A REGIONAL ANALYSIS OF AGRICULTURAL PRICE RISK IN SOUTH AFRICA

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Regional output/input price differentials and variations were calculated to evaluate price risk in South Africa. It was found that price unstable regions are not necessarily also risky regions as regions with higher output/input price ratios can handle higher price variations better. The average value of the price index for the top ten regions is over 3 times larger than the average for the ten lowest regions. The higher the prices of inputs relative to output prices (the lower the price ratio), the smaller their application to each hectare of land, and the lower the land productivity. The regional prices appears to be a function of the interaction between differential natural and economic factors in different regions.

'n Streeksanalise van landbou prysrisiko in Suid-Afrika

Regionale uitset/inset prysverskille en variasies is bereken om prys risiko in Suid-Afrika te evalueer. Daar is gevind dat prys onstabiele streke nie noodwendig ook hoë risiko streke is nie, want streke met hoër uitset/inset prys verhoudings kan hoër prys variasies beter verwerk. Die gemiddelde waarde van die prys indeks vir die tien top streke is meer as 3 keer groter as die gemiddeld vir die tien laagste streke. Hoe hoër die pryse van insette relatief tot uiset pryse (hoe laer die prys verhouding), hoe minder is hulle aanwending per hektaar, en hoe laer die grond produktiwiteit. Regionale pryse blyk 'n funksie te wees van die verskille in natuurlike en ekonomiese faktore in verskillende streke.

1. Introduction

In agriculture, decision making is usually based upon imperfect knowledge with respect to the specific outcome of a decision. Natural resource quality varies considerably in South Africa. It is influenced by a number of factors, e.g., the quantity and stability of rainfall and soil qualities that influence arability. The quality is not invariable over time and intertemporal differences are evident (Van Schalkwyk & Groenewald, 1993; Schultz, 1974). Regions with more variable rainfall are subject to larger risk than those with more stable precipitation. Different regions are involved in the production of different commodities; differences in relative prices therefore exist among different regions. Different commodities are moreover subject to differential variability in market prices; wool prices, for example show more than double the annual variation of maize and wheat prices (Nieuwoudt, 1972). Different products involve different input mixes, and differences in price stability of different inputs have been documented (Nieuwoudt, 1972). In addition, different regions are not equidistant from markets and are not equally well served by transport and marketing infrastructure. The distance from abattoirs influences supply response of beef cattle (Sartorius von Bach, 1990). The differences in attainability of favourable prices and in the stability thereof give rise to differences in price risks. Farming in regions with low and more variable output/input prices is subject to higher financial risk, as is farming in regions with above average indebtedness. An effort will be made in this paper to quantify risk differentials among regions.

2. Sources of risk and uncertainty

Knight (1921) distinguishes between two types of imperfect knowledge: Risk and uncertainty. When certainty prevails, the expected result is known without variance. Uncertainty again, is a situation in which the mean outcome may or may not be known with an unknown variance of individual outcomes. In the case of risk the mean result is known while individual outcomes vary according to a subjectively or objectively determined probability distribution (Knight, 1921; Heady, 1957).

When confronted with a lack of information managers rely on their subjective evaluations to determine the selection of an action appropriate to the uncertain situation. Subjective probabilities will therefore be determined by the manager. Viewed in this manner, Knight's dichotomy becomes unimportant and writers in modern decision theory often use either of the terms risk and uncertainty to refer to situations where complete information is lacking (Eidmann, 1990; Doll & Orazem, 1984).

Product prices cannot be forecasted with certainty, even with products subject to one channel fixed price schemes. Expectations concerning production values are thus formulated under risk and uncertainty. These fluctuations differ considerably among products; historically, potato prices have fluctuated more than wheat prices.

Input prices also vary, albeit less than product prices. These fluctuations are more important in the long run than in the short run (Van Zyl, 1989).

Other sources of risk and uncertainty include yields, technological change, institutional change, personal factors and random events. This paper is concerned with interregional price risk differences.

