The Pakistan Development Review
28 : 1 (Spring 1989) pp. 43 – 56.

Production Function, Institutional Credit and Agricultural Development in Pakistan

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This study, based on the time-series data covering the period from 1956 to 1986, estimates production function in the agricultural sector of Pakistan. The strategy for agricultural development in the country has been based on greater utilization of "high pay-off" low-cost technology. The government advanced loans through financial institutions to make it possible for the farmers to acquire this technology. Despite the infusion of seed-fertilizer technology, per acre yield of major crops like wheat, rice, cereal and sugar-cane in Pakistan is lower than in most LDCs in the region. Therefore, it is concluded that the use of present technology has reached a plateau and it is time to look for additional inputs for improvement in productivity.

I. INTRODUCTION

There is a consensus among economists that the agricultural sector in developing countries operates at a relatively low level of productivity. Traditional methods of cultivation, inadequate infrastructure and poor irrigation facilities, among other factors, account for low levels of productivity. While W. Arthur Lewis (1954) and Ranis-Fei (1961) argued in favour of simultaneous development of the agricultural and manufacturing sectors, they showed that unless productivity of the agricultural sector is raised, the manufacturing sector cannot continue to expand. Jorgenson's (1961) model, developed in the neoclassical tradition, focuses attention on three parameters, viz., (a) the rate of technological change in the agricultural sector; (b) population growth rate; and (c) the elasticity of production in the agricultural sector with response to changes in labour force participation in this sector. He argued that a rapid improvement in agricultural technology, in conjunction with a decline in birth-rates, would result in economic growth and thus break the "vicious circle of poverty".

Kuznets (1976, p. 118) suggested that without marked improvements in pro-

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Author's Note: Funding for this project was provided by the American Institute of Pakistan Studies and Central Michigan University. I am thankful to my colleagues Dr Lawrence P. Brunner and Dr Basil Zimmer for their comments, and to Dr T. Cameron Whiteman for suggesting some stylistic changes in preparing this paper. I am also thankful to Dr Holt Wilson for helping me with the TSP package in obtaining statistical results. I am also grateful to the anonymous referee for his valuable comments.

ductivity in the agricultural sector, the economies of Europe and the United States could not have attained countrywide high rates of growth. Schultz (1964, pp. 145–147) argued that modernizing traditional agricultural sector is essential for economic growth, and this objective can be achieved by making "high pay-off inputs" available to the farmers.

Hayami and Ruttan (1985, p. 45) developed the model of induced technical change. In this model, technical change is treated as an endogenous factor. In the historical context, they suggested that in order to achieve agricultural development, growth rate in this sector should accelerate and be consistent with the growth rates of other modernizing sectors of the economy. Ruttan (1987, p. 25) has stated that in this model what accounts for the direction of technical change is the economic environment itself. It is, therefore, evident that genuine economic development cannot be attained without a concomitant improvement of productivity in the agricultural sector.

In order to improve productivity, developing countries (LDCs) must introduce or increase the use of such inputs as chemical fertilizers, new varieties of seeds, tractors, and irrigation facilities among other factors. For countries like India and Pakistan, which have abundant supplies of labour, Johnston and Cownie (1969, p. 578) favoured the adoption of low-cost and simple technology for two reasons: (a) the complementary nature of such inputs; and (b) such inputs can be domestically produced. The introduction of new technology tends to increase demand for credit by farmers. Inadequate access to credit by farmers, thus, can become a major bottleneck to development. To avoid possible credit shortages, many LDCs have established government-operated or government-sponsored financial institutions. In many instances, these institutions are either controlled or supported by their governments. These institutions supply credit ồn concessional rates. The rationale for using concessional rates is based on the assumption that this would provide farmers relatively easy access to agricultural inputs that would increase productivity. Pakistan, like many other LDCs, has been active in providing credit through institutional sources.

The purpose of this paper is (1) to estimate the production function in order to determine the statistically significant variables that influence changes in output in the agricultural sector of Pakistan, and (2) to determine the pattern of institutional credit. The paper is planned as follows. The model for testing the production function and the data sources is stated in Section II. The pattern of institutional credit is explained in Section III. Empirical results are reported in Section IV, and the conclusions are presented in Section V.

