OPTIMAL ENROLLMENT AND COST EFFECTIVE EXPENDITURES FOR PUBLIC SCHOOL SYSTEM

January 1995

RESEARCH TEAM

Dr. Hafiz A. Pasha
Team Leader

Dr. M. Aynul Hasan

Muhammad Ejaz Rasheed

Nadeem Ahmed

Naveed Hanif

Syed Nasar-ul-Eman

Nooreen Mujahid

Zahid Hasnain

OUTLINE OF THE STUDY

LIST OF TABLES

ACRONYMS

GNP	Gross National Product
CIDA	Canadian International Development Agency
FLR	Female Literacy Ratio
PED	Public Education Development
E	Enrollment
T	Teachers
S	School
LDC	Less Developed Countries
UNESCO	United Nation Educational, Scientific & Cultural Organisations
RE	Recurring Expenditure
DE	Development Expenditure
w	Wage Rates
m	Unit Recurring
c	Construction Cost
Z	Socio-Economic Factors
PCI	Per Capita Income
OCL	Opportunity Cost of Labour
BPS	Basic Pay Scale
E*	Optimal Enrollment
E_M	Enrollment Male
E_F	Enrollment Female
C_M	Cost Incurred for Male School
C_F	Cost Incurred for Female School
TC	Total Cost
IWL	Iso Curve Welfare Line
'	Available Resources
T^*	Optimal Teachers
S^*	Optimal Schools
PPFE	Production Possibility Frontier for Enrollment

PR_m	Male Participation Rate
EPB	Enrollment Primary Boys
EPG	Enrollment Primary Girls
ESB	Enrollment Secondary Boys
ESG	Enrollment Secondary Girls
IWES	Iso-welfare Index for Secondary Enrollment
IWEP	Iso-welfare Index for Primary Enrollment
N	Non-Teaching Staff
OLS	Ordinary Least Squares
FATA	Federally Administered Tribal Areas
GDP	Gross Domestic Product
SAP	Social Action Programme
UNDP	United Nations Development Programme
EWF	Education Welfare Function

OPTIMAL ENROLLMENT AND COST EFFECTIVE EXPENDITURES FOR PUBLIC SCHOOL SYSTEM

EXECUTIVE SUMMARY

Traditionally economic growth is considered to be as a result of right quantity and combination of saving, investment and foreign aid, with surpluses from the primary commodity producing sectors being channelled into capital for further growth. This paradigm however, ignored the complementarity of socio-political influences on the physical variables in growth and development. Urquidi (1971) argued that social progress of a nation is a *necessary* condition for sustained economic growth. It is now increasingly evident that investments in the social sectors are as, if not more, important than investment into the commodity producing sectors or its related infrastructure.

Education also has implications on the social as well as other developments of society. Lockheed *et al* (1991, p.1) noted that:

> *(Education) improves productive capacity of societies and ..... It also helps reduce poverty by mitigating its effects on population, health, and nutrition and by increasing the value and efficiency of the labour offered by the poor. As economies worldwide are transformed ... education becomes even more significant.*

The growth experienced by countries like Singapore, Malaysia, Indonesia, South Korea, Hongkong, Taiwan is the result of investment into the social sectors, particularly education and is a testament to this paradigm. The emphasis has been at the primary school level as this makes the growing population 'literate and numerate' and creates a base for future human capital development of the society.

In order to improve the human capital asset governments in developing countries should allocate large sums of resources to the education sector. On average, in 1985, Europe and North America devoted 5.3 percent of GNP to public expenditure on education as opposed to only 3.1 percent by Asian countries (2.2 percent in Pakistan in 1993-94). Despite the fact that Pakistan spends a low amount of public expenditure as compared to other countries on education, it has been argued that the growth in enrollments do not conform with expenditures particularly at the primary level.

In 1992, a CIDA commissioned study found that in Pakistan between 1970 and 1992 for every percentage point increase in the growth of real public expenditures on education less than 0.6 percent growth in student enrollments was seen at the primary and secondary school levels. One, therefore, asks: Has the money been channelled appropriately or used *cost-effectively* so that the desired quantity and quality of students are produced every year?.

The World Development Report (1991) noted:

> *Government must spend more, and more efficiently, on primary education, basic health care, nutrition, and family planning. That requires shifts in spending priorities; greater efficiency and better targeting of expenditure...*

Thus, in view of the above, the important policy issue that needs to be investigated pertains to the adoption of a *cost-effective* and *efficient* strategy by the *public education department* (*PED*) in the allocation of outlays on primary or secondary level education. In particular, is it possible to improve the student participation rates by reallocating limited resources; if an accelerated expanded education programme is undertaken, especially for primary female students [as proposed under the *Social Action Programme*], what implications will this have on the recurring budget outlays? This will be critical in terms of the long-run sustainability of such initiatives. It is to be noted that, in general, these programmes are introduced through development plans which normally do not take into consideration the ongoing recurring expenditure liabilities in terms of teacher's, salaries, books, blackboards, etc. Thus, in order to comprehend and address these crucial policy issues one, therefore, needs to analyse the problem of public education system within an optimization framework where the output [e.g., enrollment (*E*)] and input [teachers (*T*) and schools (*S*)] linkages are established consistent with the available limited funds.

The objective of this study is, therefore, to address policy issues with respect to the public school system in Pakistan. In particular, the study

- **a)** Develops an optimization model
- **b)** Examines the impact of public education policies on improving student participation rates, and the resulting policy issues pertaining to *efficiency gains*, and *optimal allocation* of inputs within and across different levels of education, and
- **c)** Identifies the requirements for recurring and development expenditures and makes policy recommendations for each level of schools in this regard

and restricts the development of the models to Punjab only owing to the insufficiency of disaggregated data for the other provinces.

The study initially compares the performance of Pakistan's public sector education sector with some countries in the region to establish the breakdown in the effectiveness of the system. The study finds that even though the economic performance of Pakistan has been better than most other countries, during the eighties, its social sectors have lagged far behind the others. A population growth rate of 3.1 percent, a female literacy rate of 22 percent and an enrollment rate of 42 percent by 1990 at the primary level were the lowest in the basket of countries which include Nepal, India and Bangladesh which have lower per capita incomes. Even in the context of inputs into the education sector, Pakistan has a poor performance. Its intake at the primary school level was only 77 percent compared to nearly 100 percent for the basket of countries; the expenditure on education was only 2.2 percent of GDP in 1990 compared to an average of about 4 percent for the others. Performance in female education was even poorer.

In setting up the optimisation model, the study starts with the premise by Lockheed and Verspoor that *developing countries ..... could significantly improve educational effectiveness by reallocating funds within the existing primary education budget* and extends this to include the other levels of schooling also. The study develops an optimisation model which identifies the optimal allocation of outputs (student enrollment) and inputs (teachers, schools, etc.), examines the impact of public education policies on improving student participation rates, and the resulting policy issues pertaining to

efficiency gains, *optimal allocation* of inputs within and across different levels of education (e.g., primary and secondary or boys and girls) and the impact of government prescribed wage policies. In addition, the study also develops a joint enrollment (e.g., boys and girls) production model wherein the social welfare index of the enrollments is maximized subject to production possibility frontiers for enrollments.

The model assumes that the education departments maximise the total enrollments given total available funds between teachers' salaries (recurring expenditure) and construction of new schools (development expenditure). In addition, the production function of enrollments is assumed to depend on the number of teachers, schools and other socio-economic factors *such as* female literacy rate, per capita income, opportunity cost of labour, etc. These socio-economic variables are expected to capture the demand side effects in the production of enrollment. That is all things being equal, a higher female literacy ratio or per capita income may induce a greater desire on the part of the parents to send their offsprings to schools as they are more enlightened or are wealthier while a higher opportunity cost of labour may result in a lower desire for enrollment. Moreover, the model assumes that the supply of teachers is perfectly elastic. In other words, the assumption is that as a result of the surplus availability of teachers results in the education departments being able to hire unlimited numbers within the budget constraint at the wages prescribed by government.

The results of the production function (estimated for the Punjab only), for all schools irrespective of gender, suggest that the role of schools is more dominant than other inputs, namely, teaching and non-teaching staff, and that, in the context of male primary schools, the role of teachers may even be as significant as the availability of schools. The results also verify the hypothesis that an increase the literacy of mothers increases the enrollment of children, and that an increase in the opportunity cost of labour results in a decline in enrollments. The hypothesis that an increase in teachers' wages will lead to an improvement in enrollments is also supported by the estimated production function. It would appear that the policy of investment into improving the availability of schools has been *technically efficient*. the optimisation model results are used to answer the question of *allocative efficiency*.

The model suggest that *efficiency* and *cost effectiveness* in the Punjab could have been achieved, for instance in the baseline year of 1991-92 by

- constructing 9 percent more girls' primary schools
- employing 13 percent fewer teachers in them
- constructing 3 percent fewer primary schools for boys, and
- employing about 20 percent more teachers for these schools,

thus resulting in an *efficiency gain* (higher enrollment) of 15 percent in the boys' primary schools and 5 percent in the girls' primary schools.

Using two optimisation strategies, one, *normal*, and two, *constrained*. The latter assumes that resources are transferred to female education once the target of 110 percent is achieved for boys' primary school enrollment. In other words, subsequent expansion in the public sector boys' schooling system will only be for meeting additional needs in response to population growth.

The results suggest that the future mix of expenditure compared to baseline would be as follows:

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL PRIMARY EDUCATION EXPENDITURE	100.0%	100.0%	100.0%	100.0%
NORMAL OPTIMISATION				
MALE PRIMARY SCHOOLS				
Recurring Expenditure	97.8%	99.8%	90.6%	84.7%
Development Expenditure	2.2%	0.2%	9.4%	15.3%
FEMALE PRIMARY SCHOOLS				
Recurring Expenditure	95.6%	99.7%	92.5%	81.1%
Development Expenditure	4.4%	0.3%	7.5%	18.9%
CONSTRAINED OPTIMISATION				
MALE PRIMARY SCHOOLS				
Recurring Expenditure	97.8%	99.8%	90.6%	94.4%
Development Expenditure	2.2%	0.2%	9.4%	5.6%
FEMALE PRIMARY SCHOOLS				
Recurring Expenditure	95.6%	99.7%	92.5%	72.2%
Development Expenditure	4.4%	0.3%	7.5%	27.8%

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Earlier *Neoclassical, Classical* or *Structuralist* [due to Rostow (1960)] theories focused on economic growth primarily because of the right quantity and combination of saving, investment and foreign aid. Surpluses from the agriculture sector in third world countries are expected to be channelled into capital for further growth. Accordingly, the main constraint in these models of growth has been the relatively low level of capital formation available. While the above paradigm has intuitive appeal, it, however, ignores the complementarity of social-political influences on the physical variables (i.e., capital, labour, etc.) in the analysis of growth and development. Urquidi (1971) argues that social progress of a nation is a *necessary* condition for sustained economic growth. It is now increasingly evident that the allocation of resources to the social sector - education, housing, changes in land tenure system, health, social security, better social relations - must be considered as economic investment that raise a nation's capacity to develop. Today, social and economic investments are, theoretically and materially, inseparable [e.g. Urquidi, (1971)].

Investment in human capital is now well-recognized. In recent years, societies with well developed and enriched human capital assets have been able to prosper and progress rapidly on a sustainable basis. Countries like Singapore, Malaysia, Indonesia, South Korea, Hongkong, Taiwan and many others in Asia can be cited as examples in this context. Some of these nations have achieved the middle or even developed country status within a short span of less than twenty-five years. In fact, some of these countries, namely, Singapore, Hongkong and Taiwan, have developed with no significant natural resources or big land masses to their credit. What is crucial and common in their impressive growth is the vital role of human capital endowments.

Education also has implications on the social as well as other developments of society. Lockheed *et al* (1991, p.1) noted that:

> *(Education) improves productive capacity of societies and their political... and scientific institutions. It also helps reduce poverty by mitigating its effects on population, health, and nutrition and by increasing the value and efficiency of the labour offered by the poor. As economies worldwide are transformed by technological advances and new methods of production that depend on a well-trained and intellectually flexible labour force, education becomes even more significant.*

Emphasis on education is at the primary school level as primary education enhances the '*cognitive skills*' in the sense that it makes the growing population 'literate and numerate' and enables them to deal with the problems at home and at the work place. Furthermore, and, more importantly, it also creates a base for future human capital development of the society. Therefore, the focus of education should be on improving both its quantity and quality to benefit the population at large.

In order to achieve these objectives the governments in developing countries should allocate large sums of resources to the education sector. On average, in 1985, Europe and North America devoted 5.3% of GNP to public expenditure on education as opposed to only 3.1% by Asian countries. In case of Pakistan, the share is even lower at about 2.2% [Economic Survey (1993-94)] in 1993-94. Despite the fact that Pakistan spends a low amount of public expenditure as compared to other countries on education, it has been argued that the growth in enrollments do not conform with expenditures particularly at the primary level.

For instance, based on an earlier *Canadian International Development Agency* (CIDA) commissioned study (1992), it was found that, in the last two decades (1970-92), for every

percentage point increase in the growth of real public expenditures on education produced only less than 0.6 percent growth in student enrollments at the primary and secondary school levels. This raises a fundamental question as to whether the money allocated for primary education or secondary schools, although quite small, had been channelled appropriately or used *cost-effectively* so that the desired quantity and quality of students are produced every year. It is possible that the additional money spent on improving the quality of teachers, more books, blackboards, etc., rather than on constructing more schools will contribute more to increasing enrollments. Alternatively, the size of enrollments may be demand constrained: more literate mothers [measured by female literacy ratio (FLR)] can motivate their progenies; and higher per-capita income enables them to take more education.

It is true that greater provision of resources for human development is necessary for the sustainable growth of the country but, in this context, the World Development Report (1991) noted:

> *When economies are badly managed, investment in people may go waste... . Government must spend more, and more efficiently, on primary education, basic health care, nutrition, and family planning. That requires shifts in spending priorities; greater efficiency and better targeting of expenditure...*

Thus, in view of the above, the important policy issue that needs to be investigated pertains to the adoption of a *cost-effective* and *efficient* strategy by the *public education department* (*PED*) in the allocation of outlays on primary or secondary level education. In particular, is it possible to improve the student participation rates by reallocating limited resources from school construction programmes to hiring more teachers or diverting funds from boys schools to girls schools? Furthermore, if an accelerated expanded education programme is undertaken, especially for primary female students [as proposed under the *Social Action Programme*], what implications will

this have on the recurring budget outlays? This will be critical in terms of the long-run sustainability of such initiatives. It is to be noted that, in general, these programmes are introduced through development plans which normally do take into consideration the ongoing recurring expenditure liabilities in terms of teacher's, salaries, books, blackboards, etc. Thus, in order to comprehend and address these crucial policy issues one, therefore, needs to analyse the problem of public education system within an optimization framework where the output [e.g., enrollment (E)] and input [teachers (T) and schools (S)] linkages are established consistent with the available limited funds.

The objective of this study is, therefore, to address policy issues with respect to the public school system in Pakistan. In particular, the study

a) Develops an optimization model for the public school system (for both boys and girls) at the primary and secondary levels with a view to identify a *cost-effective* optimal allocation of outputs (student enrollments and participation rates) and inputs (teachers, schools, etc.).

b) Examines the impact of public education policies on improving student participation rates, and the resulting policy issues pertaining to *efficiency gains*, *optimal allocation* of inputs within and across different levels of education (e.g., primary and secondary or boys and girls) and the impact of government prescribed wage policies; and

c) Identifies the requirements for recurring and development expenditures and makes policy recommendations for each level of schools in this regard.

The organisation of rest of the study is as follows. In order to get a broad perspective as to Pakistan's standing in terms of education and other socioeconomic indicators, Chapter 2 provides

an international comparison in this context. The private sector and trust schools, particularly in big cities, also provide education facilities. Thus, to get some insight into the salary structure of these schools and to compare with the public sector institutions, Chapter 3 reports results of a sample survey based on a few selected schools in the cities of Karachi and Lahore. Chapter 4 develops the optimization model for the public school system and derives theoretical propositions which have implications for education policies. Optimal profiles of education inputs (teachers), outputs (enrollments and enrollment ratios), efficiency gains, expenditure requirements (both recurring and development) are presented in Chapter 5. Chapter 6 provides summary policy recommendations of the study. Appendix A presents the detailed analytical derivation of the optimization model. Appendix B delineates the sources, definitions, clarification and any anomalies encountered during data collection while Appendix C includes tables containing results on expenditure requirements, both actual and optimal.

CHAPTER TWO

AN INTERNATIONAL COMPARISON OF EDUCATION AND OTHER SOCIO ECONOMIC INDICATORS

2.1 INTRODUCTION

As indicated earlier, the "human capital endowment" of a nation plays a pivotal role in the growth and development of the country. More significantly, acting as a complement with physical capital and natural resources, human capital provides long-term sustainability in economic and social development. This human capital development, in turn, demands a world where no human being is denied of basic health care and, more importantly, no child is deprived of elementary primary education.

Although it is undeniable that major reforms within the Third World Education system, at large, are long overdue, from the point of view of getting a deeper insight and, at the same time, evaluating the status of Pakistan's standing in human capital development, an international comparison in relation to other selected Third World countries in the region is undertaken in this chapter.

2.2 POPULATION, PER CAPITA GNP AND LITERACY RATE

Despite an impressive economic growth of over 6.5 percent per annum, the performance in the social indicators of Pakistan has been inadequate. In relation to eleven other comparable countries considered in Table 2.1, Pakistan's population growth rate has been the highest at 2.9 percent. The other most discouraging social indicator has been the literacy rate, particularly for females which stood at a meagre 22 percent in 1992. Although Pakistan's overall literacy rate has increased from 21 percent to 36 percent in the last two decades, it is still one of the lowest next to Nepal as shown in Table 2.2. Even the first grade intake rate (77%) is the lowest among the

TABLE 2.1

SOCIO ECONOMIC INDICATORS FOR SELECTED COUNTRIES: AN INTERNATIONAL COMPARISON

COUNTRIES	GNP PER CAPITA (US$)	REAL GDP PER CAPITA (PPP $)	TOTAL GNP GROWTH RATE (%)	PEOPLE IN ABSOLUTE POVERTY %			ESTIMATED POPULATION (million)		POPULATION GROWTH RATE %	RURAL POPULATION AS % OF TOTAL
				TOTAL	RURAL	URBAN				
	1991	1991	1980-91	1980-90	1980-90	1980-90	1960	1992	1960-1992	1992
PAKISTAN	**400**	**1970**	**6.5**	**28**	**29**	**26**	**50**	**124.9**	**2.9**	**67**
BANGLADESH	220	1160	4.2	78	86	n.a	51.4	119.5	2.7	82
CHINA	370	2946	9.4	9	13	n.a	657.5	1187.4	1.9	72
EGYPT	610	3600	4.5	23	25	21	25.9	54.9	2.4	56
INDIA	330	1150	5.5	40	42	33	442.3	880.1	2.2	74
INDONESIA	610	2730	5.8	25	27	20	96.2	191.2	2.2	70
MALAYSIA	2520	7400	5.6	16	22	8	8.1	18.8	2.6	55
NEPAL	180	1130	4.7	60	61	51	9.4	20.6	2.5	88
NIGERIA	350	1360	1.4	40	51	21	42.3	115.9	2.7	63
PHILIPPINES	740	2440	1.2	54	64	40	27.6	65.2	2.7	56
SINGAPORE	14140	14734	7.1	n.a	n.a	n.a	1.6	2.8	1.7	0
SRILANKA	500	2650	4.0	39	46	15	9.9	17.7	1.8	78

n.a not available

Source: Human Development Report 1994.

