Growth of Crop Output in Pakistan—An Analysis by Component Elements

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Introduction

An assessment of production possibilities in the agricultural sector is an important aspect of the process of making projections of agricultural output. A knowledge of the determinants of production or of sources of growth as observed in the recent past is a useful starting point in delineating the production possibilities.

Locating sources of growth in agriculture is normally interpreted as an exercise in determining dimensions of the input-output relationship in crop production processes. There are mainly two approaches for analysing the issue: (a) Estimation of the production functions and (b) Disaggregation of the "gross value of production" (GVP) into its main components. This paper presents some results on sources of growth at the disaggregated district level by breaking down the increase in the gross value of production into four factors. The first section consists of the methodology and data used. Main results are presented in the second section. The last section derives some implications for research in this area.

I. Methodology and Data

Although the approach involving econometric techniques of estimating production functions is theoretically superior to the one adopted here, it is restricted by data limitations. Also, a technical argument normally quoted against this method [1] is that as inputs in agriculture are complementary it leads to a substantial amount of complexity in the input-output relationship. For instance, extension or irrigation and fertilizer use go together whereas labour and animal draught power can be substituted for each other.

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For cases in which agriculture is a multi-commodity enterprise, the approach involving arithmetical disaggregation of the gross value of production is advisable and more practical. It is less demanding in terms of data and provides a fair idea of the effects of physical inputs on output. Usually a two-factor breakdown involving the area and yield effect is used. A wider system of analysis is a four-factor disaggregation system. This method was suggested by Minhas and Vaidyanathan [1] and is used in the present study. The four factors are: (a) Area effect, (b) yield effect, (c) cropping patterns effect and (d) interaction effect.

These elements are selected in such a way that their contribution to growth is independent. For example, increases in gross area sown may be effected through any, or some, or all of the following factors: (a) Extension of cultivation to new areas, (b) reclamation of virgin lands, (c) reclamation of water-logged and saline lands and (d) reduction of fallow land.

This decomposition scheme was used by Gotsch [2] to assess the sources of growth in agricultural production for fourteen major districts of the Punjab between 1960 and 1965. Out of the fourteen districts, seven districts were found to be stagnating¹ or deteriorating in terms of agricultural output growth. Three districts had grown primarily due to the yield effect and four primarily due to acreage and the cropping patterns effects².

Notations

The notations used in this paper for representation of data are:

Crop	Weight	Proportion of Area in time period		Yield per acre in time period	
		0	t	0	t
C_1	W_1	C_{10}	C_{1t}	Y_{10}	Y_{1t}
C_2	W_2	C_{20}	C_{2t}	Y_{20}	Y_{2t}
C_n	W_n	C_{n0}	C_{nt}	Y_{n0}	Y_{nt}

where, C_i 's are the 10 major crops taken to represent output³, W_i 's are constant price weights⁴. C_{i0} 's and C_{it} 's represent proportions of acreage engaged by different crops in time period 0 and t. Y_{i0} s and Y_{it} s are per acre yields in the base and the final time period. For both acreage and yield three yearly averages have been taken on each end to smooth out the fluctuations.

¹Gotsch's criterion for stagnation is not clear. However, all the rates for stagnating districts fall below the overall population growth rate of 3.6 per annum over the period of 1960 to 1970.

²(a) Stagnating districts are: Jhelum, Sialkot, Gujrat, Rawalpindi, Campbellpur, Mianwali and Sargodha.

(b) Districts for which growth due is primarily to yield effect are: Lyallpur, Sahiwal and Multan.

(c) Districts for which growth is primarily due to acreage and cropping pattern effects are: Lahore, Sheikhupura, Gujranwala and Jhang.

³Rice, Wheat, Jowar, Bajra, Barley, Gram, Sugarcane, Maize, Cotton and Tobacco.

⁴Average harvest prices of the crop in three years: 1967-68, 1968-69 and 1969-70.

Gross value of output in time period 0 is P_0 and in period t , P_t

$$P_0 = A_0 \sum_i W_i C_{i0} Y_{i0}$$

$$P_t = A_t \sum_i W_i C_{it} Y_{it}$$

Where A_0 is the gross crop area in time period 0 and A_t in time period t .

