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Agricultural competitiveness: The case of the United States and major EU countries [1]

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Abstract

Growth in the agricultural GDP of four major European countries is compared with US agricultural growth for the period 1974–1993. The agricultural sector's relative prices are taken into account along with economy-wide factor market adjustments. For Denmark, France, Germany and the UK, the effects of declining real prices and changes in input levels on growth in agricultural GDP are relatively small. Total Factor Productivity (TFP) growth appears to be the major contributor to European agricultural GDP growth. In comparison, TFP is the major source of growth in US agricultural GDP, but its rate of growth is lower than the European countries. In contrast, the declining real prices for US agriculture had a relatively large effect on its GDP. However, in recent years, the effects of declining real prices and declining rates of growth in TFP on European agriculture are relatively large. In the longer-run, the relative competitiveness of US agriculture is largely dependent on its ability to sustain and increase growth in TFP. © 1997 Elsevier Science B.V.

1. Introduction

This paper focuses on the sources of growth in European Union (EU) agriculture and contrasts them with the sources of growth in US agriculture. Growth in European agricultural output has been relatively high over the past few decades, coincident with its support of agriculture (Arnade, 1995; Thirtle et al., 1995; Ball et al., 1996). [2] There is a belief that this growth has been stimulated by high and stable prices that producers receive under the European Union's Common Agricultural Policy (CAP). Others dispute this notion and claim that output growth is a result of technical change which would continue without price incentives. From the perspective of US agriculture, the relatively high growth rates of European agriculture are important. The EU, as a whole, has become not only self-sufficient in most of its own agricultural markets, but also a major competitor to the US in world agricultural export markets. This growth experience suggests that US agriculture might be losing 'competitiveness' relative to the EU countries. However, this conclusion needs to be tempered by whether the growth in EU agriculture has been artificially sustained by the CAP and, therefore, whether it is likely to continue under CAP reform. An analysis of the underlying factors to that growth will provide insight into that longer run question.

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[2] Although these papers use different techniques, all come to the same conclusion that total/multi-factor productivity (MFP) has been the major contributor to growth in European and US agriculture.

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This study decomposes growth in agricultural GDP into price and input effects and total factor productivity (TFP) effects. [3] The effects of changes in inputs and prices are short-run in nature (often for only a single time period), while the TFP effects tend to be longer run dynamic sources of growth. Growth driven by increases in prices/inputs is typically not sustainable in the long run, particularly if policy artificially distorts sector prices upward and otherwise slows the adjustment associated with the competition for economy-wide resources among a country's agricultural and non-agricultural sectors.

The nature and magnitude of these effects are important public policy issues since each of these effects can be greatly influenced by government programs. In addition, many of the sources of TFP growth in agriculture are not among the choices of producers and may be external to the sector. The means of internalizing the technological externalities, which are discussed in the 'new' growth literature (Romer, 1990; Lucas, 1993), include public investments in R&D, public infrastructure, patent protection, and other public investments that seek to counter the market's failure to reward the factors of production for their full contribution to productivity.

The analysis in this paper uses the sectoral GDP function developed by Gopinath and Roe (1995), following Diewert and Morrison (1986), to compute the effects of inputs, prices and TFP on the growth in the 'real value' of European and US agricultural output. The non-parametric estimates of the contributions to growth in agricultural GDP are derived by applying the Quadratic approximation lemma (Diewert, 1976) to the sectoral GDP function. Data for the period 1973–1993 from Spel (Eurostat, 1973–1993), Economic Accounts for Agriculture (EAA, OECD, 1973–1992), Ball et al. (1993, 1996) and STARS (World Bank, World Development Indicators) are used to derive Tornqvist indices of three outputs and eight inputs (prices and quantities) for this purpose. Data and choice of countries are outlined in Section 4.

Results indicate that TFP is the major source of growth in the major European (Denmark, France, Germany, and the UK) and US agricultural sectors, on average, over 1974–1993. For the United States, the price effects are significantly negative, while inputs have a small positive contribution to growth during the same period. With the exception of Germany, the effects of agriculture's declining terms of trade with the rest of the economy is relatively lower in the European countries. This, along with large rates of growth in TFP has led to relatively large growth rates in GDP. However, since 1988, declining real prices and declining rates of growth in TFP have sharply reduced the growth of European agriculture. In contrast, US agriculture shows a relatively stable growth in its TFP and less adverse effects from declining real prices.

2. Competitiveness: A definition

The concept of competitiveness has been used in a broad set of contexts. In general, the concept is poorly defined. The following defines 'competitiveness' as it relates to our growth decomposition exercise. It focuses on a sector rather than the whole economy. Competitiveness is a relative concept with two dimensions, domestic and international. If within an economy, say the United States, the rate of growth in agriculture's real GDP exceeds that of the economy, i.e.

$$\mathrm{d}(\ln \mathrm{GDP_A})/\mathrm{d}t > \mathrm{d}(\ln \mathrm{GDP})/\mathrm{d}t \qquad (1)$$

then, we say that agriculture's (A) domestic competitiveness is growing relative to the rest of the economy. The derivatives in Eq. (1) are total rather than partial, and suggest that the sources of this change can be decomposed into effects of prices and factors, and TFP effects. Now, consider a comparison of agricultural sectors of two countries, say that of the United States and country 'X':

$$\frac{\mathrm{d}(\ln \mathrm{GDP_{A,US}})/\mathrm{d}t}{\mathrm{d}(\ln \mathrm{GDP_{US}})/\mathrm{d}t} > \frac{\mathrm{d}(\ln \mathrm{GDP_{A,X}})/\mathrm{d}t}{\mathrm{d}(\ln \mathrm{GDP_X})/\mathrm{d}t} \qquad (2)$$

