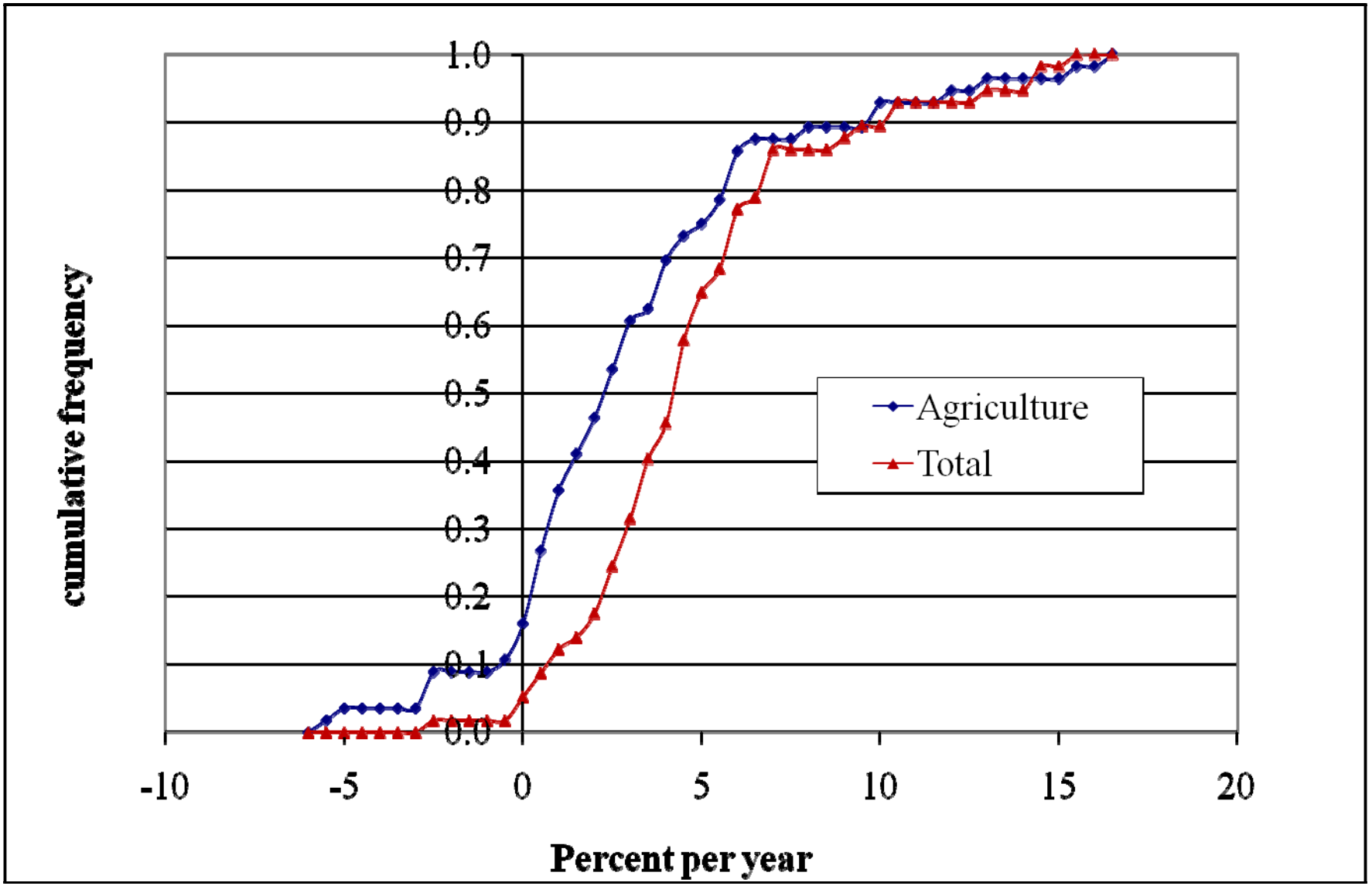
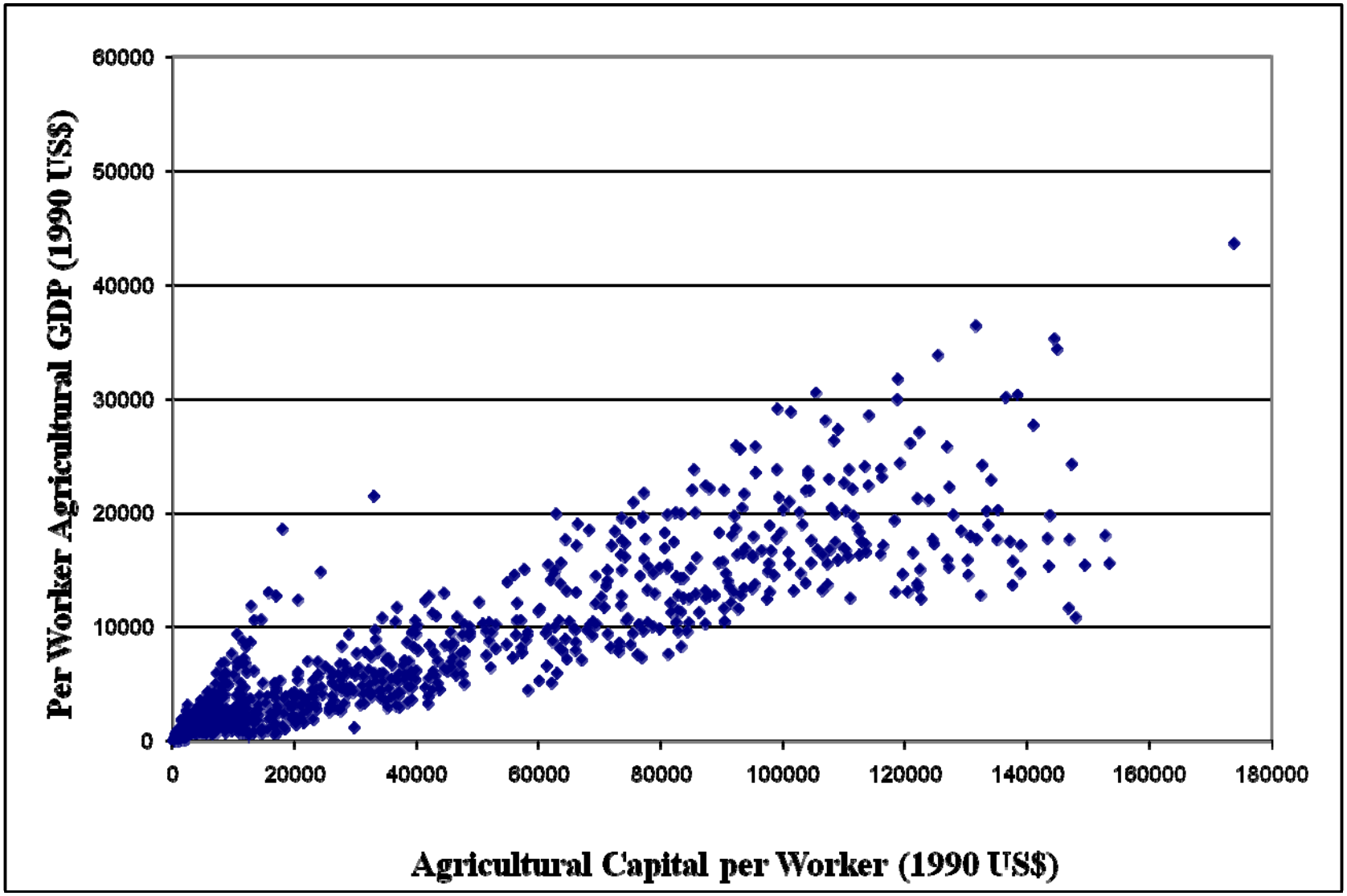
