POLICY INDUCED INN AGRICULTURE

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This paper examines whether the development path of Within an induced innovation framework the two stag results in a direct test of the inducement hypothesis v period 1947-91. Cointegration is established, and an price ratios are not the sole cause of factor-saving bia played a significant role resulting in a distorted develop

1. INTRODUCTION

The notion that at least some inventions may be induc economic forces has been entertained by historians economists at least since the 1920s (Mantoux, 1928, H 1932). There are by now several formulations o relationship and well over one hundred empirical (Thirtle and Ruttan, 1987), the great majority of v corroborate some form of the inducement hypothesis many cases, the hypothesis is not clearly stated and the amount to no more than establishing a correlation betw measure of factor scarcity and an indicator of the dire or factor-saving biases, of technical change. It is reaso to infer that the inducement hypothesis implies that should be a long run relationship between the directi technical change and a measure of factor scarcities, su relative prices. This paper examines the long relationships using cointegration techniques and forma the relationship by fitting an error correction model v separates the short run effects from the long run equilib path. A set of variables are included which, beyond are also important determinants of the bias in innova particularly the contrasted interest of large versus farmers and the role of public goods.

2. MODELLING INDUCED INNOVATIO

Hicks (1932) introduced the elasticity of substitution an idea of "induced inventions", which endogenised the fa saving bias of technical change at the level of the However, the two concepts were not clearly separate Hicks noted in his Nobel lecture of 1973 (Hicks, 197 This oversight led to critiques of induced innovation su Blaug (1963) and Salter (1960), which were later show depend largely on the definition of the isoquant (Haya Ruttan, 1985:.86). The induced innovation hypothesis rehabilitated when Ahmad (1966) introduced the innov possibility curve (IPC), which is the envelope curve the isoquants (representing different technologies) that be developed, given the state of scientific knowledge.

The IPC (together with its counterpart, the metaprodu function) form the basis of Hayami and Ruttan's (application of the hypothesis to aggregate agricultural o in a long-run historical development context. They a that rapid growth in agricultural productivity is generate technical change that facilitates the substitution of relat abundant (hence cheap) factors for relatively scarce (expensive) factors in the economy (p.73). Their mod developed by exploiting the identity

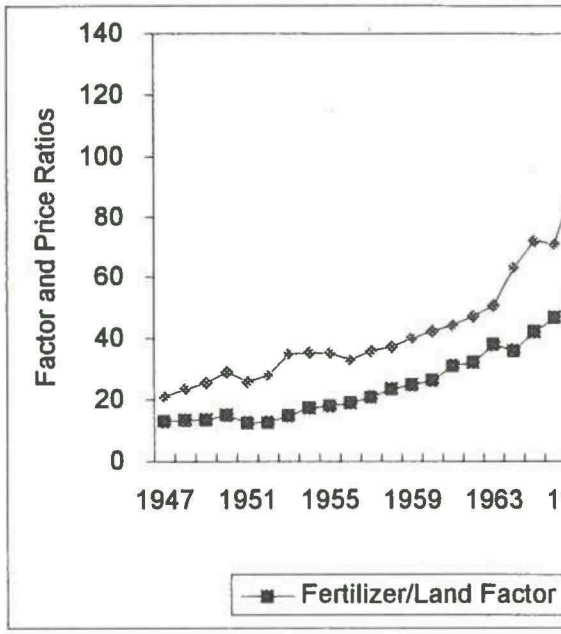

Figure 1: **Correlation of the Machinery/Labo**

first few years after the end of the war, the arable area was being extended, which led to increased use of labour (especially since harvesting was not mechanised) as well as machinery. Also, supplies of agricultural machinery and equipment were limited and animal power was still important. Then, for three decades the price of machinery falls relative to the price of labour and the machinery labour ratio rises, as the induced innovation hypothesis predicts. Then, after 1981 the favourable credit and tax policies had largely gone, the gold price had plummeted and the rand had been drastically devalued (Thirtle et al 1993). These events had a combined effect of making a domestic input like labour far cheaper relative to capital and led to a