TABLE 2.2

LITERACY TRENDS AND ENROLLMENT RATIOS: AN INTERNATIONAL COMPARISON

COUNTRIES	ADULT LITERACY RATE				ENROLLMENT RATIOS					SECONDARY TECHNICAL
		(%)			FOR ALL LEVELS		PRIMARY	SECONDARY	TERTIARY	ENROLLMENT AS % OF
	TOTAL	TOTAL	FEMALE	MALE	(% AGE 6-23)		(GROSS)	(GROSS)	(GROSS)	TOTAL SECONDARY
	1970	1992	1992	1992	1980	1990	1990	1990	1990	1988-91
PAKISTAN	**21**	**36**	**22**	**49**	**19**	**24**	**42**	**21**	**2.6**	**1.6**
BANGLADESH	24	37	23	49	30	32	77	19	3.4	0.7
CHINA	n.a	n.a	68	92	50	53	125	48	1.7	9.1
EGYPT	35	50	35	66	51	66	101	81	18.4	20.9
INDIA	34	50	35	64	40	50	99	44	n.a	1.6
INDONESIA	54	84	77	91	51	58	117	45	9.2	12
MALAYSIA	60	80	72	89	54	58	93	56	7.2	2.2
NEPAL	13	27	14	39	28	41	82	30	5	n.a
NIGERIA	25	52	41	63	50	37	72	20	3.5	3.9
PHILIPPINES	83	90	90	90	61	64	112	73	24.4	n.a
SINGAPORE	n.a	n.a	n.a	n.a	53	68	108	70	n.a	n.a
SRILANKA	77	89	85	94	58	68	107	74	5.2	n.a

n.a not available

Source: Human Development Report 1994.

TABLE 2.3
EDUCATION INPUTS
AN INTERNATIONAL COMPARISON

COUTRIES	FIRST GRADE INTAKE RATE (%)	COMPLETING PRIMARY LEVEL AS % OF FIRST GRADE ENTRANTS	MEAN YEARS OF SCHOOLING (25+)			PUPIL TEACHER RATIO	
			TOTAL	MALE	FEMALE	PRIMARY	SECONDARY
	1990	1990	1992	1992	1992	1990	1990
PAKISTAN	**77**	**48**	**1.9**	**0.7**	**2.9**	**43**	**19**
BANGLADESH	98	47	2	0.9	3.1	63	27
CHINA	100	85	5	3.8	6.3	22	15
EGYPT	87	n.a	3	1.7	4.2	24	18
INDIA	n.a	62	2.4	1.2	3.5	47	n.a
INDONESIA	100	77	4.1	3.1	5.3	23	13
MALAYSIA	88	96	5.6	5.2	5.9	20	19
NEPAL	n.a	n.a	2.1	1	3.2	37	29
NIGERIA	n.a	58	1.2	0.5	1.7	39	22
PHILIPPINES	100	70	7.6	7.2	8	33	33
SINGAPORE	n.a	100	4	3.2	4.8	26	n.a
SRILANKA	99	97	7.2	6.3	8	29	n.a

n.a not available

Source: Human Development Report 1994.

countries considered for the analysis.

Contrary to this, countries like Nigeria and Bangladesh, with a significantly lower per capita GNP than Pakistan, have a much higher female and overall literacy rate and first grade intake rates as reported in Tables 2.2-2.3, respectively. This indicates that there are many countries with low per capita income but higher human development indicators than Pakistan.

As the data suggests, the importance of education has not been recognized as a priority sector by the policy makers in Pakistan. There has always been a lot of rhetoric, but no concrete effort in the shape of public spending, when, in order to compete in a fast changing global economy, every country has to invest heavily in the education, training and skill formation of its people.

2.3 GOVERNMENT EXPENDITURES

Until very recently, Pakistan's education expenditures, as a percentage of GNP, have been consistently below the average than other Third World countries. In most of the less developed nations, there has been tremendous acceleration in their public expenditures on education during the last two decades. Both the proportion of national income and national budgets spent on education have increased. In this context, Todaro (1985, p. 328) noted that "by the early 1980s educational budgets in many Third World nations were absorbing between 20-35 percent of total government's recurrent expenditures".

As far as Pakistan is concerned, throughout the 1950s and 1960s, the total spending on education was below two percent, and in the 1970s and 1980s, it was barely above two percent of the GNP, as shown in Table 2.4. It is ironical that, although expenditure on total education as a percentage of GNP in Pakistan is lower than many of the LDCs, when a comparison is made with respect to

TABLE 2.4

EXPENDITURE PATTERN FOR EDUCATION AND DEFENCE SERVICES: AN INTERNATIONAL COMPARISON

COUNTRIES	PUBLIC EXPENDITURE ON				RATIO OF CURRENT EXPENDITURE PER TERTIARY STUDENT TO GNP PER CAPITA	MILITARY EXPENDITURE AS % OF GROSS DOMESTIC PRODUCT		MILITARY EXPENDITURE % OF COMBINED EDUCATION AND HEALTH EXPENDITURE		ARMED FORCES PER TEACHER
	EDUCATION AS % OF GROSS NATIONAL PRODUCT		PRIMARY & SECONDARY EDUCATION AS % OF ALL LEVELS	HIGHER EDUCATION AS % OF ALL LEVELS						
	1960	1990	1990	1990	1990	1960	1990-91	1960	1990-91	1990
PAKISTAN	1.1	•2.2	78	18	1.6	5.5	6.5	393	125	1.5
BANGLADESH	0.6	2.0	88	9	0.4	n.a	1.4	n.a	41	0.3
CHINA	1.8	2 3	67	19	1.9	12.0	5.0	387	114	0.4
EGYPT	4.1	6.7	70	30	0.8	5.5	4.0	117	52	0.9
INDIA	2.3	3.5	71	17	0.8	1.9	3.1	68	65	0.3
INDONESIA	2.5	n.a	n.a	n.a	n.a	5.8	1.7	207	49	0.1
MALAYSIA	2.9	6.9	76	15	12	1.9	3.1	48	38	0.7
NEPAL	0.4	n.a	n.a	n.a	n.a	0.4	1.6	67	35	0.4
NIGERIA	1.5	n.a	n.a	n.a	n.a	0.2	0.9	11	33	0.2
PHILIPPINES	2.3	2.9	73	15	0.1	1.2	1.6	44	41	0.3
SINGAPORE	2.8	3.4	65	31	0.6	0.4	5.8	11	129	2.9
SRILANKA	3.8	2 7	84	13	0.5	1.0	4.8	17	107	0.4

****** ***Statistical Supplement 1993-94***

n.a not available

Source: Human Development Report 1994.

TABLE 2.5

INEQUITY AND IMBALANCE IN EDUCATION SECTOR
AN INTERNATIONAL COMPARISON

COUNTRIES	SCIENTISTS & TECHNICIANS PER (1000) PEOPLE	R & D SCIENTISTS & TECHNICIANS PER (1000) PEOPLE	TERTIARY STUDENTS ABROAD AS % OF THOSE AT HOME
	1986-91	1986-89	1987-88
PAKISTAN	**4**	**1.5**	**9**
BANGLADESH	0.5	n.a	1
CHINA	8.1	n.a	3
EGYPT	n.a	6	2
INDIA	3.5	2.5	1
INDONESIA	12.1	n.a	2
MALAYSIA	n.a	4	38
NEPAL	0.5	n.a	2
NIGERIA	1	0.7	7
PHILIPPINES	n.a	1.3	0
SINGAPORE	22.9	18.7	25
SRILANKA	n.a	2.2	6

n.a not available

Source: Human Development Report 1994.

expenditure on higher education as a percentage of GNP, Pakistan seems to be spending more than many of these countries (e.g., Bangladesh, Malaysia, India, Sri Lanka and Philippines) as shown in Table 2.4. What this implies is that Pakistan, in relation to other LDCs, seems to place a greater priority on higher education. The importance and vital role of higher education (e.g., scientists, doctors, engineers, etc.,) for the nation cannot be disputed, however, the fact remains that the beneficiaries of such education will be those who can afford it and have the necessary basic education to qualify. In a poor country with a highly skewed distribution of income such as Pakistan's, it is, therefore, likely that the significant beneficiaries of higher education will be those at the upper echelon of the income distribution while the lower income class of the society may remain deprived.

It is also important to note that Pakistan not only spends more on higher education but, in relation to other neighbouring LDCs, many of her graduates with tertiary degrees leave the country. Of the one hundred students receiving tertiary degrees in Pakistan, nine of them go abroad for further education as opposed to only one each in India and Bangladesh, two each in Egypt and Nepal and six in Sri Lanka, as shown in Table 2.5. Leaving aside the equity consideration, if all these graduates, after acquiring more advance qualification and training from abroad, were to return home, it would be a net gain to the society at large. However, what is critical and a disturbing fact is that many of these graduates do not return to their country of origin.

As a consequence, the society as a whole that is spending relatively more of its scarce resources on higher education, in addition to creating equity problems, may also tend to lose on account of "brain drain".

Despite a greater emphasis on education due to the recently initiated *Social Action Plan*, Pakistan

TABLE 2.6

WOMEN PROFILE IN EDUCATION SECTOR: AN INTERNATIONAL COMPARISON

COUNTRIES	LITERACY RATE % OF AGE (15-24)	ENROLLMENT RATIOS			TERTIARY NATURAL & APPLIED SCIENCE ENROLLMENT AS % OF FEMALE TERTIARY	PARLIAMENT % OF SEATS OCCUPIED BY WOMEN	ILLITERATE FEMALES (15+) m
		PRIMARY (GROSS)	SECONDARY (GROSS)	TERTIARY (GROSS)			
	1980-90	1990	1990	1990	1990-91	1992	1992
PAKISTAN	**25**	**30**	**13**	**1.5**	**41**	**1**	**24.7**
BANGLADESH	27	71	12	1.1	24	10	24.8
CHINA	82	120	42	1.1	n.a	21	130.5
EGYPT	38	93	73	12.6	18	2	10.2
INDIA	40	84	32	n.a	25	7	169.3
INDONESIA	82	114	41	n.a	21	12	13.7
MALAYSIA	83	93	58	6.8	16	8	1.6
NEPAL	15	54	17	2.4	n.a	3	4.7
NIGERIA	n.a	63	17	1.9	n.a	2	17.2
PHILIPPINES	92	111	75	n.a	n.a	11	1.8
SINGAPORE	96	107	71	n.a	n.a	4	n.a
SRILANKA	90	105	77	4.1	26	5	0.9

n.a not available

Source: Human Development Report 1994.

TABLE 2.7

GENDER IMBALANCE IN EDUCATION: AN INTERNATIONAL COMPARISON

COUNTRIES	LITERACY		YEARS OF SCHOOLING	PRIMARY ENROLLMENT		SECONDARY ENROLLMENT	TERTIARY ENROLLMENT
	1970	1992	1992	1960	1990	1990	1990
PAKISTAN	**37**	**45**	**23**	**28**	**n.a**	**45**	**41**
BANGLADESH	33	47	29	39	86	46	19
CHINA	n.a	74	60	n.a	94	78	48
EGYPT	40	54	41	65	n.a	82	52
INDIA	43	55	34	50	n.a	57	n.a
INDONESIA	64	85	58	67	96	84	n.a
MALAYSIA	68	80	89	77	n.a	107	89
NEPAL	13	34	31	5	51	40	32
NIGERIA	40	65	28	59	n.a	74	37
PHILIPPINES	96	100	90	95	100	106	n.a
SINGAPORE	60	n.a	66	93	100	103	n.a
SRILANKA	81	90	79	90	n.a	108	65

n.a not available

Source: Human Development Report 1994.

**** Female As A Percentage Of Males.***

is still spending much less than 4% of its GNP on education, the figure recommended by UNESCO for all developing countries. On the other hand, the defence expenditures are far ahead and they have not only increased from 1960-1991 but, in fact, were the highest in 1990-91 (6.5%) if we were to compare with other countries as shown in Table 2.4. In simple terms, it is not the level of income alone that matters - it is also how this income is utilized. Given limited resources, a society will have to choose and allocate prudently among different activities (be it defence, education, health, etc.,) that it deems important and appropriate for its masses. In this context, it would be unwise to suggest a complete decline in defence expenditures due to the present geo-political conditions in the region but there must always be a balance that society needs to follow. Since there seems to be a strong correlation between investment in education and economic growth, in the absence of reasonable distribution of resources and implementation of efficient public policy for education, economic growth may fail to translate into improvements in human lives.

2.4 ENROLLMENT AND DROP-OUT COMPARISON

From 1960 to 1985, the total number of persons enrolled in the three main levels of education in Africa, Asia, the Middle East and Latin America rose from 163 million to 455 million, an average increase of 5% per annum [Todaro (1985, p.328)]. The African countries lagged behind at all levels. As far as Pakistan was concerned, although there seemed to be an increase in enrollment from 1960-1990, the primary gross enrollment ratio for all levels (e.g., between ages 6-23) was the lowest (only 24%) among the countries shown in Table 2.2.

When the profile for female education is compared, the situation is even worse. For example, in Table 2.6, we find that enrollment ratios for females in Pakistan at the primary, secondary and

tertiary levels are only 30%, 13% and 1.5%, respectively. In addition, the overall female literacy rate stands at a mere 25 percent and only 1 percent of the seats in the parliament are occupied by the female population. All these statistics are the lowest in the region. What this amounts to is that Pakistan's standing, in general, for education indicators, is not only inadequate but the imbalance in terms of gender is even more acute.

Another rather serious educational problem of developing nations is the very high percentage of students who drop out before completing a particular cycle. The drop-out problem is more serious mainly because of poverty and ignorance. This situation is reflected in Table 2.3 which ranks Pakistan as the second lowest country among those whose students complete primary level. There are actually more mouths to be fed relative to the income earners. Hence, as soon as the young ones are capable to fight for themselves they are asked to earn, rather than involve themselves in the so-called "unproductive work of learning".

CHAPTER 3

RESULTS OF FIELD SURVEY ON COST COMPOSITION OF INPUT AND OUTPUT FACILITIES OF PRIVATE SCHOOLS

3.1 INTRODUCTION

The objective of the field survey was to gain information on the level and composition of costs and output of schools in the private sector. This information could then be used as a basis for comparison with government schools and would enable us to gauge the level of efficiency of the government in providing education.

Section 3.2 discusses the design and setup of the field survey, Section 3.3 describes the level and composition of costs and output facilities, while section 3.4 analyzes the data obtained and presents conclusions.

3.2 DESIGN AND SETUP OF DATA COLLECTION

The field survey was limited to the urban sector, specifically Karachi and Lahore, and was conducted on schools located in the lower-middle-class areas of these two cities. It was felt that schools in the lower-middle-class areas would be comparable in quality to the average government school.

A total of twenty-four schools were surveyed, with seventeen of these from Karachi and seven in Lahore. Data was gathered in the following categories: type of school (primary, middle, secondary); nature of ownership and management (private or trust); number of teaching staff; levels of enrollment; tuition fees; expenditures on salaries of teaching and non-teaching staff; expenditures on rent, supplies and other items.

3.3 LEVEL AND COMPOSITION OF COSTS AND OUTPUT FACILITIES

The table below provides a comparison of government and sampled private schools. Due to the smallness of the sample size, it was not deemed feasible to differentiate the private schools by city or type of ownership. Therefore, data from the twenty-four sampled schools was aggregated to compute the wage rate of teachers and the student-teacher ratios. The average wage rate of teachers in the private sector was calculated by dividing the total wage bill of teachers by the total number of teachers employed. The student-teacher ratio was obtained by dividing the total enrollment in primary, middle, and secondary schools by the total number of teachers employed in these schools. The student-teacher ratio for the government is that for Punjab only. The wage rate for government teachers was obtained by dividing the recurring expenditures on salaries in the education sector by the total number of teachers employed. The wage rates for government teachers is the average of all the four provinces.

Before proceeding to the comparative analysis, the following points need to be made. First, the number of private schools sampled was very small and, therefore, it would not be reasonable to assume that the survey provided a complete picture of private school facilities in Karachi and Lahore. Second, the survey was limited to the two largest cities and, therefore, provides no information on private facilities in rural areas and smaller urban areas. Third, the data on government schools is not totally reliable.

3.4 ANALYSIS OF COST COMPOSITION AND OUTPUT FACILITIES

From the Table 3.1, it can be seen that government teachers enjoy substantially higher wages than

their counterparts in the private sector. The student-teacher ratios, which give a measure of the quality of education, are higher for government middle and secondary schools. This seems to indicate that government schools are not providing education of the same quality and that the government is considerably less efficient than the private sector in providing education. On the basis of this information, one could recommend a reduction in the salaries the government pays to its teachers.

TABLE 3.1

COMPARISON OF COSTS AND OUTPUT FACILITIES OF PUBLIC AND SAMPLED PRIVATE SCHOOLS

	WAGE RATE OF TEACHERS			STUDENTS PER TEACHER RATIO		
	Primary	Middle	Secondary	Primary	Middle	Secondary
PRIVATE	886	900	2075	31	23	25
GOVT	2310	3534	3653	47	33	-

*Rupees per month

It has to be said that this conclusion is, at most, tentative. Apart from the limitations in the survey mentioned above, the comparative analysis had another serious drawback. The wage rates

obtained for both the government and the sampled private schools are not a true indication of the yearly income of teachers. A majority of teachers in the private and public sector augment their incomes by giving private tuition to their students. This additional income is not captured in our data.

Our comparative analysis raises one important question. It appears that the wages paid to teachers, particularly to primary and middle teachers, are considerably below those given to semi-skilled and even unskilled workers. The question then is why would anyone wish to become a school teacher? In other words, one needs to know whether the labour market is operating rationally.

To answer this question one would need to conduct a survey to get a better picture of the incomes earned by teachers, both in the private and public sectors. An estimate would be needed for the additional income teachers obtain by giving private tuition. One would also need information on other career options open to teachers and their expectations of future earnings. Only with a more in-depth understanding of the market for teachers could one talk about reform in the educational system and give policy recommendations.

CHAPTER FOUR

A PUBLIC POLICY OPTIMIZATION MODEL FOR THE EDUCATION SECTOR

4.1 INTRODUCTION

On the issue of *cost effectiveness* and *efficient* allocation of public funds, Lockheed and Verspoor (1991), write:

> *Developing countries can progress toward these (social) goals only when available resources are allocated to the most cost-effective inputs...(and) countries could significantly improve educational effectiveness by reallocating funds within the existing primary education budget.*

A better understanding of *efficient* and *cost-effective* allocation of resources for the education system will be possible when this public policy problem is viewed within an optimization framework where the output [e.g., enrollment (E)] and input [teachers (T) and schools (S)] linkages are established consistent with the available limited funds.