If the real GDP of the agriculture relative to the non-agriculture of one country is growing compared with that of another, then we say the first country is gaining bilateral agricultural competitiveness over the second. In this case, US agriculture is growing relative to country X and is said to be gaining bilateral competitiveness. Note this is again a func-

[3] TFP effects lead to persistent changes in rates of growth of GDP. Changes in prices/inputs bring about changes in the level of GDP and not necessarily the rate of growth.

tion of the underlying sources of growth in agricultural GDP. For the US to be globally competitive, it has to be the case that:

$$\frac{d(\ln GDP_{A,US})/dt}{d(\ln GDP_{US})/dt} > \frac{d(\ln GDP_{A,W})/dt}{d(\ln GDP_{W})/dt} \qquad (3)$$

where $GDP_{A,W} = \Sigma_x GDP_{A,X}$ is world agricultural GDP. In a competitive economy with no trade distortions this result implies that in the aggregate and on average over a period, the US farmers are competing more successfully for world consumers of food, including the US consumers, than are the rest of the world's farmers. [4]

The distinction between price/input effects and TFP effects has implications for sustaining the competitiveness of a sector. [5] For instance, assume country X has high price support policies, while the US agricultural growth is dominated by TFP effects or growth in TFP. The price and input effects result in one time benefits and have to recur periodically to sustain growth, but the TFP effects are long-run in the sense that they do not perish in one time period. Further, annual increases in price supports can increase growth in real GDP, but this source can be artificial and not sustainable when prices are supported above world market levels. In this example, the US agriculture will maintain its competitiveness in the long-run, while country X may have high growth rates during the period of time of increasing price supports. However, increasing price supports only come about through growing budget support which over time becomes increasingly difficult to sustain.

Krugman (1996) points out that productivity of a sector per se has little, if anything, to do with international competitiveness. Instead, it is relative sectoral efficiency gains (in the case of this study, efficiency gains in the US agriculture relative to US non-agriculture compared with that of its major competitors) that determines trade performance. While productivity growth of a sector or an economy is vital to a country's standard of living, absolute productivity comparisons across countries alone provide no insights into competitive advantage. The productivity of agriculture relative to non-agriculture in the US compared with that of its major competitors determines international competitiveness or as Krugman suggests "the success of a country depends not on absolute but on comparative productivity advantage" (p. 272).

In what follows we outline a framework that decomposes the numerator of Eq. (2) for the US and the major European agricultural sectors. We draw information on the denominator of Eq. (2) from related studies. As our focus is on long-term growth, the key ratio of interest is the relative rates of growth in TFP.

3. The model

Consider an economy with two outputs (vectors) y_j, j = primary agriculture (A), and non-agriculture (N) and three categories of inputs (v_A, v_N, v_E) where the input vector v_j, j = A,N is specific to sector 'j' and v_E is a vector of economy-wide factors, such as labor and material inputs. Following Woodland (1982), define the economy-wide GDP function as

$$G(p_A, p_N, \bar{v}_A, \bar{v}_N, \bar{v}_E; \gamma) \equiv \max_X \left\{ \Sigma_{j=A,N} p_j Y_j\left(v_j, v_E^j; \gamma_j\right)\right\}$$
$$X = \left\{\left(v_A, v_N, v_E^A, v_E^N\right): v_A \le \bar{v}_A, v_N \le \bar{v}_N, v_E^A + v_E^N \le \bar{v}_E\right\} \qquad (4)$$

and Y_j (v_j,v_E^j, γ_j) for j = A,N is a constant returns to scale or vintage production function (Diewert, 1980). The Lagrangian multipliers of this (constrained) maximization problem, namely (λ_A, λ_N, λ_E) are the shadow prices for the two sector-specific inputs and one economy-wide factor. The feasible set X is bounded by the endowments of the private sector. The variable 'γ_j' in Y_j is an 'externality' in the sense that it is not a choice variable of the individual firm. It broadly represents the 'level of efficiency' or 'technology' of the economy. The sources of efficiency gains include learning-by-doing, and public investments in infrastructure, research and development, and other social investments. Since most of these sources of efficiency gains are external to and

[4] Of course, at the individual commodity level, some countries may be more competitive than the US. Moreover, as the denominator of Eq. (3) is an estimate of mean growth rates, some countries included in the aggregate may have larger growth rates than the US.

[5] As a reviewer notes, these definitions of competitiveness are not normative.

not necessarily made within a sector, they are referred to as 'externalities'.

