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Productivity Gaps Between European and United States Agriculture

Abstract: A set of purchasing power parities was constructed for the inputs and the outputs of the agricultural sector in 10 European countries and the United States. This made it possible to deflate both spatially and in time the nominal agricultural accounts. Real values of inputs and outputs made it possible to construct spatial indexes of productivity. These indexes measure the productivity gaps between countries for a given year. Extrapolation between 1973 and 1989 measures how these gaps have changed over time. The results show that the productivity of the United States has been 20 percent higher than the average productivity of European agriculture. This gap has persisted over time. However, large discrepancies exist in Europe and a few countries such as The Netherlands obtain a higher productivity than the United States.

INTERNATIONAL PRICE AND QUANTITY INDEXES

A purchasing power parity is an exchange rates that equalizes the price of a basket of goods in two countries. Although most of the applications have focused on the final consumption of Gross Domestic Product, PPPs can be constructed for other baskets of goods[1]. PPPs are constructed for the inputs and outputs of the agricultural sector in the European Community and the United States. Using PPPs as spatial deflators, real values are then constructed, which are more meaningful indicators of production and consumption levels than simple conversions into dollars using nominal exchange rates. Real values of inputs and outputs are used to compute multilateral indexes of productivity between countries, that is, measures of the gaps in productivity for a given year (as opposed to different growth rates over time). In this paper, spatial comparisons in the agricultural sector are extrapolated over time in order to investigate the changes in productivity gaps between US and EC agriculture between 1973–90.

METHODOLOGY AND DATA

The EKS index number is used to construct PPPs and real values. The EKS index relies on the idea that the best way to compare a pair of countries is to use a bilateral Fisher index (that is, a geometric average of a Laspeyres and Paasche index, Diewert, 1992). When the comparison involves more than two countries, a matrix of bilateral Fisher indexes can lead to inconsistent results. The EKS index ensures transitivity of the comparisons between $I (I > 2)$ countries (Eurostat, 1983). The EKS price index between country A and country B is expressed as:

$$(1)\quad P_{EKS_{A-B}} = \left[\prod_{k=1}^{I} P_F\left(p^B, p^k, y^B, y^k\right) / P_F\left(p^A, p^k, y^A, y^k\right)\right]^{\frac{1}{I}}$$

* INRA-Economie, Grignon, ERS-USDA, Washington, D.C., INRA-Economie Forestiére, ENGREF, Nancy, respectively.

where P_F is the bilateral Fisher price index between A and B, and a country k. A direct EKS quantity index can be obtained in the same way using Fisher quantity indexes.

Prices, real values and productivity are compared for 10 members of the EC-10 and the USA. Real values and price indexes (PPPs) are constructed for agricultural production as well as for the inputs used in the sector. For the year 1985, a bilateral PPP for each basic heading level commodity (for example, wheat) is constructed as the ratio of prices in national currency between countries. The real value is implicit. Prices and real values are then computed for a more aggregated list of commodities (for example, grains) using EKS index numbers. At this level, the spatial indexes for 1985 are matched to the time series indexes (base 1 in 1985) for each country. Time series indexes are Fisher indexes between 1973 and 1985. This double deflation (space and time) leads to the construction of a complete set of PPPs and real values for every year of the period (Ball *et al.,* 1994). The annual productivity indexes (such as in Table 1) are expressed relative to the aggregate EC-10 in 1985.

The construction of the set of PPPs for the agricultural sector requires a huge amount of data since it is necessary to get a price per kg in 1985 for every input and output at the basic heading level (that is, 63 outputs and 24 inputs) (Ball *et al.,* 1994). A PPP was also constructed for the livestock capital, machinery and buildings. PPPs on land and labour were computed using a user cost. Numerous sources were used to obtain price data. Most of the data for the USA were collected from the National Agricultural Statistical Service (NASS) and the Economic Research Service (ERS) of the US Department of Agriculture. Data were obtained for the EC from Eurostats' Farm Accountancy Data Network, as well as numerous national sources. Unpublished data were provided by many statistical agencies, the OECD, Eurostat and some farm business associations. In the US, deficiency payments were included in the output prices. The European accounts (source Eurostat) were matched to the US accounts (source ERS) on the basis of the European accounting rules. A stock of capital was constructed (Ball *et al.*, 1993) for all countries from series of Gross Formation of Fixed Capital (GFCF). The Permanent Inventory Method was used to generate series of stock of productive capital and series of economic depreciation. A truncated normal vintage distribution and hyperbolic decay were assumed. The PPPs for capital were constructed (Conrad and Jorgenson, 1985). Values and quantities for livestock were calculated for 1985 using 15 types of farm animals. The volume of labour is an estimation of the number of hours worked, expressed in Annual Worker Units (AWU).