This chapter is, therefore, devoted to developing a theoretical optimization model for the public school system with a view to identifying the optimal allocation of outputs (student enrollment) and inputs (teachers, schools, etc.). In addition, we also examine the impact of public education policies on improving student participation rates, and the resulting policy issues pertaining to *efficiency gains*, *optimal allocation* of inputs within and across different levels of education (e.g., primary and secondary or boys and girls)[1] and the impact of government prescribed wage policies. We also develop a joint enrollment (e.g., boys and girls) production model wherein the social welfare index of the enrollments is maximized subject to production possibility frontiers for enrollments. In this context, we suggested propositions in terms of improving enrollments for a

---

1 In this study, boys or girls, respectively, will be used as male or female interchangeably.

particular group whose participation rates are low.

4.2 THEORETICAL MODEL

The theoretical model for the public education system constructed in this chapter is based on the assumption that the provincial education departments (*PED*) maximize the total enrollments (E_l) of the *lth* level of school (e.g., primary or secondary) subject to available resources $\overline{C}$ [both recurring (*RE*) and development (*DE*) expenditures] allocated to them by the provincial government. Given institutionally fixed wage rates (w) for teachers (T) and unit recurring (m) and construction (c) costs for schools (S), *PED* is assumed to allocate the given total available funds $\overline{C}$ between teachers' salaries (referred to as *RE*) and construction of new schools (referred to as *DE*) in such a way that the total number of students enrolled each year at a particular level of school is maximum. Furthermore, the students enrolled in a given level of school or, more appropriately, the production function of enrollments is assumed to depend on the number of teachers, schools and other socio-economic factors (Z), namely, female literacy rate (*FLR*), per capita income (*PCI*), opportunity cost of labour (*OCL*), etc. These socio-economic variables are expected to capture the demand side effects in the production of enrollment. In other words, everything else being equal, a higher *FLR* or *PCI* may induce a greater desire on the part of the parents to send their offsprings to schools as they are now more enlightened or wealthier while a higher *OCL* may result in a lower desire for enrollment.

In addition, the supply of teachers is assumed to be perfectly elastic in the sense that due to surplus availability of teachers, they are willing to offer their services without much hesitation at the existing

fixed wage rates. Thus, *PED* can hire any number of teachers with average qualifications without necessarily paying them a salary over and above the present BPS. Incorporating the above assumptions, the optimization problem of *PED* then involves:

$$Max: \quad E = E(T, S, w, Z); \tag{1}$$

$$Subject\ to: \quad \overline{C} = wT + (c+m)[S - S_{-1}] \tag{2}$$

Applying the standard Lagrange technique to the above problem, we get the following three first-order conditions:

$$\partial E/\partial T - \lambda w = 0; \tag{3}$$

$$\partial E/\partial S - \lambda c = 0; \tag{4}$$

$$\overline{C} - wT + (c+m)[S - S_{-1}] = 0; \tag{5}$$

where λ is an undetermined multiplier. Solving Equations (3) to (5) simultaneously, we can derive the optimal values [represented by an asterisk (*)] for teachers (T^*) and schools (S^*) which will be dependent on exogenous factors of the model *viz:* w, c, S_{-1}, $\overline{C}$, Z and the estimated parameters. Optimal values for enrollments (E^*) can then simply be obtained by substituting T^* and S^* into Equation (1). Thus, the optimal time profile for E^*, T^* and S^* can be written as:

$$E^* = E^*(w, c, m, S_{-1}, \overline{C}, Z); \tag{6}$$

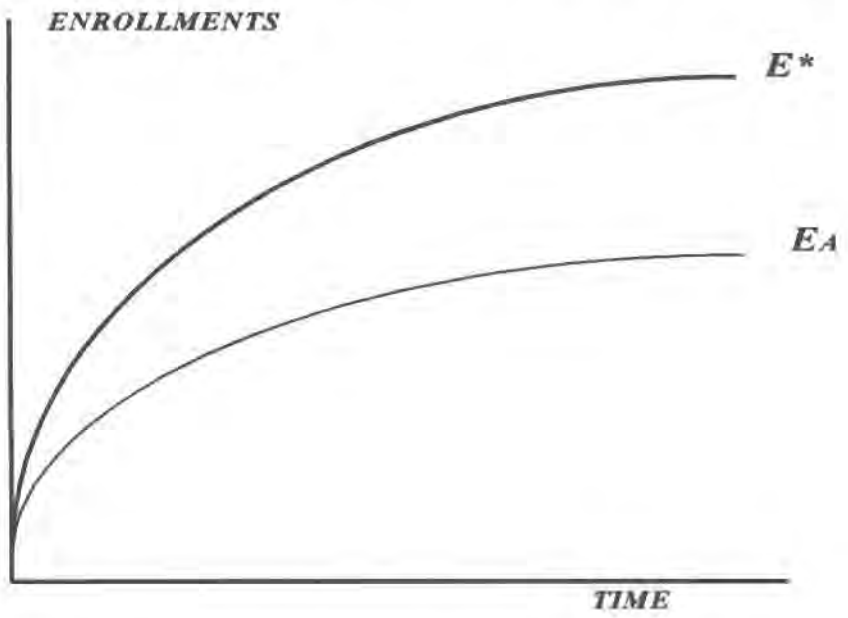
$$T^* = T^*(w, c, m, S_{-1}, \overline{C}, Z); \tag{7}$$

$$S^* = S^*(w, c, m, S_{-1}, \overline{C}, Z). \tag{8}$$

4.2.1 Enrollment Efficiency Gain/Loss

The above model will enable us to identify the extent of efficiency gain that may result in the production of enrollments by pursuing an optimal strategy as compared to the one adopted by *PED* in the past. This can be shown by simply comparing the actual historical observed time series for E_A with the optimal time profile of E^*. E^* may be simply imputed from observed historical values of all exogenous variables and the estimated parameter values of the enrollment production function. Historical time profiles for these two variables are shown in Figure 4.1.

FIGURE 4.1
ENROLLMENT EFFICIENCY GAINS DUE TO OPTIMAL ALLOCATION OF RESOURCES



In Figure 4.1, the time path represented by E_A is expected to lie below E^* for several reasons. Since the non-optimal *PED*, in the production of enrollments, does not allow for a consistent and consolidated approach in allocating their total available resources between *RE* and *DE*, it, therefore,

faces two separate sets of constraints: one for *RE* and the other for *DE*. Because of the additional constraint faced by the non-optimal *PED*, the allocation of resources between *T* and *S* is likely to be sub-optimal and, consequently, production of enrollments will be non-optimal as well.

The extent of possible inefficiency resulting from pursuing a non-optimal strategy by *PED* is simply the difference between time paths represented by E^* and E_A and that is denoted by the shaded area in Figure 4.1.

4.3 WAGE EFFICIENCY

In this section, we discuss the *efficiency* dimension of teachers' wages on enrollment. This is based on the premise that, although teachers' supply with respect to wages is highly elastic, in order to get better quality or effective teachers, some sort of attractive salary incentive has to be offered by *PED* to these superior teachers. Thus, the presence of a *wage* variable (w) in the enrollment production function [Equation (1)] acts as a proxy for the quality aspect of teachers reflecting *efficiency effect* of wages on enrollments. In terms of the production function, an increase in wages will shift the production function upwards. This implies that the higher wages will now attract better qualified teachers, with the same number of teachers imparting good quality education, thus improving enrollments as well.

Based on the above discussion and the model presented, we can analytically derive the possible conditions under which the flexible wage policy will have a positive *efficiency* effect on the optimal profile of enrollments (E^*). This can be done by first taking the total differential of Equations (3) - (5) and then re-writing it in compact matrix form as:

$$\begin{bmatrix} 1 & -\frac{\partial E}{\partial T} & -\frac{\partial E}{\partial S} \\ 0 & \left\{(c+m)\frac{\partial^2 E}{\partial T^2} - w\frac{\partial^2 E}{\partial S \partial T}\right\} & \left\{(c+m)\frac{\partial^2 E}{\partial S \partial T} - w\frac{\partial^2 E}{\partial S^2}\right\} \\ 0 & w & -(c+m) \end{bmatrix} \begin{bmatrix} dE \\ dT \\ dS \end{bmatrix} = \begin{bmatrix} \frac{\partial E}{\partial W} \\ \left\{-c\frac{\partial^2 E}{\partial T \partial W} + \frac{\partial E}{\partial S} + w\frac{\partial^2 E}{\partial S \partial W}\right\} \\ T \end{bmatrix} dW$$

$$+ \begin{bmatrix} \frac{\partial E}{\partial Z} \\ -c\frac{\partial^2 E}{\partial T \partial Z} + w\frac{\partial^2 E}{\partial S \partial Z} \\ 0 \end{bmatrix} dZ + \begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix} d\bar{C}$$

Applying Cramer's rule to the above system of differential equations, we get

$$\frac{dE}{dW} = \left[\frac{\partial E}{\partial W} - \frac{T}{c}\frac{\partial E}{\partial S}\right]$$

From Equations (3) and (4), $\partial E/\partial S = (c/w)\partial E/\partial T$, and if elasticities of enrollments with respect to wages and teachers are defined as $\xi_{EW} = (W/E)\partial E/\partial W$, *and* $\xi_{ET} = (T/E)\partial E/\partial T$, then the above equation can be re-written as:

$$\frac{dE}{dW} = \left[\xi_{EW} - \xi_{ET}\right] \bullet \frac{E^*}{W^*}$$

This leads us to make the following proposition regarding the impact of wage efficiency on enrollment

Proposition 1: ***A flexible wage policy will lead to efficiency gains in education enrollments provided the enrollment elasticities of wages exceed that of teachers.***

4.4 AN OPTIMIZATION MODEL FOR JOINT ENROLLMENT

A standard practice of the government involves allocating funds to each level of education (e.g., primary or secondary) separately. However, within a given level, say primary education, allocations for outlays are made from the same pool for male as well as female schools. In this context, one may contemplate that the *public education department* (PED) takes decisions in the production (or educating students) of enrollments for boys (E_m) and girls (E_f) ***jointly***. The basic optimization problem of *PED*, therefore, entails the maximization of an index of combined total enrollment (boys and girls) function (E) subject to the given level of funds ($\overline{TC}$) available to the government which is simply the sum of costs incurred for male (C_m) and female (C_f) schools[2]. Thus, for given teachers' wages (w), unit recurring (m) and development (c) costs and other exogenous (Z) and predetermined (S_{-1}) variables, the optimization problem can be written as:

$$\textit{Max:} \quad E = W(E_m, E_f); \tag{9}$$

$$\textit{Subject to:} \quad \overline{TC} = C_m + C_f; \tag{10}$$

$$\textit{where} \quad C_m = wT_m + (c+m)[S_m - S_{m-1}]; \tag{11}$$

$$C_f = wT_f + (c+m)[S_f - S_{f-1}]; \tag{12}$$

$$E_m = E_m(w, c, m, S_{m-1}, C_m, Z); \quad 0 \le C_m \le \overline{TC} \tag{13}$$

---

2 This combined index of enrollment function is labelled as an *iso-curve welfare line* (IWL) in this study.

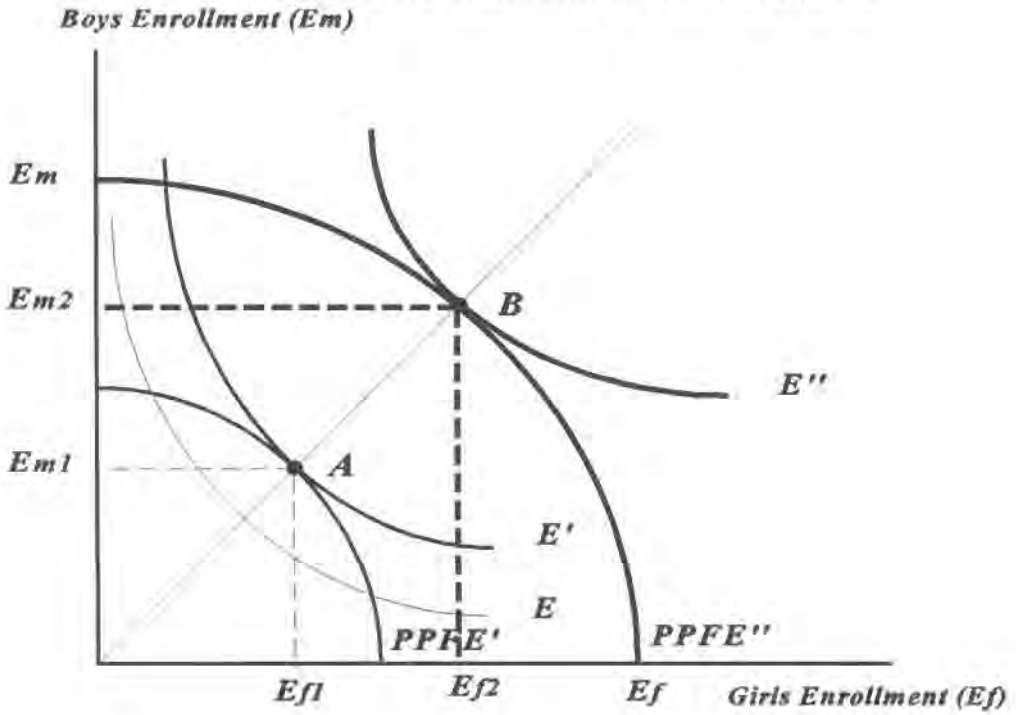
$$E_f = E_f(w, c, m, S_{f-1}, C_f, Z); \quad 0 \leq C_f \leq \overline{TC} \qquad (14)$$

In the above optimization problem, with given total available funds ($\overline{TC}$) and input prices, if *PED* were to devote all its budgeted resources towards male schools, then, with a given production technology represented by Equation (13), it can, at best, produce male enrollments up to $\overline{Em}$ as shown in Figure 4.2. On the other hand, if all resources are allocated to female education, then a maximum of $\overline{Ef}$ number of girl students may be produced by the public education system. However, if resources are devoted to both male and female education such that, at each point in time, all funds are exhausted, the public education system will then be able to produce both male and female students in different combinations. The locus of such different combinations of male and female students is termed as a *production possibility frontier for enrollment* (*PPFE'*) as shown in Figure 4.2. The particular shape of *PPFE'* (bow outside from the origin) is due to the assumptions that the enrollment production functions for boys and girls are well-behaved and that there are *increasing opportunity* costs involved in the production of one type of enrollment (say, boys) *versus* the other (girls). That is, given limited allocated funds, if resources are transferred from one activity (boys) to the other (girls), the enrollment for the girls will increase but at a diminishing rate. *PPFE'* can also move outward, such as at *PPFE''*, if only more funds are made available by *PED* to the *public school system*.

A discussion on the *production possibility frontier* so far has simply divulge the technical capabilities of the *public school system* in terms of producing varying proportions of male and female enrollment

with given budget and prices. However, in order to determine the optimal combination of the two types of enrollments (boys and girls) and the underlying *cost-effective efficient* inputs requirements (e.g., physical magnitude of teachers and schools), one needs to what is societies or in this case *PEDs* preference or *iso-social welfare function* for enrollments between boys and girls. Equation (9) represents such a preference function which shows the various combinations of male and female enrollments that a society (or *PED*) would prefer to have for a given total enrollment as shown by E in Figure 4.2.

FIGURE 4.2
JOINT ENROLLMENT OPTIMIZATION MODEL: A DIAGRAMATIC APPROACH



Obviously, for a given outlay of $\overline{TC}$ represented by a production possibility frontier for enrollment (*PPFE*) and the initial *iso-welfare function* E' equilibrium will be established at point such as A where

the societies preference for enrollment between boys and girls matches with what the *public education system* is capable of delivering with available funds. Thus at point *A* in Figure 4.2 equilibrium values of E_{m1} and E_{f1} are *optimal, efficient* and also *cost-effective*. With time as more resources will become available to *PED,* of course, the *public education system* will move to a higher *iso-welfare function E''* and a new equilibrium will be established at point *B*.

Having developed the standard optimization model for joint enrollment maximization, the next subsection analyses a constrained optimization wherein the boys school participation rate is constrained.

4.4.1 Efficiency Gains Under Constrained Optimization

In this section, we will analyse the impact of additional resources on enrollments for male and female students when the boys school participation rate (PR_m) or enrollment ratio[3] (e.g., male) is close to the maximum possible level (i.e., 100 percent enrollment ratio). More specifically, at a given point in time, if primary boys enrollment ratio (E_m) is very high and also substantially greater than that of the girls and if additional resources are allotted (say for the construction of male schools), we will examine the type of impact or *efficiency gains/losses* that may occur in terms of higher enrollments for boys or girls or the total enrollment of the primary school system due to this action. Furthermore, by reallocating resources - under the constrained optimization - from male to female schools, we will analyse if it is possible to enhance *efficiency gains* in the system.

---

3 School participation rate (PR_m) is defined as the percentage of students enrolled in a given level of education (say primary) in relation to the population of that relevant age group (e.g., 5 to 9 years for primary level). It should be noted that, in this chapter, participation rate and enrollment ratio will be used interchangeably.

In order to examine the above public policy problem, we consider the joint enrollment optimization model developed in the previous section [represented by Equations (9)-(14)] and introduce an additional constraint namely that the male student participation rate is at the stipulated maximum level of $\overline{PRm}$. That is:

$$\overline{PRm} = E_m/P \qquad (15)$$

where P is the total population of the relevant age group (e.g., 5-9 years for primary level).

The above optimization problem can also be illustrated with the help of a similar diagram (Figure 4.2), developed in the previous section, however, now with an additional contraint imposed by the physical maximum possible male student participation rate given in Equation (15). For pedagogical reason, if we assume the size of the population for the relavant male age group to be constant[4] then the new constraint will render a horizontal line at $\overline{Em}$ as shown in Figure 4.3. It is important to note that due to new constraint, the dotted portions on production possibility frontiers for enrollment *PPFE* (e.g., $E_m'A$) and *PPFE'* (e.g., $E_m''C$) are no longer available to the society as at points *A* and *C*, *public education system* has attained the desired 100 percent participation rate for male students.