The difference between P_t and P_0 is the net change in the gross value of production. It is split into four sources:

$$(a) \text{ Area effect: } (A_t - A_0) \sum_i W_i C_{i0} Y_{i0}$$

$$(b) \text{ Yield effect: } A_t \sum_i W_i C_{i0} (Y_{it} - Y_{i0})$$

$$(c) \text{ Cropping pattern effect: } A_t \sum_i W_i Y_{i0} (C_{it} - C_{i0})$$

$$(d) \text{ Interaction effect: } A_t \sum_i W_i (Y_{it} - Y_{i0}) (C_{it} - C_{i0})$$

The change in the gross value of production ($\Delta G.V.P.$) equals the sum of the above mentioned four effects.⁵

Data

For the present exercise, 27 districts, of the provinces of the Punjab and the NWFP have been taken into account. The period under consideration for decomposing the change in G.V.P. is from 1960 to 1970. The major source of data is the *Report on Season and Crops* [3]. These reports were not available for all the years, however. Another publication, the *Season and Crop Report*, of the provincial Department of Agriculture, [4] was used to obtain data for the missing years. *Acreage Statistics*, a publication of the Bureau of Statistics [5] was also used for obtaining data on cropped area in some years.

There are only minor differences between the different sources of data. This is because different agencies are required to co-ordinate the basic data before making them available for use. For example, the Department of Agriculture corrects its production statistics by multiplying its yield factor⁶ into the acreage figures provided by the Bureau statistics from the Department of Agriculture.

Reliability of Data

Different degrees of reliability can be attached to the three sets of statistics used, viz. acreage, production and harvest prices.

- (a) Acreage: Relatively speaking, these statistics are the most reliable of the three. Theoretically, revenue officials are supposed to map

⁵Simplification of the right hand side of this equation shows that it is equal to $P_t - P_0$ or $\Delta G.V.P.$

⁶Per acre yield calculated by taking an average field of a randomly selected piece of land of size 33 ft. $\times$ 16-1/2 ft.

the cultivated areas. However, errors can arise first, from the negligence on the part of revenue official secondly, from mixed cropping patterns, (adopted as a safeguard against uncertain weather conditions) and thirdly, from consolidation processes.

- (b) **Production:** Data on production are the most defective kind of the agricultural statistics being published. Total yield is arrived at by multiplying the acreage under crops by the yield factor. This figure is then adjusted by the seasonal factor which is subjective and leads to erroneous final figures.

Also, there is a tendency on the part of senior district officials to smooth out production figures leading to underestimation for good years and overestimation for the bad ones. We had averaged production data for three years for both the initial and the terminal period of our study. As such, this factor is not liable to influence the results of this study.

- (c) **Harvest Prices:** Harvest price is defined to be the price at which a commodity of average quality is disposed off by the producer at the village market during the harvesting period of six to eight weeks. On the basis of this price, a median price is then calculated for each district. Prices paid to farmers are not open to verification; as such, the error component is indeterminate. However, most of the agricultural authorities agree on a 5-10% correction either way on these prices. Since the price weights used for the purpose of this study are constant, our results are not likely to be impaired, however.

II. Results

Table I gives district-wise disaggregation in gross value of production. Table II provides the percentage contribution of different sources to the change in gross value of production. Results for most districts are realistic. Some districts show a curious breakup. In the case of Bannu, the contribution through yield effect is negative by 300%; however, the negative effect is counterbalanced by a 312.87% positive increase in the area effect. On the other hand, yield effect for Sialkot is positive by 304.47% when area effect in the same district is negative by 439.47%. Similarly, Kurram shows a negative contribution of 135% to the growth through the yield effect and a 210% positive contribution from area effect. Gujrat has a negative contribution from the area as well as yield effects.

One explanation for such results is that when area effect is high, marginal land, which is normally of poorer quality, is brought under cultivation resulting in a fall in yield. On the other hand, when area effect is negative, yield effect goes up since marginal land is kept fallow. Another factor that may explain the situation is that these districts might have experienced a decline in the agricultural output during the last years for this study due to abnormalities in weather or other natural hazards.

