# REFINING RETURNS TO R SOUTH AFRICAN COMMERC

Y. Khatri
*London School of Economics*

D. Schimmelpfennig,
*United States Department of Agriculture*

C. Thirtle
*University of Reading*

J. van Zyl
*University of Pretoria*

Use of a long-run profit function provides accurate estin that is tied to the long term basic and applied nature of t fundamentally different with a more adaptive characte changes in TFP. In this situation, the long-run profit fur overestimation of returns to R&D. A potential solution returns to R&D. Several other inputs are held fixed a favourably with long-run return levels that have been est

## 1. INTRODUCTION

In this paper, the profit function approach to estima agricultural productivity and returns to agricultural R& South Africa is refined by comparing the returns fro short-run profit function to the returns from a long-run p function.

Productivity statistics compare agricultural inputs to out in order to measure the performance of the sector. The of aggregate output to an aggregate of all inputs comb gives a measure of total factor productivity (T "Explaining" TFP growth, using non-conventional in such as R&D and extension expenditures, has been the t of a large number of studies (listed in Echeverria, 19 Changes in the TFP index are usually explained determining or conditioning variables, such as the stoc knowledge (accumulated research capital, generated by research expenditures), extension services and fa education, as well as changes in weather.[1] The b argument is that R&D generates technology, exten diffuses it and better-educated farmers are better screening new technology. Consequently, they a technologies more quickly and also adapt technol thereby adding an element of on-farm techno generation. For South Africa, spillovers thro international technology transfers may also be important the influence of the weather is considerable, so a wea index should reduce the unexplained errors.

There are essentially two approaches to explaining cha in agricultural productivity, which forms the basis calculating the returns to R&D. Evenson, et al. (1987) these the *integrated approach* (where the producti enhancing, or conditioning, factors are included directly primal or dual representation of production) and the *stage decomposition*, in which changes in total fa productivity (TFP) are first calculated, and then explai in a second stage, by the factors, such as R&D extension, that are thought to account for growth. The *integrated approach* has the advantage of minimi restrictive separability assumptions, as well as avoiding need for the assumptions of full static equilibrium, H lag length k. Using fewer lags than the 'true' specificatio implies biased estimates and too many lags implie inefficient estimates. To estimate the lag length tw approaches can be employed. The usual approach is that c searching over a range of k using appropriate mode selection criteria. Geweke and Meese (1981) investigat various model selection criteria for this purpose, includin the Akaike information criterion (AIC), the final predictio error (FPE), the Bayesian estimation criterion (BEC) an the Schwarz Criterion (SC). The tests are not always i agreement, but for the R&D lag all suggested nine or te lags.

Then, the shape of the lag distribution must be determinec The conventional approach is to fit a function such as a inverted "U"-shaped second degree polynomial, but thi formulation fitted the South African data poorly. Amongs the large number of alternative lag structures fittec generalisations of the Beta and Gamma distribution (Tsurumi, 1971 and Schmidt, 1974) gave the best result according to the same model selection criteria (Adjuste $R^2$>0.77 in both cases). The best fit is negative skew wit peak effects at one to four lags. Figures 1 and 2 provide th details.

This result can be contrasted with similar tests for the UI system, where the lag was sixteen years and the distributio was positively skewed, with the peak effects at twelve t sixteen lags (Khatri, 1994). This suggests that whereas th UK system includes a high proportion of basic scientifi research with a long gestation period, the South Africa research system is dominated by short-term developmenta work.[3]

In the profit function, which is described in the next sectior the lag distribution is represented by a knowledge stoc constructed using the perpetual inventory model (PIM which is a reasonable approximation of the "true" la structure. Thus, the knowledge stock (KS), with R&I entering with a one period lag, at period t is

$$KS_t = RD_{t-1} + (1-\delta)\, K_{t-1} \qquad (1)$$

where d is the rate of depreciation, which is set at 10%, s that 90% of the weight is on the first nine years. In thi application the starting value of KS, at t=0, is irrelevant b 1947, because the series begins in 1929.

International technology transfers is approximated by patent count (see section on data).

Applying the same methodology to the patent count serie gave a lag of twelve to thirteen years and again a negativel skewed distribution. So, the patent knowledge stock i approximated in the profit function by a PIM with depreciation rate of 8.3%, which is appropriate for a twelv year lag. The patent variable is the means of allowing fo both private spillovers from abroad and for the technolog provided by multinational seed, chemical and machiner companies, which may or may not be performing the research in South Africa.