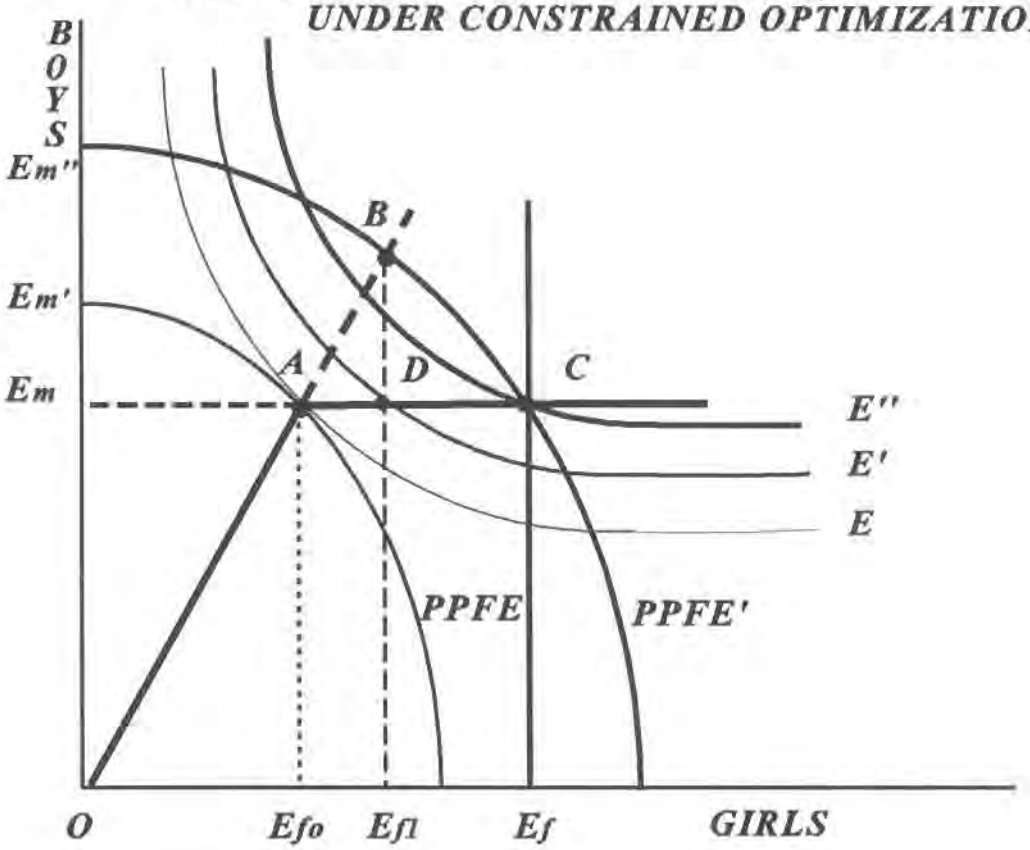
Incorporating these conditions and for a given initial outlay $\overline{TC}$ represented by a production possibility frontier for enrollment (*PPFE*), a point such as *A* on *PPFE* will be *optimal* as well

---

4 Relaxing this assumption is not going to change the analysis and the direction of the final results. Incorporating a growing population for the relevant age group is only going to make the participation rate contraint upward sloping instead of horizontal as shown in Figure 4.3. In fact, in the application of this model in Chapter 5, we did consider the actual growth of population for the relevant age group as reported in various census reports.

as *efficient* as this combination will be consistent not only with available resources but also with the existing prices of inputs (such as wages for teachers, unit construction cost for school) and the growth pattern of other exogenous factors (*Z*).

FIGURE 4.3
EFFICIENCY GAINS FOR JOINT ENROLLMENT MODEL UNDER CONSTRAINED OPTIMIZATION



Starting at a point such as *A* in Figure 4.3 where the enrollment target for male students ($\overline{Em}$) has already been achieved, if, over time, more resources are made available to *PED* to attain a point such as *B* on *PPFE'*, it will only frustrate *PED's* effort in this regard. The current allocation practice of *PED* in favour of constructing more schools for boys will simply create an *excess capacity* or *loss of efficiency* in male schools (e.g., in the amount of BE_{f1} - DE_{f1} in Figure 4.3) as this will not increase

the actual enrollment for boys [as the maximum ($\overline{Em}$) has already been achieved] while the girls enrollment will still remain at E_{fl}. Thus, although this policy of more emphasis on boys' schools by *PED* will achieve, at best, a new equilibrium at point *D* as shown in Figure 4.2, it will neither be *efficient* nor *optimal*. In this situation, however, if resources are reallocated and diverted towards the construction of female schools where the maximum enrollment target has still not been reached, *PED* can then attain a point such as *C* which will be *cost-effective, optimal* and possibly achieve the target enrollment for females ($\overline{Ef}$) as well. The extent of *efficiency gains*, in this context, measured in terms of female enrollment can be as high as $O\overline{Ef} - OE_{fl}$.[5] Thus, this leads us to make our second proposition that:

Proposition 2: ***Additional allocation of resources towards boys' schools will only lead to a creation of excess capacity in those schools with no appreciable increment in enrollment for girls if the educational system has already achieved a higher participation rate for boys. However, in this context, enrollments for girls can be improved if excess resources from boys' schools are diverted and allocated towards girls' education in a cost-efficient manner.***

In summary, the broad conclusions of this are:

a) Given limited funds available to the *Public Education Department* (PED), a *cost-effective* allocation of resources in the public school system may produce student enrollments for education that will be *optimal* and *efficient*.

---

5 It should be noted that point *C* in Figure 3.2, may also represent an equilibrium which can be termed as *optimum-optimorum* in the economic jargon. This is so, because it is not only on the *production possibility frontier of enrollment* but it is also tangent to the societies welfare preference function (in terms of enrollments for boys and girls) as represented by *W* in Figure 3.2. Here, presumably the *PED* has achieved the maximum targets for both boys and girls enrollments (i.e., 100 percent enrollment ratios).

b) In the present setup of institutionally fixed wages, a new flexible wage policy may attract more competent *superior* teachers thus leading to improved student participation rates.

c) Expanded school construction programs for male students where the participation rate is already high will only impede *PED's* struggle to enhance enrollments for boys. However, shifting resources in this situation from boys to girls in a cost effective fashion will lead to *efficiency gains* for female as well the entire public education system.

CHAPTER FIVE

EXPENDITURE ALLOCATIONS, OPTIMAL MIX OF INPUTS AND EFFICIENCY GAINS FOR THE PUBLIC EDUCATION SYSTEM: SOME SIMULATION RESULTS

5.1 INTRODUCTION

The purpose of this chapter is to report and discuss the estimated simulation results, both historical (*ex-post*) and future (*ex-ante*), based on the optimization model developed earlier for the public education system in Pakistan. A comparison of the *cost-effective ex-post* forecasts on enrollments, teachers and schools, generated from the optimization education sector model, with the actual observed data will enable us to ascertain the extent of diversion that may have occurred in these variables due to the pursuance of suboptimal *inefficient* policies in the past.

On the other hand, *ex-ante* simulation forecasts will help us identify future *cost-effective optimal* requirements of physical inputs (e.g., schools, teachers), costs (recurring and development) and the magnitude of student enrollment output that will be possible for the public education system. In addition, a comparison of these *ex-ante* forecasts with the suboptimal projected figures based on historical growth rates[1] may assist us in determining the possible extent of future efficiency gains by adopting a *cost-effective and efficient* approach.

More significantly, all these simulation results based on the optimization model will endow us with the necessary information to suggest future recommendations for the public education system with respect to optimal wage policy for teachers, school construction program and its implication, and the sustainability of recurring expenditure.

---

1 The projected values on physical inputs (teachers, schools, etc.), costs and output (enrollments) will simply reflect the government's future course of action on these variables based on their behaviour in the recent past. What is assumed in these projections is that the government's future course of action may not be significantly different from the past.

The organization of rest of the chapter is as follows. Simulation results estimated in this study are based on an optimization model whose algebraic solution, at times, is fairly complex. In Section 5.2, we, therefore, explain the optimization process, definition of key variables and the underlying assumptions with the help of a simple flow chart diagram while the detailed algebraic derivations are relegated to *Appendix A*. Section 5.3 presents a discussion on estimated simulation results and ensuing policy implications for the public school system firstly for Primary schools in Section 5.3.2 followed by secondary institutions in Section 5.3.3. Before extending the model to simulation results for all four provinces combined, we also report results for each category of the school system for Punjab in Sections 5.3.2.1 and 5.3.3.1. This gives us an occasion to test the forecasting power of our model by comparing the simulated values with those of the actual data. The discussion on simulation results for primary and secondary schools for all four provinces are presented in Sections 5.3.2.2 and 5.3.3.2, respectively.

5.2 A DIAGRAMMATIC APPROACH TO THE OPTIMIZATION MODEL

Since the optimization model estimated for the education system in this study is a complex one with too many equations and variables,[2] and in order to get an intuitive understanding of the model and the results generated from it, in this section, we illustrate the optimization process and its linkages among outputs, inputs and the cost constraints with the help of a flow chart diagram as shown in Figure 5.1.

Before discussing the optimizing process, in the following, we provide a brief explanation of various education outputs, inputs, cost and other exogenous variables used in the simulation model.

---

2 The detailed algebraic derivation of the optimization model and the optimal expansion paths for all endogenous variables are relegated to *Technical Appendix A*.

Enrollment

With a view to covering only the school system in the public sector, we have considered primary and secondary[3] level institutions in this study. Enrollment at each level is then further divided according to gender.[4] Thus, student enrollment outputs for the public school system can be classified into four categories, namely, primary boys (*EPB*), primary girls (*EPG*), secondary boys (*ESB*) and secondary girls (*ESG*). In order to get a combined enrollment output for the public education system at a given level, an aggregate index consisting of enrollments for boys and girls named *iso-welfare index for enrollment* has been generated by simply adding boys and girls enrollment geometrically. Hence, for the primary level, the *iso-welfare index for enrollment* is abbreviated *IWEP* while, for the secondary, it is denoted by *IWES*. The geometric weights attached to boys and girls enrollments in the construction of the index at a given level of education may reflect societies' (or *PED*'s) preference in allocating funds towards a given gender in the *public school system*.

Inputs

Three major inputs, namely, *teachers* (T), *schools* (S), and *non-teaching staff* (N) are considered to be used in the production process of educating student for the *public school system*. Although other inputs such as books, blackboards, science laboratory equipments, etc., are important in delivering education, due to lack of explicit data on them, they are excluded from the analysis.

---

3 It should be noted that secondary level schools include students from middle as well high schools.

4 It would be useful if the study could have classified data in terms of location (urban and rural) as the focus of *SAP* is primarily rural based. Unfortunately, the long time series data for most of the variables taken form government documents, e.g., *Development Statistics,Estimates of Charged Expenditure for Grants* etc., do not report separate information for the urban or rural sector. Although *National Education Management and Information System* (NEMIS) data base does collect information on the school system extensively and includes urban and rural classification, however, the data collected by this source is cross-sectional and is available only starting 1991.

They are, however, included on the recurring expenditure side of the optimization model. In order to capture the demand side of the enrollment production function, factors such as *female literacy rate* (FLR), *opportunity cost of agriculture labour* (OCL), and *per capita income* (PCI) are also included in the production model.

Wages and Unit Costs

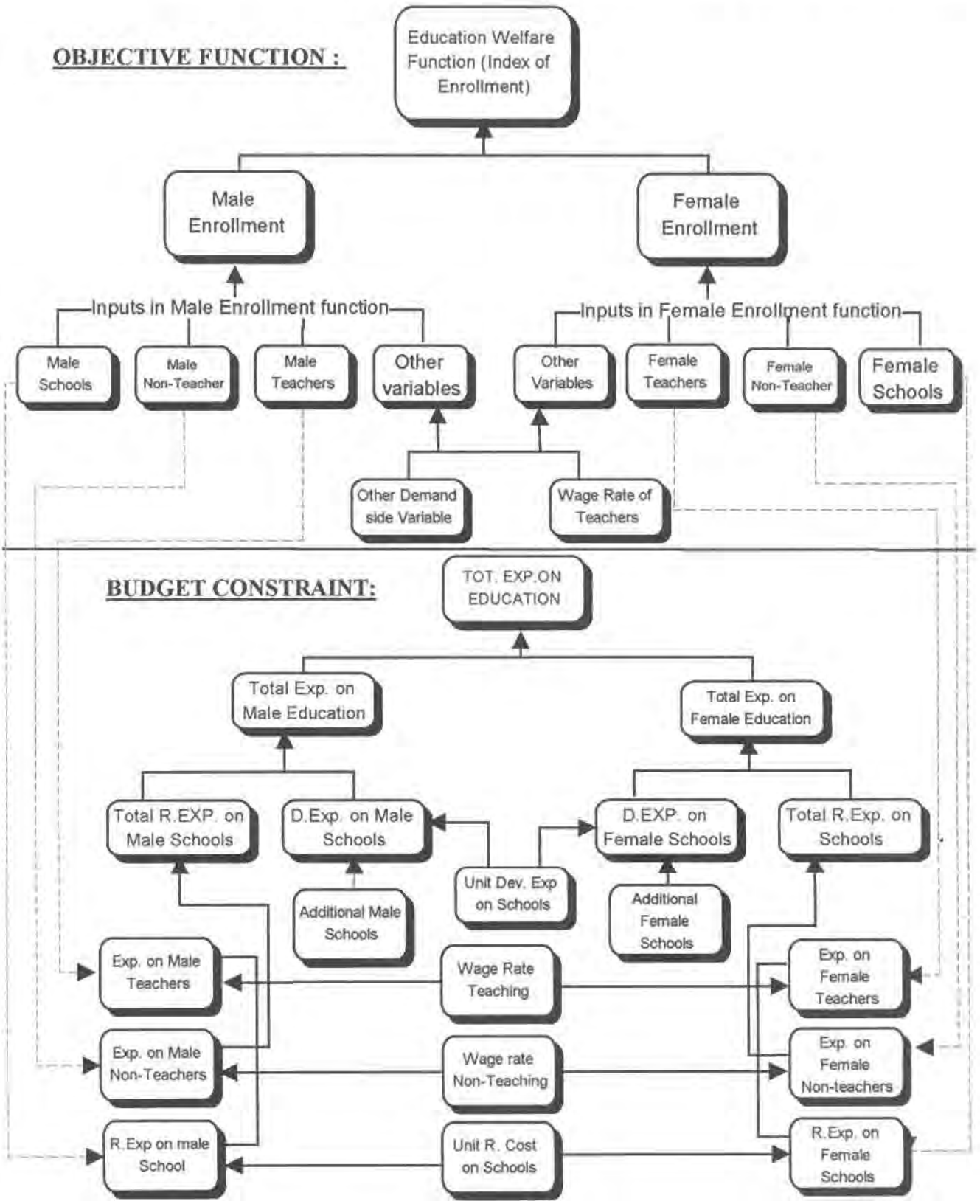
Total budgeted cost of the public education system at each level (primary and secondary) is assumed to be divided into expenditures incurred by boys and girls schools. Within a given type of school (boys or girls), costs are again divided into recurring and development expenditures. A major portion of the recurring outlay is expended for expenditures on hiring teachers and other supporting staff while the remaining recurring budget (very small in size) is allocated to buying books, blackboards, etc. Development costs are simply the expenditures incurred for additional infrastructure (e.g., schools). It should be noted that in view of adopting a *cost-saving* approach in this study, new secondary level schools are simply assumed to be upgrades from existing primary schools. New school construction programmes are permitted only at the primary level. Therefore, unit construction cost for secondary school consists of upgradation cost while, at the primary level, it represents cost of building new schools.

Optimization Problem

Figure 5.1 presents a schematic flow diagram of the optimization problem of the public education system for a given level of education (i.e., primary or secondary). The upper half of the diagram outlines the objective function (aggregate index of enrollment for boys and girls) while the lower half describes the available budget constraint faced by *PED*. The basic optimization process, as shown in Figure 5.1, entails the maximization of the index of total student enrollment (also termed

FIGURE 5.1

OPTIMIZATION PROBLEM OF PUBLIC EDUCATION SYSTEM



as the *iso-welfare function*) subject to the available budgeted funds. It is important to note that the optimization strategy, as presented in Figure 5.1, simultaneously maximizes the enrollments of boys and girls at a given level of education (primary or secondary) represented by the welfare function of the *public education system* as shown in the upper half of Figure 5.1. In addition, the budget constraint is assumed not to be limited to each type of school (i.e., boys or girls), but rather an overall budget for a given level (primary or secondary) of school system (given in the lower half of Figure 5.1) is expected to be satisfied.

The advantage of such an aggregated optimization approach is that now reallocation is possible not only between inputs within a given type of school (e.g., whether to hire more teachers or have fewer primary boys schools) but substitution is also possible between outputs (enrollments) produced by primary (or secondary) level boys and girls schools. For example, for given input prices and total available resources, the *cost-effective* optimal strategy (to achieve higher output) may require that more female student enrollments be encouraged, rather than have additional schools for boys. It is now possible with this optimization approach for not only a reallocation of funds to take place from other inputs to teachers within the female primary institutions but, interestingly enough, additional funds may now be reallocated from boys to girls schools so that the overall aggregated output (or the welfare function) of the entire primary level education system is maximized.

Given the estimated share of inputs, unit costs, predetermined and exogenous variables, this global optimization approach will yield expansion paths for inputs (teachers, schools, non-teaching staff), and outputs (enrollments for boys and girls) of the education system that will be *optimal*, *efficient* and *cost-effective*. Detailed derivations and explicit solutions for these optimal expansion paths are given in *Technical Appendix A*.

5.3 SIMULATION RESULTS AND POLICIES ANALYSIS FOR THE PUBLIC EDUCATION SYSTEM

In this section, we report estimated simulation results based on an extended model developed for the public education system. The basic parameters (e.g., elasticities, output share, etc.) used for simulation purposes, in this study, were estimated employing the education sector data on Punjab.[5] However, given that Punjab is the largest province in the country in terms of population, these parameters are likely to be representative of the other provinces as well. Thus, using these basic estimated parameters for Punjab, all simulation forecasts (whether for Punjab or all four provinces combined) are undertaken. Although the focus of this study is to generate optimal expansion paths for all four provinces combined, we have also produced simulation results for Punjab as well. Simulation results for Punjab will be useful as they will give us an opportunity to test the forecasting power of our model at the provincial level before extending it to the combined provincial data.

Thus, after discussing the estimated enrollment production parameters or output elasticities for different types (boys and girls) and levels of institutions (primary and secondary), we then present the simulation results, *historical* and *ex-ante*, for Punjab, and subsequently, for all four provinces combined at the primary school level. The same exercise will then be repeated for secondary schools. Since there is a plethora of numbers generated by the simulation model, in order to describe these numbers more effectively, only the broad policy oriented results are discussed in the main text.

---

5 A discussion on data sources, definition of variables and ensuing problems and anamolies on it are given in *Appendix C*.

5.3.1 ESTIMATED PRODUCTION FUNCTION

Estimated *ordinary least squares* (OLS) parameter values for student enrollment production functions for boys and girls schools at both primary and secondary levels based on Punjab data are reported in Table 5.1. Since the function used is in logarithmic form, the parameters estimated in this context simply represent elasticities. It should also be noted that a constant returns to scale assumption is imposed on the three inputs (*T, S and N*) in the estimation of the production function for enrollments.[6] In general, an overwhelming majority of the parameters are statistically significant at least at the 10 percent level of significance (represented by an asterisk) with exceptionally high explanatory powers (indicated by R^2) of each production function (over 90 percent).

These estimated regression results in Table 5.1 indicate that, invariably, the role of schools (in terms of large parameter values for schools as compared to other inputs) for all types of institutions in the production process is more dominant than other remaining inputs, namely, teaching and non-teaching staff. However, in case of male primary schools, the importance of teachers cannot be underestimated as the coefficient for this parameter is as large as that of the schools (about .35). It is interesting to note that all demand side variables included in the production equations have the correct signs. For instance, the coefficients for female literacy rate (*FLR*) variables in girls schools (both primary and secondary) are positive, implying that, every-thing else being equal, literate mothers do encourage their progeny to acquire education. On the other hand, as expected, a higher opportunity cost of agricultural labour (*OCL*) leads to a substitution away from male education (be it primary or secondary), everything else being equal.

