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An Annotated Bibliography of Selected Productivity Literature

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AN ANNOTATED BIBLIOGRAPHY OF SELECTED PRODUCTIVITY LITERATURE

By

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AN ANNOTATED BIBLIOGRAPHY OF SELECTED PRODUCTIVITY LITERATURE

This paper annotates and cites literature that is relevant to my interest in agricultural productivity analysis. I have attempted to locate agricultural productivity studies for all countries dating back to World War II, whether the articles were in well-known journals or obscure monographs.

First, I have annotated those articles that I consider to be particularly significant in the development of agricultural productivity analysis. These articles were selected for one of the following reasons: the article was a pioneering empirical effort; the article had a major impact on subsequent efforts by offering new theory or improving existing productivity estimation procedures; or, the article was the first multifactor productivity analysis for some country in a geographic region of the world. These articles include comparative productivity analysis (for example, Hayami and Ruttan, 1970) and country-specific multifactor productivity analysis (for example, the United States in Ball, 1983).

In the second section ("Other Productivity Studies"), I have cited references of articles in which the authors have undertaken formal empirical productivity analysis. Many of these excellent studies could have been written up in the annotated bibliography section. Most of the studies are either comparative productivity studies or country-specific multifactor productivity studies; however, there are some studies cited that are early partial-factor productivity studies (for example, land or labor productivity) for countries in which complete data were not available.

In the third section, I have listed references that incorporate negative externalities into productivity or environmental accounting analysis. These citations are listed separately since I have an interest in incorporating negative externalities into future productivity research. While there appears to have been much research on environmental accounting (see, for example, U.S. Commerce Department, 1994; Repetto, 1989), it seems that there have been only two articles attempting to incorporate negative externalities into

productivity analysis. At the micro level, Archibald (1988) has provided an analysis of farm-level productivity in California's Imperial Valley; at the macro level, Oskam (1991) has provided an analysis of The Netherlands agricultural sector's MFP growth rate (see "Chronological Annotated Bibliography" section).

In the last section ("Related References: Method and Data"), I have listed other references that are related to the previously cited articles. An important category of articles here includes the theoretical articles that underlay the empirical studies. Other categories include country-specific economic performance articles (without formal productivity analysis) and productivity critique articles.

Empirical productivity studies have proliferated rapidly in recent years, especially for developing countries. To summarize some of my findings, I have put together in Table 1 a listing of country-specific multifactor productivity studies. According to my count, this table shows that there has been a total of 72 studies for 29 countries. This is not to mention the numerous studies in which comparative productivity theory has been evolving and in which developed countries' researchers are beginning to collaborate and "harmonize" government accounts (see Narayan and King, 1992). Thus, I find this evolving field to be exciting and I trust that this bibliography will be useful to other researchers.

Chronological Annotated Bibliography

Barton, Glen T. and M.R. Cooper. "Relation of Agricultural Production to Inputs." *Review of Economics and Statistics* 30(1948):117-126.

This study is one of the very earliest published reports on agricultural productivity. This report laid the foundation for the report by Ralph Loomis and Glen Barton in 1961, which provided a more thorough analysis of the productivity of the U.S. agricultural sector (Loomis and Barton, 1961). The Loomis and Barton report established U.S.D.A.'s Economic Research Service as the first governmental agency to publish annual multifactor productivity (MFP) statistics (it was not until 1983 that the Department of Labor's Bureau of Labor Statistics began publishing MFP statistics for other sectors). Barton and Cooper did not publish productivity indices per se, but instead provided numerous charts that explicitly and implicitly showed partial and multifactor productivity results for the 1910-1944 period. Barton and Cooper discussed in detail the problems of input and output definition, measurement, aggregation, and weighting procedures.

Ruttan, Vernon W. "The Contribution of Technological Progress to Farm Output: 1950-75." *Review of Economics and Statistics* 38(1956): 61-69.