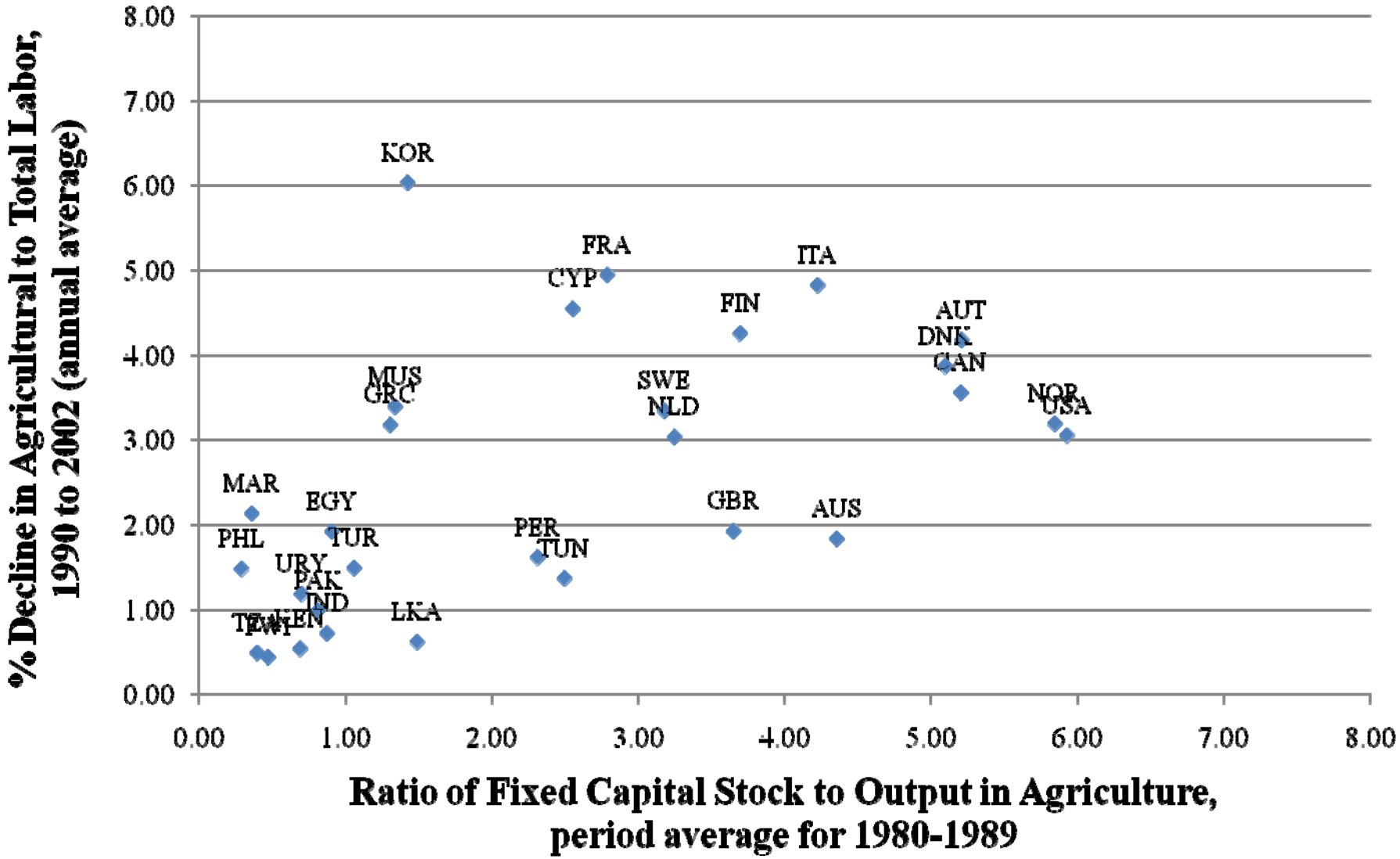