For the non-international private sector, very little is know about R&D. This is a handicap, but need not preven economic analysis of the returns to R&D, since private R&I is not outside the market system, like the publi expenditures. Indeed, as was noted by Griliches (1973), agricultural inputs were supplied by a monopolist, and th input statistics took proper account of quality adjustment

The functional form employed is the generalised quad
(GQ). The GQ profit function is defined as:

$$\Pi = \alpha_0 + \alpha'\hat{P} + \delta'\Theta + \frac{1}{2}\hat{P}'\beta\hat{P} + \frac{1}{2}\Theta'\phi\Theta + \hat{P}'\gamma\Theta \qquad ($$

where P hat is the stacked vector of normalised outpu
non-numeraire input prices, (P,R)' and Q is the sta
vector of k quasi-fixed and l fixed and conditioning fa
The vector $\alpha$ ($\alpha_1$,..,$\alpha_{m+n-1}$) and matrices $\beta$ ($\beta_{ij}$, i,j=1,..,
1), f ($f_{gh}$, g,h=1,..,K+L) and g ($g_{ig}$,i=1,..,m+n-1, g=1,.
contain the parameter coefficients to be estimated.
vector of parameters d is of particular interest as thes
the shadow prices of the fixed factors and techn
variables. Applying Hotelling's lemma, we derive
(short-run) optimal levels of output supply and
demand:

$$y^*_i = \alpha_i + \sum_{j=1}^{m} \beta_{ij} p_j + \sum_{j=m+1}^{m+n-1} \beta_{ij} w_j + \sum_{g=1}^{k+l} \gamma_{ig}\Theta_g, \quad i = 1,..,m \qquad ($$

$$-x^*_i = \alpha_i + \sum_{j=1}^{m} \beta_{ij} p_j + \sum_{j=m+1}^{m+n-1} \beta_{ij} w_j + \sum_{g=1}^{k+l} \gamma_{ig}\Theta_g, \quad i = m+1,..,m+n-1 \qquad ($$

The long-run profit function, in contrast, consists of
variable factors of production. Since factors suc
machinery, land, and livestock inventory are assumed
at long-run equilibrium levels, no quasi-fixed factor
represented in the profit function. The vector Q
contains conditioning factors such as weather
technology, that are always exogenously supplied. Pri
the inputs that were quasi-fixed factors in the short ru
included in the vector w. Variable input demands for
factors are obtainable using Hotelling's Lemma, an
estimated jointly with other input demands and other s
equations.

The price elasticities are derived as logarithmic deriva
of the supply and derived demand equations with resp
prices (Lass, 1985; Khatri, et al., 1994a). Shadow valu
given by the partial derivatives of the profit fun
(Diewert, 1974) with respect to the Q variables. The de
shadow values can be interpreted equivalently -as
marginal change in profits for an increment in a part
element of Q or as the imputed rental value for an addi
unit of that factor. Of particular interest are the sh
values of capital, land and research. The difference bet
the rental value and shadow value indicates whethe
factor is over, under or optimally utilised. The sh
value of research can be used to derive the rate of retu
research investment (Huffman, 1987).

## 4. DATA

The national farm-level production data for the period
92 were obtained from several sources, largely RSA (1
and are described in some detail in Thirtle, et al. (1993
both the short and long-term profit function specifica
the three output aggregates are: Crops, Horticulture
Livestock and Livestock Products.