3. Regional output/input price ratios

No data are directly available on regional price differences in South Africa. The use of elementary principles of production economics however renders it possible to derive implied differences, assuming farmers to be profit maximizers (Peterson, 1988). If it is assumed that over the long run the use of inputs will tend toward profit maximizing quantities, then implied price ratios for different regions can be constructed from the formula for profit maximization:

$$Py/Px_i = 1/MPPx_i$$

Where Py and Px are aggregated agricultural output and input prices of different regions, and $MPPx_i$; is the marginal physical product of input x_i. In order to take account of shifts in the MPP curve of an input due to differences in the levels of complementary inputs employed, the predicted value of an input's MPP for a region is obtained holding the level of other inputs constant at the sample mean. For input X_1 it is:

$$MPP_{1j} = Ab_1 X_{1j}^{b_1 - 1}\ \overline{X_2^{b_2}} \ldots \overline{X_n^{b_n}}$$

where MPP_{1j} is the marginal physical product of input X_1 in region j, X_{1j} is the observed level of X_1 in region j, and $X_2,\ldots,X_n$ are mean levels of X_2 through X_n.

The same procedure can be followed with all other inputs. It becomes necessary to standardise the price ratios of the conventional inputs and to keep this constant when MPP is used for this purpose. This procedure involves less bias than observed short-term price ratios (Peterson, 1988). The weighted output/input price ratio for each of the conventional inputs in each region was therefore compiled using the following formula:

$$P_j = \sum_{i=1}^{n} W_i P_{ij}$$

Where W_i is the factor share of input i from the production function standardized to sum to 1, and P_{ij} is the index of the output/input price ratio of input i in region j. The use of the implicit price ratio does not impose an unusual assumption since profit maximization (Py = MC) is an underlying assumption of all supply functions. The profit maximizing condition Py/Px = 1/MPP is equivalent to Py = MC[1]. This ratio should reflect the net prices paid and received after transport costs are taken into account by farmers. Because this method measures the expected behaviour of farmers, the price ratio reflects expected prices.

Van Schalkwyk and Groenewald (1992) estimated aggregate production functions based on cross-sectional observations. Data from Agricultural censuses of 1976, 1981 and 1988 as reported by the Central Statistical Service were used with statistical regions as units of observation. Good fits were obtained with F-values above 946 and R^2 above 0,96. The following equation from that study was used to derive price ratios:

APE = 1,2171 + 0,8583.RLU/LQ + 0,0464.FER/RLU + 0,2354.TR/RLU + 0,1653.AU + 1,01148.LQ - 0,1938.D1 + 0,2265.D2

Where,

APE	=	Agricultural production equivalents
RLU/LQ	=	Regular labour units per land quality unit
FER/RLU	=	Fertilizer per regular labour unit
TR/RLU	=	Traction per regular labour unit
AU	=	Animal units
LQ	=	Land quality as calculated by Van Schalkwyk and Groenewald (1993)
D1 and D2	=	Dummy variables to incorporate change over time.

The price ratio (P_y/P_x = 1/MPP) was calculated from the quantities of inputs used in a region. The input quantity depends on relative prices in the particular region. Higher input prices relative to product prices are associated with smaller input quantities. Since the calculated price ratios were based on cross sectional observations, intertemporal price variation can be expected to be smaller than variations that would result from time series analysis, and instability may be underrated. The calculated average output/input price ratios appear in Table 1 and is visually presented in Figure 1.

The derived price ratios do however need adjustment in order to measure stability. This was done by dividing the output/input price ratio of each region by the average price ratio of the particular year. The average output/input price ratio index for any year thus became 100, rendering regional price ratios comparable over time.

Table 1 shows Region 66 to have the largest and 14 to have the lowest output/input price ratios. Region 41 has the smallest price variation and Region 27 the largest. It is therefore concluded that Region 41 is the most stable region of all. The price risk of a region is however influenced by both the variations in prices and the size of the output/input price ratio. The ratio between the price variation and the output/input price ratio in Region 41 is the lowest (0,008) indicating Region 41 to be the less risky region of all the regions. It does not however, necessarily indicate Region 41 to have the lowest risk as regions with higher output/input price ratios can handle higher price variations better. This point is emphazised by looking at region 13 and 2. Although the price variation in Region 13 is lower than that in Region 2 (6,55 versus 7,49), price risk is much higher in Region 13 because its average price ratio is only one-half of that in Region 2 (60,84 versus 123,51).

The average value of the price index for the top ten regions in the sample is over 3 times larger than the average for the ten lowest regions. Land productivity declines as the price ratio declines. This is to be expected. The higher the prices of inputs relative to output prices (the lower the price ratio), the smaller their application to each hectare of land, and the lower the land productivity.