PRODUCTIVITY GAPS AND PRICE DIFFERENCES BETWEEN US AND EC AGRICULTURE

Over the 1973–89 period, the growth rate of the volume of agricultural production is comparable in the EC and in the USA at, respectively, 1.8 and 1.7 percent. Although the growth rate of EC production was high in the beginning of the period, supply limitation measures in the EC have lowered this rate at the end of the period. Export programs and a weaker dollar helped US exports stimulate production in the 1980s. A gap of 10 percent between the volume of production in the USA and in the EC-10 in the beginning of the period can also be observed in 1989.

Table 1 *Spatial Indexes of Productivity and Annual Growth Rates of Productivity*

Annual indexes, base 100 for aggregate EC-10 in 1985

	GER	FRA	ITA	NET	B-L	UK	IRL	DEN	GRE	USA	EC10
1973	73.2	87.8	62.6	110.3	108.2	86.3	70.4	85.8	67.5	104.0	79.0
1974	76.7	87.4	63.7	115.2	111.7	89.9	73.7	98.1	68.2	93.0	80.7
1975	75.7	85.9	67.0	113.4	104.2	84.8	77.0	87.3	71.4	99.1	80.1
1976	74.5	83.5	64.2	114.4	103.2	82.4	73.6	84.6	71.0	96.8	78.1
1977	78.5	86.3	65.4	118.5	106.7	89.1	78.4	91.8	67.0	105.2	81.0
1978	80.6	91.6	66.3	122.5	111.4	91.7	78.1	91.5	73.1	98.2	83.9
1979	79.8	97.3	69.9	124.3	110.8	92.3	72.9	91.5	70.2	102.2	86.0
1980	81.1	96.9	73.5	123.3	112.8	97.6	75.7	94.4	76.5	98.0	88.3
1981	82.0	97.7	75.0	130.4	115.9	99.4	74.3	99.4	77.0	112.1	89.9
1982	89.5	108.2	77.2	135.6	119.4	103.7	79.7	106.5	77.7	115.1	96.0
1983	87.2	105.7	81.2	131.6	118.1	101.3	81.0	103.5	74.0	100.2	95.1
1984	91.7	111.9	78.7	139.7	122.9	111.9	88.4	118.8	76.7	119.0	99.4
1985	88.8	113.6	82.0	137.2	123.5	109.6	87.4	120.9	78.5	129.9	100.0
1986	94.3	115.8	83.9	143.3	126.7	108.7	84.9	123.6	82.7	130.0	102.8
1987	91.7	119.4	87.7	139.0	123.9	110.2	89.2	119.9	81.4	132.4	103.9
1988	95.9	121.0	88.1	142.8	128.4	110.6	90.3	128.3	91.3	127.5	106.6
1989	98.0	124.5	91.0	147.5	129.7	114.2	90.1	134.1	95.9	137.5	109.9

Spatial index 73–74–75, base 100 for aggregate EC-10 in '74'.

	GER	FRA	ITA	NET	B-L	UK	IRL	DEN	GRE	USA	EC10
'74'	94	109	81	141	135	110	92	113	86	124	100

Spatial index 1987–88–89, base 100 for aggregate EC-10 in '88'.

	GER	FRA	ITA	NET	B-L	UK	IRL	DEN	GRE	USA	EC10
'88'	89	114	83	134	119	105	84	119	84	124	100

Annual growth rate, percent ('88'/ '74').

	GER	FRA	ITA	NET	B-L	UK	IRL	DEN	GRE	USA	EC10
'88'/ '74'	1.7	2.4	2.3	1.7	1.2	1.7	1.4	2.5	1.9	2.1	2.1

Note: '74' = average 1973–74–75. '88' = average 1987–88–89.

In the EC-10, the growth rate of agricultural production is very different between countries — 3.2 percent a year in The Netherlands, compared to 1.2 percent a year in the Belgium-Luxembourg Economic Union (BLEU). The highest growth rate is achieved in The Netherlands, due to a dramatic increase in production of pigs, poultry, flowers and vegetables which has persisted over the period. In Denmark, an increase in pig and wheat production contributed to a high growth, although it has declined during the last years of the period. The growth rate in the Republic of Ireland and the UK was very high at the beginning of the period, concurrent with EC membership which resulted in a sudden

increase in prices. Although the growth rate of BLEU production is the lowest in the EC, it has increased in recent years.