II. BASIC MODEL

The production function in the agricultural sector of Pakistan is developed on the assumption that the size of the land is fixed; the variable inputs that affect output are capital (K) and Labour (L). The model is patterned after Cobb-Douglas production function. This model is used primarily because the resulting coefficients make it possible to interpret the elasticities of production function with respect to inputs. Furthermore, the coefficients also indicate the relative importance of each input with respect to output.

$$Q_t = A_t K_t^{\beta_1} L_t^{\beta_2} e^{\xi_t} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where: Q_t = output at time-period t; K_t = capital inputs in time-period t; L_t = labour force employed in the time-period t; and e = stochastic or random disturbance. Transformed into log, Equation (1) takes the following form,

$$\log Q_t = \log A_t + \beta_1 \log K_t + \beta_2 \log L_t + \xi_t \quad \ldots \quad (2)$$

Equation (2) may be written in the following manner:

$$Y_t = A_t + \beta_1 k_t + \beta_2 l_t + \xi_t \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where $Y_t = \log Q_t$, $k_t = \log K_t$, $l_t = \log L_t$ and $A_t = \log A_t$

In this model Y, A, k, and l represent the logarithms of their counterparts. It becomes quite apparent that Equation (3) is clearly linear multiple regression, and its estimates proceed along the usual lines. The coefficients β_1, and β_2 estimate the output elasticities of capital and labour respectively. The production function in its present form simply states that given the size of land, agricultural output is a function of labour and capital.[1]

Official time-series data covering a period from 1961 to 1985 were used in estimating the production function [Government of Pakistan (1986), p. 31]. There are two major problems encountered in estimating a production function based on time-series data: (i) multicollinearity, and (ii) autocorrelation. However, these problems can be minimized by (a) selecting appropriate explanatory variables that capture the most significant influence on output; and (b) by applying Cochran-Orcutt techniques to the regression model.

Traditionally, in the estimation of production functions, land and livestock serve as proxy variables for resource endowments, machinery and fertilizer for technical inputs and education for human capital. Through a search process the variables that best predict output were selected.

[1] Land has not been included in estimating the production function in the agricultural sector in Pakistan, even though the data on the cultivation of land were readily available. Whenever land was included in the model, the model yielded statistically meaningless results.

When labour, livestock, land, seed, water, tractor, and fertilizer were entered in the model, the results were highly confusing despite a high R^2. An analysis of the raw data suggests that neither the size of the land nor the number of livestock change significantly on a yearly basis. The changes in the stock of these two variables are such that the incorporation of these factors does not enhance understanding about changes in output in a significant manner. What was surprising was the insignificant coefficient for water. However, the raw data suggest that the government had attached great importance to water, and major investments occurred in the development of the tubewell system and canal water in the early 1960s. Investment in this area tapered off in the 1970s. Although funds continue to be allocated for the development of new tubewells, the number of additional tubewells is so small that the knowledge about the availability of additional water does not significantly increase the ability to predict changes in agricultural output. Therefore, only those variables that had significant coefficients were included in the model along with labour. The model now included labour, seeds and fertilizer as independent variables.

Agricultural output was then regressed against labour, seed and fertilizer. In this model the standard error for labour turned out to be greater than the coefficient for labour itself. Subsequently, a Divisia index [Richter (1966)] of seed (S) and fertilizer (F) was developed by using the following specification:

$$SF = S^{\alpha_1} F^{\alpha_2} \qquad \text{where } \alpha_1 + \alpha_2 = 1$$

and SF = Seed-Fertilizer

$$\alpha_1 = \frac{S}{S+F}, \quad \alpha_2 = \frac{F}{S+F}$$

This index was then substituted for seed and fertilizer in the regression equation. Divisia index was particularly useful because the data on seed prior to 1971-72 were not available, while the data on fertilizer were available for the period 1961-62 to 1984-85. This procedure made it possible to retain the information prior to 1971-72 in the regression equation.

The government of Pakistan has asserted that "fertilizers are the single most important source of growth of agricultural production" [Government of Pakistan (1983), p. 55]. This assertion is supported by the results reported in this paper. The importance of fertilizer in the agricultural development of Pakistan becomes quite evident by the size of the institutional credit allocated to it.