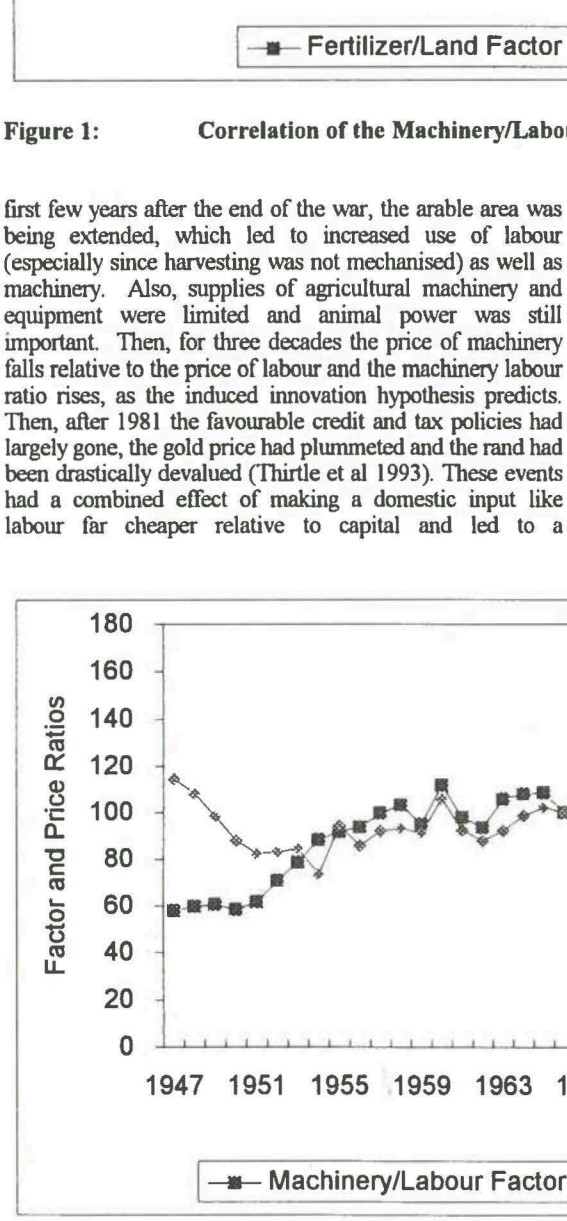

Figure 2: **Correlation of the Fertilizer/Land**

land during the period 1947 to 1959, when the cult
area was being expanded. The fertilizer/land factor
shows two distinct trends, growing rapidly at 7.38%
annum from 1947-79 and then falling at a rate of -3.98%
year. The decrease in fertilizer use in 1975 can be attri
to the rise in the relative price of fertilizer that resulted
the OPEC oil crisis. Then, the fertilizer/land ratio rose
as land rents increased rapidly in the late
Groenewald (1986) and van Schalkwyk and Groen
(1992) suggest that many farmers in South A
particularly grain farmers, over-fertilized, so the redu
contributed to the increase in productivity growth rep
by Thirtle et al. (1993).

3. A DIRECT TEST OF THE INDU INNOVATION HYPOTHESIS

The model of de Janvry et al (1989), which exploi
tractability of the two-stage constant elasticity of substi
production function, incorporating transaction costs
collective action as determinants of the factor saving
of technological change, is used in this analysis. A
transaction costs of labour (supervising, negoti
information costs) increase with farm size there will
increasing bias in research towards labour saving techn
if large farmers' demands prevail. Conversely,
transaction costs for land decrease with farm size be
the fixed cost in land implies that the price of land de
with farm size. This effect decreases the bias towards
saving technology if small farmer demands prevail. Fr
(1991) uses this framework to test induced innovation
US. Cointegration was used to establish long
relationships and an error correction model was estim
This separates the short run effects (factor substitution)
the long run equilibrium path.

4. RESULTS

Table 1 shows the error correction model results which
derived using the general to specific approach of Hend
Richard (1982). The data series for R&D, extensio

Table 1: Unrestricted ECM Results: Significant

Variable
SHORT RUN
CONSTANT
D(Price of machinery/Price of labour)$_t$
D(Price of fertilizer/Price of land)$_t$
D(Price of land/Price of labour)$_t$
Taxation policy variable
Real interest rate variable
Rainfall
LONG RUN
(Machinery/Labour)$_{t-1}$
(Fertilizer/Land)$_{t-1}$
(Price of machinery/Price of labour)$_{t-1}$
(Price of fertilizer/Price of land)$_{t-1}$
(Price of land/Price of labour)$_{t-1}$
R&D expenditure $_{t-1}$
Chemical patents$_{t-1}$
Extension expenditure$_{t-1}$
Farm size$_{t-1}$
R^2
DW

The critical t values are 1.3 for 90 percent confiden

70 percent correction towards the long run equilibrium level in the current period. The positive sign on the land/labour price coefficient is in agreement with Frisvold's (1991) prediction. Public R&D expenditure is positive and significant with a long-run elasticity of 0.13, (0.09/0.70). The long run elasticity of 0.33, (0.23/0.70), for farm size agrees with de Janvry et al.'s (1989) argument that larger farms will have a greater machinery-using bias, due to the costs of labour management.

The fertilizer/land model, did not perform as well in terms of explaining the deviations in the dependent variable with an adjusted R^2 of 0.51. The short run coefficient on the fertilizer to land price ratio, of -0.39, is the direct partial elasticity of substitution suggests that the short run substitution possibilities between land and fertilizer are very limited. The land/labour price ratio coefficient is positive and significant in the short run The reliance of fertilizer application on the weather is reflected by the rainfall variable.

The error correction term for the fertilizer to land equation is -0.40. This indicates slow adjustment towards the long run equilibrium level in the current period. The negative sign shows that the direction of correction is towards equilibrium. The long-run own price elasticity of -0.90, (-0.36/0.40) indicates that a decrease in the fertilizer/land price ratio generates land-saving technological change, in the manner predicted by the induced innovation hypothesis. The negative sign on the land/labour price coefficient is in agreement with Frisvold's (1991) prediction. The patent variable, representing international technological spillovers is positive and significant and so is the effect of extension efforts having long run elasticities of 0.15, (0.06/0.40), and 0.50, (0.20/0.40), respectively. The public R&D expenditures fail to show any effect due to collinearity with these two variables, but this weakness does suggest that the South African research system has tended to adapt foreign technology rather than developing its own basic genetic material.

5. CONCLUSION

This paper tests Hayami and Ruttan's (1985) induced innovation hypothesis for South African agriculture. The two stage CES production function leads to estimating equations that directly test the inducement hypothesis, by making factor ratios functions of factor price ratios. The model also incorporates the variables that generate the new technologies (public R&D and extension and private patents) and variables that affect the factor saving biases, such as farm size, negative real interest rates and tax concessions.

Cointegration is established and an error correct model constructed, which separates short run effects, such as factor substitution, from the long run equilibrium, which incorporates induced technological change. All of these tests corroborate the inducement hypothesis and the empirical results indicate that average farm size, research and extension expenditures, favourable tax and interest rate policies are also important determinants of the observed rates and biases of technological change. This suggests there is more than prices to the bias of technical change, public choice variables, public good delivery and macroeconomic policies also matter. Hence the results support the need to look not only at price (the Hayami and Ruttan formulation) but also at the structural, political and macro context to understand the bias of technical change.

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