Except for the districts of Gujrat, Jhelum and Sialkot, all other districts have had a positive contribution from the acreage effect. The districts of Bannu, Kurram, Rawalpindi, Jhang and North Waziristan have shown an appreciable increase in the agricultural output from increased area under crops.

In the case of the yield effect, Bannu, Gujrat, Kurram, Jhang, Rawalpindi and North Waziristan, have had a negative contribution. (Yield effect for Mardan is negative on the margin only). Districts benefiting substantially from this factor are Multan, Sheikhpura, Sargodha, Campbellpur, Jhelum, Bahawalnagar, Sialkot, Sahiwal and D.I. Khan. Of these districts only D.I. Khan district is located in the NWFP. Growth attributable to cropping pattern changes is high for Bannu, Gujrat, Sialkot, Rawalpindi and Mardan. It is negative for Campbellpur, Jhelum and Jhang. The districts of Lahore, Sheikhpura Sardgodha, Bahawalnagar, Gujranwala and Rahim Yar Khan have had a marginally negative contribution from this source.

Table 1
Disaggregation of District Growth over 1960-1970

(in rupees)

District	Total change in value terms	Area effect	Yield effect	Cropping pattern effect	Interaction effect
Lahore	3054026	2250254	600854	-48937	251856
Hazara	766862	307479	340054	82416	36912
Multan	20527600	5473963	12667953	1511891	873839
Sheikhpura	3638512	1833183	2338904	-31613	-501960
Sargodha	8806396	1701171	6738660	-29107	-1604327
Bannu	55671	174177	-167344	121561	-72722
Kohat	161755	99552	49236	16950	-3984
Gujrat	-2726085	2673001	3010533	-7134750	-1274869
Campbellpur	263595	258052	350562	-150897	-194122
Jhelum	-514037	481615	-1049435	246489	-192707
Peshawar	2932354	446630	957646	1244007	284070
D.I. Khan	562538	70215	453821	68991	-30490
Kurram	4278	8989	-5787	2333	-1256
Bahawalnagar	1632247	105771	165527	-28771	-100278
Jhang	-2648434	-4045285	923759	366530	106559
D.G. Khan	2724041	551486	961010	175264	1036280
Sialkot	-789084	3459911	-2402515	-2960731	1114251
Mardan	2973350	609080	-1044	2236914	127608
Rawalpindi	210924	432627	-148876	-87056	14230
Gujranwala	3144003	2318023	931139	-118587	13420
North Waziristan	14937	17389	-12556	5289	4814
Muzaffargarh	5247062	1778289	2865227	342193	261353
Bahawalpur	3381946	1048223	1706000	440859	186864
Sahiwal	10477841	2373779	6336939	1362762	404361
Lyallpur	8627509	4738498	128440	3568697	-964105
Rahim Yar Khan	8376180	1948081	5860346	279629	378123
Mianwali	2121833	1948081	517735	65498	-409481

Table II

Percentage contribution of the four sources to G.V.P.

District	Area effect	Yield effect	Cropping pattern effect	Interaction effect
Lahore	73.68	19.67	-1.60	8.25
Hazara	40.10	44.34	10.75	4.81
Multan	26.67	61.71	7.37	4.26
Sheikhupura	50.38	64.28	-0.87	-13.80
Sargodha	42.03	76.52	-0.33	-18.22
Bannu	312.87	-300.59	218.35	-130.63
Kohat	61.55	30.44	10.48	-2.46
Gujrat	-98.05	-110.43	261.72	44.77
Mianwali	91.81	24.40	3.09	-19.30
Campbellpur	97.90	132.99	-57.25	-73.64
Jhelum	-93.69	204.16	-47.95	37.49
Peshawar	15.23	32.66	42.42	9.69
D.I. Khan	12.48	80.67	12.26	-5.42
Kurram	210.10	-135.27	54.54	-29.37
Bahawalnagar	6.48	101.43	-1.76	-6.14
Jhang	152.74	-34.88	-13.84	-4.02
D.G. Khan	20.25	35.28	6.43	38.04
Sialkot	-439.47	304.47	375.21	-141.21
Mardan	20.51	-0.04	75.23	4.29
Rawalpindi	205.11	-70.58	-41.27	6.57
Gujranwala	73.73	29.62	-3.77	0.43
North Waziristan	116.42	-84.06	35.41	32.23
Muzaffargarh	33.89	54.61	6.52	4.98
Bahawalpur	30.99	50.44	13.04	5.53
Sahiwal	22.66	60.48	13.01	3.86
Lyallpur	54.92	14.89	41.36	-11.17
Rahim Yar Khan	22.18	66.96	3.34	4.51