---

6 This assumption simply implies that, in the production of enrollments, all resources will be exhausted and that a doubling of all inputs will double the size of enrollments.

TABLE - 5 . 1

ESTIMATED REGRESSION RESULTS OF ENROLLMENT PRODUCTION FUNCTION FOR PUNJAB

VARIABLES	PRIMARY		SECONDARY	
	Male	Female	Male	Female
Constant	4.626	3.560	7.521	3.460
	(1.856)*	(2.599)*	(8.171)*	(1.576)*
Non-Teaching	0.258	0.049	0.006	0.006
	(2.483)*		(0.118)	(.027)
Schools	0.397	0.553	0.807	1.062
	(1.752)*	(2.232)*	(2.156)*	(9.311)*
Teaching	0.344	0.398	0.002	0.010
		(2.322)*	(.006)	(.020)
Wage Rate			0.020	
			(0.298)	
Opportunity Cost of Labour	-0.031		-0.079	
	(-0.121)		(-0.850)	
Female Literacy Rate		0.206		0.419
		(0.439)		(1.724)*
R^2	0.976	0.982	0.91	0.995
D.W.	1.358	1.178	2.071	2.548
SAMPLE PERIOD	1972-91		1972-91	

Notes : 1. Numbers in parenthesis are t-values.

2 . Asterisk indicates, significance of the estimated parameter at 10 percent or less level of significance

The results from Table 5.1 also support our proposition (made in an earlier chapter), particularly for male secondary education, that a wage increase will have a positive efficiency effect on enrollments as long as the wage elasticity (2%) exceeds that of the teachers (.2%). Intuitively, what this means is that, given an environment of institutionally fixed wages for teachers by the public education system and, at the same time, a high elasticity of teachers supply, a flexible wage policy (e.g., higher wages) will weed out and attract superior quality teachers to the public education system. Although wages are assumed to be fixed in this context, there is still scope for enhancing efficiency in enrollments, especially for male secondary education if attractive wages are provided to the teachers.

Analysing the problem of the education system on the basis of production function alone, in this case, may suggest that resources be diverted towards building of schools in order to improve enrollments. However, it should be noted that a production function approach may tell us only about the *technical efficiency* of the inputs. Whether a *technically efficient* input is also *cost-effective* can be established if the problem is analysed within a broader optimization framework where the available cost constraints are also considered. Inputs derived from the optimization approach will not only be *optimal* but, more importantly, they will be *cost-effective*. Distribution of education inputs through this optimization principle will ensure the *allocative efficiency* of the school system.

We now discuss the optimization simulation results in the following order. Broadly, analysis of the results will be divided into two main categories, namely, ***Primary*** and ***Secondary Schools.***

5.3.2 PRIMARY EDUCATION

Within a given level of school, namely primary, we first discuss simulation results for Punjab

followed by a similar format for all four provinces combined. The same pattern of discussion will be adopted for the analysis of the *Secondary School* simulation results.

5.3.2.1 Infrastructure, Estimated Gain/Loss of Efficiency and Key Ratios in Public Education for Punjab

Based on the estimated output elasticities for primary education from Tables 5.1 and exogenously given profile for total cost and other demand side variable (i.e., *FLR*, *OCL*), we can now directly compute the optimal expansion paths for inputs, outputs and the distribution of recurring and development expenditures required to educate both *boys* and *girls* student at the primary level schools using the expressions given in *Technical Appendix A*.

Historical Simulation Results for Punjab: Historical simulation results (between 1981-1992) for optimal expansion paths of inputs (teachers, schools and non-teaching staff), expenditure requirements, outputs (enrollment ratios) efficiency gains and key ratios along with their corresponding observed figures are presented in Tables 5.2 to 5.4[7], respectively. These simulation results are useful in that they give us an opportunity to test the forecasting power of the model by comparing it with actual observed data. Analysing the results in these tables carefully, several interesting points can be made:

- Our model predicts that, in order to improve the *efficency* and *cost effectiveness* of the public school system, in the baseline year (1991-92), 9 percent more schools (28,932 vs 26,402) and 13 percent fewer teachers (71,957 vs 81,106) should have been hired for female primary schools as compared to actual figures currently allocated as reported in Table 5.2. On the other hand, for male students, the requirements are about 20% more

---

7 Tables containing data on recurring, development and total expenditures are reported in Appendix C.

TABLE - 5.2

STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: A HISTORICAL SIMULATION FOR PUNJAB 1981-1992

VARIABLES	YEARS	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
TEACHING	*ACTUAL*	62,970	65,880	68,814	75,370	79,412	84,982	92,836	107,430	105,110	108,035	113,219
	OPTIMAL	**61,510**	**63,004**	**68,815**	**68,568**	**72,068**	**81,880**	**93,119**	**106,808**	**105,223**	**117,308**	**130,014**
NON-TEACHING	*ACTUAL*	6,025	6,152	7,232	9,197	10,379	10,342	11,136	13,629	17,100	17,436	19,245
	OPTIMAL	**15,301**	**16,222**	**12,681**	**12,796**	**15,294**	**16,745**	**20,037**	**24,266**	**15,761**	**18,108**	**20,195**
SCHOOLS	*ACTUAL*	25,214	24,919	26,199	27,502	29,134	34,484	36,186	37,905	39,758	41,151	41,499
	OPTIMAL	**21,058**	**20,777**	**21,716**	**23,645**	**25,648**	**29,750**	**31,347**	**33,406**	**37,776**	**40,468**	**40,505**
		FEMALE										
TEACHING	*ACTUAL*	37,315	39,379	41,478	44,797	46,998	53,366	59,788	70,251	74,297	80,716	81,106
	OPTIMAL	**34,043**	**34,870**	**38,087**	**37,950**	**39,887**	**45,317**	**51,538**	**59,114**	**58,237**	**64,925**	**71,957**
NON-TEACHING	*ACTUAL*	3,570	3,677	4,359	5,466	6,143	6,495	7,172	8,912	12,087	13,027	13,616
	OPTIMAL	**8,744**	**9,269**	**7,246**	**7,312**	**8,739**	**9,569**	**11,450**	**13,866**	**9,006**	**10,348**	**11,540**
SCHOOLS	*ACTUAL*	15,650	15,518	16,134	16,835	17,302	18,278	19,320	20,804	23,740	25,891	26,402
	OPTIMAL	**15,041**	**14,840**	**15,512**	**16,890**	**18,320**	**21,250**	**22,390**	**23,861**	**26,983**	**28,906**	**28,932**

TABLE - 5.3

EFFICIENCY GAIN/LOSS IN PRIMARY EDUCATION : A HISTORICAL SIMULATION FOR PUNJAB 1981-992

VARIABLES	YEARS	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
ENROLLMENT	*ACTUAL*	1,891,000	1,911,000	1,931,000	2,071,000	2,501,000	2,575,000	2,815,000	3,179,000	3,543,000	3,608,000	3,760,258
	OPTIMAL	2,246,186	2,241,729	2,347,778	2,493,643	2,682,580	3,085,328	3,336,701	3,636,201	3,883,600	4,212,146	4,346,269
ENROLLMENT RATIO	*ACTUAL*	49.82%	49.09%	48.29%	50.53%	59.53%	59.79%	63.77%	70.26%	76.39%	75.89%	77.16%
	OPTIMAL	59.18%	57.59%	58.72%	60.84%	63.85%	71.64%	75.59%	80.36%	83.73%	88.60%	89.19%
EFFICIENCY		18.78%	17.31%	21.58%	20.41%	7.26%	19.82%	18.53%	14.38%	9.61%	16.74%	15.58%
		FEMALE										
ENROLLMENT	*ACTUAL*	1,209,000	1,244,000	1,279,000	1,447,000	1,556,000	1,577,000	1,726,000	2,053,000	2,380,000	2,524,000	2,675,247
	OPTIMAL	1,365,670	1,370,129	1,442,538	1,546,529	1,681,359	1,950,260	2,110,996	2,309,655	2,507,722	2,732,970	2,824,309
ENROLLMENT RATIO	*ACTUAL*	34.80%	34.83%	34.56%	37.94%	39.58%	38.92%	41.34%	47.71%	53.67%	55.23%	56.81%
	OPTIMAL	39.31%	38.36%	38.98%	40.55%	42.77%	48.14%	50.56%	53.68%	56.55%	59.80%	59.97%
EFFICIENCY		12.96%	10.14%	12.79%	6.88%	8.06%	23.67%	22.31%	12.50%	5.37%	8.28%	5.57%
		COMBINED										
ENROLLMENT	*ACTUAL*	3,100,000	3,155,000	3,210,000	3,518,000	4,057,000	4,152,000	4,541,000	5,232,000	5,923,000	6,132,000	6,435,505
	OPTIMAL	3,611,856	3,611,858	3,790,317	4,040,172	4,363,940	5,035,589	5,447,697	5,945,856	6,391,322	6,945,116	7,170,578
ENROLLMENT RATIO	*ACTUAL*	42.64%	42.27%	41.69%	44.46%	49.89%	49.68%	52.87%	59.27%	65.28%	65.77%	67.16%
	OPTIMAL	49.68%	48.39%	49.23%	51.06%	53.66%	60.25%	63.42%	67.35%	70.45%	74.49%	74.83%
EFFICIENCY		16.51%	14.48%	18.08%	14.84%	7.57%	21.28%	19.97%	13.64%	7.91%	13.26%	11.42%

teachers (130,014 vs 113219) and same or slightly fewer (less than 3%) schools (40,505 vs 41,499). As for the non-teaching staff, the optimal desired values are either close to that of the actual in case of boys (20,195 vs 19,245) or substantially lower [over 15 % (11,540 vs 13,616)] for girls.

- A careful analysis of these results reveals the government's investment allocation priorities and utilisation strategies adopted for the primary education sector. In the past years, it appears that there was **a greater emphasis on constructing more schools**, especially for boys (perhaps in rural areas) by the public education department without giving due consideration to the staff and other recurring expenditure (e.g., books, blackboard, etc.) requirements. This is evident from Table 5.4 wherein we can observe that the **actual** student and teacher per school ratios for boys over the years were noticeably lower than those in the girls schools. For instance, for every boy's school in 1991-92, there were only less than 91 students enrolled as opposed to over 101 in girls primary schools. Similarly, teacher per school ratio was maintained at 2.73 for males as compared to 3.07 for females by *PED* in 1991-92 as shown in Table 5.4. In this context, however, our optimization model suggests that *PED* should have gone for higher (at least 107) students and (over 3) teachers per schools ratio for boys while slightly lower ratios for the same variables for girls schools [e.g., less than 98 student and over 2.5 teachers per school].

- Adopting an optimization approach as proposed in this study, may not only lead to *cost-effective* and *efficient* allocation of resources but, more importantly, it may provide a significantly enhancement of enrollments and student participation rates for both boys and girls at the primary level utilizing the same budgeted resources available to the public

TABLE - 5.4

KEY RATIOS FOR PRIMARY EDUCATION : A HISTORICAL SIMULATION FOR PUNJAB 1981-1992

VARIABLES	YEAR	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
PUPIL/TEACHER	ACTUAL	30.03	29.01	28.06	27.48	31.49	30.30	30.32	29.59	33.71	33.40	33.21
	OPTIMAL	**36.52**	**35.58**	**34.12**	**36.37**	**37.22**	**37.68**	**35.83**	**34.04**	**36.91**	**35.91**	**33.43**
TEACHER/SCHOOL	ACTUAL	2.50	2.64	2.63	2.74	2.73	2.46	2.57	2.83	2.64	2.63	2.73
	OPTIMAL	**2.92**	**3.03**	**3.17**	**2.90**	**2.81**	**2.75**	**2.97**	**3.20**	**2.79**	**2.90**	**3.21**
NON-TEACHER/SCHOOL	ACTUAL	0.24	0.25	0.28	0.33	0.36	0.30	0.31	0.36	0.43	0.42	0.46
	OPTIMAL	**0.73**	**0.78**	**0.58**	**0.54**	**0.60**	**0.56**	**0.64**	**0.73**	**0.42**	**0.45**	**0.50**
PUPIL/SCHOOL	ACTUAL	75.00	76.69	73.71	75.30	85.84	74.67	77.79	83.87	89.11	87.68	90.61
	OPTIMAL	**106.67**	**107.90**	**108.11**	**105.46**	**104.59**	**103.71**	**106.45**	**108.85**	**102.81**	**104.09**	**107.30**
		FEMALE										
PUPIL/TEACHER	ACTUAL	32.40	31.59	30.84	32.30	33.11	29.55	28.87	29.22	32.03	31.27	32.98
	OPTIMAL	**40.12**	**39.29**	**37.88**	**40.75**	**42.15**	**43.04**	**40.96**	**39.07**	**43.06**	**42.09**	**39.25**
TEACHER/SCHOOL	ACTUAL	2.38	2.54	2.57	2.66	2.72	2.92	3.09	3.38	3.13	3.12	3.07
	OPTIMAL	**2.26**	**2.35**	**2.46**	**2.25**	**2.18**	**2.13**	**2.30**	**2.48**	**2.16**	**2.25**	**2.49**
NON-TEACHER/SCHOOL	ACTUAL	0.23	0.24	0.27	0.32	0.36	0.36	0.37	0.43	0.51	0.50	0.52
	OPTIMAL	**0.58**	**0.62**	**0.47**	**0.43**	**0.48**	**0.45**	**0.51**	**0.58**	**0.33**	**0.36**	**0.40**
PUPIL/SCHOOL	ACTUAL	77.25	80.16	79.27	85.95	89.93	86.28	89.34	98.68	100.25	97.49	101.33
	OPTIMAL	**90.80**	**92.32**	**93.00**	**91.57**	**91.78**	**91.78**	**94.28**	**96.79**	**92.94**	**94.55**	**97.62**

school system. In fact, in 1991-92, *PED* in Punjab could have attained about 90 percent and 60 percent participation rates (or enrollment ratio) for boys and girls, respectively, as opposed to the actual figures of only 77 percent for the former and 57 percent for the latter as shown in Table 5.4.

- Another important result from Table 5.3 is the efficiency *gain/loss* which is simply the percentage deviation of enrollment ratio under *cost-effective* strategy in relation to the corresponding actual values. It appears that there are substantial year to year variations in *efficiency gains* in both boys and girls schools. However, comparing the most recent (1991-92) figures, it appears from Table 5.3 that *boys* and *girls schools* could have achieved, respectively, over 15% and 5% percent *efficiency gains* by adopting the *cost-effective* strategy while the *gains* for *combined* (boys and girls) *primary schools* system were as high as about **12 percent**.

Placing these historical simulation results in a broader public policy perspective, we may conclude that the *Punjab Public Education Department* could have adopted a more consolidated approach in the allocation of funds for boys schools (in terms of more teachers and fewer additional schools) with an accelerated expanded strategy for girls institutions (more schools) in order to maximize the student participation rates at the primary school level. A selective public policy program such as the one proposed above with respect to school construction program could have improved the participation rates significantly at the primary school level.

Ex-Ante Forecast for (1993-2003): Table 5.2 shows that there were more schools for boys in *Punjab* than they should have had in 1991-92 if *PED* had operated under *a cost-efficient*

TABLE - 5.5(A)

STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	113,219	120,060	127,314	135,007	143,164	151,814	160,987	170,715	181,029	191,968	203,567	215,867
	OPTIMAL	**130,014**	**137,609**	**146,691**	**157,214**	**169,192**	**182,690**	**197,819**	**214,734**	**233,629**	**254,749**	**278,385**	**304,885**
NON-TEACHING	ACTUAL	19,245	21,615	24,277	27,266	30,624	34,395	38,630	43,388	48,731	54,732	61,471	69,041
	OPTIMAL	**20,195**	**20,391**	**20,737**	**21,202**	**21,767**	**22,423**	**23,163**	**23,986**	**24,897**	**25,898**	**26,999**	**28,209**
SCHOOLS	ACTUAL	41,499	43,619	45,848	48,190	50,652	53,240	55,960	58,819	61,824	64,982	68,302	71,792
	OPTIMAL	**40,505**	**42,465**	**44,838**	**47,599**	**50,738**	**54,265**	**58,200**	**62,574**	**67,431**	**72,825**	**78,821**	**85,499**
		FEMALE											
TEACHING	ACTUAL	81,106	87,654	94,730	102,377	110,642	119,574	129,227	139,659	150,934	163,118	176,287	190,518
	OPTIMAL	**71,957**	**76,161**	**81,187**	**87,011**	**93,641**	**101,111**	**109,485**	**118,846**	**129,304**	**140,993**	**154,075**	**168,741**
NON-TEACHING	ACTUAL	13,616	15,567	17,797	20,346	23,260	26,591	30,400	34,754	39,732	45,423	51,930	59,368
	OPTIMAL	**11,540**	**11,652**	**11,850**	**12,115**	**12,439**	**12,813**	**13,236**	**13,707**	**14,227**	**14,799**	**15,428**	**16,119**
SCHOOLS	ACTUAL	26,402	27,819	29,313	30,887	32,545	34,292	36,134	38,073	40,118	42,271	44,541	46,932
	OPTIMAL	**28,932**	**30,332**	**32,027**	**33,999**	**36,242**	**38,761**	**41,571**	**44,696**	**48,165**	**52,018**	**56,301**	**61,071**

approach. In addition, the optimal student participation rate in that year for primary boys was relatively high (about 90%) and would soon be able to attain the maximum possible target, say 110 percent.[8] A pertinent public policy question that may arise in this context is what steps the *PED* should take or what are the options that are available to them to bring about a real improvement in the system in terms of *positive efficency gains*? Obviously, one thing *PED* possibly *cannot* or *should not* do is to dismantle the existing schools for boys or completely stop constructing it. In fact, one of the viable options in the future would be to slow down the growth of boys schools construction programme and divert resources towards female schools. Adopting such a policy will enable the *PED* to achieve the optimal maximum target for boys participation rate (e.g., 110%) in due course of time and, concurrently, enhance the female participation rates.

In the following, we present *ex-ante* simulation results for *Punjab*, relying on two strategies:

a) *standard strategy* based on normal optimization approach adopted earlier; and

b) *constrained strategy* based on an optimization problem wherein the resources are diverted from boys to girls schools once the boys participation target of 110 percent is achieved.

It should be noted that, under *constrained strategy*, the expansion of boys schools will take place only to meet the growth in population over the years. *Ex-ante* simulation results for *standard strategy* are reported in Tables 5.5(A) to 5.8(A), respectively, while forecasts for *constrained strategy* are given in Tables 5.5(B)-5.8(B), respectively.