Total factor input (land, labor, capital and operating expenses) measures were employed, using a Cobb-Douglas production function with coefficients based on factor shares, to estimate total and partial productivity growth rates for 1910-1950. Scenarios involving alternative land and labor productivity projections were constructed to estimate the implications for capital and operating input and total factor productivity requirements to meet projected 1960 and 1980 agricultural output levels. This was the first attempt to construct consistent projections for the agricultural sector based on consistent factor input and partial and total factor productivity growth rates.

Hsieh, S.C. and T.H. Lee. *An Analytical Review of Agricultural Development in Taiwan -- An Input-Output Approach*. Taipei, Taiwan, China: Chinese-American Joint Commission on Rural Reconstruction, Economic Digest Series No. 12, 1958.

To our knowledge, this study was the first agricultural multifactor productivity study for a developing country. This report is interesting for a few reasons: the authors do not cite the study by Barton and Cooper (1948), but do cite the work of Schultz (1953) and Ruttan (1956); this study came out at nearly the same time as Solow's influential growth accounting article (1957); the authors distinguishes between "production efficiency" (input per unit of output) and the reciprocal "resource productivity" (output per unit of input); and labor input is adjusted for "man-year equivalents." Except for the war years, Hsieh and Lee showed that aggregate production efficiency decreased about 16 percent over the 1935-1956 period (less input required to produce the same level of output) and (conversely) that resource productivity increased by about the same amount for the same period. Hsieh and Lee weighted output and inputs using 1935-1937 base year (Laspeyres) average prices. Detailed tables are provided in the appendices. This analysis was later updated by the same authors in 1966 (Hsieh and Lee, 1966).

Hayami, Yujiro and Vernon W. Ruttan. "Agricultural Productivity Differences Among Countries." *American Economic Review* 60(1970): 895-911.

This article is important for several reasons. First, this study used aggregate country observations as the unit of analysis, which although not original, substantially improved the results given first by Bhattacharjee (1955). Secondly, the study helped establish human capital variables as important variables that allow countries to adopt the latest technology. Thirdly, the coefficients obtained in the aggregate intercountry production function estimates were used in the growth accounting exercise, which helped explain why some countries were relatively more efficient than other countries. These productivity findings were important in the larger context of the theory of induced innovaton, that is, that countries pursue technologies that are biased towards the direction of factors of production that are relatively scarce. Lastly, this article stimulated a new literature on identifying the sources of agricultural productivity growth (for a review, see Trueblood, 1991). The authors themselves frequently updated this study, most recently in Kawagoe, Hayami, and Ruttan (1985). This analysis has also been incorporated into the authors' book, *Agricultural Development: An International Perspective* (first and second editions).

Brown, Randall. "Productivity Returns and the Structure of Production in U.S. Agriculture, 1947-74." Ph.D. Thesis, University of Wisconsin, 1978.

This study, supervised by Laurits Christensen, represented the first challenge to official ERS multifactor productivity statistics. The study appears to have been influential, judging by later references to it by subsequent studies; also the timing of the thesis slightly preceded a joint ERS-AAEA Task Force study (U.S.D.A., 1980), which called for substantial changes in the way ERS measured outputs and inputs and then calculated official multifactor productivity growth rates. Brown used Tornqvist indices and made substantial quality adjustments in the measurements of labor and capital. Brown calculated MFP growth at 1.15 percent per year over the 1948-1974 period, which for that time period compared to ERS' 1.57 percent per year. Since this thesis, there have been at least 10 other studies that have similarly tried to improve upon official ERS statistics (see Trueblood and Ruttan, 1992, for a comparative analysis).

Tang, Anthony M. and Bruce Stone. *Food Production in the People's Republic of China*. Washington, DC: International Food Policy Research Institute, Research Report 15, May 1980.

This lengthy report updates and analyzes more completely the earlier reports by Tang on China's agricultural performance. Subsequent studies on China's agricultural sector have used this study as a starting reference point. Tang and Stone show that while output grew substantially over the 1952-1977 period, input use grew even faster, leading to a MFP growth rate of -0.6 percent per year. This is one of a few studies that shows a country with negative productivity growth.