In the analysis of fourteen districts carried out by Gotsch, the districts of Jhelum, Gujrat, Sialkot, Rawalpindi, Campbellpur, Mianwali and Sargodha were classified as stagnating with growth rate [G.V.P.] ranging from -2.4 to 3.2 percent. The present exercise seems leads to the following findings: Jhelum has improved relatively from -2.4% to -1.9% growth [annual]?. Gujrat has deteriorated from 2.2% to -1.13%, Sialkot has improved marginally from -1.2% to -.98%, Rawalpindi also improved marginally from 1.0% to 1.05%

*Growth rates below 3.6% per annum, which is the overall population growth rate of the period, are held to signify stagnating districts. On the other hand growth rate of agricultural production greater than population growth rate is the cut-off point to signify growing districts.

and Campbellpur from -2.2% to .62%. Mianwali has moved out of the stagnating category with a growth rate of 4.1%. Sargodha has made a phenomenal improvement from 2.6% to 9.5% per annum [Table III].

The districts of Dera Ghazi Khan, Peshawar and Mardan did not fall into the three classifications. These districts had high growth rates but in the case of Peshawar and Mardan, contribution of the cropping pattern effect was mainly responsible for change in G.V.P., and in D.G. Khan, it was the interaction of all three sources which made a maximum contribution to G.V.P. growth in the district.

III. Conclusion

Of the 14-district sample considered by Gotsch, 50% of the districts were found to be growing and, out of these, the ratio of those growing primarily due to area effect to those growing primarily due to yield effect was 4 to 3. The changes noted here are that, out of a sample of 29 districts comprising the northern zone of the country (including the Punjab and the NWFP), nearly 60% are growing and only 40% stagnating. Moreover, the ratio of those growing primarily due to area effect to those growing primarily due to yield effect is 4 to 9.

Table III

Growth Position of Districts According to Primary Connection for growth (1960-70)

Districts Group	Average annual Growth Rate
(I) <i>Stagnating Districts</i>	
Bahawalnagar	2.44%
Kohat	1.78%
Rawalpindi	1.05%
North Waziristan	.96%
Campbellpur	.62%
Bannu	.31%
Kurram	.13%
Sialkot	-.98%
Gujrat	-1.13%
Jhelum	-1.9%
Jhang	-3.54%

—Continued—

District Group	Annual *Growth rate	Area Effect	Yield Effect	Cropping Pattern	Interaction Effect
(II) <i>Growth due Primarily to yield effects</i>					
Mianwali	4.1%	91.81%	24.4%	3.09%	-19.3%
Gujranwala	4.3%	73.73%	26.62%	-3.77%	0.43%
Lahore	6.1%	54.92%	14.89%	41.89%	-11.17%
(III) <i>Growth due primarily to yield effect</i>					
D.I. Khan	5.9%	12.48%	80.67%	12.26%	-5.42%
Sargodha	9.5%	42.03%	76.52%	-0.33%	-18.22%
R.Y. Khan	6.6%	22.18%	69.96%	3.34%	4.51%
Sheikhupura	5.3%	50.38%	64.28%	-0.87%	13.00%
Multan	9.5%	26.67%	61.71%	7.37%	4.26%
Sahiwal	4.9%	22.66%	60.48%	13.01%	3.86%
Muzaffargarh	13.38%	33.89%	54.61%	6.52%	4.98%
Bahawalpur	7.25%	30.99%	50.44%	13.04%	5.53%
Hazara	4.27%	40.10%	44.34%	20.75%	2.81%

This clearly underlines the effect of the green revolution during the period 1960 to 1970, and supports the hypothesis that yields improved substantially after the advent of the green revolution and made agricultural growth yield-oriented, as compared to growth in the period 1960 to 1965 which was area-oriented.