Agricultural Output per Worker and Agricultural Capital per Worker, 1967-92



Capital Intensity and Structural Transformation



Utilization of Agricultural Capital Stock Dataset

Mundlak, Larson & Butzer, 1997

- uses initial dataset, 1967-1992
- panel data analysis of agricultural production function
- demonstrates relative importance of capital, accounting for ~40% of output
- physical capital serves as constraint to agricultural growth
- agriculture is cost-capital intensive as compared to nonagriculture

Martin & Mitra, 2001

- uses initial dataset, 1967-1992
- provide basic estimates of TFP growth in agriculture & manufacturing
- high rates of technical progress in both sectors
- faster technological progress in agriculture than in manufacturing,
  at all levels of development

Heterogeneous Technology and Panel Data: The Case of the Agricultural Production Function

- Panel data analysis of agricultural productivity
- Heterogeneous technology framework
- State variables included in analysis
- Apply within and between transformations to data

1. *Within-country-time*
    - cleaned from between-time and between-country variations
    - best represents a measure of the core implemented technology
2. *Between-time*
    - represent time-series component, common to all countries
    - captures the impact of changes over time in the available technology
3. *Between-country*
    - summarize the between-country variability
    - based on the locus of points that go across the different techniques implemented by the countries, all operating under the same available technology

Data

Balanced panel: 30 countries, 29-year period year (1972-2000)

- ***Output***: GDP in agriculture
- ***Inputs***
  - Land
  - Capital
    - Fixed Capital in Agriculture
    - Capital of Agricultural Origin (Livestock and Treestock)
  - Labor
  - Fertilizers
- ***State Variables***

State Variables Included in Analysis

- ***Technology***
  - Schooling
  - Peak yield
  - Development Indicator
- ***Institutions***
  - Political Rights
  - Civil Liberties
- ***Incentives***
  - Relative Prices
  - Price Variability
  - Inflation
- ***Physical Environment***
  - Potential Dry Matter
  - Factor of Water Availability

Growth Rates, 1972-2000

Variable	Average Annual Growth Rate (%)
Output:	
GDP	5.43
Inputs:	
Capital	5.77
Fixed capital	5.80
Capital of agricultural origin	4.94
Livestock	3.59
Orchards	5.77
Agricultural area	0.01
Labor	-0.60
Fertilizer	1.87
Technology:	
Schooling	1.67
Peak yield	1.41
Prices:	
Relative prices	-1.26

Decomposition of the Sum of Squares

Variable	Decomposition of Sum of Squares (expressed as a percentage of total)		
	SSB(t)	SSB(i)	SSW(it)
Output:			
GDP	9.00	89.47	1.54
Inputs:			
Capital	8.84	88.62	2.54
Fixed capital	6.60	91.03	2.37
Capital of agricultural origin	5.50	91.94	2.55
Livestock	3.09	95.72	1.18
Orchards	4.13	93.35	2.53
Agricultural area	0.00	99.93	0.07
Labor	0.07	99.03	0.90
Fertilizer	1.01	96.47	2.53
Technology:			
Schooling	7.32	88.05	4.63
Peak yield	79.37	6.30	14.33
Development indicator	1.10	95.46	3.44
Institutions:			
Political rights	1.57	79.28	19.16
Civil liberties	1.17	82.67	16.16
Prices:			
Relative prices	25.01	23.14	51.85
Price variability	11.06	27.34	61.60
Inflation	3.12	8.50	88.37

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Results from Estimation of Extended Production Function