4. Size of output/input price ratios

The distribution of land resource quality, as calculated by Van Schalkwyk & Groenewald (1993), also appears in Table 1. The next step was to calculate correlations between the mean price ratio, the variation in output/input prices and land resource quality. These correlations appear in Table 2. It appears that most regions identified as having higher resource quality also exhibit more favourable price ratios (r = 0,429). This phenomenon corresponds with theoretical expectations. Better resource quality leads to higher yields per hectare and larger quantities are produced with the same input. Regions with better resources are on higher production frontiers and should therefore apply larger input quantities. Such regions can normally produce a wider variety of products. This adaptability enables farmers in the region to follow market trends and mainly produce those products that have favourable output price ratios. Although they may have lower stability in prices because of the wider product portfolio from which they can choose their levels of **price risks** should accordingly be relatively low over the long run.

Table 1: Average regional output/input price ratios, variations and resource quality

Statistical regions and Magisterial districts	Output/Input		Resource quality Index
	Price ratio	Price variation	
CAPE			
01 Cape Town	113,79	34,17	224
Wynberg			
Simons Town			
Goodwood			
Bellville			
02 Stellenbosch	123,51	7,49	239
Kuils River			
Somerset-West			
Strand			
Paarl			
Wellington			
03 Caledon	85,5	27,32	151
Hermanus			
Bredasdorp			
Swellendam			
Heidelberg			
04 Knysna	111,97	10,71	162
George			
Mossel Bay			
Riversdale			
05 Uniondale	72,88	23,69	74
06 Oudtshoorn	103,89	15,13	93
Calitzdorp			
Ladismith			
07 Worcester	98,54	19,82	114
Ceres			
Tulbagh			
Robertson			
Montagu			
08 Malmesbury	100,68	10,64	171
Hopefield			
Piketberg			
Vredenburg			
Moorreesburg			
09 Clanwilliam	88,38	7,62	75
Vredendal			
Vanrhynsdorp			
10 Namakwaland	45,99	12,94	53
12 Beaufort West	64,63	4,89	56
Fraserburg			
Laingsburg			
Prince Albert			
Victoria West			
Murraysburg			
13 Calvinia	60,84	6,55	64
Sutherland			
14 Williston	45,85	8,12	65
15 Prieska	56,38	15,12	72
Carnarvon			
16 Hopetown	80,00	4,17	69
Britstown			
De Aar			
Philipstown			
Richmond			
Hanover			
Colesberg			
Noupoort			
17 Gordonia	71,94	4,32	50
Kenhardt			
18 Hay	60,49	14,43	103
19 Herbert	95,04	6,41	90
Barkly-West			
Warrenton			
Hartswater			
20 Kimberley	84,79	10,33	73
22 Kuruman	65,72	8,44	56
Postmasburg			
23 Vryburg	109,24	17,95	69
35 Lady Grey	106,96	11,93	75
Aliwal North			
Albert			
Venterstad			
Steynsburg			
36 Barkly-East	115,79	9,91	81
Wodehouse			
Indwe			
Elliot			
Maclear			
37 Komga	106,83	5,76	78
Stutterheim			
Cathcart			
Queenstown			
Tarka			
Sterkstroom			
Molteno			
38 East London	128,36	11,04	86
King William's Town			
39 Albany	113,40	7,77	67
Alexandria			
Bathurst			
Fort Beaufort			
Adelaide			
Bedford			