III. INSTITUTIONAL CREDIT

The indigenous money-lenders, called *Bunyas,* were the principal suppliers of credit in the region that constituted Pakistan prior to 1947. They were Hindus, and most of them left for India after independence. The vacuum caused by their departure could not be filled by Muslims, whose religion prohibits usury. This vacuum initially necessitated the participation of government as a provider of credit to the agricultural sector. With the passage of time, however, alternative private sources of credit appeared. Now Artyas, who are businessmen and serve as middlemen in the agricultural sector, also provide credit. It is, however, uncertain what percentage of total credit Artyas actually provide, as no studies on the subject are available.[2]

Adams (1971, p. 165) suggested that institutional credit in the agricultural sector in Pakistan forms only a small fraction of the total credit. The Director of the research at the Agricultural Development Bank of Pakistan has indicated that Adams's statement will not be valid in 1980s. Often researchers have mistakenly assumed that the share of non-institutional credit in the agricultural sector in Pakistan is roughly the same as in India. This is an erroneous assumption, because the departure of Hindu money-lenders (*Bunyas*) to India wiped out the age-old indebtedness, at least in Punjab, and reduced it in other parts of the country as well.

Whereas the departure of the *Bunyas* freed the farmers from the old debt, it also dried up the sources to meet the credit needs of the farmers. It has often been suggested that people borrow from their relatives. However, most relatives are also poor farmers without adequate income or savings to loan funds to anyone else. Therefore, *a priori*, it can be established that the size of the non-institutional credit in Pakistan has been exaggerated.

There are four sources through which institutional credit is disbursed in Pakistan, viz., Taccavi or Government Loans, Cooperatives, Agricultural Development Bank of Pakistan (ADBP), and commercial Banks.[3] Taccavi loans are essentially relief loans and do not directly contribute to the development of the agricultural

[2] The credit provided by the Artyas, I was told by the Director of the Research at the ADBP, is largely to meet short-term credit needs of the farmer. Artyas tend to charge 10 percent interest rate per month or 120 percent a year. People continue to borrow from Artyas for a variety of reasons: (a) they lack information about other sources of credit; (b) no security is required; and (c) timely availability of credit. I was further told by the Director that, in his judgement, private credit does not exceed 50 percent.

[3] For a detailed study of Taccavi loans, [see Khan (1969)]. Also see the *Credit Enquiry Commission Report, 1959,* Aslam Ghayur and Masuda Akhtar "Study Concerning the Working of Taccavi Loans", USAID/Pakistan, "Pakistan Agricultural Inputs Loans", 1975, various *Five-Year Plans,* and various *Annual Economic Surveys.*

For further information on cooperatives see *Credit Enquiry Committee Report, 1959,* various *Five-Year Plans, Financial Institutions: National and International,* 1964, various *Annual Economic Surveys,* and *Annual Reports* of the FBC since 1980.

For further information on ADBP, see *Agricultural Development Bank of Pakistan* annual reports since 1970, *Annual Economics Surveys* for various years, and *Agricultural Indicators Series-4, 1985.*

For detailed information on commercial bank credit, see Agricultural Credit Study in Pakistan, *Agricultural Credit Survey (Commercial Banks-Production Loans),* 1983 and *Annual Economic Surveys* for various years.

sector any more. The other three sources receive funds from the government and disburse credit on short-term, medium-term, and long-term basis.

As a result of an informal understanding between the Federal Bank of Co-operatives (FBC) and the ADBP, the FBC concentrates on the disbursement of short-term loans (about 90 percent) to finance variable inputs such as fertilizers, seed, and pesticides, and the ADBP concentrates on the disbursement of medium- and long-term development funds, towards the purchase of tractors or the construction of tubewells, etc., (about 80 percent).[4] However, it should be noted that in 1985 FBC did provide 10 percent of its loans to be used for the purchase of tractors, while ADBP disbursed almost 20 percent of its loans to finance short-term seasonal inputs for the same period.

In 1985, commercial Banks were the single largest institution providing credit to the agricultural sector. Commercial bank credit is primarily designed to finance seasonal inputs. They have rarely provided long-term development credit. Almost 99 percent of the amount of loans disbursed by the commercial banks were in irrigated areas [National Fertilizer Corporation (1983), p. 17] and were made primarily toward the purchase of fertilizer, for which the consumption has increased from 3,792,000 tons in 1971-72 to 14,887,000 tons in 1985-86. Since the objective of the government is to take seasonal inputs to the farmers, commercial banks disburse 88 percent of the production loans in kind rather than in cash.