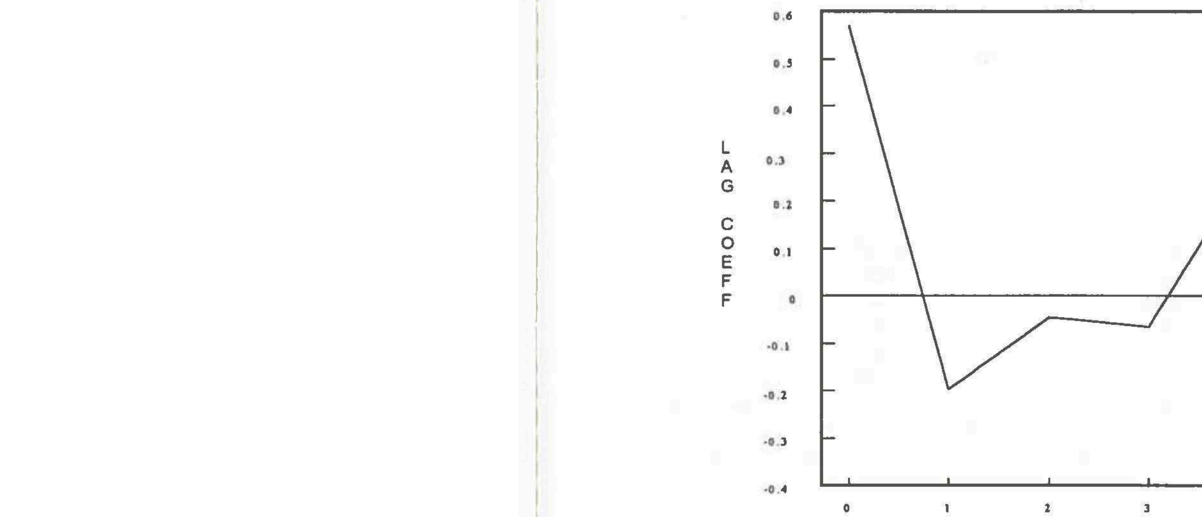


**Figure 1: Unrestricted lagged round (9 years)**

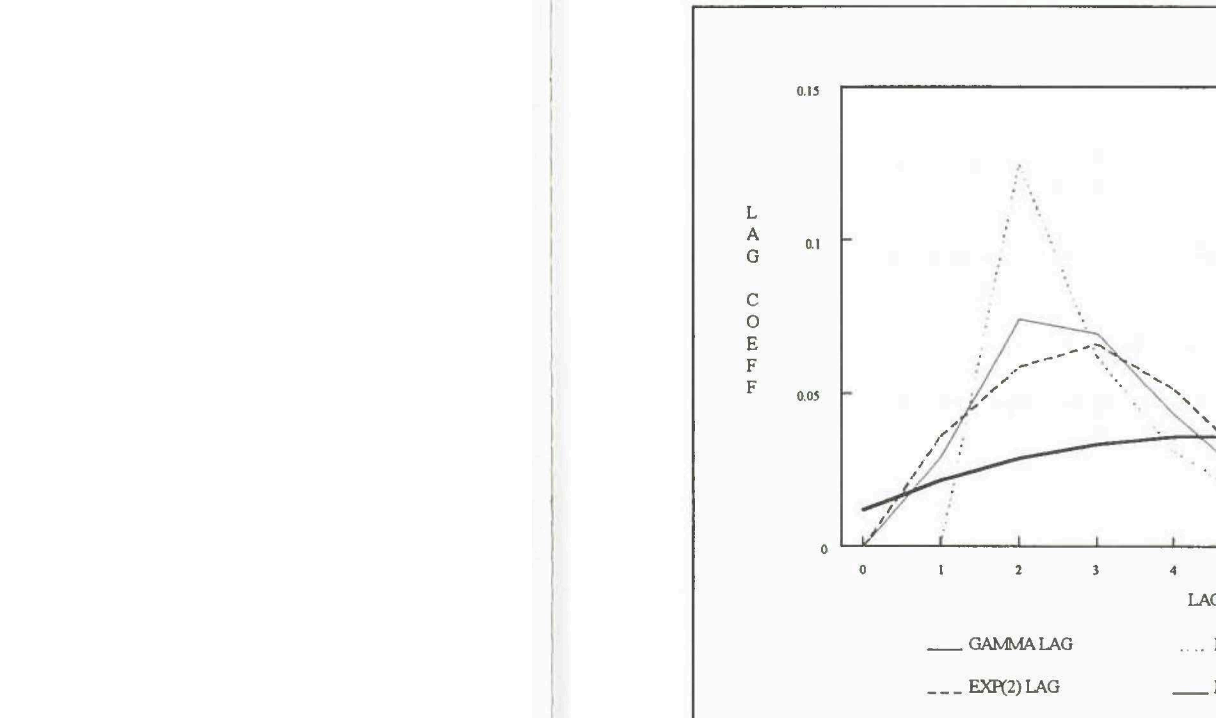


**Figure 2: Lagged effects of research on producti**

respect to their statistical performance and theoretica consistency.

The results obtained with the short-run and long-run prof functions (that can be estimated in one stage) specificall the elasticity estimates, are in accordance with expectation The elasticities of the outputs and variable inputs in th estimation obtained with the long-run approach and th short-run estimations are remarkably similar. As expecte the long-run elasticities for land, capital and livestock a

***Shadow Prices***

The change in the profit function with respect to technology variables represents their shadow values, tha shadow values of technology factors are given by the pa derivatives of the profit function (Diewert, 1974) respect to the technology variables. The derived sha values can be interpreted equivalently as the marg change in profits for an increment in a particular elemer technology. This shadow value for R&D can be use derive the rate of return to research investment (see Kh et al., 1996). Note, however, that the shadow values o short and long-run conditioning variables are not dir comparable due to differences in the units of measuren for the capital items. These shadow values are reporte Table 1 for both the short and long-run specifications, a variable means.