Antle, John M. "Infrastructure and Aggregate Agricultural Productivity: International Evidence." *Economic Development and Cultural Change* 31(1983): 609-618.

In this study, Antle attempted to improve the previous intercountry production function studies by Hayami-Ruttan and others. Antle argued that while all countries may have access to agricultural technology, a country's adoption and diffusion rate of new technology is affected by its level of infrastructure, particularly for developing countries. Using a cross-section of countries for 1965, Antle found that the partial output elasticity for infrastructure, measured as a country's portion of GDP spent on transportation and communications, was positive and statistically significant for all countries and for a LDC subsample. Econometrically, Antle attempted to address problems of multicollinearity by comparing OLS results with the Principal Components Regression (PCR) estimator, an approach that was later emulated by others.

Ball, V. Eldon. "Output, Input, and Measurement in U.S. Agriculture, 1948-79." *American Journal*

of Agricultural Economics 67(1985): 475-486.

This article essentially replicates Ball's 1984 staff report (see Other Productivity Studies). The article is highlighted since it represented an alternative methodology to the official ERS productivity statistics. Since publishing this article, Ball (an ERS employee) has helped lead ERS in revising its productivity calculations. Ball found that MFP had grown at 1.75 percent per year over the 1948-1979 period. The most important revision of the official ERS methodology by Ball was the use of the Tornqvist index, as opposed to the Laspeyres index. Other revisions included the use of quality-adjusted labor input and improved capital input measurements.

Wong, Lung-Fai. *Agricultural Productivity in the Socialist Countries.* Boulder, CO: Westview Press, 1986.

This study represents a significant breakthrough in terms of trying to understand the agricultural performance of the former Centrally Planned Economies (Eastern Europe, former U.S.S.R., and People's Republic of China). Until this study, economists had attempted to measure agricultural productivity with very limited success (see for example, Falcon and Nelson, 1978; and Barker, 1980). Wong calculated both arithmetic and geometric productivity indices; the factor shares used as weights were obtained from pooled regression results. All nine countries experienced negative MFP growth rates over the 1950-1980 period (some countries, such as China and Romania, showed average annual growth rates at over negative 8 percent!). Most countries' MFP growth rates stabilized after the 1950's, with much slower negative growth rates for the 1960-1980 period. The data in the study are similar to the Hayami-Ruttan stock variables, using a variety of sources. The output variable is based upon the author's construction of wheat unit equivalents for the 1976 period, then interpolated for other years based upon ERS estimates of output growth rates.

Lau, Lawrence J. and Pan A. Yotopolous. "Do Countries Idiosyncrasies Matter in Estimating a Production Function for World Agriculture?" *Journal of Economic Development* 13(1988): 7-19.

This study attempted to address implausible regression results obtained by Kawagoe-Hayami-Ruttan (1985) and other intercountry production function studies. For instance, Lau and Yotopolous argued that it was not likely that in the developed countries that general education (a human capital variable) could have a negative partial elasticity of output; nor was it plausible that with pooled data that the developing countries as a group regressed 22 and 43 percent from 1960-1970 and 1960-1980, respectively (inward shifts of the production function). Lau and Yotopolous argued that these peculiarities could be traced to a sample in which the observations were closely clustered together, thereby lacking sufficient variation for a reliable linear fit. To overcome this problem, the authors used first differences for the pooled Hayami-Ruttan database observations. Subsequently, the authors rejected the Cobb-Douglas functional form, favoring the translog form instead. They found that the returns to scale vary in each country according to a country's ability to exploit mechanization (that is, only the second order machinery variable was found to be statistically significant along with the first order terms).

Oskam, Arie. "Productivity Measurement, Incorporating Environmental Effects of Agricultural Production." *Agricultural Economics and Policy: International Challenges for the Nineties (Essays in Honour of Prof. Jan De Veer)*, ed. K. Burger, M. De Groot, J. Post, and V. Zachariasse, pp. 186-204. Amsterdam: Elsevier, 1991.