Variable	Within time country		Between time		Between country	
	Estimate	t-score	Estimate	t-score	Estimate	t-score
Inputs:						
Fixed capital	0.31	17.47	0.59	49.46	0.13	7.29
Capital of agricultural origin	0.06	2.89	0.24	22.18	0.14	12.08
Agricultural area	0.45		0.34	1.01	0.03	3.16
Fertilizer	0.10	4.39	-0.24	-9.79	0.44	21.78
Labor	0.09	2.34	-0.78	-9.01	0.19	11.88
Sum of estimates	1.00				0.93	
Technology:						
Schooling	-0.13	-2.51	0.14	2.56	0.14	3.31
Peak yield	-0.02	-0.19			0.23	0.62
Institutions:						
Civil liberties	-0.02	-1.75	-0.00002	-0.002	0.03	0.81
Political rights	0.01	0.70	-0.16	-15.37	0.03	1.19
Development indicator	0.63	9.04	0.58	19.32	-0.19	-2.38
Price block:						
Relative prices	0.29	9.13	-0.07	-2.42	0.97	5.97
Price variability	-0.31	-3.13	0.24	4.11	-1.84	-3.35
Inflation	0.002	0.76	0.004	1.62	-0.07	-3.99
Environmental:						
Potential dry matter					-0.66	-12.31
Factor of water availability					0.22	4.96

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Factor of water availability					0.22	4.96

Productivity Evaluation

Growth decomposition			
	Growth rate	**Elasticity**	**Contribution**
Factors:			
Fixed capital	5.80	0.31	1.80
Capital of agricultural origin	4.94	0.06	0.30
Area	0.01	0.45	0.00
Fertilizer	1.87	0.10	0.19
Labor	-0.60	0.09	-0.05
Total Factors	2.23		
Total Factor Productivity	3.20		
Output	5.43		

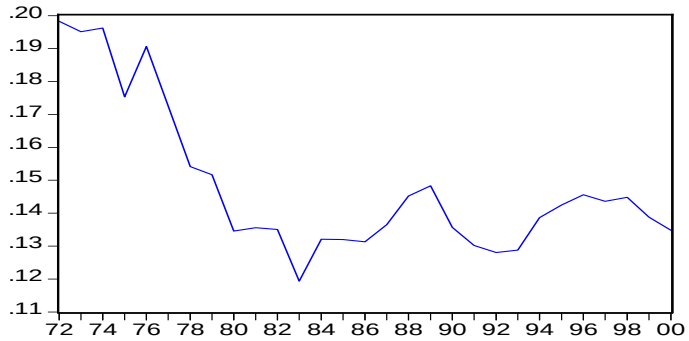
Productivity Evaluation

Marginal Value Productivity

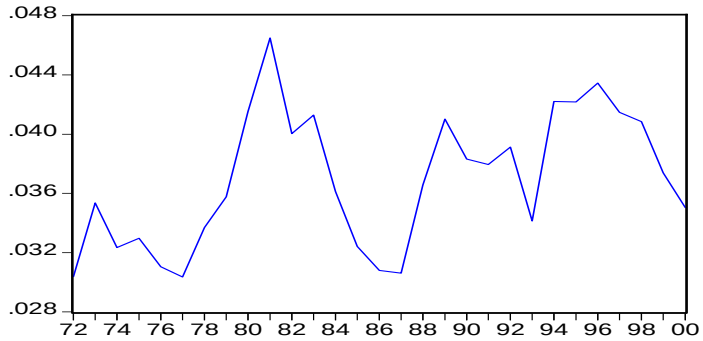
	Elasticity	Mean	Median	Growth rate of median value
Factors:				
Fixed capital	0.31	0.31	0.16	-0.37
Capital of agricultural origin	0.06	0.06	0.04	0.49
Area	0.45	568	271	5.43
Fertilizer	0.10	1,468	1,097	5.24
Labor	0.09	911	307	6.03