The envelope properties of G (see Woodland, 1982) imply the supply function y_j (for $j=$ A,N) and the factor rental rate or inverse demand function λ_j (for $j=$ A,N,E):

$$\frac{\partial G}{\partial p_j}=y_j\left(p_A,p_N,\bar{v}_A,\bar{v}_N,\bar{v}_E;\gamma_j\right);$$

$$\frac{\partial G}{\partial v_j}=\lambda_j\left(p_A,p_N,\bar{v}_A,\bar{v}_N,\bar{v}_E;\gamma_j\right) \quad (5)$$

Given the solutions (v_E^{j*}, v_A, v_N) to the problem in Eq. (4), redefine it as:

$$\max_X\left\{\Sigma_{j=\mathrm{A,N}}p_jY_j\left(v_j,v_E^j;\gamma_j\right)\right\}$$
$$X=\left\{v_A\le\bar{v}_A,v_N\le\bar{v}_N,v_E^j\le v_E^{j*}\text{ for all }j\right\} \quad (6)$$

Proposition [6]

The solution to problem (6) is given by:

$$G\left(p_A,p_N,\bar{v}_A,\bar{v}_N,\bar{v}_E;\gamma\right)$$
$$\equiv\Sigma_{j=\mathrm{A,N}}g_j\left(p_j,v_E^{j*},\bar{v}_j;\gamma_j\right) \quad (7)$$

g_j, referred to as the 'sectoral GDP' function, under certain regularity conditions, completely characterizes the underlying technology set (following Diewert, 1974). This product function (g_A) is homogeneous of degree one in each of p_A, and (v_E^{A*}, v_A^*) and has the same envelope properties as the economy-wide GDP function. g_A and its specific (translog) functional form are the basis for the non-parametric analysis (see Kohli, 1993 for the terminology) of contributions to growth in sectoral GDP.

The agricultural sector's GDP function is given by g_A (for notational convenience, g hereafter) with three outputs, seven sector specific inputs and one economy-wide input (see Section 4 for a description). For given real prices [7] and sector-specific inputs, and the quantity of economy-wide and intermediate inputs used in this sector, define the period 't' theoretical productivity index (following Diewert and Morrison, 1986 who provide indices for an economy wide GDP function) as:

$$R^t\left(p,v_E^A,\bar{v}_A\right)\equiv\frac{g\left(p,v_E^A,\bar{v}_A;\gamma_A^t\right)}{g\left(p,v_E^A,\bar{v}_A;\gamma_A^{t-1}\right)} \quad (8)$$

R^t is the percentage increase in sectoral GDP (valued at reference output prices) that can be produced by period t technology relative to period $t-1$ technology. Two special cases of R^t are:

$$R_L^t\equiv\frac{g\left(p^{t-1},v_E^{A,t-1},\bar{v}_A^{t-1};\gamma_A^t\right)}{g\left(p^{t-1},v_E^{A,t-1},\bar{v}_A^{t-1};\gamma_A^{t-1}\right)};$$

$$R_P^t\equiv\frac{g\left(p^t,v_E^{A,t},\bar{v}_A^t;\gamma_A^t\right)}{g\left(p^t,v_E^{A,t},\bar{v}_A^t;\gamma_A^{t-1}\right)} \quad (9)$$

R_L^t is a Laspeyres type index which uses period $t-1$ output prices and primary input quantities as references, while R_P^t is a Paasche type productivity index based on period t prices and quantities. Since the two indices in Eq. (9) are not observable, a geometric mean of the two can be obtained using a translog functional form for the sectoral GDP function. For an explicit specification refer to appendix 3 of Gopinath and Roe (1995). Given the translog functional form and the assumption of competitive profit maximization, it follows that

$$g\left(p^t,v_E^t,v_A^t;\gamma^t\right)\equiv\lambda_E^tv_E^t+\Sigma_l\lambda_{Al}^tv_{Al}^t\equiv\Sigma_kp_k^ty_k^t \quad (10)$$

where v_E is the quantity of economy-wide factor used in this sector and λ_A is the vector of sector-specific factor returns. Following Diewert and Morrison (1986), a geometric mean of the Laspeyres and Paasche index is derived as:

$$\left(R_L^tR_P^t\right)^{1/2}=\frac{a}{b\times c\times e};\text{where } a=\frac{p^ty^t}{p^{t-1}y^{t-1}} \quad (11)$$

$$\ln b=\frac{1}{2}\Sigma_{k=1}^K\left(\frac{p_k^ty_k^t}{p^ty^t}+\frac{p_k^{t-1}y_k^{t-1}}{p^{t-1}y^{t-1}}\right)\left(\ln\frac{p_k^t}{p_k^{t-1}}\right)$$

$$\ln c=\frac{1}{2}\Sigma_{l=1}^L\left(\frac{\lambda_{Al}^tv_l^t}{p_ty^t}+\frac{\lambda_{Al}^{t-1}v_l^{t-1}}{p^{t-1}y^{t-1}}\right)\left(\ln\frac{v_l^t}{v_l^{t-1}}\right) \quad (12)$$

$$\ln e=\frac{1}{2}\left(\frac{\lambda_E^tv_E^t}{p^ty^t}+\frac{\lambda_E^{t-1}v_E^{t-1}}{p^{t-1}y^{t-1}}\right)\left(\ln\frac{v_E^t}{v_E^{t-1}}\right)$$

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[6] See appendix 2 of Gopinath and Roe (1995) for proof.

[7] We derive the real prices by deflating the sectoral price indices by a GDP deflator, in principle discounting them for average price increases in the economy.