This study appears to be the first one that attempts to incorporate (negative) externalities into productivity analysis at the aggregate level (Netherlands). Oskam cites possible sources of externality effects in agriculture: air pollution, surface water pollution, groundwater pollution, soil

pollution, landscape attractiveness, and nature conservation. Theoretically, indices used in productivity analysis with externalities can be modified by acknowledging that besides producing the desired output good, there is also produced an accompanying side effect (whether positive or negative externalities) (see Pittman, 1983). That is, the new output is defined as (**p'y** + **v'z**), where **p'** is an output price vector, **y** the output quantity vector, and **v'** a shadow price vector for the associated externality quantity output vector **z**. The quantitative negative externalities were estimated for pollution of air, surface water, ground water, and soils using technical procedures. Since shadow prices were not readily observable, alternative prices scenarios were tested (low, medium, and high prices). The final results show that MFP was lowered by 2 to 10 percent compared to results without negative externalities included.

Arnade, Carlos A. *Productivity of Brazilian Agriculture: Measurement and Uses*. Washington, DC: U.S. Department of Agriculture, Economic Research Service, Staff Report No. AGES 9219, July 1992.

This report study appears to be the first published multifactor productivity (MFP) study for the agricultural sector of a Latin American country. Under the assumption of constant returns to scale, MFP grew at an annual rate of 2.57 percent per year over the 1968-1987 period; allowing non-contant returns to scale, MFP grew at an annual rate of 1.17 percent per year. The study uses an Tornqvist index approach. Thorough documentation is provided of the data sources. Output indices are constructed for 62 crop and livestock products, while 49 inputs are aggregated into 8 categories. The data were combined from a variety of sources, including United Nations Food and Agriculture Organization, World Bank, Inter-American Institute for Cooperation in Agriculture, Brazilian Government yearbooks, and U.S. Department of Agriculture. Importantly, most of the price data for constructing the indices come from the Getulio Vargas Foundation and are incomplete for a few commodities, requiring the author to make some educated guesses on prices.

Luh, Yir-Hueih and Spiro E. Stefanou. "Learning-By-Doing and the Sources of Productivity Growth: A Dynamic Model with Application to U.S. Agriculture." *The Journal of Productivity Analysis* 4(1993): 353-370.

Luh and Stefanou argue in this article that shifts in the U.S. agricultural production function have been largely attributable to learning-by-doing. Using a dynamic optimization framework, Luh and Stefanou decompose production function shifts into four components: technical change, scale economies, disequilibrium effects, and learning-by-doing. The data used in the study are from Capalbo, Vo, and Wade (1985), with the learning-by-doing variable proxied by accumulated current gross investment in durable equipment and labor. Estimates with a modified generalized Leontief production function show that MFP grew at a slower rate (1.31 percent per year) than other studies report, with learning-by-doing and technical change representing almost 90 percent of the growth.

Thirtle, C. et al. "Agricultural Productivity in Zimbabwe, 1970-90." *The Economic Journal* 103(1993): 474-480.

This study represents the first multifactor productivity study for a country in Sub-Saharan Africa. Since this study, there have been two other working papers on MFP growth rates for Sub-Saharan African countries: one on Kenya (Njue and Fox, 1993) and one on South Africa (Thirtle, von Bach, and van Zyl, 1993). Lack of analysis on Sub-Saharan Africa countries is the motivating force behind the study by Block, 1993. The authors argue that Zimbabwe's national accounts are similar to the United Kingdom, allowing the authors to use a methodology developed by Thirtle and Bottomley for that country. These authors estimate MFP growth rates with Tornqvist indices for the

separate (dualistic) commercial and communal agricultural sub-sectors. They find that MFP growth rates are impressive for both sub-sectors: the commercial sub-sector grew at 3.43 percent per year for the 1970-89 period and the communcal sub-sector grew at 4.64 percent per year for the 1975-90 period.