Marginal Value Productivity

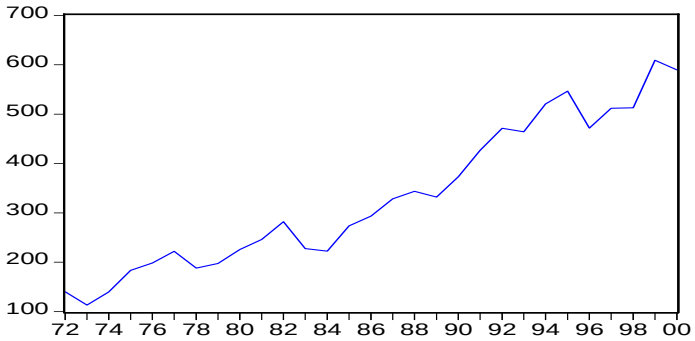
FIXED CAPITAL



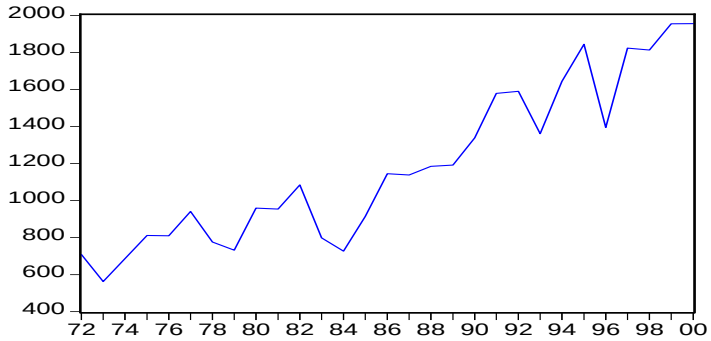
CAPITAL OF AGRICULTURAL ORIGIN



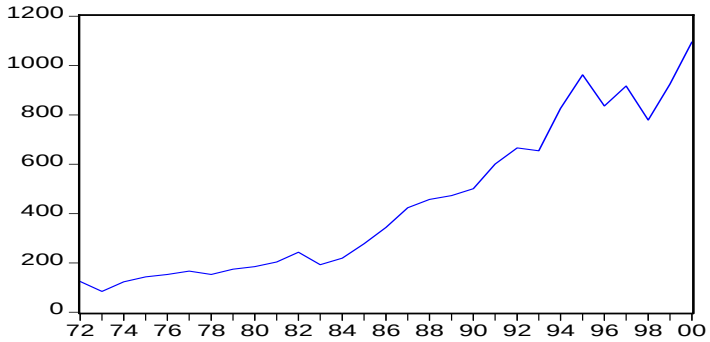
AGRICULTURAL AREA



FERTILIZER



LABOR



Concluding Remarks

- Data on agricultural capital critical to research on agricultural productivity
- Agricultural capital explains 37% of the variation in production
- Agricultural fixed capital accounts for 33% of growth in agricultural output
- Fertilizer and labor contribute far less to output growth
- Implementation of new technologies constrained by level of capital stock

Final Thought

With such overwhelming evidence that capital plays a critical role in agriculture, agricultural productivity, and overall economic growth, there clearly needs to be a concerted effort to expand and improve upon the current datasets on agricultural capital stocks.

Thank you

Capital in Agriculture: A Panel Dataset

Rita Butzer
Yair Mundlak
Donald F. Larson

Global Agricultural Productivity Conference, May 11-12, 2010

Agricultural Capital – Types and Examples

- Fixed Capital
  - buildings
  - structures
  - equipment
  - machinery
  - irrigation devices
- Livestock
  - breeding stock
  - dairy cattle
  - sheep raised for wool
  - draught animals
  - poultry
  - animals for slaughter
- Treestock
  - fruit trees
  - vines
  - rubber trees
  - palm trees

Dataset on Agricultural Capital – Country Coverage

Argentina
Australia
Austria
Belgium/Luxembourg
Canada
Chile
Colombia
Costa Rica
Czechoslovakia (former)
Cyprus
Denmark
Dominican Republic
Egypt
El Salvador
Finland
France
Greece
Guatemala
Honduras
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Kenya
Republic of Korea
Madagascar
Malawi
Malta
Mauritius
Morocco
The Netherlands
New Zealand
Norway
Pakistan
Peru
Philippines
Poland
Portugal
South Africa
Sri Lanka
Sweden
Syria
Taiwan (China)
Tanzania
Trinidad & Tobago
Tunisia
Turkey
United Kingdom
United States
Uruguay
Venezuela
West Germany (former)
Zimbabwe

Construction of Fixed Capital Series

Method of Construction

- Modified Perpetual Inventory Method
- Generate lengthier time series of investment
  rather than seeding initial value of capital stock