Note that the right-hand side of Eq. (11) can be obtained using aggregate price and quantity data. In Eq. (11), a is growth in real value of output, b is a translog output price index, so (a/b) is an implicit output quantity index, while c and e are primary and economy-wide input quantity indices. Therefore $(a/(b \times c \times e))$ denotes a productivity index. Individual real price and input contributions to growth in real agricultural GDP can be obtained by disaggregating the indices in Eq. (12) (Diewert and Morrison, 1986). The output (real) price effect for each good k is given by ln b_k while, for each input I, input effect is given by ln c_l. For instance, b_k is interpreted as the change in farm real GDP (between periods t and $t-1$) attributable to change in real price of the kth good from p_k^{t-1} to p_k^t holding other prices (including the economy-wide input price) and all inputs constant. Eqs. (11) and (12) comprise the key components of the non-parametric analysis.

The index Eq. (11) is akin to Solow's residual, total factor productivity (TFP). In the context of competitive markets and constant returns to scale technologies, it encompasses sources of technological change that are not necessarily among the choice set of producers. Examples include 'spill-in' effects from new ideas, learning-by-doing and expansion of knowledge leading to increased efficiency that, while requiring resources to produce, are typically not taken into account when individual producers make production choices. These types of effects are common to the endogenous growth literature where markets fail to internalize technological externalities. Note also that the efficiency gains in other sectors of the economy enter the jth sector's procurement vector $\mathbf{v}$. However, empirically TFP also includes unanticipated changes in exogenous variables such as weather and other shocks.

Our measures of competitiveness described in Eq. (2) relates to Eq. (11) in the sense that the components b (price effects), c and e (input effects) and a/bce (TFP effects) make up the total growth in real GDP (which is 'a' in Eq. (11) and also the numerator of the left-hand side of Eq. (2)).

4. Data and choice of countries

The technique outlined in Section 3 was applied to data from four European countries, Denmark, UK, France, and West Germany (referred to as Germany) from the years 1973 through 1993 and compared with results obtained for the United States elsewhere (Gopinath and Roe, 1995).

4.1. The United States

Quantities and prices for four outputs, meat, other livestock (referred to as dairy), grain and other crops are derived as Tornqvist indexes. Similarly, hired labor (an economy-wide resource), family labor, real property, materials and other capital are the five inputs for which prices and quantities are derived as Tornqvist indexes. See Ball et al. (1996) for the construction of the data series for US agriculture. The GDP deflator series published by the Department of Commerce is used to obtain real agricultural output prices.

4.2. European countries

The countries were chosen on the basis of the degrees to which they compete with the United States. All countries, except Denmark, compete with the United States in world wheat markets. France and the United States generally compete in the same markets (countries) for wheat exports. Each country is also a major producer of livestock products, particularly beef and pork, and thus compete with the United States in these areas. In contrast, southern European countries (Italy, Spain, Portugal, Greece) export few products in common with the United States. Holland and Belgium do not produce enough output of competing goods to be considered a major competitor.

The major sources of data were the Spel data base of Eurostat (1973–1993) and EAA from OECD (1973–1992). The Spel data base was used to obtain most of the outputs and inputs and their unit values for the period 1973–1993, except capital and land. Data from EAA, OECD on the value of labor, capital and intermediate inputs employed in agriculture are obtained for the same period. The GDP deflator for each of the four countries was taken from the STARS data series of the World Bank. We have adopted techniques similar to Ball et al. (1996) in the construction of EU time series. However, the intermediate input quantity index was not adjusted for quality because of lack of data on quality attributes.

4.2.1. Outputs

Each country produced 32 outputs (Spel) which were grouped into three major categories, grains, other crops, and animal products. Grains include wheat, barley, rye, oats, flax, pulses and corn. Potatoes, other tuber crops, all vegetables, fruits, all industrial crops, sugar, flowers, and tobacco constitute 'other crops'. Livestock products include beef, eggs, chicken, mutton, veal, milk, wool, pork and other animals. The above three major output quantities and their unit values were derived as Tornqvist indexes. The database lists the unit values (prices) as market based and accounts for various forms of protection. Real output prices were obtained by deflating the nominal unit values from above by the GDP deflator.

4.2.2. Inputs

Inputs were grouped into eight major categories. Energy and machine repairs, fertilizers and seeds, pesticides and pharmaceutical inputs, feed inputs, animal inputs, capital, land, and labor. Most of the data on intermediates (unit values and quantities for the first five) are from Spel, while data on the payments to hired labor and net income (remuneration to capital, land and family labor) are from EAA. The total cost of intermediates derived from Spel and EAA were different largely due to the opportunity cost of animals. The EAA takes into account new animal purchases, while ignoring the opportunity costs of the existing stock of animals. The opportunity costs were computed (procedure outlined below) using the data from Spel. Data on two types of land (arable and pasture from Production Yearbooks of FAO, 1973–1993) and their rental rates were obtained from The Agricultural Situation in The Community (European Commission, 1973–1993) and aggregated into a single land input. From the payments to capital (EAA) the value of land was subtracted to obtain the value of non-land capital. [8,9]