Table 1: Continued

Statistical region and Magisterial districts	Output/Input		Resource quality Index	Statistical region and Magisterial districts	Output/Input		Resource Quality Index
	Price ratio	Price variation			Price ratio	Price variation	
40 Hofmeyr	78,95	4,84	78	60 Kliprivier Weenen Estcourt Bergville	121,87	9,61	100
41 Middelburg Cradock	83,76	0,73	90				
42 Somerset East	91,91	8,44	72	61 Newcastle Utrecht Dannhauser Dundee Glencoe	125,72	16,66	94
43 Kirkwood	115,21	14,57	149				
44 Aberdeen Graaff-Reinet Pearston	78,17	3,21	83	62 Paulpietersburg Ngotshe Vryheid Babanango	120,54	15,63	99
45 Jansenville Steytlerville Willowmore	68,04	6,39	61				
46 Joubertina Humansdorp Hankey	118,88	17,17	98	63 Hlabisa Lower Umfolozi Mtonjaneni Eshowe Mtunzini	78,00	7,49	175
47 Port Elizabeth Uitenhage	94,08	5,98	69	**TRANSVAAL**			
NATAL				24 Potchefstroom Ventersdorp Coligny Lichtenburg Delareyville Wolmaransstad Schweizer-Reneke Bloemhof Christiana	125,43	9,86	128
48 Durban Pinetown Inanda Chatsworth	96,41	5,89	216				
49 Lower Tugela	68,37	0,98	202				
50 Camperdown	51,70	9,86	196				
51 Pietermaritzburg	110,19	8,91	148	25 Rustenburg Swartruggens Marico	114,10	9,67	95
52 Umzinto	77,96	12,71	134	26 Klerksdorp	119,98	5,37	112
53 Port Sheptstone Alfred	102,01	11,44	175	64 Bethal Standerton Volksrust Carolina Ermelo Amersfoort Wakkerstroom Piet Retief	112,43	3,76	125
54 Mount Currie	111,88	6,07	96				
55 Underberg Polela	120,32	13,25	110				
56 Ixopo	105,49	18,99	132				
57 Umvoti Kranskop Lions River New Hanover Richmond	108,21	4,24	131	65 Highveld Ridge Balfour	123,64	18,71	128
				66 Witbank Middelburg Groblersdal Belfast Waterval-Boven	129,36	9,08	121
58 Mooi River	125,78	12,55	112				
59 Impendle	92,00	29,73	230				

Table 1: Continued

Statistical region and Magisterial districts	Output/Input		Resource quality Index
	Price ratio	Price variation	
67 Nelspruit Barberton White River Pilgrims Rest Lydenburg	103,33	18,41	135
68 Pietersburg Messina Soutpansberg Letaba Phalaborwa	107,53	10,82	90
69 Potgietersrus Waterberg Ellisras	108,46	4,69	79
70 Thabazimbi Warmbath	117,92	16,24	85
71 Pretoria Wonderboom Soshanguve	114,03	4,32	116
72 Johannesburg Randburg	81,30	27,03	77
73 Germiston Alberton Boksburg Kempton Park Benoni	102,14	28,81	167
74 Brakpan Springs Nigel Delmas Heidelburg	109,31	16,52	144
75 Krugersdorp Roodepoort Westonaria Randfontein Oberholzer	123,13	7,45	136
76 Brits Cullinan Bronkhorstspruit	129,15	10,95	127
77 Vereeniging Vanderbijlpark	114,89	23,71	157
79 Koster	117,82	8,37	136
OFS			
21 Boshoff Jacobsdal Koffiefontein	108,61	6,80	75

Statistical region and Magisterial districts	Output/Input		Resource Quality Index
	Price ratio	Price variation	
27 Odendaalsrus Welkom Virginia	102,90	37,35	163
28 Kroonstad Ventersburg Hennenman Parys Vredefort Koppies Heilbron Viljoenskroon Bothaville Wesselsbron Hoopstad Bultfontein Theunissen	111,53	5,04	139
29 Bethlehem Harrismith Vrede Frankfort Reitz Lindley Senekal Ficksburg	120,82	3,88	120
30 Petrusburg Brandfort Winburg Marquard Clocolan Excelsior Ladybrand Wepener Dewetsdorp Reddersburg Edenburg Trompsburg Jagersfontein Philippolis Botshabelo	115,62	6,40	91
31 Bloemfontein	107,31	4,25	97
32 Fauresmith	113,19	28,85	77
33 Smithfield	107,91	15,52	78
34 Zastron Rouxville Bethulie	88,37	17,47	77
78 Sasolburg	117,82	11,51	138

It is thus productivity and costs that determine comparative advantage. Two sets of factors are vital in this respect: Natural factors and economic location. The latter largely involves the effect of transport and marketing costs on producers' prices. This has been shown to be a function of bulkiness and perishability (Hall, 1966). Changes in transport facilities can change the pattern, influence comparative advantage, cause overlapping and change regional specialization (Brinkmann, 1935; Tomek & Robinson, 1987). Intensity of agricultural production is constrained by the more limiting factor - nature or economic location. This body of theory sheds more light on the pattern evident in Figure 1. Regions associated with high output/input price ratios largely appear to be close to large urban centres or along main traffic routes in addition to having high resource quality indexes. Regions 29, 55, 58, 60 and 65 are situated along or close to the N3 main route connecting the Witwatersrand with the Durban- Pinetown Complex.