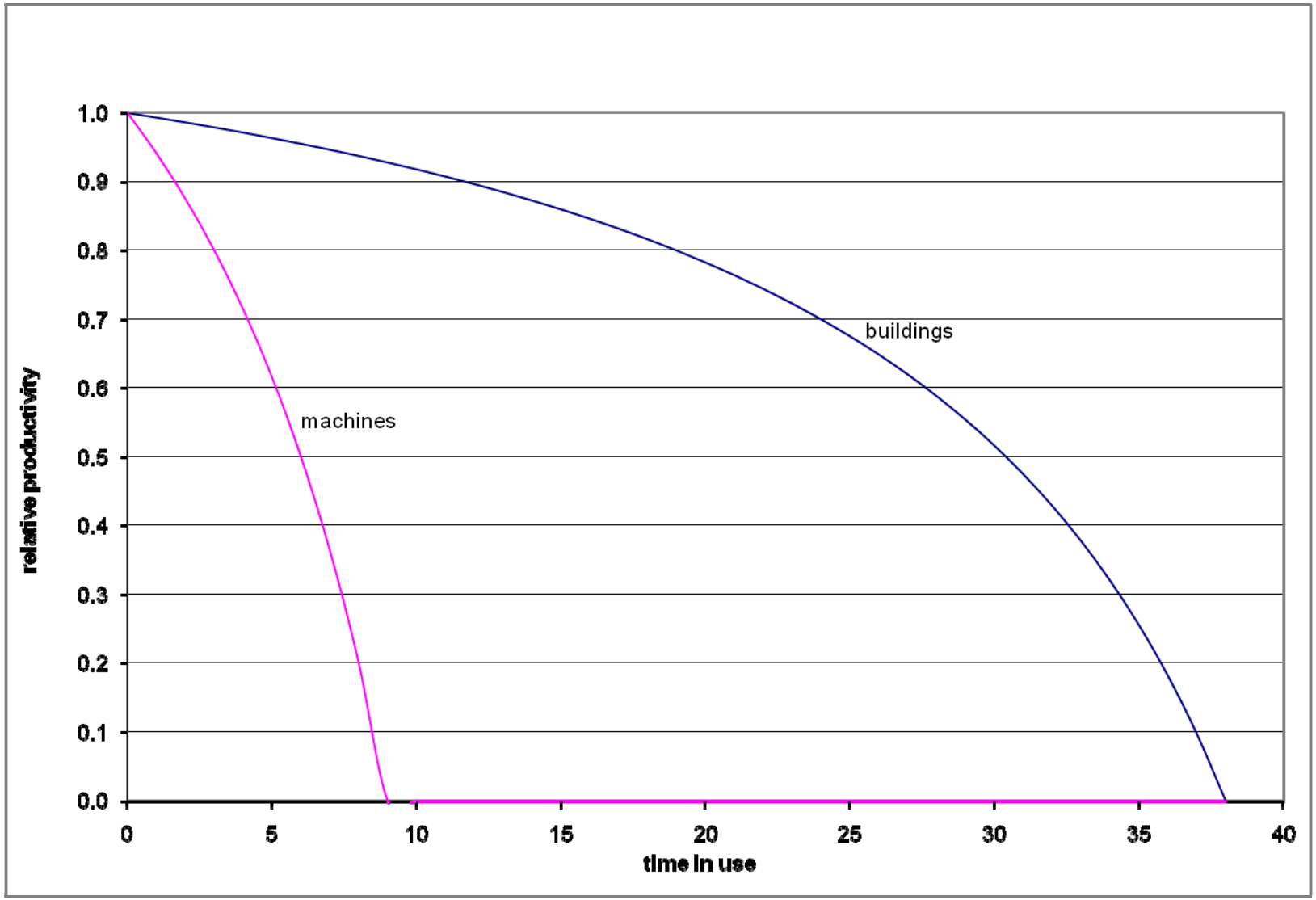
Data Needed

- National Accounts data on sectoral Gross Fixed Capital Formation
- National Accounts data on sectoral Gross Domestic Product
- Nominal Exchange Rates
- US GDP deflator

Assumptions

- Lifetime of Assets, normally distributed, mean of 20 years,
  standard error of 8 years
- Rate of Productivity Decline, 0.70

Examples of Relative Productivity Paths



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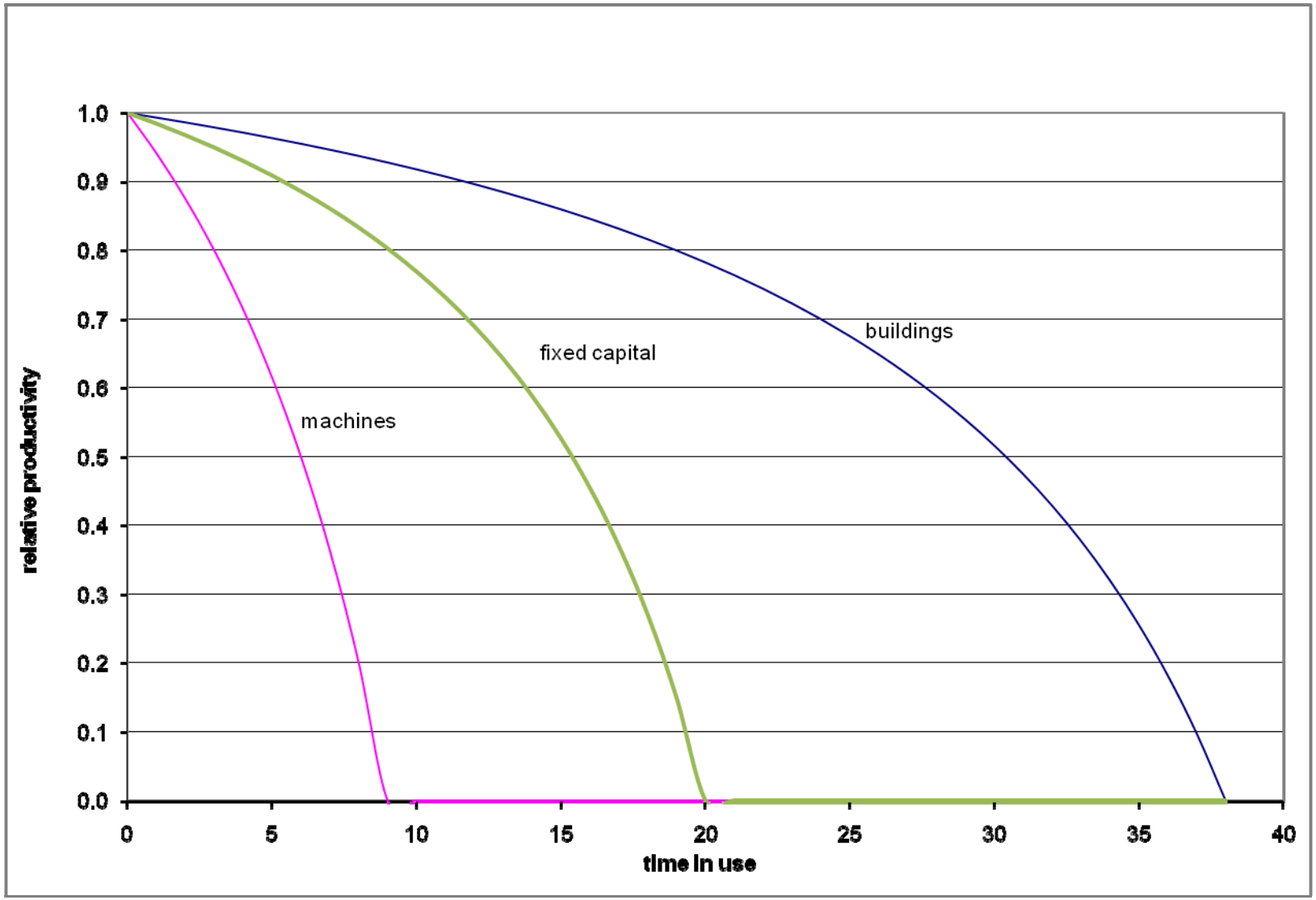