The eight input quantities and prices were also derived as Tornqvist indices. Expenditure on energy and machine repairs were available in constant 1990 local currency. Data on the use of the three major types of fertilizers, nitrogen, phosphate and potassium (in tons of nutrient) and their unit values (per tonne of nutrient) were combined with the expenditure on seed (in constant 1990 local currency which is multiplied by the unit value deflator to obtain the nominal expenditure). Cost of pesticides and pharmaceutical products were also available in constant 1990 local currency (with unit value deflators). Feed inputs include barley, oats, rye, corn, pulses and feed potatoes (unit values and quantities). The opportunity cost of animal inputs turned out to be the most difficult to measure. Pigs, and chickens are harvested within one year, while non-dairy cattle were either harvested within 1 year as veal, or in 2 years as beef. Hence, it was important to make sure that the cost of calves were allocated to the year in which they were harvested. It was assumed that the share of beef and veal in total meat output (exclusive of other animals like pigs, sheep and goats, etc.) was representative of the percentage of calves harvested in one year (veal), while all other calves were harvested in the second year (beef). The total number of calves were then decomposed into those for veal and for beef. The cost of calves were taken into account for veal directly, and the opportunity cost of calves for beef were computed using IMF market interest rates. The same procedure was applied to non-dairy cows. Capital in constant 1990 local currency for each of the four countries were obtained from Ball et al. (1993) and hired labor data were available in annual work units from Spel.

5. Results

Tables 1–3 present the estimates of the contributions to GDP growth in Denmark for the periods 1974–1993. Similar estimates are presented for France (Tables 4–6), Germany (Tables 7–9) and the UK (Tables 10–12). The results for the US are presented in Tables 13–15. As the sample covers the 1970s and 1980s, several sub-period averages are considered including the period 1980–1993 and four 5-year averages. A detailed discussion of individual countries is followed by a comparison of the EU countries with the US.

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[8] Unfortunately, existing databases are unable to decompose this data series further (Bureau et al., 1995; Ball et al., 1996).

[9] For the year 1993 we obtained (i) wage and labor data from the United Nations' National Account Systems, and (ii) rental price and stock of capital from Ball et al. (1993).

Table 1
Components of agricultural GDP growth in Denmark

	GDP growth	Price effect	Input contribution	TFP growth
1974–1993	4.40	−0.65	−0.04	5.09
1980–1993	2.06	−0.62	−0.22	2.90
1974–1978	11.16	−0.29	0.69	10.77
1979–1983	11.99	−0.23	0.07	12.14
1984–1988	−2.70	0.23	−0.91	−2.02
1989–1993	−2.88	−2.32	0.01	−0.56

Table 2
Price effects on agricultural GDP growth in Denmark

	Aggregate price	Grains	Other crops	Livestock
1974–1993	−0.65	−0.15	−0.25	−0.25
1980–1993	−0.62	−0.32	−0.35	0.05
1974–1978	−0.29	−0.06	0.08	−0.32
1979–1983	−0.23	−0.38	0.25	−0.11
1984–1988	0.23	0.17	−0.52	0.59
1989–1993	−2.32	−0.34	−0.81	−1.18

Table 3
Input contributions to agricultural GDP growth in Denmark

	Aggregate inputs	Land	Labor	Capital	Intermediates
1974–1993	−0.04	−0.00	−0.00	−0.03	−0.00
1980–1993	−0.22	−0.01	0.02	−0.13	−0.10
1974–1978	0.69	0.00	−0.05	0.21	0.53
1979–1983	0.07	−0.02	0.03	−0.37	0.42
1984–1988	−0.91	0.01	−0.07	0.05	−0.91
1989–1993	0.01	−0.01	0.08	0.01	−0.07

Table 4
Components of agricultural GDPgrowth in France

	GDP growth	Price effect	Input contribution	TFP growth
1974–1993	5.24	−0.62	−0.18	6.04
1980–1993	3.97	−0.05	−0.43	4.45
1974–1978	6.96	−2.65	0.49	9.12
1979–1983	11.73	1.02	−0.31	11.02
1984–1988	3.47	1.43	−0.04	2.08
1989–1993	−1.18	−2.27	−0.85	1.94

Table 5
Price effects on agricultural GDP growth in France

	Aggregate price	Grain	Other crops	Livestock
1974–1993	−0.62	−0.37	−0.06	−0.19
1980–1993	−0.05	−0.40	0.22	0.12
1974–1978	−2.65	−0.45	−1.07	−1.12
1979–1983	1.02	0.13	0.85	0.03
1984–1988	1.43	0.31	0.24	0.88
1989–1993	−2.27	−1.46	−0.24	−0.56

Table 6
Input contributions to agricultural GDP growth in France

	Aggregate inputs	Land	Labor	Capital	Intermediates
1974–1993	−0.18	−0.00	−0.02	0.00	−0.17
1980–1993	−0.43	0.00	−0.02	−0.09	−0.33
1974–1978	0.49	0.00	−0.02	0.16	0.34
1979–1983	−0.31	−0.01	−0.02	0.02	−0.31
1984–1988	−0.04	−0.01	−0.01	−0.16	0.15
1989–1993	−0.85	0.01	−0.02	0.01	−0.85

Table 7
Components of agricultural GDP growth in Germany

	GDP growth	Price effect	Input contribution	TFP growth
1974–1993	1.76	−0.11	−0.13	2.00
1980–1993	1.12	−0.13	−0.11	1.36
1974–1978	3.59	−1.46	−0.01	5.05
1979–1983	3.33	1.37	−0.15	2.11
1984–1988	−1.65	0.22	−0.10	−1.76
1989–1993	1.78	−0.59	−0.23	2.60

Table 8
Price effects on agricultural GDP growth in Germany

	Aggregate price	Grain	Other crops	Livestock
1974–1993	−0.11	−0.04	−0.05	−0.02
1980–1993	−0.13	−0.01	−0.15	0.03
1974–1978	−1.46	−0.15	−0.43	−0.89
1979–1983	1.37	0.04	0.67	0.67
1984–1988	0.22	0.09	−0.39	0.51
1989–1993	−0.59	−0.13	−0.07	−0.39