Despite these different rates of growth, the share of each country in the volume of production has not changed very much. It is worth noting the progression of The Netherlands, which had a volume share of 7.5 percent of EC production in 1973 and 9 percent in 1989.

Real values of outputs and inputs were used to calculate spatial indexes of productivity. Table 1 presents total factor productivity figures for the beginning and end of the period. Table 1 also shows how the productivity gaps have changed over time. In Table 1 the base is 100 for the EC in 1985. The table of annual indexes makes possible both spatial comparisons (for instance, rows give the relative level of productivity of the USA compared to the EC in a given year) as well as time series comparisons (columns give the growth in productivity for a given country). In the three-year average at the end and the beginning of the period (Table 1) the base is 100 for the EC during the three-year period.

The total productivity of US agriculture is 23 percent higher than the total productivity of the aggregated EC-10. This gap remains constant between '74' (that is, average of 1973–74–75) and '88', since the growth rate of productivity in the EC is similar to the US growth rate, about 2.2 percent a year. However, two periods can be distinguished. After a lower growth rate between 1973 and 1981, the gains in the USA are superior to the gains in the average EC after 1981.

If the EC countries are considered independently, the productivity of US agriculture remains lower than the productivity of The Netherlands over the period. The gap, however, tends to decrease: Dutch productivity was 14 percent higher than that of the USA in '74', and only 8 percent higher in '88'. US agriculture is more productive than that of any European country, even if the gap between the US and Denmark, as well as between the USA and France, has decreased over time (from 10 percent in '74' to 4 percent in '88' for the USA compared to Denmark and from 14 percent to 9 percent for the USA compared to France).

Denmark, France and Italy show a growth rate of global productivity higher than the European average, as the Belgium-Luxemburg Economic Union and Republic of Ireland achieve lower rates. However, Italy and Greece remain among the low productivity countries at the end of the period.

DIFFERENT INPUT COMBINATIONS

The input combinations are very different between countries, so are the partial productivities (Table 2). The high productivity levels of US agriculture can be explained partially by the availability of land, which allows the USA to substitute intermediate inputs for land. Intermediate inputs per hectare are 15 times lower than in The Netherlands. The quantity of land per unit of aggregate output is higher in the USA than in any European country (Table 2). The high productivity of labour and intermediate inputs compensate the poor partial productivity of land. In Europe, the productivity of land reflects not only high yields of major crops, but also the structure of the output mix and substitutions with other inputs. For instance, in '88' the yields for wheat were 2.5 t/ha in Greece, compared to 5.7 t/ha in France, 6.4 t/ha in UK and 7.3 t/ha in The Netherlands. However, if the whole quantity of aggregate production is considered, Greece appears to use a relatively small

quantity of land to produce one unit of output, due to high production of fruit and vegetables. The opposite is true for UK and French agriculture, where the quantity of land per unit of output is high, since these countries use extensive grazing areas for animal production. High yields with specialization in land saving production (horticulture, pigs, intensive milk production), generate very high land productivity in The Netherlands.

Table 2 *Spatial Indexes of Partial Productivity Average 73–89 (E10=100); Annual Growth Rate of Productivity ('88'/ '74')*

Partial productivity: average 1973–89

	GER	FRA	ITA	NET	B-L	UK	IRL	DEN	GRE	EC10	USA
Intermediate inputs	79	107	151	87	79	80	114	80	161	100	104
Land	126	85	113	363	206	63	44	115	115	100	29
Capital	62	122	95	139	154	112	106	88	167	100	91
Labour	135	125	57	255	224	177	66	217	40	100	286
Total	94	111	78	146	131	112	87	119	80	100	121

Annual growth rate of partial productivity : ('88'/'74')

	GER	FRA	ITA	NET	B-L	UK	IRL	DEN	GRE	EC10	USA
Intermediate inputs	0.0	–0.1	–1.0	0.6	–0.2	1.2	–1.1	0.6	–0.9	0.1	0.4
Land	1.7	2.5	2.2	3.4	1.8	1.5	2.6	2.8	0.7	2.1	1.6
Capital	1.1	1.4	0.5	–0.8	–0.8	0.9	1.3	2.0	–1.2	0.9	3.6
Labour	4.2	4.8	4.2	4.4	4.0	3.1	4.2	6.5	4.0	4.3	4.1
Total	1.7	2.4	2.4	1.7	1.2	1.7	1.4	2.5	1.9	2.1	2.1

These differences in land productivity are explained by very different uses of intermediate inputs. Clearly, The Netherlands have substituted intermediate inputs for land to cope with a shortage of arable land. Given the very high rates of fertilization and the very intensive use of feedstuffs, the productivity of the intermediate inputs is high and demonstrates how efficient the Dutch farmers are in the use of these intermediate inputs. This productivity of the variable inputs is only 13 percent below the EC average. The productivity of labour and capital is very high too. Dutch agriculture succeeds in saving land, capital and labour, using a large amount of intermediate inputs in a very efficient way. This explains the impressive performance of The Netherlands in terms of total productivity.