It should be noted that the future data under the headings of ***actuals*** in Tables 5.5-5.8,

---

8 A target of maximum 110 % rather than 100 % participation rate (or enrollment ratio) has been set for the reason that, at the primary level (grades 1 to 5), there will be some students from an age group other than the stipulated range of 5 to 9 years for this level. Younger students (below 5 years) will be considered as the achievers and older students (above 9 years) will be the slow learners.

respectively, do not exist anywhere. They are, however, generated in this study by simply taking the annual compound growth rates of the past five to ten years of actual historical data on these variables for *Punjab*. The underlying behaviour in projecting these actual data is predicated on the presumption that the *Punjab Education Department* continues to follow a future course of actions based on their education polices and practices of the recent past in matters pertaining to setting wages, hiring teaching and non-teaching staffs, annual development plans, etc. Comparing these actual data with the simulated ones generated by our optimization model will not only enable us to examine the extent of divergence between optimal and sub-optimal education inputs within the education system, but, more importantly, the above analysis will permit us to compute the size of *ex-ante efficiency gain/loss* of the optimal approach by simply calculating the yearly percentage deviation between optimal and actual outputs of a given education facility.

Considering 1991-92 as the ***baseline*** year, future projections are made up to the end of the Perspective Plan period (2002-03). In addition, forecasts for all monetary variables are measured in current rupees. Having computed the actual projected data on education inputs (between 1992-93 to 2002-03) based on the methodology explained above, the corresponding actual education output (enrollments) variables are generated using the underlying estimated production technology parameters reported in Table 5.2.[9]

Focusing on the broad policy issues again, the future simulation results for *Punjab*, as reported in Tables 5.5 to 5.8, respectively, reveal some interesting facts. Our results in Table 5.6(A), suggest that the *public school system* can attain the maximum stipulated primary boys participation target (110%) as early as 1997-98 and about 100 percent enrollment rate for girls can be possible by the end of perspective plan period (2002-03) with the available allocated

---

9 Forecasting actual student enrollments based on the estimated production function, as reported in Table 5.1, will not be unreasonable as the predictive power of these equations are very high (99%).

TABLE - 5.5(B)

STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	*ACTUAL*	113,219	120,060	127,314	135,007	143,164	151,814	160,987	170,715	181,029	191,968	203,567	215,867
	OPTIMAL	**130,014**	**137,609**	**146,691**	**157,214**	**169,192**	**182,690**	**196,385**	**202,083**	**207,912**	**213,847**	**219,871**	**225,970**
NON-TEACHING	*ACTUAL*	19,245	21,615	24,277	27,266	30,624	34,395	38,630	43,388	48,731	54,732	61,471	69,041
	OPTIMAL	**20,195**	**20,391**	**20,737**	**21,202**	**21,767**	**22,423**	**23,093**	**23,371**	**23,652**	**23,950**	**24,270**	**24,615**
SCHOOLS	*ACTUAL*	41,499	43,619	45,848	48,190	50,652	53,240	55,960	58,819	61,824	64,982	68,302	71,792
	OPTIMAL	**40,505**	**42,465**	**44,838**	**47,599**	**50,738**	**54,265**	**57,827**	**59,303**	**60,818**	**62,374**	**63,974**	**65,618**
		FEMALE											
TEACHING	*ACTUAL*	81,106	87,654	94,730	102,377	110,642	119,574	129,227	139,659	150,934	163,118	176,287	190,518
	OPTIMAL	**71,957**	**76,161**	**81,187**	**87,011**	**93,641**	**101,111**	**110,555**	**128,379**	**149,248**	**173,448**	**201,361**	**233,460**
NON-TEACHING	*ACTUAL*	13,616	15,567	17,797	20,346	23,260	26,591	30,400	34,754	39,732	45,423	51,930	59,368
	OPTIMAL	**11,540**	**11,652**	**11,850**	**12,115**	**12,439**	**12,813**	**13,365**	**14,806**	**16,421**	**18,206**	**20,163**	**22,302**
SCHOOLS	*ACTUAL*	26,402	27,819	29,313	30,887	32,545	34,292	36,134	38,073	40,118	42,271	44,541	46,932
	OPTIMAL	**28,932**	**30,332**	**32,027**	**33,999**	**36,242**	**38,761**	**41,977**	**48,281**	**55,594**	**63,992**	**73,580**	**84,494**

TABLE - 5.6(A)
EFFICIENCY GAIN/LOSS IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
ENROLLMENT	*ACTUAL*	3,760,258	4,027,821	4,314,424	4,621,420	4,950,260	5,302,499	5,679,803	6,083,953	6,516,861	6,980,573	7,477,280	8,009,332
	OPTIMAL	4,346,269	4,559,428	4,817,251	5,117,006	5,457,970	5,841,048	6,268,530	6,743,958	7,272,068	7,858,807	8,511,397	9,238,459
ENROLLMENT RATIO	*ACTUAL*	77.16%	80.61%	84.22%	87.98%	91.91%	96.02%	100.32%	104.80%	109.49%	114.38%	119.50%	124.84%
	OPTIMAL	87.30%	91.25%	94.03%	97.42%	101.34%	105.78%	110.71%	116.17%	122.18%	128.77%	136.02%	144.00%
EFFICIENCY		15.58%	13.20%	11.65%	10.72%	10.26%	10.16%	10.37%	10.85%	11.59%	12.58%	13.83%	15.35%
		FEMALE											
ENROLLMENT	*ACTUAL*	2,675,247	2,841,681	3,018,469	3,206,256	3,405,725	3,617,604	3,842,664	4,081,726	4,335,661	4,605,393	4,891,906	5,196,244
	OPTIMAL	2,824,309	2,982,591	3,172,270	3,392,142	3,642,305	3,923,943	4,239,203	4,591,132	4,983,668	5,421,679	5,911,041	6,458,749
ENROLLMENT RATIO	*ACTUAL*	56.81%	58.53%	60.31%	62.15%	64.04%	65.98%	67.99%	70.05%	72.18%	74.38%	76.64%	78.97%
	OPTIMAL	59.97%	61.44%	63.39%	65.75%	68.48%	71.57%	75.00%	78.80%	82.97%	87.56%	92.60%	98.15%
EFFICIENCY		5.57%	4.96%	5.10%	5.80%	6.95%	8.47%	10.32%	12.48%	14.95%	17.72%	20.83%	24.30%
		COMBINED											
ENROLLMENT	*ACTUAL*	6,435,505	6,869,502	7,332,893	7,827,676	8,355,985	8,920,103	9,522,467	10,165,679	10,852,521	11,585,966	12,369,187	13,205,576
	OPTIMAL	7,170,578	7,542,019	7,989,521	8,509,148	9,100,275	9,764,991	10,507,733	11,335,089	12,255,736	13,280,486	14,422,437	15,697,207
ENROLLMENT RATIO	*ACTUAL*	67.16%	69.73%	72.40%	75.18%	78.06%	81.06%	84.17%	87.40%	90.75%	94.23%	97.85%	101.61%
	OPTIMAL	74.83%	76.56%	78.89%	81.72%	85.02%	88.73%	92.87%	97.45%	102.48%	108.02%	114.10%	120.79%
EFFICIENCY		11.42%	9.79%	8.95%	8.71%	8.91%	9.47%	10.35%	11.50%	12.93%	14.63%	16.60%	18.87%

TABLE - 5.6(B)
EFFICIENCY GAIN/LOSS IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
ENROLLMENT	ACTUAL	3,760,258	4,027,821	4,314,424	4,621,420	4,950,260	5,302,499	5,679,803	6,083,953	6,516,861	6,980,573	7,477,280	8,009,332
	OPTIMAL	4,346,269	4,559,428	4,817,251	5,117,006	5,457,970	5,841,048	6,227,697	6,385,689	6,547,510	6,713,241	6,882,940	7,056,660
ENROLLMENT RATIO	ACTUAL	77.16%	80.61%	84.22%	87.98%	91.91%	96.02%	100.32%	104.80%	109.49%	114.38%	119.50%	124.84%
	OPTIMAL	87.30%	91.25%	94.03%	97.42%	101.34%	105.78%	109.99%	110.00%	110.00%	110.00%	110.00%	109.99%
EFFICIENCY		15.58%	13.20%	11.65%	10.72%	10.26%	10.16%	9.65%	4.96%	0.47%	-3.83%	-7.95%	-11.89%
		FEMALE											
ENROLLMENT	ACTUAL	2,675,247	2,841,681	3,018,469	3,206,256	3,405,725	3,617,604	3,842,664	4,081,726	4,335,661	4,605,393	4,891,906	5,196,244
	OPTIMAL	2,824,309	2,982,591	3,172,270	3,392,142	3,642,305	3,923,943	4,280,622	4,959,405	5,752,333	6,669,691	7,725,161	8,935,926
ENROLLMENT RATIO	ACTUAL	56.81%	58.53%	60.31%	62.15%	64.04%	65.98%	67.99%	70.05%	72.18%	74.38%	76.64%	78.97%
	OPTIMAL	59.97%	61.44%	63.39%	65.75%	68.48%	71.57%	75.74%	85.12%	95.77%	107.72%	121.02%	135.80%
EFFICIENCY		5.57%	4.96%	5.10%	5.80%	6.95%	8.47%	11.40%	21.50%	32.67%	44.82%	57.92%	71.97%
		COMBINED											
ENROLLMENT	ACTUAL	6,435,505	6,869,502	7,332,893	7,827,676	8,355,985	8,920,103	9,522,467	10,165,679	10,852,521	11,585,966	12,369,187	13,205,576
	OPTIMAL	7,170,578	7,542,019	7,989,521	8,509,148	9,100,275	9,764,991	10,508,319	11,345,094	12,299,843	13,382,931	14,608,100	15,992,586
ENROLLMENT RATIO	ACTUAL	67.16%	69.73%	72.40%	75.18%	78.06%	81.06%	84.17%	87.40%	90.75%	94.23%	97.85%	101.61%
	OPTIMAL	74.83%	76.56%	78.89%	81.72%	85.02%	88.73%	92.88%	97.54%	102.85%	108.85%	115.57%	123.06%
EFFICIENCY		11.42%	9.79%	8.95%	8.71%	8.91%	9.47%	10.35%	11.60%	13.34%	15.51%	18.10%	21.10%

TABLE - 5.7(A)
KEY RATIOS FOR PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEAR	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
PUPIL/TEACHER	ACTUAL	33.21	33.55	33.89	34.23	34.58	34.93	35.28	35.64	36.00	36.36	36.73	37.10
	OPTIMAL	33.43	33.13	32.84	32.55	32.26	31.97	31.69	31.41	31.13	30.85	30.57	30.30
TEACHER/SCHOOL	ACTUAL	2.73	2.75	2.78	2.80	2.83	2.85	2.88	2.90	2.93	2.95	2.98	3.01
	OPTIMAL	3.21	3.24	3.27	3.30	3.33	3.37	3.40	3.43	3.46	3.50	3.53	3.57
NON-TEACHER/SCHOOL	ACTUAL	0.46	0.50	0.53	0.57	0.60	0.65	0.69	0.74	0.79	0.84	0.90	0.96
	OPTIMAL	0.50	0.48	0.46	0.45	0.43	0.41	0.40	0.38	0.37	0.36	0.34	0.33
PUPIL/SCHOOL	ACTUAL	90.61	92.34	94.10	95.90	97.73	99.60	101.50	103.44	105.41	107.42	109.47	111.56
	OPTIMAL	107.30	107.37	107.44	107.50	107.57	107.64	107.71	107.78	107.84	107.91	107.98	108.05
		FEMALE											
PUPIL/TEACHER	ACTUAL	32.98	32.42	31.86	31.32	30.78	30.25	29.74	29.23	28.73	28.23	27.75	27.27
	OPTIMAL	39.25	39.16	39.07	38.99	38.90	38.81	38.72	38.63	38.54	38.45	38.36	38.28
TEACHER/SCHOOL	ACTUAL	3.07	3.15	3.23	3.31	3.40	3.49	3.58	3.67	3.76	3.86	3.96	4.06
	OPTIMAL	2.49	2.51	2.53	2.56	2.58	2.61	2.63	2.66	2.68	2.71	2.74	2.76
NON-TEACHER/SCHOOL	ACTUAL	0.52	0.56	0.61	0.66	0.71	0.78	0.84	0.91	0.99	1.07	1.17	1.26
	OPTIMAL	0.40	0.38	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.28	0.27	0.26
PUPIL/SCHOOL	ACTUAL	101.33	102.15	102.97	103.81	104.65	105.49	106.35	107.21	108.07	108.95	109.83	110.72
	OPTIMAL	97.62	98.33	99.05	99.77	100.50	101.23	101.97	102.72	103.47	104.23	104.99	105.76

budget if *PED* is to adopt an *efficient cost-effective* approach. What is more interesting to note is that, if *PED*, in this context, were to reallocate resources from boy's institutions (as it has achieved the target) and pursue an accelerated school construction programme for girls then even with limited budgeted resources, *PED* will attain a 110 percent participation rate for girls before the end of the perspective plan period as shown in Table 5.6(B).

Efficiency gains in enrollment rates for *female primary schools* are more pronounced than *male institutions* and reach a level of over 24 percent by the year 2003 followed by over 19 percent for the *combined* primary school system as reported in Table 5.6(A). All these benefits are expected to be possible with the same budget that the *Punjab* government would have allocated to its education departments for that year by simply reallocating the resources.

As far as the optimal mix of expenditures are concerned, in the baseline year 1991-92, the optimization model suggests that approximately over 64 percent of the total resources be allocated for male primary schools and the remaining 36 percent for girls schools as reported in Table 5.8(A). However, by the end of the plan period 2002-03, the distribution of these expenditure allocations are reversed with more spending for girls (over 57 percent) as compared to boys primary schools. For a given type of primary school (whether boys or girls), obviously, the recurring expenditure (salary for staff) liabilities far exceed (over 90%) the development outlays. What is critical to be highlighted at this point is the importance of recurring expenditure liabilities of the primary school system. Many of the programmes (such as Jonejo's Mosque schools in the mid-eighties or SAP, etc.) were biased towards constructing more infrastructure without paying much attention towards long term recurring expenditure obligations. As a result, although some of these programmes carried high expectations, they were not sustainable. Consistent with our earlier analysis, the optimal development expenditure outlays for girls schools will increase substantially due to an expanded school construction programme for them.

TABLE - 5.7(B)
KEY RATIOS FOR PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEAR	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
PUPIL/TEACHER	ACTUAL	33.21	33.55	33.89	34.23	34.58	34.93	35.28	35.64	36.00	36.36	36.73	37.10
	OPTIMAL	33.43	33.13	32.84	32.55	32.26	31.97	31.71	31.60	31.49	31.39	31.30	31.23
TEACHER/SCHOOL	ACTUAL	2.73	2.75	2.78	2.80	2.83	2.85	2.88	2.90	2.93	2.95	2.98	3.01
	OPTIMAL	3.21	3.24	3.27	3.30	3.33	3.37	3.40	3.41	3.42	3.43	3.44	3.44
NON-TEACHER/SCHOOL	ACTUAL	0.46	0.50	0.53	0.57	0.60	0.65	0.69	0.74	0.79	0.84	0.90	0.96
	OPTIMAL	0.50	0.48	0.46	0.45	0.43	0.41	0.40	0.39	0.39	0.38	0.38	0.38
PUPIL/SCHOOL	ACTUAL	90.61	92.34	94.10	95.90	97.73	99.60	101.50	103.44	105.41	107.42	109.47	111.56
	OPTIMAL	107.30	107.37	107.44	107.50	107.57	107.64	107.70	107.68	107.66	107.63	107.59	107.54
		FEMALE											
PUPIL/TEACHER	ACTUAL	32.98	32.42	31.86	31.32	30.78	30.25	29.74	29.23	28.73	28.23	27.75	27.27
	OPTIMAL	39.25	39.16	39.07	38.99	38.90	38.81	38.72	38.63	38.54	38.45	38.36	38.28
TEACHER/SCHOOL	ACTUAL	3.07	3.15	3.23	3.31	3.40	3.49	3.58	3.67	3.76	3.86	3.96	4.06
	OPTIMAL	2.49	2.51	2.53	2.56	2.58	2.61	2.63	2.66	2.68	2.71	2.74	2.76
NON-TEACHER/SCHOOL	ACTUAL	0.52	0.56	0.61	0.66	0.71	0.78	0.84	0.91	0.99	1.07	1.17	1.26
	OPTIMAL	0.40	0.38	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.28	0.27	0.26
PUPIL/SCHOOL	ACTUAL	101.33	102.15	102.97	103.81	104.65	105.49	106.35	107.21	108.07	108.95	109.83	110.72
	OPTIMAL	97.62	98.33	99.05	99.77	100.50	101.23	101.97	102.72	103.47	104.23	104.99	105.76

TABLE 5.8(A)

MIX OF EXPENDITURE SHARES FOR PRIMARY EDUCATION : AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR PUNJAB

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL PRIMARY EDUCATION EXPENDITURE	*100.0%*	*100.0%*	*100.0%*	*100.0%*
MALE PRIMARY SCHOOLS				
TOTAL EXPENDITURE:	*57.8%*	*64.2%*	*53.9%*	*63.3%*
RECURRING EXPENDITURE:	*97.8%*	*99.8%*	*90.6%*	*84.7%*
TEACHERS	86.6%	87.7%	68.4%	88.0%
NON-TEACHERS	12.5%	11.6%	31.2%	11.6%
SCHOOLS	0.9%	0.8%	0.4%	0.4%
DEVELOPMENT EXPENDITURE :	*2.2%*	*0.2%*	*9.4%*	*15.3%*
FEMALE PRIMARY SCHOOLS				
TOTAL EXPENDITURE	*42.2%*	*35.8%*	*46.1%*	*36.7%*
RECURRING EXPENDITURE:	*95.6%*	*99.7%*	*92.5%*	*81.1%*
TEACHERS	86.8%	87.1%	69.0%	87.6%
NON-TEACHERS	12.4%	11.9%	30.7%	11.9%
SCHOOLS	0.8%	1.0%	0.3%	0.5%
DEVELOPMENT EXPENDITURE :	*4.4%*	*0.3%*	*7.5%*	*18.9%*

TABLE 5.8(B)

MIX OF EXPENDITURE SHARES FOR PRIMARY EDUCATION : AN EX-ANTE ACTUAL VS CONSTRAINT OPTIMAL FORECAST FOR PUNJAB

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL PRIMARY EDUCATION EXPENDITURE	*100.0%*	*100.0%*	*100.0%*	*100.0%*
MALE PRIMARY SCHOOLS				
TOTAL EXPENDITURE:	*57.8%*	*64.2%*	*53.9%*	*42.9%*
RECURRING EXPENDITURE:	*97.8%*	*99.8%*	*90.6%*	*94.4%*
TEACHERS	86.6%	87.7%	68.4%	86.2%
NON-TEACHERS	12.5%	11.6%	31.2%	13.4%
SCHOOLS	0.9%	0.8%	0.4%	0.4%
DEVELOPMENT EXPENDITURE :	*2.2%*	*0.2%*	*9.4%*	*5.6%*
FEMALE PRIMARY SCHOOLS				
TOTAL EXPENDITURE	*42.2%*	*35.8%*	*46.1%*	*57.1%*
RECURRING EXPENDITURE:	*95.6%*	*99.7%*	*92.5%*	*72.2%*
TEACHERS	86.8%	87.1%	69.0%	87.6%
NON-TEACHERS	12.4%	11.9%	30.7%	11.9%
SCHOOLS	0.8%	1.0%	0.3%	0.5%
DEVELOPMENT EXPENDITURE :	*4.4%*	*0.3%*	*7.5%*	*27.8%*