Table 9
Input contributions to agricultural GDP growth in Germany

	Aggregate inputs	Land	Labor	Capital	Intermediates
1974–1993	−0.13	0.01	−0.01	0.02	−0.15
1980–1993	−0.11	0.02	−0.00	−0.03	−0.10
1974–1978	−0.01	−0.00	−0.02	0.15	−0.13
1979–1983	−0.15	−0.00	0.02	−0.19	0.02
1984–1988	−0.10	0.01	0.01	−0.02	−0.10
1989–1993	−0.23	0.05	−0.04	0.13	−0.37

Table 10
Components of agricultural GDP growth in the UK

	GDP growth	Price effect	Input contribution	TFP growth
1974–1993	7.02	−0.04	−0.08	6.40
1980–1993	4.25	0.10	−0.22	4.37
1974–1978	12.49	−1.82	0.48	13.83
1979–1983	11.53	1.57	−0.11	10.07
1984–1988	0.87	−1.13	−0.48	2.49
1989–1993	3.18	1.23	−0.18	2.13

Table 11
Price effects on agricultural GDP growth in the UK

	Aggregate price	Grain	Other crops	Livestock
1974–1993	−0.04	−0.08	−0.15	0.19
1980–1993	0.10	−0.13	−0.25	0.48
1974–1978	−1.82	−0.28	−1.01	−0.53
1979–1983	1.57	0.52	1.26	−0.21
1984–1988	−1.13	−0.78	−0.73	0.38
1989–1993	1.23	0.23	−0.13	1.12

Table 12
Input contributions to agricultural GDP growth in the UK

	Aggregate inputs	Land	Labor	Capital	Intermediates
1974–1993	−0.08	−0.03	−0.01	−0.01	−0.04
1980–1993	−0.22	−0.04	0.01	−0.08	−0.12
1974–1978	0.48	−0.00	−0.01	0.21	0.27
1979–1983	−0.11	−0.01	−0.01	−0.10	0.01
1984–1988	−0.48	−0.00	−0.03	−0.12	−0.33
1989–1993	−0.18	−0.09	0.03	−0.01	−0.11

Table 13
Components of agricultural GDP growth in the United States

	GDP growth	Price effect	Input contribution	TFP growth
1974–1991	0.93	−1.23	−0.01	2.17
1980–1991	0.63	−0.53	−0.93	2.09
1974–1977	2.80	−0.69	1.00	2.48
1978–1982	−0.39	−2.92	0.62	1.92
1983–1987	−1.68	−2.43	−1.91	2.65
1988–1991	3.52	1.72	0.29	1.51

Table 14
Price effects on agricultural GDP growth in the United States

	Price	Meat	Dairy	Grain	Other crops
1974–1991	−1.23	−0.18	−0.10	−0.62	−0.32
1980–1991	−0.53	0.09	−0.26	−0.47	0.11
1974–1977	−0.69	−0.93	0.53	−0.66	0.37
1978–1982	−2.92	0.10	−0.40	−0.81	−1.81
1983–1987	−2.43	−0.46	−0.76	−0.77	−0.44
1988–1991	1.72	0.75	0.31	−0.15	0.81

Table 15
Input contributions to agricultural GDP growth in the United States

	Input contribution	Labor	Capital	Real prop.	Materials
1973–1991	−0.01	−0.26	0.42	−0.09	−0.07
1980–1991	−0.93	−0.20	−0.03	−0.35	−0.35
1973–1977	1.00	−0.41	0.80	0.33	0.29
1978–1982	0.62	−0.24	0.84	−0.05	0.06
1983–1987	−1.91	−0.59	−0.24	−0.58	−0.50
1988–1991	0.29	0.29	0.23	−0.06	−0.17

5.1. Denmark

For Denmark, growth in agricultural GDP averaged 4.40% annually over the entire sample period. [10] With declining real prices and almost stable input levels, growth in TFP (5.09%) is the major contribu-

[10] Other data sets including STARS (World Bank, World Development Indicators) confirm that the growth in agricultural sector was relatively larger than the economy's GDP growth rate for Denmark and France.

tor to growth in agricultural GDP. The estimates of components of growth between the 1970s and 1980s are significantly different, but the underlying 'stylized facts' remain the same. The post-1980 period witnessed a relatively modest growth in agricultural GDP and TFP at 2.06% and 2.90%, respectively. Declining prices appear to have larger effects during the post-1980 period, but TFP growth has been the key to growth of agricultural GDP in Denmark. However, the period 1984–1993 (particularly 1984, 1987, 1992 and 1993) witnessed large negative growth rates of GDP, and hence the 5 year averages of TFP growth are also negative. On average, the effects of declining prices averaged −0.65% per annum. A decomposition of price effects (Table 2) shows that declining livestock product and other crop prices have had a larger impact on agricultural GDP than the prices of grains. However, during the post-1980 period the impact of declining grain and other crop prices had a larger impact than the prices of livestock products. Table 3 provides estimates of the contribution from inputs to growth, most of which are relatively small. Intermediate inputs contributed significantly to growth in agricultural GDP during the period 1974–1983. During 1980–1993, the inputs declined relatively faster at −0.22% per annum.