An important feature of institutional credit in Pakistan is the pattern of its distribution. About 89 percent of the total credit disbursed by the FBC went to small farmers (farmers owning 12.5 acres of land or less); 70 percent of ADBP loan recipients owned less than 25 acres of land, while 90 percent of the commercial bank credit was disbursed among farmers holding 12.5 acres or less and economic farms ranging between 12.5 to 25 acres. The data show that institutional credit has enabled farmers to have access to seed-fertilizer technology.

IV. EMPIRICAL RESULTS AND ANALYSIS

For purposes of statistical analysis indexes were constructed from the official raw data. A regression equation utilizing OLS and based on the Cobb-Douglas model as explained in Section II, which included land, labour, seed, water, fertilizer and tractor, yielded confusing results. Multicollinearity, as Hayami and Ruttan (1985, pp. 141–143) have suggested, was suspected in this case also. Therefore, correlation matrices were prepared and, indeed, most of these variables turned out to be highly correlated. Through a search process the following model, which yielded the best results, was selected.

[4]The Director for Research at the FBC in Islamabad told me about the informal understanding with the ADBP about the disbursement of short-term, medium-term, and long-term loans.

$$Y = \alpha_0 + \beta_1 X_1 + \beta_2 X_2$$

In this model $Y = \log Q_t$, $X_1 = SF$, and $X_2 = Z_t$.
Preliminary results indicated autocorrelation.[5] Therefore, with the help of Cochran-

[5] The following log linear equation, which included institutional credit as an independent variable, offered meaningless results.

Y	=	−2.44	+	1.03 Land	+	.011 Seed	+	.033 Water	+	.335 Fertilizer
		(4.987)		(.625)		(.045)		(.370)		(.174)
		−.165 Tractor	+	.275 Labour	+	.01 Credit				
		(.330)		(1.41)		(.043)				

R^2 = .9828, $S.E.$ = .0311, $D.W.$ = 1.94

T-statistics were insignificant for all variables. Another test, which included the seed-fertilizer index, labour, and institutional credit as independent variables, yielded the following equation:

Y	=	−.137	+	.195 SF	+	.838 Labour	+	.011 Credit
		(1.277)		(.0238)		(.3087)		(.0222)

R^2 = .9799, $S.E.$ = .0515, $D.W.$ = 1.53

T-statistics were significant for SF and labour but insignificant for institutional credit.

These statistical results show that the inclusion of credit as an independent variable in the production function does not improve predictability of changes in agricultural production. Therefore, credit as an independent variable in the production function was deleted. Now, a model that included only physical input as independent variables was regressed against output. The following log linear equation was obtained.

Y	=	−2.349	+	1.122 Land	+	.01 Seed	+	.085 Water	+	.305 Fertilizer
		(4.624)		(.439)		(.042)		(.276)		(.113)
		− .115 Tractor	+	.096 Labour						
		(.238)		(1.106)						

R^2 = .9826, $S.E.$ = .02899, $D.W.$ = 1.9769

T-statistics were insignificant for all variables except land (.019) and Fertilizer (.015).

However, when only labour and fertilizer were used as independent variables and Cochran-Orcutt techniques were utilized to avoid autocorrelation, the following results were obtained:

Y	=	.575	+	.201 K	+	.666 L
		(.276)		(.0001)		(.001)

R^2 = .98, while $D.W.$ = 1.66. These results are statistically significant and do make it possible to predict changes in agricultural output on the basis of the information about utilization of labour and fertilizer.

The nature of data available on Pakistan is such that it was virtually impossible to include human capital and research in the model. It would be helpful to the researcher if data were available on expenditures for research, extension services and education in the rural areas.

Future researchers will benefit in estimating agricultural production function for Pakistan if data were available on the volume of water used for irrigation per acre, and perhaps if land were identified by the type of irrigation, e.g., canal or tubewell, applied to it. Similarly, a breakdown of tractors, based on their size, would permit an aggregation into horsepower. At the present time, only the tractors could be entered in the regression equation.