Construction of Livestock Series

Method of Construction

- Value of animals for each country at current prices

Data Needed

- Live Animal Stocks, FAOSTAT: Production database
- Export Values (US$) and Export Quantities,
  FAOSTAT: TradeSTAT database
- US GDP deflator

Treestock – Method of Construction and Data Needed

Method of Construction

- Present value is discounted stream of future net revenues
- Net revenue is imputed forward in time, with discounting by the real interest rate for the lifetime of each treecrop

Data Needed

- Production Quantities by crop, FAOSTAT: Production database
- Producer Prices (US$) by crop, FAOSTAT: PriceSTAT database
- US interest and inflation rates
- Lifetime for each treecrop (assumed at 26 years for initial data set)
- US GDP deflator

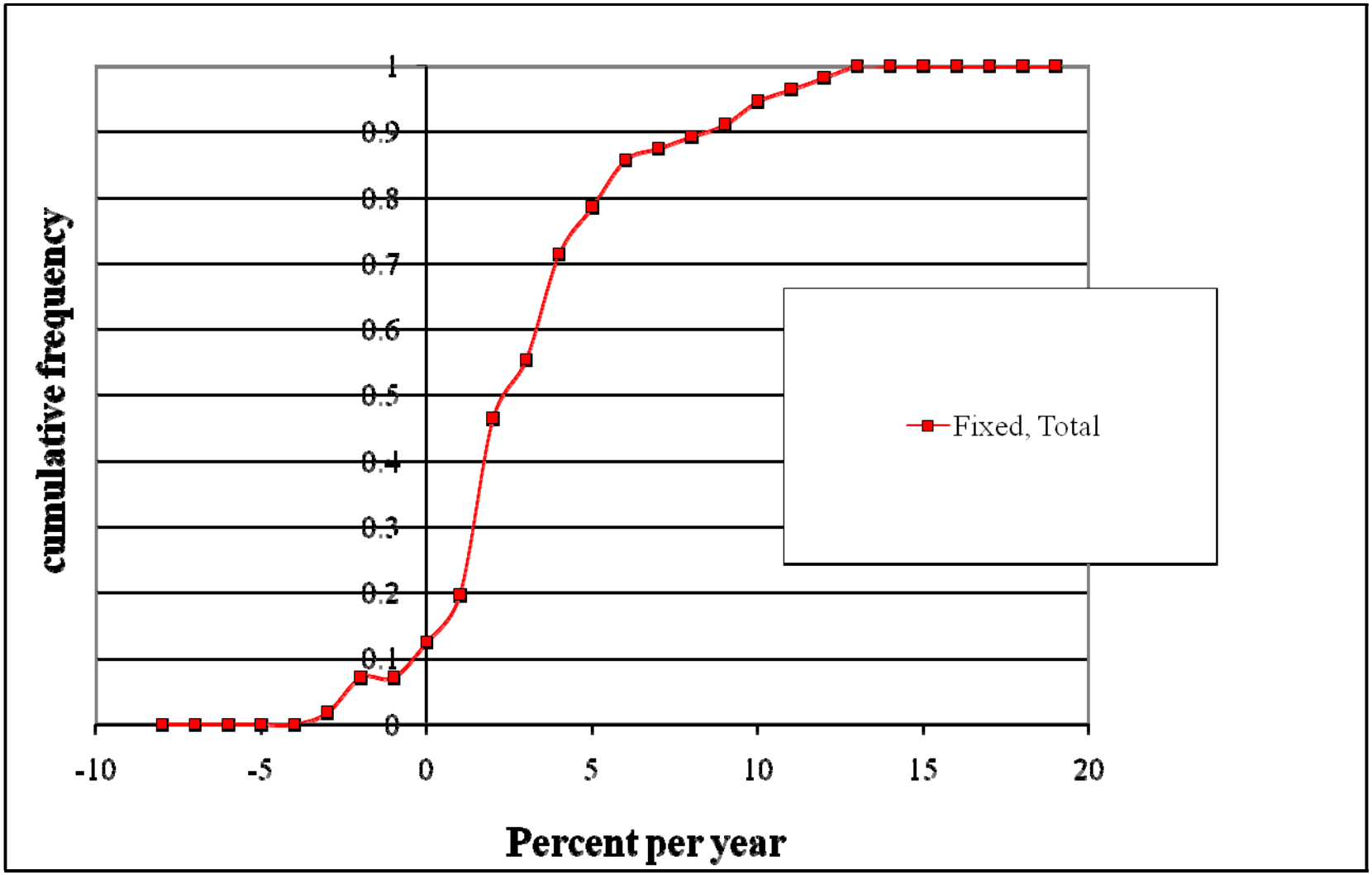
Assumptions

- Production costs account for 80% of revenues
- Orchards are halfway through their assumed lifetime