5.2. France

France appears to have one of the relatively fast growing agricultural sectors. The growth rates are significantly higher even for the period 1980–1993, when agricultural GDP growth averaged 3.97% annually. The price effects and input contributions are similar to Denmark, but the growth rate of TFP is the largest in France (4.45%). Five-year averages suggest a pattern of high growth rates of GDP and TFP in the 1970s, but in recent years declining prices appear to have had a larger effect. Moreover, TFP's contribution to growth in GDP appears to decline significantly in the later periods of the sample. The declining prices of grain had a larger impact on agricultural GDP growth than the prices of other crops and livestock (Table 5). Among inputs, mostly intermediates had a relatively large negative effect on agriculture's growth, while land, labor and capital appear not to have impacted growth (Table 6). TFP growth has consistently been the major contributor to growth in agricultural GDP during the entire period 1974–1993.

5.3. Germany

Growth rate of agricultural GDP in Germany is relatively low at an average annual rate of 1.76% during 1974–1993. The growth rate falls significantly to 1.12% for the post-1980 periods. The effects of declining prices and input contributions are small and similar for the entire sample period (−0.11% and −0.13%, respectively). As is the case with Denmark and France, growth in TFP is the single largest contributor to agriculture's GDP growth in Germany (2%), but it shows a downward trend and seems to be highly variable. Individual inputs and prices have relatively small effects on growth except the intermediate inputs (−0.15%) and prices of other crops (−0.05%), over the period 1974–1993.

5.4. United Kingdom

The growth rate of agricultural GDP in the United Kingdom is the largest among the countries considered here. It averaged a 7.02% growth in its GDP during the period 1974–1993. However, the growth rate is significantly lower during the post-1980s, at 4.25% per annum and exhibits a downward trend over the entire period of the sample. The effect of real prices and input contributions on growth in GDP are relatively small (−0.04% and −0.08%, respectively). The net effects from prices and input changes do not change significantly after the oil price shocks ($0.10 - 0.22 = -0.12\%$). The major contributor, rather the major source of growth in agricultural GDP has been the growth in TFP in both the entire sample period and all sub-periods. TFP growth averaged a 6.40% over the entire period, but dropped to 4.37% during 1974–1983. This growth rate of TFP is second largest following France among the countries studied. [11]

[11] Our rates of TFP growth are larger than those obtained by Thirtle et al. (1995) and Ball et al. (1996). However, as will be seen in Section 5.5, they do not change the results on comparative productivity advantage. Moreover, there are other studies (Bouchet et al., 1989; Bureau et al., 1995) that find high rates of growth of TFP in EU agriculture.

In summary:

1. agricultural growth in the major European countries is largely dependent on TFP growth;
2. TFP growth rates appear to exhibit high variability and a declining time trend;
3. for the entire period, the real price declines for agriculture were modest suggesting a large degree of insulation from world price movements; [12]
4. after the introduction of supply control measures (1988–1993), prices declined reflecting a move towards world prices.

5.5. Comparison with the United States

Tables 13–15 present the results of the growth decomposition for the United States. Growth in agricultural GDP is surprisingly low, at 0.93% annually on average over 1974–1991. This is due to the declining real prices for agricultural commodities, although growth in agricultural output averaged over 2%. The contribution from inputs to growth is relatively small, which is similar to the EU countries. TFP growth, at 2.17% per annum, is the major contributor to growth in agricultural GDP. The declining real prices of US agriculture had a larger effect on its GDP, relative to the EU. Unlike EU, the price effects appear to be lower, particularly in the later periods of the sample, suggesting that the US economy stayed relatively open to agricultural trade. Moreover, TFP growth rates have been relatively stable (Table 13).

As discussed in Section 2, the success of a country in exporting depends not on absolute but on comparative productivity advantage (Krugman, 1996). For the US, our analysis shows that the ratio of agricultural to non-agricultural productivity growth is about 10 (2.17% TFP growth in agriculture and 0.21% TFP growth in the entire economy during 1974–1991). [13] For the EU countries, agricultural TFP growth ranged from 6.4% for UK to 2% for Germany. Boskin and Lau (1992) find that their estimate of economy-wide TFP growth rates for the European countries are consistent with most other studies. Their estimate of economy-wide TFP growth rates vary between 1.7% for UK and 2.9% for France. This suggests that the ratio of agricultural to non-agricultural productivity in major EU countries is between 1 and 4. The above reiterates our earlier assertion that competitiveness is a relative concept and the US agriculture has remained competitive largely due to its comparative technological progress. [14] Therefore, the relative competitiveness of US agriculture is likely to depend, largely, on its ability to sustain higher growth in TFP.

TFP growth in US agriculture has been found to be associated strongly with public investments in agricultural specific R&D and public infrastructure (Huffman and Evenson, 1993; Alston and Pardey, 1996). [15] For a sensitivity analysis of the association of TFP growth with various sources of 'technological externalities' (public R&D, private R&D, infrastructure and learning-by-doing), see Gopinath and Roe (1995). They also find that public agricultural specific R&D is robustly associated with TFP growth. However, the contribution from R&D stock to productivity growth in the United States appears to decline, in recent years, largely due to stagnation in federal agricultural specific R&D expenditures.