TABLE - 5.9

STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	*ACTUAL*	200,000	212,084	224,899	238,488	252,898	268,179	284,383	301,566	319,787	339,109	359,599	381,327
	OPTIMAL	**221,221**	**232,941**	**247,096**	**263,535**	**282,205**	**303,138**	**326,432**	**352,247**	**380,799**	**412,362**	**447,267**	**485,910**
NON-TEACHING	*ACTUAL*	33,996	38,182	41,265	44,596	48,196	52,087	56,292	60,836	65,748	71,055	76,791	82,991
	OPTIMAL	**34,361**	**34,517**	**34,930**	**35,540**	**36,307**	**37,206**	**38,222**	**39,347**	**40,579**	**41,921**	**43,378**	**44,958**
SCHOOLS	*ACTUAL*	94,178	98,989	104,047	109,362	114,950	120,822	126,995	133,483	140,303	147,471	155,005	162,924
	OPTIMAL	**68,919**	**71,883**	**75,529**	**79,789**	**84,630**	**90,042**	**96,038**	**102,646**	**109,907**	**117,881**	**126,638**	**136,264**
		FEMALE											
TEACHING	*ACTUAL*	120,000	129,687	140,157	151,472	163,700	176,915	191,197	206,632	223,313	241,341	260,824	281,880
	OPTIMAL	**122,437**	**128,923**	**136,758**	**145,856**	**156,189**	**167,774**	**180,667**	**194,954**	**210,757**	**228,225**	**247,544**	**268,931**
NON-TEACHING	*ACTUAL*	20,146	23,032	26,331	30,102	34,414	39,343	44,978	51,421	58,786	67,206	76,832	87,837
	OPTIMAL	**19,635**	**19,724**	**19,960**	**20,309**	**20,747**	**21,261**	**21,841**	**22,484**	**23,188**	**23,955**	**24,787**	**25,690**
SCHOOLS	*ACTUAL*	34,615	36,473	38,432	40,495	42,669	44,960	47,374	49,917	52,597	55,421	58,397	61,532
	OPTIMAL	**49,228**	**51,345**	**53,949**	**56,992**	**60,450**	**64,316**	**68,599**	**73,318**	**78,505**	**84,201**	**90,456**	**97,332**

5.3.2.2 Ex-Ante Optimal Expansion Paths and Estimated Efficiency Gain/Loss of Primary Education Output for All Four Provinces Combined (National)

Having discussed the *ex-ante* simulation results for *Punjab*, in this section, we extend the analysis of the *primary school system* to national data consisting of all four provinces combined between the period 1993-2003.[10] *Baseline* national data in majority of the cases were obtained by simply aggregating figures for all four provinces, however, wherever the numbers were not available or discrepancies were observed between different sources, information from *Economic Survey* was considered after making appropriate adjustments.[11] Future growth projections for actual national variables (e.g., wages, unit costs, etc.), were assumed to follow *Punjab* data. *Ex-ante* simulation forecasts for the *primary school system* , based on national data, are reported in Tables 5.9-5.12, respectively.

An analysis of the simulation results in Tables 5.9-5.12 reveals several interesting facts which have important implications for *Public Health Policies* in Pakistan. The salient features of the results are summarised below:

School and Staff Infrastructure

- Actual number of schools for male students appeared to be greater than what an *optimal optimization strategy* would stipulate by over 37 percent (94,176 as opposed to 68,919) in the baseline period (1991-92) as shown in Table 5.9. If *PED* continues to pursue its past policies with respect to boys primary school construction programme then, by the end

---

10 It should be noted that the national data in this study considers neither Federal nor Federally Administered Tribal Territories (*FATA*).

12 Since *Economic Survey* data, particularly on registered personnel, also includes private sector information along with *Federal* and *FATA*, appropriate adjustments were, therefore, made to provincial public sector data.

TABLE - 5.10
EFFICIENCY GAIN/LOSS IN PRIMARY EDUCATION : AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
ENROLLMENT	*ACTUAL*	6,626,948	7,139,918	7,692,594	8,288,052	8,929,601	9,620,811	10,365,525	11,167,885	12,032,352	12,963,735	13,967,214	15,048,368
	OPTIMAL	7,395,232	7,718,066	8,114,509	8,577,558	9,103,685	9,692,058	10,344,012	11,062,708	11,852,935	12,721,019	13,674,817	14,723,786
ENROLLMENT RATIO	*ACTUAL*	71.95%	75.19%	78.58%	82.11%	85.81%	89.67%	93.71%	97.92%	102.33%	106.94%	111.75%	116.78%
	OPTIMAL	80.29%	81.28%	82.89%	84.98%	87.48%	90.33%	93.51%	97.00%	100.81%	104.94%	109.41%	114.26%
EFFICIENCY		11.59%	8.10%	5.48%	3.49%	1.95%	0.74%	-0.21%	-0.94%	-1.49%	-1.87%	-2.09%	-2.16%
		FEMALE											
ENROLLMENT	*ACTUAL*	3,298,712	3,555,128	3,831,475	4,129,304	4,450,283	4,796,212	5,169,031	5,570,831	6,003,863	6,470,555	6,973,524	7,515,590
	OPTIMAL	4,805,598	5,048,843	5,343,590	5,686,195	6,075,225	6,511,004	6,995,319	7,531,238	8,123,011	8,776,050	9,496,961	10,293,626
ENROLLMENT RATIO	*ACTUAL*	38.54%	40.28%	42.11%	44.02%	46.01%	48.10%	50.28%	52.56%	54.94%	57.43%	60.04%	62.76%
	OPTIMAL	56.14%	57.21%	58.73%	60.62%	62.82%	65.30%	68.04%	71.06%	74.33%	77.90%	81.76%	85.95%
EFFICIENCY		45.68%	42.02%	39.47%	37.70%	36.51%	35.75%	35.33%	35.19%	35.30%	35.63%	36.19%	36.96%
		COMBINED											
ENROLLMENT	*ACTUAL*	9,925,661	10,695,046	11,524,069	12,417,355	13,379,884	14,417,023	15,534,556	16,738,715	18,036,215	19,434,290	20,940,738	22,563,958
	OPTIMAL	12,200,829	12,766,909	13,458,099	14,263,753	15,178,910	16,203,062	17,339,331	18,593,946	19,975,946	21,497,069	23,171,777	25,017,413
ENROLLMENT RATIO	*ACTUAL*	63.11%	65.96%	68.93%	72.04%	75.30%	78.69%	82.24%	85.95%	89.83%	93.88%	98.12%	102.55%
	OPTIMAL	77.58%	78.74%	80.50%	82.76%	85.42%	88.44%	91.80%	95.48%	99.49%	103.85%	108.57%	113.70%
EFFICIENCY		22.92%	19.37%	16.78%	14.87%	13.45%	12.39%	11.62%	11.08%	10.75%	10.61%	10.65%	10.87%

of the *Perspective Plan* period (2002-03), this figure may still be in the order of about 20 percent (162,924 as opposed to 136,264). On the other hand, for girls primary education, the optimization model suggests an accelerated school expansion programme so much so that *PED* should be constructing about 60 percent more female schools (97,332 vs 61,532) than what it would be doing based on their past practices.

- Since our model derives optimal time paths for education inputs based on the same budget as available to *PED*, an expanded school programme for females will obviously need a reallocation of the limited resources. Major adjustments will be required in terms of curtailing non-teaching staff. For instance, a reduction in non-teaching staff of up to one-third in girls schools and almost one-half in boys will be needed as compared to the ones that *PED* would have hired by the end of the plan period as shown in Table 5.9.

Participation Rates, Efficiency Gains and Key Economic Ratios

- A crucial part of our analysis in this study is to investigate whether, by becoming more *cost-effective*, it is possible for the *Public Education Departments* to improve their provision of *primary education facilities*. The results in Table 5.10 indicate that the *public education system* in the country may attain the stipulated participation rate targets for boys primary schools by the turn of the century. However, as for female primary school participation rate, at best, it can be increased up to about 63 percent if *PED* continues to pursue its past policies in the future. What is important to note from the public policy point of view is that, if the government in this context opted for an *efficient cost-effective* optimization approach and reallocates its resources from boys schools and reduces the non-teaching staff, a significant *efficiency gain* can be made as argued earlier in *Proposition 2* (Chapter 4).

TABLE - 5.11
KEY RATIOS FOR PRIMARY EDUCATION : AN EX-ANTE FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEAR	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
PUPIL/TEACHER	ACTUAL	33.13	33.67	34.20	34.75	35.31	35.87	36.45	37.03	37.63	38.23	38.84	39.46
	OPTIMAL	**33.43**	**33.13**	**32.84**	**32.55**	**32.26**	**31.97**	**31.69**	**31.41**	**31.13**	**30.85**	**30.57**	**30.30**
TEACHER/SCHOOL	ACTUAL	2.12	2.14	2.16	2.18	2.20	2.22	2.24	2.26	2.28	2.30	2.32	2.34
	OPTIMAL	**3.21**	**3.24**	**3.27**	**3.30**	**3.33**	**3.37**	**3.40**	**3.43**	**3.46**	**3.50**	**3.53**	**3.57**
NON-TEACHER/SCHOOL	ACTUAL	0.36	0.39	0.40	0.41	0.42	0.43	0.44	0.46	0.47	0.48	0.50	0.51
	OPTIMAL	**0.50**	**0.48**	**0.46**	**0.45**	**0.43**	**0.41**	**0.40**	**0.38**	**0.37**	**0.36**	**0.34**	**0.33**
PUPIL/SCHOOL	ACTUAL	70.37	72.13	73.93	75.79	77.68	79.63	81.62	83.67	85.76	87.91	90.11	92.36
	OPTIMAL	**107.30**	**107.37**	**107.44**	**107.50**	**107.57**	**107.64**	**107.71**	**107.78**	**107.84**	**107.91**	**107.98**	**108.05**
		FEMALE											
PUPIL/TEACHER	ACTUAL	27.49	27.41	27.34	27.26	27.19	27.11	27.04	26.96	26.89	26.81	26.74	26.66
	OPTIMAL	**39.25**	**39.16**	**39.07**	**38.99**	**38.90**	**38.81**	**38.72**	**38.63**	**38.54**	**38.45**	**38.36**	**38.28**
TEACHER/SCHOOL	ACTUAL	3.47	3.56	3.65	3.74	3.84	3.93	4.04	4.14	4.25	4.35	4.47	4.58
	OPTIMAL	**2.49**	**2.51**	**2.53**	**2.56**	**2.58**	**2.61**	**2.63**	**2.66**	**2.68**	**2.71**	**2.74**	**2.76**
NON-TEACHER/SCHOOL	ACTUAL	0.58	0.63	0.69	0.74	0.81	0.88	0.95	1.03	1.12	1.21	1.32	1.43
	OPTIMAL	**0.40**	**0.38**	**0.37**	**0.36**	**0.34**	**0.33**	**0.32**	**0.31**	**0.30**	**0.28**	**0.27**	**0.26**
PUPIL/SCHOOL	ACTUAL	95.30	97.47	99.70	101.97	104.30	106.68	109.11	111.60	114.15	116.75	119.42	122.14
	OPTIMAL	**97.62**	**98.33**	**99.05**	**99.77**	**100.50**	**101.23**	**101.97**	**102.72**	**103.47**	**104.23**	**104.99**	**105.76**

In fact, the *public school system* can improve upon over 36 percent participation rate for girls and over 10 percent for the combined primary school rate as shown in Table 5.10. Again, all this would be possible within the allocated budget available to *PED*. It is interesting to note that all these measures will also improve upon teacher to students ratios for boys (30.3 vs 39.46) and students to school ratios for girls (105.76 vs 122.14). Although, in this process of reallocation, the students to school ratio for boys and teacher to pupils ratio for girls will increase, this increment is still marginal and well within the standard ratios adopted elsewhere.

Expenditure Pattern

- The critical public policy issue that deserves some discussion in this context is the availability of funds to meet the future recurring expenditure obligations for the primary school education system. Our optimization model predicts recurring outlays of over 95 percent that of the total expenditures for both boys and girls primary schools in 1991-92 as shown in Table 5.12. These figures are expected to decrease but will still remain over 80 percent until the end of the *Perspective Plan period*. Within recurring expenditures, the major portion of expenses will be required to meet payments for teachers' salaries. What is crucial for the long-term sustainability of the *Public Primary Education System* is the commitment from the policy makers for the provision of steady inflow of funds to meet *recurring expenditures*.

In terms of broad policy issues for the *Public Primary School System*, two important conclusion emerge from the foregoing discussion: a) There are significant gains to be made if *PED* adopts an overall *efficient cost-effective* approach in designing the education policy, particularly by diverting resources from boys to female school construction programme;

TABLE 5.12

MIX OF EXPENDITURE SHARES FOR PRIMARY EDUCATION : AN EX-ANTE ACTUAL VS CONSTRAINT OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL PRIMARY EDUCATION EXPENDITURE	*100.0%*	*100.0%*	*100.0%*	*100.0%*
MALE PRIMARY SCHOOLS				
TOTAL EXPENDITURE:	*65.3%*	*64.0%*	*56.9%*	*63.4%*
RECURRING EXPENDITURE:	*86.5%*	*96.2%*	*87.1%*	*85.9%*
TEACHERS	86.4%	87.7%	75.9%	88.0%
NON-TEACHERS	12.5%	11.6%	23.6%	11.6%
SCHOOLS	1.1%	0.8%	0.5%	0.4%
DEVELOPMENT EXPENDITURE :	*13.5%*	*3.8%*	*12.9%*	*14.1%*
FEMALE PRIMARY SCHOOLS				
TOTAL EXPENDITURE	*34.7%*	*36.0%*	*43.1%*	*36.6%*
RECURRING EXPENDITURE:	*97.1%*	*95.2%*	*93.3%*	*82.6%*
TEACHERS	86.9%	87.1%	69.1%	87.6%
NON-TEACHERS	12.4%	11.9%	30.7%	11.9%
SCHOOLS	0.7%	1.0%	0.2%	0.5%
DEVELOPMENT EXPENDITURE :	*2.9%*	*4.8%*	*6.7%*	*17.4%*

TABLE - 5.13

STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: A HISTORICAL SIMULATION FOR PUNJAB 1981-1992

VARIABLES	YEARS	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
TEACHING	*ACTUAL*	32,109	32,638	33,167	36,593	39,013	43,221	47,825	52,853	58,012	65,943	70,953
	OPTIMAL	31,440	32,015	34,194	34,587	35,032	41,059	44,729	50,742	54,249	63,166	71,898
NON-TEACHING	*ACTUAL*	6,908	7,309	8,092	9,999	11,899	12,270	13,886	15,491	17,598	18,052	19,346
	OPTIMAL	9,863	9,899	10,382	10,174	9,860	11,449	11,897	12,770	13,468	15,311	16,802
SCHOOLS	*ACTUAL*	3,570	3,466	3,708	4,106	4,318	4,623	4,985	5,386	5,625	5,898	6,462
	OPTIMAL	3,028	2,939	3,087	3,437	3,824	4,154	4,640	5,251	5,835	6,214	6,675
		FEMALE										
TEACHING	*ACTUAL*	15,329	15,751	16,352	17,720	20,010	21,063	21,688	27,110	27,937	29,258	29,524
	OPTIMAL	15,244	15,522	16,579	16,770	16,985	19,907	21,687	24,602	26,303	30,626	34,859
NON-TEACHING	*ACTUAL*	3,165	3,306	3,613	4,298	5,551	5,739	6,126	9,071	9,052	9,027	9,369
	OPTIMAL	4,384	4,400	4,614	4,522	4,382	5,088	5,288	5,676	5,986	6,805	7,468
SCHOOLS	*ACTUAL*	1,706	1,677	1,763	1,887	2,070	2,217	2,560	2,979	3,459	3,728	4,069
	OPTIMAL	2,207	2,142	2,250	2,505	2,787	3,028	3,382	3,828	4,253	4,529	4,865

and b) Recurring liabilities, particularly in terms of paying teachers salaries, will be crucial as the major expenditure at the primary level pertains to this activity.

5.3.3 SECONDARY EDUCATION SYSTEM

In this section, we analyse simulation results for the secondary education system which consists of public schools for boys and girls from grades six to ten. The discussion of the results in this section will also be organized like the primary schools, starting with historical simulation (1981-1992) of secondary schools in Punjab followed by its *ex-ante* forecasts (1992-2003). An analysis based on the combined four provinces secondary school data will conclude the chapter. Since the format of empirical analysis for secondary schools is similar to that of the primary level, in order to avoid repitition, detailed definitions and clarification of variables for the former institutions will be provided wherever they differ from the latter.

5.3.3.1 Infrastructure, Estimated Gains/Loss of Efficiency and Key Ratios for Secondary Schools in Punjab

A summary of the important results for historical and *ex-ante* simulation forecasts for the public secondary school system in Punjab along with actual values are presented below.

Historical Simulation: Tables 5.13-5.15 contain historical simulation results for the secondary school system in Punjab. It is interesting to note that, unlike primary schools, the *efficient and cost-effective* optimization results suggest an increase in schools and teachers for both boys and girls at the secondary level institutions as compared to that of actual figures as shown in Table 5.13.[12]

---

12 It should be noted that, in our analysis, in order to impose *cost-effective* strategy we have assumed that, at the secondary level, additional schools are simply upgrades from primary level. As such, the unit construction cost for secondary school is the upgradation cost from primary to middle or secondary level.