Orcutt techniques, the following equation was obtained:

$$Y = .409 + .201X_1 + .703X_2$$
$$(.868) \quad (.029) \quad (.213)$$

T-statistics were significant at .0001 level for X_1, and .002 level for X_2. Adjusted R^2 = .975. The *S.E.* of regression was .051 and *D.W.* = 1.926 was significant at α = .05 level. The F-statistics of 305.69 was significant at α = .0001 level. Standard errors obtained for capital and labour are reported in parantheses. Based on this equation 97.5 percent changes in output can be explained by changes in the amount of fertilizer and seeds plus the number of labour force employed in farming in Pakistan, assuming all other inputs remaining constant. This model, though simple, catches the most significant variables that influence agricultural output.

This study shows that the sum of the coefficients of X_1 and X_2 is not significantly different than 1 at α = .05 level. Therefore, it may be concluded that the agricultural sector in Pakistan has experienced constant returns to scale over the period covered by this study.

The results presented in this study are consistent with the path institutional credit has followed during the past two decades. According to the published data of the cooperatives, the ADBP, and the commercial banks, over 80 percent of the short-term credit is used toward the purchase of seeds and fertilizers among farmers located primarily in the irrigated area. It is not a surprise that the contribution of other variables, such as tractors, turned out to be insignificant.

Khan (1985, p. 48) had suggested that the use of tractors had almost no positive effect "on the yield". Chaudhry (1986, pp. 433 -435) pointed out that whereas only three (3) percent of the total farms used tractor-driven blades and some used both tractors and bullocks, the vast majority of the farmers continued to depend upon manual labour and bullocks for cultivation. Yet, in areas where tractors are used, agricultural output, according to Chaudhry, is positively related to farm incomes. He cites his earlier study based on a survey of 21 farmers in the districts of Lahore, Gujranwala, Jhang and Toba Tek Singh to show that when farmers rented tractors instead of using bullock to plough the field, the cost of cultivation declined by one-third. He also states the availability of water combined with fertilizer and new varieties of seed to be positively related to output. Although Chaudhry's explanation that the use of tractors reduced the cost and positively contributed to output may be fine in the case of the 21 farms he studied, it should be remembered that only three (3) percent of the total farms used tractor-driven blades and some used fore, not widely used and, hence, has no real effect on agricultural output at the present time for the country as a whole.

A close analysis of the data on the disbursement of institutional credit and the estimated results of the production function indicate that Pakistan has pursued a labour-using, capital-saving type approach for its agricultural development.

Johnston and Cownie (1969, p. 573) pointed out that new seed-fertilizer combinations resulted in contradictory conclusions in selecting between two alternative agricultural development strategies, one emphasizing increased productivity while maintaining small farm-units and the other emphasizing a shift to large-scale farming that would employ tractor mechanization. The authors recommended that in economies where relatively small structural transformation has occurred and land/labour ratio on the farm continues to decline, large-scale farming utilizing tractors will not be profitable. They favour simple and low-cost equipment for countries like India and Pakistan.

In the case of Pakistan, as Figure 1 shows, the land/labour ratio has continued to decline between 1962 and 1985, except for the years 1967 and 1974, for which no explanation is available other than the land reforms that were put into effect in 1974. An explanation of the 1967 situation may be found in the after-effects of the war with India in 1965.