The extension and education variables have nega shadow values, indicating that these variables, on margin, are of no use to producers. In contrast, internati research spillovers (PATENTS) and public R expenditure (RES) have relatively high positive sha values, indicating that expansion of these factors is like benefit South African agriculture.

The shadow price for public research was negative at beginning of the period, after which the value has risen increasing rate, suggesting that the public research syste now making a considerable contribution to profitability Van Zyl, et al., 1993). The shadow price of the internati knowledge stock (representing spillovers) indic spillovers significantly affect productivity and profitab The shadow price of extension is surprisingly s (although highly significant) in the short-run formula implying a near zero return on public extension expendi While in the long-run formulation, the shadow pric extension is substantially negative. The shadow pric extension has been falling over the period, which sug that South African commercial farmers have become dependent on public extension advice. This corresp with the findings of Koch, et al. (1991), who show government extension officers spend increasingly more on administrative duties and do very little actual exten work.

As with extension, the education index appears to considerable explanatory power in the model, judging b significance levels of the education related coefficients. results in a highly significant, but unexpectedly nega shadow price for education. The education index is a p for the farmer's managerial ability and thus we w certainly expect a positive shadow price for education. T is a strong indication from the fixed factor elasticities[10] education augments output but also augments input (more than proportionately in the case of non-labour inp As the education level of South African commercial far is relatively high, it is entirely possible that the minir

**Table 1: Estimated Shadow Values of the Condition**

| Factor | Sho |
|---|---|
| Public Research | |
| International Patents | |
| Public Extension | |
| Farmer Education | |

**Note:** All the shadow prices are significant at the 0.0

takes 11 years to adjust, indicating an 11 year lag between R&D and TFP growth. The longer lag lowers the long-run MIRR to 58%. The correct rate of return is some unknown weighted average of the lags between R&D items that provide quick impacts, like improvements in seed varieties, and those that take longer to have an impact. The long-run rate is bounded by 113 and 58%, a range that exceeds the short run return.

These are certainly respectable rates of return on public expenditure. There are, however, the usual arguments that this figure may be somewhat diminished if we adjust for the dead-weight losses associated with tax collection (the means of financing public expenditure) and the possibility that public funding may be crowding out private sector research. The major point of interest, however, is the large difference between these rates when measured over the short and the long term.

## 6. CONCLUSION

Use of a long-run profit function has been shown to provide accurate estimates of returns to agricultural R&D in Europe and North America, a result that is tied to the long term basic and applied nature of the research institutions in these areas. Basic research into plant physiology and development takes place before plant breeders use the information to create new varieties with desirable characteristics. An additional lag occurs before outputs increase as the new seed varieties are diffused among farmers (see Khatri, 1994).

Agricultural R&D in South Africa is fundamentally different with a more adaptive character, and a shorter lag of five years for variable factors (see Thirtle and Van Zyl, 1994; 1996). The lag from basic to applied research is short cut in South Africa by making slight adjustments to seed varieties developed for similar environmental conditions in the northern hemisphere. Even when the fact is taken into account that some capital stock items take longer than five years to be impacted by R&D (by assuming that all of the capital stock adjusts more slowly) the result is a range of long-run returns that is greater than the short-run return. In this situation, the long-run profit function input demand and output supply elasticities are too high resulting in overestimation of returns to R&D.

A possible solution to this problem is to employ a short-run profit function in the calculation of returns to R&D. Several other inputs are held fixed and the result is a short-run return to R&D in South Africa that compares favourably with long-run return levels that have been established for the northern hemisphere.

## NOTES:

1. There is a huge volume of literature on the returns to agricultural research. See, for example, Echeverria (1990) and Thirtle and Bottomley (1992).

2. Thirtle and Van Zyl (1994) used the two-stage decomposition approach to determine the returns to R&D and extension in South Africa and it is used here to predetermine the length and shape of the lags for the technology variables. These are then imposed in estimating the profit function, the results of which show that technical change is not Hicks neutral. This violates the assumptions implicit to the two-stage approach, which may give biased results.

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