Arnade, Carlos A. *Using Data Envelopment Analysis to Measure International Agricultural Efficiency and Productivity*. Washington, DC: U.S. Department of Agriculture, Economic Research Service, Technical Bulletin No. 1831, February 1994.

This recent report uses "data envelopment analysis" (DEA) to measure technical efficiency and multifactor productivity for 77 countries. The technical efficiency concept relates observed production points to best-practice observation points for production units at any time period (the "distance function"). The multifactor productivity component relates overall changes of outputs to inputs over time for a given production unit. These two concepts are captured in the Malmquist index initially developed theoretically by Caves, Christensen, and Diewert and later refined by Färe and others. Countries were divided into four categories by the author: advanced technology, middle technology, low technology, and Asian rice technology. Within these categories, the countries' technical efficiency is measured relative to the "best-practice" countries for each 3 year average increment. Overall MFP indices for each country are also given relative to the 1961-1963 base period, as well as the technical change component of MFP. The data are taken from ERS'*World Agriculture: Trends and Indicators*, which uses stock data only.

Pardey, Philip G., Barbara J. Craig, and Klaus Deininger. "A New Look at State-Level Productivity Growth in U.S. Agriculture." *Evaluating Agricultural Research and Productivity in an Era of Resource Scarcity*, ed. W. Burt Sundquist. Department of Agricultural and Applied Economics Staff Report P94-2, University of Minnesota, 1994.

This recent article revises the MFP growth rate calculations in the Deininger Ph.D. dissertation, which was given an honorable mention award by the AAEA for best dissertation in 1993. The dissertation examines multifactor productivity using disaggregated state level data, a significant improvement from official ERS aggregate data. Furthermore, the dissertation examines the diffusion of nationally available technology and whether there has been a convergence of productivity growth rates. Another topic addressed is the role of (lagged) R&D as an explanatory variable for technical change. Pardey et al. find that MFP grew at 1.59 percent per year over the 1949-1985 period. A very similar study by Huffman and Evenson (see Other Productivity Studies) came out at about the same time as the Deininger dissertation; Huffman and Evenson found that MFP grew at 1.84 percent per year over the 1950-1952 period. ERS is in the process of revising of its productivity methodology again, this time to use dissaggregated data like the Pardey et al. and the Huffman and Evenson studies (preliminary results are available in Ball et al., 1994).

U.S. Department of Commerce. "Integrated Economic and Environmental Satellite Accounts," *Survey of Current Business*, April 1994, pp. 33-49.

This article explains the Commerce Department's commitment to develop new auxillary GDP statistics; that is, GDP statistics that allow for environmental and resource use accounting. These new auxillary statistics will not substitute for the existing GDP statistics, but rather will complement them. This new commitment reflects the Clinton's Administration's interest in producing so-called "green GDP" statistics, which partly was a result of the Earth Day summit in Brazil. Two proposed supplementary GDP tables are given in the text, with a detailed explanation of those statistics that are currently available and those that are not. There will be some experimentation for statistics that are not currently available and are subject to much valuation debate (for example, renewable

resources such as fish stocks). A companion article on minerals highlights some of the valuation issues and how these issues affect the supplementary GDP figures. This article also provides an excellent history of proposals to revise GDP statistics.

Table 1 - An overview of MFP growth rate esimates for different countries' agricultural sectors