The inter-district growth differentials can be attributable to a rather large number of variables. Research into an explanation for such growth has not been done in Pakistan. The major question for policy maker would be whether more resources should be injected into the stagnating districts or concentrated into growing districts. Almost all stagnating districts are in the unirrigated zone. Rapid growth in these districts can result only when an adequate irrigation system for the supply of water has been developed for this region and/or new crop varieties suitable for the dry farming are available. *A priori*, it seems that returns from concentrating resources in the growing areas would be greater because an irrigation system in these districts is already present. We must add, however, that the case for concentration of resources in districts which have performed well in the past is based on short-run efficiency criterion. Equity considerations demand that the broad based programmes for the uplift of the poor regions be adopted to narrow the gap between rich and poor regions.

Appendix Table I
Percentage area under Major Crops Sown in Punjab and N.W.F.P. during 1959-60

District	Rice	Wheat	Barley	Jowar	Bajra	Maize	Gram	Sugarcane	Cotton	Tobacco
1. Lahore	11,000	42,400	4,900	0,300	4,600	3,700	9,600	8,300	14,700	0,400
2. Sialkot	27,000	45,300	5,200	0,200	5,500	4,900	3,400	6,000	2,000	0,500
3. Gujranwala	31,200	40,200	2,100	0,500	3,800	10,100	4,600	4,000	3,000	0,500
4. Sheikhupura	27,300	46,400	1,800	0,200	2,100	3,400	4,700	6,100	7,500	0,400
5. Gujrat	8,400	49,600	1,500	2,500	18,200	3,100	5,600	3,300	7,500	0,200
6. Sargodha	1,600	45,500	1,500	1,800	7,400	3,400	23,100	3,200	12,300	0,200
7. Jhelum	0,300	14,000	1,400	6,000	64,000	1,300	10,900	0,300	1,700	0,200
8. Rawalpindi	0,100	55,400	1,000	12,800	14,600	14,200	1,800	0,010	0,020	—
9. Campbellpur	—	69,200	3,100	5,000	13,100	2,900	6,300	0,030	0,200	0,300
10. Mianwali	0,010	41,900	2,200	1,900	3,600	0,010	47,60	1,900	0,900	0,010
11. Lyallpur	1,700	52,400	1,000	0,400	1,100	7,400	9,000	11,300	15,400	0,500
12. Sahiwal	7,300	45,100	1,600	0,400	3,400	4,100	12,200	5,700	19,700	0,500
13. Jhang	2,300	52,600	1,100	2,800	6,200	4,300	10,200	4,000	16,100	0,300
14. Multan	2,000	49,200	0,300	1,100	2,400	2,100	1,100	3,000	38,600	0,200
15. Muzaffargarh	3,000	65,600	2,400	3,500	3,000	0,200	13,500	4,000	4,800	0,100
16. D.G. Khan	11,000	47,000	0,900	19,300	7,700	0,013	9,800	0,300	3,800	0,200
17. Bahawalpur	1,800	51,600	0,200	8,400	7,800	2,100	11,500	4,600	11,900	0,100
18. Bahawalnagar	3,300	38,600	3,000	2,700	5,500	1,200	21,600	5,100	19,200	0,090
19. R.Y. Khan	2,000	41,500	0,200	6,000	3,000	1,900	4,600	5,300	35,900	0,100
20. Hazara	2,700	32,000	7,700	1,500	1,100	54,300	0,700	0,100	0,100	0,100
21. Peshawar	0,700	46,400	8,400	0,300	—	22,600	0,900	19,700	—	1,300
22. Mardan	0,020	39,300	11,700	1,900	—	24,500	1,500	14,700	0,300	6,400
23. Bannu	0,500	64,200	3,600	1,000	0,900	8,100	20,700	1,100	0,200	0,100
24. Kohat	0,400	68,400	4,400	0,500	9,800	6,500	10,100	0,100	—	0,100
25. D.I. Khan	0,800	65,200	2,200	8,800	7,200	0,600	13,800	1,200	0,400	—
26. N. Waziristan	3,500	53,600	5,900	—	—	34,600	—	2,400	0,200	0,100
27. Kurram	27,600	47,800	3,100	—	—	21,600	—	—	—	0,100