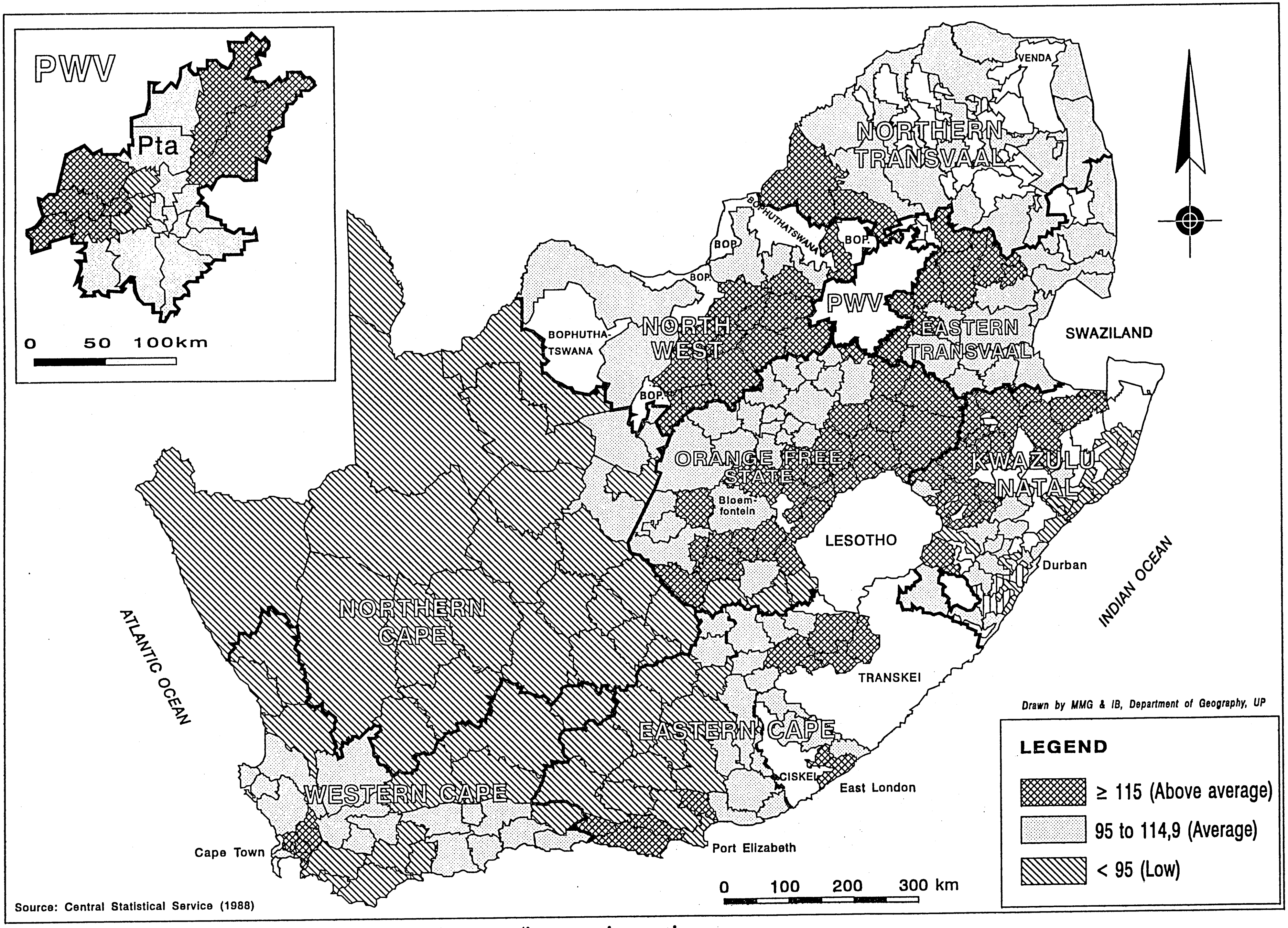

Figure 1: Presentation of average regional output/input price ratios

Table 2: Correlation matrix of regional output/input price ratios, price variations and resource quality