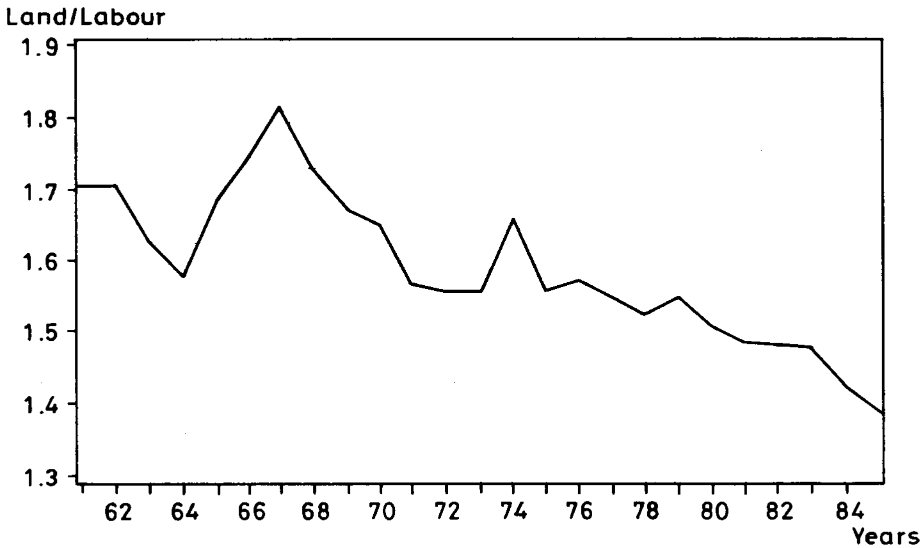

Fig. 1. Land/Labour Ratio from 1961-62 to 1985-86

Given a steady decline in the land/labour ratio, an analysis of the data suggests that the government has pursued a strategy of agricultural development which is based on small land-size, capitalizing on the seed-fertilizer revolution. Short-term institutional credit has moved in this direction, as well as the statistical results support the importance of seeds and fertilizer in predicting agricultural output.

The analysis presented here so far does not say anything about the performance of Pakistan's agriculture. The data presented in Table 1 show that agricultural

Table 1

KG/HA per (Hectare) Yield of Selected-crops in Selected Countries

Country	Wheat	Rice	Sugar-cane	Cereal
Bangladesh	2,281	1,971	44,366	1,977
China	2,975	5,271	51,411	3,880
Egypt	3,300	5,310	81,818	4,326
India	1,851	2,103	56,208	1,556
Pakistan	1,510	2,507	35,684	1,574

Source: Agricultural Development Bank of Pakistan (1986), pp. 74–86.

productivity in Pakistan, relative to some other LDCs in the region, is rather low.

Per hectare yield of wheat in Pakistan is less than half of Egypt's, and the lowest among the five LDCs listed in Table 1. However, per hectare yield of rice is somewhat better in Pakistan when compared with India and Bangladesh, but still less than half that of Egypt or China. Pakistan ranks at the bottom in terms of the yield of sugar-cane. What accounts for the poor performance of Pakistan's agriculture in terms of per hectare yield relative to other LDCs in the region, according to Ruttan (1987, p. 25), is the low investment in human capital in the rural areas of the country. The rate of literacy is estimated to be 26.037 percent for the country as a whole. However, it is only 17.07 percent in the rural sector [Government of Pakistan (1983a), p. 6, p. 8]. Hence, the rate of literacy in Pakistan is lower than in any other South Asian country, and this may have prevented people from taking advantage of the high pay-off technology that is available in the country. The induced-innovative model of Hayami and Ruttan shows that the direction of technological change that a country follows is based on the economic environment that permeates throughout the system. Therefore, education will play a critical role in the adoption of modern technology in any future strategy of the development of agricultural sector in Pakistan.

V. CONCLUSIONS

This study shows that since the early 1960s, when heavy investments occurred in the development of tubewells and canal-water systems for irrigation, the agricultural development of Pakistan has been based on "high pay-off" low-cost technology centred around greater utilization of seeds and fertilizer. The consumption of fertilizer increased from 283.2 N/tons in 1970-71 to 1,43.71 N/tons in 1985-86. For the same periods, credit disbursed among farmers through institutional sources increased from Rs 158.38 million to Rs 11,174.00 million. Over 70 percent of this credit was allocated to the purchase of seeds and fertilizer. Seeds and fertilizer as a proxy variable for capital and labour are the best predicators of change in agricultural output. Since the number of observations on the basis of which these conclusions are drawn are limited, readers are cautioned to consider these results as first approximations.

Despite an increase in the use of seed-fertilizer technology, per hectare yield in Pakistan is lower relative to other LDCs in the region. It may, therefore, be concluded that seed-fertilizer technology, though highly desirable – and without which the "green revolution" would not have occurred, given the resources available for development in Pakistan – is not a sufficient condition for modernizing agriculture. Hence, it is time to seek additional inputs for improvement in productivity. It is strongly recommended that any strategy designed to increase productivity in the agricultural sector must include investment in human capital, particularly in primary and secondary education.

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