Appendix Table II
Percentage Area under Major Crops sown in Punjab during 1969-70 and N.W.F.P. during 1967-68

District	Rice	Wheat	Barley	Jowar	Bajra	Maize	Gram	Sugarcane	Cotton	Tobacco
1. Lahore	13.600	60.200	2.500	0.200	1.600	3.700	5.700	5.700	8.600	0.300
2. Sialkot	30.900	46.900	1.900	0.200	7.200	5.300	1.300	3.500	1.900	1.200
3. Gujranwala	40.100	44.200	0.900	0.700	4.300	1.200	1.100	2.700	4.500	0.400
4. Sheikhupura	32.000	49.100	0.900	0.200	1.800	4.300	1.000	5.000	5.000	0.200
5. Gujrat	12.500	51.100	0.800	2.800	15.800	3.200	2.800	6.800	3.400	0.800
6. Sargodha	3.100	39.500	0.700	1.200	5.200	3.300	31.400	5.000	10.600	0.100
7. Jhelum	0.200	62.800	0.500	5.700	26.900	1.400	1.500	0.200	0.900	0.040
8. Rawalpindi	0.100	60.200	0.800	11.000	12.100	14.900	0.700	0.020	0.100	—
9. Campbellpur	—	75.900	1.400	4.400	11.100	3.000	3.600	0.030	0.200	0.300
10. Mianwali	—	45.000	1.700	1.700	3.000	0.200	44.800	2.300	1.300	—
11. Lyallpur	4.000	54.300	0.400	0.300	0.700	8.600	1.900	14.800	14.400	0.600
12. Sahiwal	10.600	39.400	1.000	0.300	1.300	3.500	2.100	6.100	34.800	0.900
13. Jhang	4.300	55.000	0.600	1.800	4.900	4.600	3.300	4.500	20.500	0.300
14. Multan	2.000	49.200	0.300	1.100	2.400	2.100	1.100	3.000	38.600	0.200
15. Muzaffargarh	3.600	64.000	1.200	3.400	1.700	0.500	10.900	4.800	9.700	0.100
16. D.G. Khan	10.000	53.800	0.600	16.300	4.000	0.100	5.300	1.000	8.800	0.200
17. Bahawalpur	3.500	49.400	0.100	4.800	6.400	0.400	3.900	6.300	25.200	0.048
18. Bahawalnagar	4.500	44.000	2.200	3.300	5.700	1.000	8.100	7.700	23.700	0.200
19. R.Y. Khan	3.700	39.200	0.100	5.800	3.500	2.800	1.600	9.300	34.200	0.100
20. Hazara	3.000	37.800	5.600	1.600	0.600	50.600	0.600	0.200	—	0.200
21. Peshawar	0.900	49.100	4.500	1.500	—	24.400	0.400	18.900	—	0.600
22. Mardan	0.200	39.800	6.700	2.000	—	26.500	0.400	13.400	—	11.200
23. Bannu	1.200	55.100	1.000	0.600	0.600	8.900	30.300	2.200	0.200	0.200
24. Kohat	0.600	63.900	3.000	1.500	2.600	10.500	8.100	—	—	—
25. D.I. Khan	1.200	51.100	1.200	12.600	11.100	1.200	19.300	2.000	0.500	—
26. N. Waziristan	4.800	47.700	9.600	—	—	28.600	—	9.600	—	—
27. Kurram	28.600	48.600	2.000	—	—	20.900	—	—	—	0.100

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