Variable	Output/Input price ratio	Output/Input price variation	Resource quality
Output/Input price ratio	1,00		
Output/Input price variation	0,088 (0,439)^{ns}	1,00	
Resource Quality	0,429 (0,043)*	0,363 (0,019)*	1,00

Figures in parentheses are levels of significance: Ns - Not significant; * - Significant at $p \leq 0,05$

Some other areas with output/input price ratios over 115 are situated in fairly close proximity to the PWV area (Regions 64, 66, 70, 75, 76, 78, 79), Cape Town (Region 02) and Port Elizabeth (Regions 43, 46), while two more (Regions 61, 62) are in close proximity of the Northern Natal development axis. Regions with poor natural resource quality, eg the Karoo, also experience poor price ratios, although those parts of the Karoo - eg. Regions 9, 16 and 20 - situated closer to main population centres have more favourable price ratios than other parts further away from the urban centres. Although Johannesburg and Randburg (Region 72), have an ideal economic location, they have very poor soils and have an output/input price ratio of only 81,3. Thus, differential regional price ratios appear to be a function of the interaction between differential natural and economic factors in regions.

5. Price stability

In regions where mostly products with highly variable prices such as fresh vegetables are produced, producers should also vary inputs over the short term in order to adjust to price changeability. The four conventional inputs labour, traction, livestock and fertilizers were used in the compilation of price ratios. When product prices decline, farmers should economize on those inputs with which this can readily be done: Labour, fertilizer and to a lesser degree, livestock.

The calculated output/input price ratios were used to quantify price stability which is the inverse of variation. Stability of input use was calculated by deducting the lowest output/input price ratio from the highest, and dividing the difference by two. This method was used, rather than the calculation of standard deviations because only three observations were available per region. The lower the calculated variation, the more stable are price ratios deemed to be in the particular region.

It appears from Table 1 and 2 that particularly extensive farming regions are characterised by relatively high price stability. With the exception of Statistical Regions 15 and 18, the Karoo shows high price stability. In these two regions, irrigation is possible, and more capital and labour intensive products are produced. These regions are however far from markets and thus relatively sensitive to price changes. Declining product/input price ratios will affect production of such intensive products earlier and more severely in such areas. The ratio between the price variation and the output/input price ratio is respectively 0,27 for region 15 and 0,24 for region 18 indicating that these regions are subject to higher price risk.

The Eastern Free State and maize producing areas have been identified as areas with stable price ratios, largely because grain prices have been rather stable under fixed price schemes. Regions specializing in products with less stable prices have been identified as price-unstable regions.

The fruit production areas (eg. Regions 1, 3 and 7) show instability in price ratios. In Transvaal, Statistical Regions 72, 73 and 74 have been classified as unstable with relative low output/input price ratios and therfore risky because of instabilities in labour supply and low land quality. The Natal Coastal Region (the sugar belt) appears to enjoy high stability.

6. Land quality; interregional price differentials and public policy

Land quality per se is of little significance for residential and most industrial uses, but vital for agricultural production. Therefore, if both high and low quality land is available for urban usage, there is a definite opportunity cost to the community if land with a high agricultural potential is used for these urban purposes (Groenewald, 1973). High quality land which is used or which is earmarked for urban purposes, naturally has a favourable location and will therefore also exhibit higher output/input price ratios.

Over time, technological change causes upward shifts in agricultural production frontiers, and these upward shifts are larger on high quality than on low quality land. Thus, the social costs involved in the use of high quality agricultural land increases over time - the long run welfare impeding effects of indiscriminate alienation of high quality agricultural land exceed the short-run effects (Groenewald, 1973).

The argument that high density traffic should always enjoy preferential treatment over less intensive use, is therefore not invariably correct. Alternative routes can sometimes be constructed with relatively small cost and/or efficiency differences, and in such cases, opportunity costs involved with production potential for other purposes should also be considered - an issue which has until recently received scant attention in South Africa (Groenewald, 1973) and which is still underemphasized. Groenewald (1973) mentioned high density highways in the Hex River Valley and high quality residential development at Constantia as possible examples.