6. Summary and conclusions

Agricultural growth in the US and major EU countries is decomposed into short-run effects (prices and inputs) and long-run TFP effects in the context of the broader economy. Sources of growth in agriculture's TFP are not among choices of producers and may be outside the sector, which are referred to as technological externalities and include public investments in R&D, public infrastructure, learning-by-doing and other social investments.

For the four major European countries, Denmark,

[12] This claim stems from the fact that US agricultural prices, which often reflect world market prices, have witnessed large declines.

[13] See Gopinath and Roe (1996) for the computation of TFP growth rates for the US economy.

[14] Note that a comparison using GDP growth rates will lead to slightly different results, but technology (TFP growth) is key to long-term competitiveness.

[15] We are not able to comment about sources of European TFP growth because data on R&D and infrastructure are not available.

France, Germany and the UK the major source of growth in agricultural GDP is TFP. France and the UK have relatively large rates of growth in GDP and TFP, followed by Denmark. The growth in German agricultural sector has been relatively small. Except for Germany, the other EU countries' agricultural terms of trade with the rest of the economy have declined, but the effect on growth in GDP is relatively small. These price effects suggest that the CAP policies have adequately insulated agricultural producers against adverse domestic terms of trade. Input contributions to growth in agriculture are relatively small. In the last period of the sample (1988–1993), real prices are falling rapidly and there is a downward trend in the rates of growth of TFP.

For the US, TFP is the major source of growth in agricultural GDP, but its rate of growth is lower than the European countries for the same period. The declining real prices for US agriculture had a relatively large effect on its GDP, on average. However, US agriculture shows a relatively stable growth in its TFP throughout the sample period and in the 1980s the adverse effects from declining real prices are relatively small. In the longer run, the relative competitiveness of US agriculture is likely to depend on its ability to sustain and increase growth in TFP.

References

Alston, J.M. and Pardey, P.G., 1996. Making Science Pay. The American Enterprise Institute Press, Washington, D.C.

Arnade, C., 1995. Productivity Growth in 76 Countries. Economic Research Service, US Department of Agriculture, Washington, DC.

Ball, V.E., Bureau, J.C., Butault, J.P., Witke, H.P., 1993. The stock of capital in European Community agriculture. Eur. Rev. Agric. Econ. 20, 437–450.

Ball, V.E., Bureau, J.C., Butault, J.P., 1996. Agricultural Productivity in Developed Countries: A Comparison of the United States and European Community. Proceedings of the Conference on Global Agricultural Science Policy for the Twenty-First Century, Melbourne, Australia.

Boskin, M.J., Lau, L.J., 1992. Post-war economic growth in the group of five countries: A new perspective. Tech. Pap., Stanford University, Stanford.

Bouchet, F., Orden, D., Norton, G.W., 1989. Sources of growth in French agriculture. Am. J. Agric. Econ. 71 (2), 280–293.

Bureau, J-C., Fare, R., Grosskopf, S., 1995. A comparison of three nonparametric measures of productivity growth in European and United States agriculture. J. Agric. Econ. 46 (3), 309–326.

Diewert, W.E., 1974. Applications of duality theory. In: Intriligator, M.D., Kendrick, D.A. (eds.), Frontiers of Quantitative Economics, vol. II. North-Holland, Amsterdam.

Diewert, W.E., 1976. Exact and superlative index numbers. Journal of Econometrics 4, 115–145.

Diewert, W.E., 1980. Aggregation problems in the measurement of capital. In: Usher, D. (ed.), The Measurement of Capital, Studies in Income and Wealth, Vol. 45. National Bureau of Economic Research, Cambridge.

Diewert, W.E., Morrison, C.J., 1986. Adjusting output and productivity indexes for changes in terms of trade. Econ. J. 96, 659–679.

European Commission, 1973–1993. The Agricultural Situation in the Community. European Commission.

Eurostat, 1973–1993. Spel electronic data base. Eurostat.

FAO, 1973–1993. Production Yearbook. FAO, Rome.

Gopinath, M., Roe, T.L., 1995. Sources of sectoral growth in an economy-wide context: The case of U.S. agriculture. Bull. 95-7, Economic Development Center, University of Minnesota, Minneapolis-St. Paul.

Gopinath, M., Roe, T.L., 1996. Sources of growth in U.S. GDP and economy wide linkages to the agricultural sector. J. Agric. Resourc. Econ. 21 (2), 152–169.

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

Kohli, U.R., 1993. GNP growth accounting in the open economy: Parametric and non-parametric estimates for Switzerland. Swed. J. Econ. Stat. 129, 601–615.

Krugman, P., 1996. Peddling Prosperity: Economic Sense and Non-Sense in the Age of Diminished Expectations. Norton, New York.

Lucas, R.E., 1993. Making a miracle. Econometrica 61 (2), 251–272.

OECD, 1973–1992. Agricultural Statistics. Economic Accounts for Agriculture. OECD.

Romer, P.M., 1990. Endogenous technological change. J. Pol. Econ. 98 (5), s71–s102.

Thirtle, C., Ball, V.E., Bureau, J-C., Townsend, R., 1995. Accounting for productivity differences in European agriculture: Cointegration, multilateral TFPs and R&D spillovers. In: Peters, G.H. (ed.), Agricultural Competitiveness: Market Forces and Policy Choices, Proceedings of the 22nd International Conference of Agricultural Economists. Dartmouth Press, Oxford.

Woodland, A.D., 1982. International Trade and Resource Allocation. North-Holland, Amsterdam.