COUNTRY	Author(s)	Period	Growth Rate
AUSTRALIA	Young (1971)	1948-1967	1.9
BRAZIL	Arnade (1992)	1968-1987	2.57
BULGARIA	Wong (1986)	1960-1980	-0.90
CANADA	Furniss (1970)	1949-1969	1.90
	Danielson (1975)	1946-1970	1.97
	McInnis (1980)	1871-1921	0.77 to 0.87
	Tung and Strain (1985)	1961-1980	1.66
	Agriculture Canada (1992)	1961-1990	2.14
	Veeman and Fantino (19920	1962-1990	1.25
CHINA, PEOPLE'S REP.	Tang and Stone (1980)	1952-1977	-.60
	Wiens (1980)	1952-1977	-1.55 to 0.53
	Tang and Huang (1980)	1952-1979	-0.35
	Wong (1986)	1960-1980	-3.14
	Fan (1990)	1965-1986	1.14
CZECHO-SLOVAKIA	Wong (1986)	1960-1980	0.17
GERMANY, FED. REP.	Weber (1973)	1950-1968	2.0
GERMAN DEM. REP.	Wong (1986)	1960-1980	0.83
HUNGARY	Wong (1986)	1960-1980	-0.19
INDIA	Galgalikar and Alshi (1987)	1951-1981	1.1
	Rosegrant and Evenson (1993)	1956-1985	1.01
INDONESIA	Ahmad (1982)	1950-1978	0.60
	Reksasudharma (1987)	1951-1980	0.5
ITALY	De Meo (1966)	1951-1963	4.40
	Barbero (1974)	1951-1970	2.09
JAPAN	Yamada and Hayami (1979)	1880-1965	0.9
	Yamada (1982)	1880-1975	1.0
	Yamada (1987)	1945-1980	1.7
KENYA	Njue and Fox (1993)	1964-1989	-0.58
KOREA, REP. OF	Ban (1979)	1920-1969	0.52
	Ban (1982)	1946-1977	2.00
	Ban (1987)	1946-1980	2.52
NETHERLANDS	Oskam (1991)	1949-1988	2.06
PAKISTAN	Ahmed (1987)	1950-1983	1.10
	Rosegrant and Evenson (1987)	1956-1985	1.07
PHILIPPINES	Lawas (1965)	NA	NA
	Hooley (1968)	1902-1961	Unclear
	Paris (1971)	1948-1967	0.4
	Crisostomo (1972)	NA	NA
	David and Barker (1979)	1950-1969	0.7
	David et al. (1987)	1955-1980	0.9
POLAND	Wong (1986)	1960-1980	-3.25
	Gemma (1989)	1950-1986	1.25,5.56
ROMANIA	Wong (1986)	1960-1980	-1.67
SOUTH AFRICA	Thirtle, von Bach, and van Zyl (1993)	1947-1991	1.3
SPAIN	Evenson et al. (1993)	1962-1989	2.57
TAIWAN	Hsieh and Lee (1958)	1945-1956	5.80
	Hseih and Lee (1966)	1950-1960	2.19
	Lee and Chen (1979)	1913-1970	0.7
	Chen and Wang (1982)	1913-1977	1.0
	Shih (1982)	1901-1942	1.0
	Chen (1987)	1951-1981	1.6
THAILAND	Wannitikul (1972)	1950-1969	2.00
	Tananasanta et al (1978)	1950-1976	Unclear
	Thanomvongtai (1984)	NA	NA
	Budhaka (1987)	1951-1981	2.6
UNITED KINGDOM	Thirtle and Bottomley (1992)	1967-1990	1.88
UNITED STATES	Barton and Loomis (1961)	1870-1956	0.80
	Brown (1978)	1947-1974	1.42
	Kendrick (1983)	1948-1979	3.50
	Ball (1984)	1948-1979	1.75
	Capalbo-Vo (1988)	1950-1983	1.22
	Capalbo (1988)	1950-1983	1.4 to 1.6
	Cox-Chavas (1990)	1950-1983	1.89
	Jorgenson (1990)	1948-1979	1.61
	USDA/ERS (1991)	1948-1989	1.58
	USDA/BLS	1948-1990	3.06
	Luh and Stefanou (1993)	1950-1982	1.31
	Huffman and Evenson (1993)	1950-1982	1.84
	Pardey et al. (1994)	1949-1985	1.59
U.S.S.R.	Wong (1986)	1960-1980	-1.69
ZIMBABWE	Thirtle et al. (1993)	1970-1989	3.43, 4.64

Other Productivity Studies

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