Freedom of choice in land use maximizes welfare of the individual but may lead to social costs through the withdrawal of high quality land resources from agriculture, particularly in urban or peri- urban areas where food prices are already higher than in rural areas. There may be an inherent conflict between individual and societal interest. Further food price increases may be seen as externalities and a motive to preserve some land for food production (Nieuwoudt, 1990). This need is possibly demonstrated by the increase in urban food production, particulary in townships with a large concentration of low income people.

Resource quality can be artificially improved in some regions, for example by irrigation. Multiplier effects of irrigation can benefit whole communities (Kirsten & Van Zyl, 1990). It is however also subject to limitations, particularly in regions with unfavourable locations. Such areas are more susceptible to low output/input price ratios and price instability. If public funds are used to promote development in economically unfavourable locations, it will therefore be vitally important to include economic distance and the associated risk phenomena explicitly in cost/benefit analyses.

Scarce public resources should be used to promote development and welfare optimally, and an optimal direction of production involves equal marginal substitution rates, both intratemporarily and extratemporarily. This in turn necessitates public policy to be conducted in such a manner, and public funds spent in such a way so as to promote Pareto optimality which is a necessary, though not sufficient condition for welfare maximization. This will involve *inter alia* using land for its best long run purpose, and prevention of antagonistic land uses, including cases involving pollution (Groenewald, 1973).

Agricultural policy has artificially improved regional price ratios in some regions and reduced them in others, possibly the reason for the low correlation between the price ratio and land quality in table 2. Wheat and maize producers have for instance received exactly the same price nationally for their commodities irrespective of the distance from the markets. This resulted in an implied tax to some producers and a subsidy to others. These policies affect production incentives by making certain products less attractive in some regions and more attractive in others. What have been the effects of such direct and indirect interventions in South Africa? Marginal land has been ploughed, overmechanization has occurred, labour is underutilized and underpaid and the Karoo is overstocked (Van Schalkwyk, 1992). Producer prices should reflect the distances of the producing area from its markets, in order to eliminate distortions and enhance comparative advantage. Producer prices should equal market prices less transport costs.

The analysis in this article indicates that infrastructure, particularly transport networks, influences the economic location of a region favourably. Development of such infrastructure can therefore be expected to have positive multiplier effects via improved agricultural production. This will be vitally important for development of agriculture in the present subsistence areas. It will help farmers to move to the right on upward shifting production frontiers provided tenure and other factors are not limiting, and stimulate related activities such as input provision and marketing services.

7. Land quality, price differentials and credit accessibility

Regions differ among each other in terms of quality of resources, favourabality of price ratios and stability thereof. There are differences in agricultural risks, which in turn affect capital redemption abilities of the agricultural sector.

The degree of price riskiness (i.e., the combined effect of the aggregrated output/input price ratio and the stability of the output/input price ration over time) should form part of the complex of factors determining the amount of credit to be granted in different regions and also the cost of credit. Both should be a function of *inter alia* redemptionality.

There are signs that in the past, credit institutions have erred in the sense that much of the credit forwarded to agriculture was granted to farmers in risky situations. In such cases, credit increases financial risk to farmers (Janse van Rensburg and Groenewald, 1987) and to the financial institutions themselves. The degree of mechanization, in a country generally overmechanised (Van Schalkwyk and Groenewald, 1992) has been associated with higher farm indebtedness (Van Schalkwyk et al, 1992). Sound policy should dictate considering risk in credit decisions.

8. Conclusion

Price risk were measured by investigating the combined effect of the aggregated output/input price ratio and the price stability of the output/input price ratio over time. Differences in agricultural price risks have been identified among regions. Price instability can be caused directly or indirectly by resource, economic location, type of product produced, types of inputs used and factors promoting or impeding the flow of inputs to a region. Creation of infrastructure can improve economic location. Eventually, public and private funds ought to be allocated to uses and regions where the best long-term benefits can accrue from their use. The ideal is to equalize marginal rates of substitution between regions, uses and time periods.

Notes

1. This is shown algebraically as follows:

$$Py/Px = 1/MPP = 1/(\Delta y/\Delta x) = \Delta x/\Delta y$$
$$\text{Thus; } Py = (Px.\Delta x)/\Delta y = MC$$

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