EXTENDED PRODUCTION FUNCTION BY SUB-PERIODS

Variable	Within time-country				Between time			
	1972-1985		1985-2000		1972-1985		1985-2000	
	Estimate	t-score	Estimate	t-score	Estimate	t-score	Estimate	t-score
Inputs:								
Fixed capital	0.38	10.29	0.43	14.38	0.80	50.84	0.76	42.72
Capital of agricultural origin	0.20	5.54	0.07	2.83	0.14	9.85	-0.06	-4.54
Agricultural area	0.15		0.06		7.55	12.76	-6.55	-28.98
Fertilizer	0.14	4.38	0.13	3.83	0.40	9.08	0.10	7.18
Labor	0.13	1.41	0.31	4.92	0.54	2.08	-1.12	-5.71
Sum of estimates	1.00		1.00					

Changes in Capital to Labor Ratios, 1967-1992



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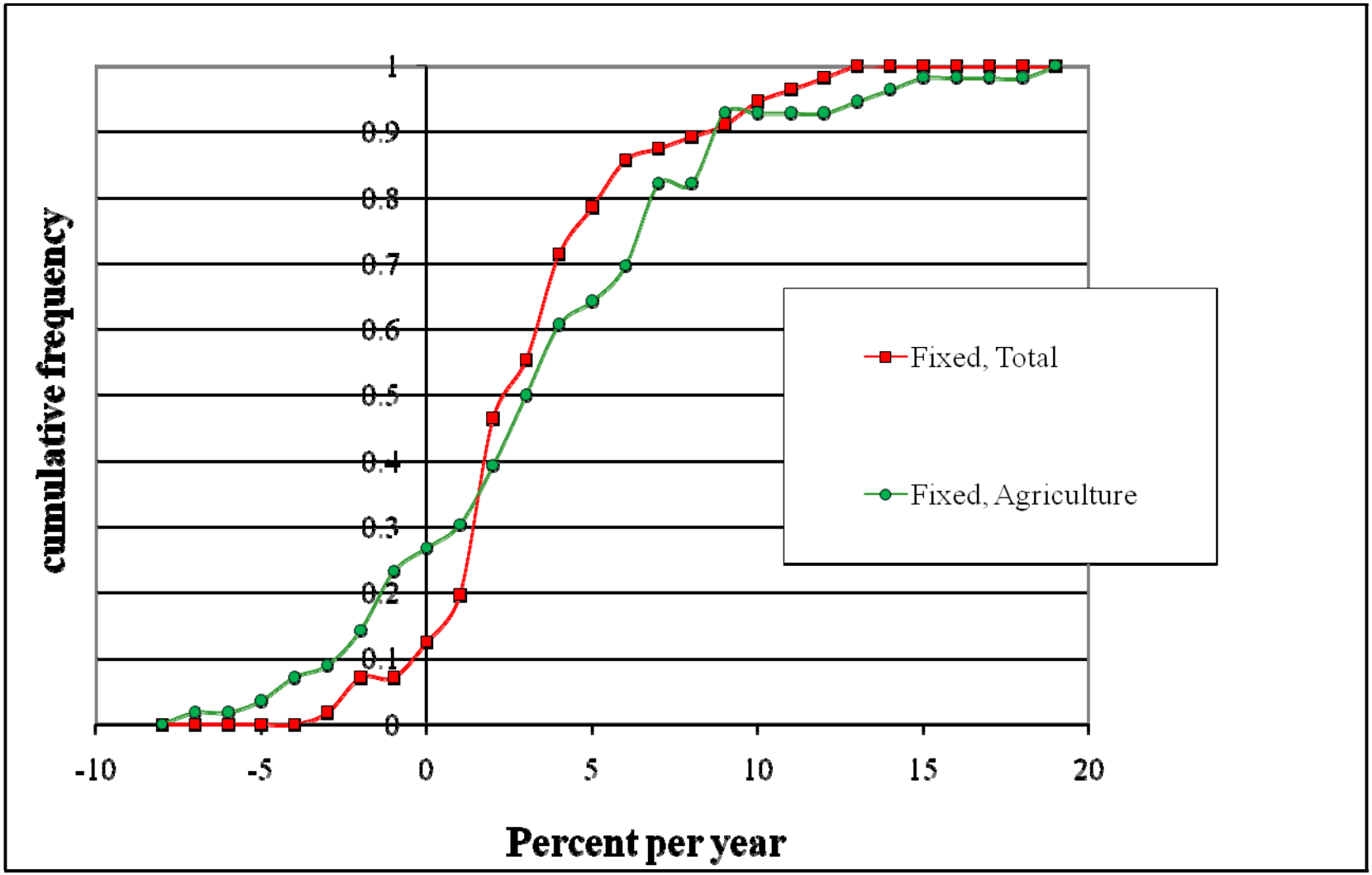

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