Despite the extensive land use of US agriculture, partial productivities of intermediate inputs and fixed capital are not very high. Productivity of intermediate inputs is only 4 percent higher than in the EC, because of the low yields in the grain sector. Productivity of intermediate inputs is 9 percent lower than the EC average, even though it has improved more over the period (growth rate of 4.1 percent a year compared to 1.3 percent in the EC). The low investment in the USA after 1985 has not influenced the production. The source of high total factor productivity in US agriculture is mainly the high productivity of labour, about three times as high as the EC average, due to the large size of farms as well as the high level of mechanization.

The total productivity of French agriculture is about 10 percent above the EC average, due to the good productivity of intermediate inputs and fixed capital. Productivity of labour is low in France, compared to the other North-European countries. Large less-favoured areas and highlands contribute to a low average land productivity, despite high yields in the crop sector.

The total productivity of UK agriculture is lower than that of France, Denmark or The Netherlands. German agriculture is among the least productive in the EC. This confirms the finding of other studies about productivity as well as costs of production in Germany. It has been suggested that the main explanation for this is small farm size and over-mechanization, which both generate a low productivity of capital and labour, compared to other North-European countries. Of course, when looking at these figures, one should remember that since reunification, German agriculture is no longer dominated by small farmers. Large Eastern farms have to be taken in consideration.

Good productivity of intermediate inputs can be found in Southern agriculture (Italy and Greece), partly due to the large share of fruit and vegetables in the total production. Another reason is the low use of variable inputs in some disadvantaged areas. Italian and Greek agriculture has remained very labour-intensive. However, the low productivity of labour reflects not only substitutions between labour and capital, but also reveals an excess of labour on the farms, and a certain form of 'hired unemployment'. Because of this poor productivity of labour, total factor productivity is low compared to the EC average. The growth rate of total productivity in Italy is higher than the EC average. However, Greek agriculture does not seem to catch up and a gap of –20 percent between the average total productivity in Europe and in Greece persists at the end of the period.

In general, there is little change in the ranking of the different countries in terms of total productivity over the period. The situation of Germany, Belgium and Republic of Ireland, compared to the EC average, has worsened during the period. The situation of Denmark, France and Italy has improved.

CONCLUSION

Productivity is the main determinant of real prices in the long term. Compelling evidence of this can be seen by comparing changes in prices of computers, a sector where high rates of productivity have been achieved, with changes in the prices of some services where almost no productivity gains have been achieved. In most of industrialized countries, real agricultural prices have decreased more than prices in the aggregate economy. Lower costs of food have freed resources, and have fostered economic growth. This was achieved thanks to a high rate of productivity growth in agriculture, compared to other sectors (Jorgenson and Gollop, 1992).

Productivity indexes are one of the most relevant indicators of long term trends in real prices and competitiveness. Sectoral studies show that the comparatively more rapid efficiency gain in a country is the major reason why long-run average costs decrease relatively to other countries (Fuss and Waverman, 1985). Productivity enhances the competitive and financial position of a nation within the international community. In the agricultural sector, productivity differences are a much more important determinant of costs of production than are low input prices (Bureau and Butault, 1992).

This paper shows that productivity gaps between the most productive country (The Netherlands) and the least productive (Greece) in the sample are considerable. Although the USA is not as productive as The Netherlands, US total factor productivity is much higher than that in the EC as a whole. US productivity growth has kept in pace with the EC since 1973 and remains the best guarantee for the competitiveness of US agriculture in the future, whatever the issue of international negotiations.

NOTE

[1] These global PPPs based on the GDP are published by several international organization (OECD, 1987, Eurostat, 1983). These PPPs are used in comparative studies of price levels. They form the basis from which the over-valuation or under-valuation of a currency is determined, since the rate of PPP can be compared to the Nominal Exchange Rate (NER). They are usually used to compute real GDP per capita, which is a major issue for international organizations, since it is an important element in the determination of loans and international payments.

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