TABLE - 5.14

EFFICIENCY GAIN/LOSS IN SECONDARY EDUCATION : A HISTORCAL SIMULATION FOR PUNJAB 1981-1992

VARIABLES	YEARS	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
ENROLLMENT	ACTUAL	894,319	899,435	913,743	972,812	1,056,271	1,136,000	1,190,000	1,313,000	1,475,000	1,669,000	1,799,308
	OPTIMAL	846,681	820,974	876,783	988,254	1,112,187	1,226,088	1,401,177	1,581,356	1,765,520	1,891,256	2,010,950
ENROLLMENT RATIO	ACTUAL	26.75%	26.14%	25.94%	26.94%	28.54%	29.94%	30.60%	32.94%	36.10%	39.85%	41.91%
	OPTIMAL	25.32%	23.86%	24.89%	27.37%	30.05%	32.32%	36.03%	39.67%	43.21%	45.15%	46.84%
EFFICIENCY		-5.33%	-8.72%	-4.04%	1.59%	5.29%	7.93%	17.75%	20.44%	19.70%	13.32%	11.76%
		FEMALE										
ENROLLMENT	ACTUAL	292,000	307,000	324,000	356,000	390,000	434,000	528,000	606,000	683,000	822,000	894,887
	OPTIMAL	394,686	391,311	417,445	462,342	511,897	570,864	642,409	735,955	822,339	901,055	989,949
ENROLLMENT RATIO	ACTUAL	10.15%	10.27%	10.57%	11.27%	12.06%	13.21%	15.27%	17.50%	19.12%	21.72%	22.95%
	OPTIMAL	13.72%	13.09%	13.62%	14.64%	15.82%	17.38%	18.58%	21.25%	23.02%	23.81%	25.39%
EFFICIENCY		35.17%	27.46%	28.84%	29.87%	31.26%	31.54%	21.67%	21.44%	20.40%	9.62%	10.62%
		COMBINED										
ENROLLMENT	ACTUAL	571,543	585,110	603,549	650,725	709,073	773,077	859,769	963,713	1,084,035	1,257,253	1,360,726
	OPTIMAL	623,925	610,388	651,591	729,300	815,417	903,080	1,025,700	1,164,551	1,300,601	1,405,888	1,514,558
ENROLLMENT RATIO	ACTUAL	9.19%	9.10%	9.16%	9.61%	10.22%	10.92%	11.70%	12.94%	14.16%	15.77%	16.61%
	OPTIMAL	10.03%	9.49%	9.89%	10.77%	11.76%	12.76%	13.96%	15.63%	16.98%	17.63%	18.49%
EFFICIENCY		9.17%	4.32%	7.96%	12.08%	15.00%	16.82%	19.30%	20.84%	19.98%	11.82%	11.31%

Increases in schools and teachers are, however, much larger for female institutions in the order of over 18 percent in 1991-92 while, for boys schools, the expansion is relatively modest. Obviously, this increase in schools and teachers will come at the cost of reducing the non-teaching staff significantly. Reallocating resources in this manner could have increased the student participation rates to about 47 percent (as opposed to 42 percent) for boys and over 25 percent (as opposed to 23 percent) for girls in 1991-92. In terms of *efficiency gains*, obviously male and female secondary schools could have benefitted by about 12 and 11 percentages, respectively.

Analysing the key ratios in Table 5.15, some interesting facts emerge pertaining to the distribution and utilization of education inputs for the secondary school sytem. In general, girls institutions have a higher pupils to teacher ratio (30.31) as compared to that in boys schools (25.36) in 1991-92 as shown in Table 5.15. This implies that fewer teachers in female schools were teaching more students relative to those in male secondary schools. Although boys institutions have more students per school (278 as opposed to 219 for girls), the teacher per school ratio for these schools is considerably higher (10.98 vs 7.26 for girls). Therefore, our *cost-effective* model that maximizes enrollment, in this context, suggests that fewer schools be built for boys and more for girls. This strategy will, of course, increase the pupils to school ratio for boys (278.44 vs 301.26) and lower it for female (from 219.93 to 203.47). One can justify this strategy on the grounds that, for boys schools, consolidation of the existing facilities (with more staff, library, laboratory, etc.) may create more economies of scale. As for girls, more schools with small capacity in many different locations, particularly in rural areas, may attract more female students. The justification for spreading out female schools is based on the fact that, in many cases, due to local social customs (particularly in rural areas) parents are reluctant to send their female offsprings to schools that are at a greater distance and inconvenient locations.

TABLE - 5.15

KEY RATIOS FOR SECONDARY EDUCATION : A HISTORICAL SIMULATION FOR PUNJAB 1981-1992

VARIABLES	YEAR	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
PUPIL/TEACHER	ACTUAL	27.85	27.56	27.55	26.58	27.07	26.28	24.88	24.84	25.43	25.31	25.36
	OPTIMAL	**26.93**	**25.64**	**25.64**	**28.57**	**31.75**	**29.86**	**31.33**	**31.16**	**32.54**	**29.94**	**27.97**
TEACHER/SCHOOL	ACTUAL	8.99	9.42	8.94	8.91	9.04	9.35	9.59	9.81	10.31	11.18	10.98
	OPTIMAL	**10.38**	**10.89**	**11.08**	**10.06**	**9.16**	**9.89**	**9.64**	**9.66**	**9.30**	**10.16**	**10.77**
NON-TEACHER/SCHOOL	ACTUAL	1.93	2.11	2.18	2.44	2.76	2.65	2.79	2.88	3.13	3.06	2.99
	OPTIMAL	**3.26**	**3.37**	**3.36**	**2.96**	**2.58**	**2.76**	**2.56**	**2.43**	**2.31**	**2.46**	**2.52**
PUPIL/SCHOOL	ACTUAL	250.51	259.50	246.42	236.92	244.62	245.73	238.72	243.78	262.22	282.98	278.44
	OPTIMAL	**279.62**	**279.32**	**283.99**	**287.56**	**290.85**	**295.19**	**301.99**	**301.14**	**302.59**	**304.35**	**301.26**
		FEMALE										
PUPIL/TEACHER	ACTUAL	19.05	19.49	19.81	20.09	19.49	20.61	24.35	22.35	24.45	28.10	30.31
	OPTIMAL	**25.89**	**25.21**	**25.18**	**27.57**	**30.14**	**28.68**	**29.62**	**29.91**	**31.26**	**29.42**	**28.40**
TEACHER/SCHOOL	ACTUAL	8.99	9.39	9.28	9.39	9.67	9.50	8.47	9.10	8.08	7.85	7.26
	OPTIMAL	**6.91**	**7.25**	**7.37**	**6.69**	**6.09**	**6.58**	**6.41**	**6.43**	**6.18**	**6.76**	**7.16**
NON-TEACHER/SCHOOL	ACTUAL	1.86	1.97	2.05	2.28	2.68	2.59	2.39	3.05	2.62	2.42	2.30
	OPTIMAL	**1.99**	**2.05**	**2.05**	**1.81**	**1.57**	**1.68**	**1.56**	**1.48**	**1.41**	**1.50**	**1.53**
PUPIL/SCHOOL	ACTUAL	171.16	183.06	183.78	188.66	188.41	195.76	206.25	203.42	197.46	220.49	219.93
	OPTIMAL	**178.83**	**182.65**	**185.50**	**184.57**	**183.66**	**188.56**	**189.95**	**192.28**	**193.36**	**198.94**	**203.47**

TABLE - 5.16(A)

STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	*ACTUAL*	70,953	76,808	180,768	90,007	97,434	105,474	114,177	123,598	133,797	144,838	156,789	169,727
	OPTIMAL	**71,898**	**76,659**	**162,687**	**88,394**	**95,386**	**103,167**	**111,784**	**121,294**	**131,769**	**143,292**	**155,961**	**169,886**
NON-TEACHING	*ACTUAL*	19,346	21,445	49,783	26,350	29,209	32,377	35,890	39,783	44,099	48,883	54,185	60,063
	OPTIMAL	**16,802**	**17,395**	**35,845**	**18,911**	**19,815**	**20,810**	**21,893**	**23,067**	**24,332**	**25,692**	**27,152**	**28,718**
SCHOOLS	*ACTUAL*	6,462	6,857	11,832	7,721	8,193	8,694	9,225	9,789	10,388	11,023	11,697	12,412
	OPTIMAL	**6,675**	**7,091**	**14,993**	**8,116**	**8,726**	**9,402**	**10,150**	**10,973**	**11,876**	**12,866**	**13,952**	**15,141**
		FEMALE											
TEACHING	*ACTUAL*	29,524	31,523	33,659	35,939	38,373	40,972	43,748	46,711	49,875	53,254	56,861	60,713
	OPTIMAL	**34,859**	**37,168**	**39,834**	**42,858**	**46,248**	**50,021**	**54,198**	**58,809**	**63,888**	**69,475**	**75,618**	**82,369**
NON-TEACHING	*ACTUAL*	9,369	10,443	11,640	12,974	14,461	16,119	17,966	20,026	22,321	24,880	27,731	30,910
	OPTIMAL	**7,468**	**7,731**	**8,045**	**8,405**	**8,807**	**9,249**	**9,730**	**10,252**	**10,814**	**11,419**	**12,067**	**12,764**
SCHOOLS	*ACTUAL*	4,069	4,439	4,842	5,281	5,761	6,284	6,855	7,477	8,156	8,897	9,705	10,586
	OPTIMAL	**4,865**	**5,168**	**5,519**	**5,916**	**6,360**	**6,853**	**7,398**	**7,998**	**8,656**	**9,378**	**10,169**	**11,036**

Ex-Ante Simulation (1993-2003): Future simulation forecasts from 1992-93 up to the end of the perspective plan period 2002-03 for the Punjab public secondary school system, based on standard optimization model, are reported in Tables 5.16(A)-5.19(A) while results derived from the constrained approach are presented in Tables 5.16(B)-5.19(B), respectively. As indicated earlier, constrained optimization simulation forecasts are undertaken with the assumption that, whenever the targetted participation rate for a given type of secondary institution (say boys at 60%) is attained, further development allocation outlays from this point on will be diverted towards other types of school (e.g., girls). Of course, standard resource allocations will continue to cover recurring and some development costs to meet the normal population growth for this age group (10 to 14 years).

Based on the past government practices, it appears that *PED* will go for a programme where large amount of resources will be spent on non-teaching staff and construction of schools for boys. Our standard optimization model also suggests an expanded school construction (15,141 vs 12,141) programme with fewer non-teaching staff (28,718 vs 60,053 for boys and 12,764 vs 30,910 for girls) as shown in Table 5.16(A). This reallocation of resources will produce a relatively higher enrollment rate of over 87 percent (as opposed to 69%) for boys and only less than 48 (as opposed to 43%) percent for girls as reported in Table 5.17(A). In this context, it is interesting to note that girls enrollment rates can be significantly enhanced (up to 63% by 2002-03) if a further reallocation constraint is imposed on our optimization strategy[13] in such a way that the resources be transferred from boys schools to the female institutions particularly to undertake an expanded school construction programme whenever the stipulated participation rate (of 70%) for boys is achieved as shown in Table 17(B).

---

13 This constrained optimization and the efficiency gains resulting from it have been discussed in Figure 4.3 in Chapter 4.

TABLE - 5.16(B)

STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	*ACTUAL*	70,953	76,808	83,146	90,007	97,434	105,474	114,177	123,598	133,797	144,838	156,789	169,727
	OPTIMAL	**71,898**	**76,659**	**82,158**	**88,394**	**95,386**	**103,167**	**111,784**	**121,294**	**127,213**	**129,508**	**131,822**	**134,140**
NON-TEACHING	*ACTUAL*	19,346	21,445	23,772	26,350	29,209	32,377	35,890	39,783	44,099	48,883	54,185	60,063
	OPTIMAL	**16,802**	**17,395**	**18,102**	**18,911**	**19,815**	**20,810**	**21,893**	**23,067**	**23,781**	**24,063**	**24,355**	**24,674**
SCHOOLS	*ACTUAL*	6,462	6,857	7,276	7,721	8,193	8,694	9,225	9,789	10,388	11,023	11,697	12,412
	OPTIMAL	**6,675**	**7,091**	**7,571**	**8,116**	**8,726**	**9,402**	**10,150**	**10,973**	**11,483**	**11,681**	**11,883**	**12,087**
		FEMALE											
TEACHING	*ACTUAL*	29,524	31,523	33,659	35,939	38,373	40,972	43,748	46,711	49,875	53,254	56,861	60,713
	OPTIMAL	**34,859**	**37,168**	**39,834**	**42,858**	**46,248**	**50,021**	**54,198**	**58,809**	**67,059**	**79,300**	**93,303**	**109,184**
NON-TEACHING	*ACTUAL*	9,369	10,443	11,640	12,974	14,461	16,119	17,966	20,026	22,321	24,880	27,731	30,910
	OPTIMAL	**7,468**	**7,731**	**8,045**	**8,405**	**8,807**	**9,249**	**9,730**	**10,252**	**11,351**	**13,033**	**14,890**	**16,919**
SCHOOLS	*ACTUAL*	4,069	4,439	4,842	5,281	5,761	6,284	6,855	7,477	8,156	8,897	9,705	10,586
	OPTIMAL	**4,865**	**5,168**	**5,519**	**5,916**	**6,360**	**6,853**	**7,398**	**7,998**	**9,086**	**10,704**	**12,548**	**14,629**

TABLE - 5.17(A)
EFFICIENCY GAIN/LOSS IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
ENROLLMENT	ACTUAL	1,799,308	1,929,598	2,069,322	2,219,164	2,379,856	2,552,184	2,736,990	2,935,179	3,147,718	3,375,648	3,620,082	3,882,216
	OPTIMAL	2,010,950	2,152,226	2,315,288	2,500,420	2,708,377	2,940,339	3,197,886	3,482,982	3,797,978	4,145,617	4,529,060	4,951,909
ENROLLMENT RATIO	ACTUAL	41.91%	43.83%	45.85%	47.95%	50.16%	52.46%	54.87%	57.39%	60.03%	62.78%	65.67%	68.68%
	OPTIMAL	45.77%	48.89%	51.30%	54.03%	57.08%	60.44%	64.11%	68.10%	72.43%	77.11%	82.16%	87.61%
EFFICIENCY		11.76%	11.54%	11.89%	12.67%	13.80%	15.21%	16.84%	18.66%	20.66%	22.81%	25.11%	27.55%
		FEMALE											
ENROLLMENT	ACTUAL	894,887	976,911	1,066,454	1,164,204	1,270,913	1,387,403	1,514,571	1,653,394	1,804,942	1,970,381	2,150,983	2,348,139
	OPTIMAL	989,949	1,065,287	1,152,261	1,251,197	1,362,663	1,487,454	1,626,581	1,781,272	1,952,980	2,143,388	2,354,429	2,588,310
ENROLLMENT RATIO	ACTUAL	22.95%	24.30%	25.74%	27.25%	28.86%	30.56%	32.36%	34.27%	36.29%	38.43%	40.70%	43.10%
	OPTIMAL	25.39%	26.50%	27.81%	29.29%	30.94%	32.77%	34.76%	36.92%	39.27%	41.81%	44.55%	47.51%
EFFICIENCY		10.62%	9.05%	8.05%	7.47%	7.22%	7.21%	7.40%	7.73%	8.20%	8.78%	9.46%	10.23%
		COMBINED											
ENROLLMENT	ACTUAL	2,694,195	2,906,509	3,135,776	3,383,367	3,650,769	3,939,587	4,251,561	4,588,573	4,952,660	5,346,028	5,771,065	6,230,355
	OPTIMAL	3,000,900	3,217,513	3,467,549	3,751,617	4,071,040	4,427,793	4,824,467	5,264,255	5,750,958	6,289,005	6,883,489	7,540,218
ENROLLMENT RATIO	ACTUAL	32.89%	34.51%	36.22%	38.02%	39.91%	41.89%	43.98%	46.17%	48.47%	50.90%	53.45%	56.13%
	OPTIMAL	36.63%	38.21%	40.05%	42.16%	44.50%	47.08%	49.90%	52.97%	56.29%	59.88%	63.75%	67.93%
EFFICIENCY		11.38%	10.70%	10.58%	10.88%	11.51%	12.39%	13.48%	14.73%	16.12%	17.64%	19.28%	21.02%

TABLE - 5.17(B)
EFFICIENCY GAIN/LOSS IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
ENROLLMENT	ACTUAL	1,799,308	1,929,598	2,069,322	2,219,164	2,379,856	2,552,184	2,736,990	2,935,179	3,147,718	3,375,648	3,620,082	3,882,216
	OPTIMAL	2,010,950	2,152,226	2,315,288	2,500,420	2,708,377	2,940,339	3,197,886	3,482,982	3,672,282	3,763,583	3,856,917	3,952,274
ENROLLMENT RATIO	ACTUAL	41.91%	43.83%	45.85%	47.95%	50.16%	52.46%	54.87%	57.39%	60.03%	62.78%	65.67%	68.68%
	OPTIMAL	45.77%	48.89%	51.30%	54.03%	57.08%	60.44%	64.11%	68.10%	70.03%	70.00%	69.96%	69.92%
EFFICIENCY		11.76%	11.54%	11.89%	12.67%	13.80%	15.21%	16.84%	18.66%	16.66%	11.49%	6.54%	1.80%
		FEMALE											
ENROLLMENT	ACTUAL	894,887	976,911	1,066,454	1,164,204	1,270,913	1,387,403	1,514,571	1,653,394	1,804,942	1,970,381	2,150,983	2,348,139
	OPTIMAL	989,949	1,065,287	1,152,261	1,251,197	1,362,663	1,487,454	1,626,581	1,781,272	2,049,926	2,446,489	2,905,074	3,430,932
ENROLLMENT RATIO	ACTUAL	22.95%	24.30%	25.74%	27.25%	28.86%	30.56%	32.36%	34.27%	36.29%	38.43%	40.70%	43.10%
	OPTIMAL	25.39%	26.50%	27.81%	29.29%	30.94%	32.77%	34.76%	36.92%	41.22%	47.72%	54.97%	62.97%
EFFICIENCY		10.62%	9.05%	8.05%	7.47%	7.22%	7.21%	7.40%	7.73%	13.57%	24.16%	35.06%	46.11%
		COMBINED											
ENROLLMENT	ACTUAL	2,694,195	2,906,509	3,135,776	3,383,367	3,650,769	3,939,587	4,251,561	4,588,573	4,952,660	5,346,028	5,771,065	6,230,355
	OPTIMAL	3,000,900	3,217,513	3,467,549	3,751,617	4,071,040	4,427,793	4,824,467	5,264,255	5,722,208	6,210,072	6,761,991	7,383,206
ENROLLMENT RATIO	ACTUAL	32.89%	34.51%	36.22%	38.02%	39.91%	41.89%	43.98%	46.17%	48.47%	50.90%	53.45%	56.13%
	OPTIMAL	36.63%	38.21%	40.05%	42.16%	44.50%	47.08%	49.90%	52.97%	56.01%	59.12%	62.62%	66.51%
EFFICIENCY		11.38%	10.70%	10.58%	10.88%	11.51%	12.39%	13.48%	14.73%	15.54%	16.16%	17.17%	18.50%

TABLE - 5.18(A)
KEY RATIOS FOR SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEAR	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-200	2000-01	2001-02	2002-03
		MALE											
PUPIL/TEACHER	ACTUAL	25.36	25.12	24.89	24.66	24.43	24.20	23.97	23.75	23.53	23.31	23.09	22.87
	OPTIMAL	27.97	28.08	28.18	28.29	28.39	28.50	28.61	28.72	28.82	28.93	29.04	29.15
TEACHER/SCHOOL	ACTUAL	10.98	11.20	11.43	11.66	11.89	12.13	12.38	12.63	12.88	13.14	13.40	13.67
	OPTIMAL	10.77	10.81	10.85	10.89	10.93	10.97	11.01	11.05	11.10	11.14	11.18	11.22
NON-TEACHER/SCHOOL	ACTUAL	2.99	3.13	3.27	3.41	3.57	3.72	3.89	4.06	4.25	4.43	4.63	4.84
	OPTIMAL	2.52	2.45	2.39	2.33	2.27	2.21	2.16	2.10	2.05	2.00	1.95	1.90
PUPIL/SCHOOL	ACTUAL	278.44	281.40	284.39	287.42	290.47	293.56	296.68	299.83	303.02	306.24	309.49	312.78
	OPTIMAL	301.26	303.52	305.79	308.09	310.39	312.72	315.07	317.43	319.81	322.21	324.62	327.06
		FEMALE											
PUPIL/TEACHER	ACTUAL	30.31	30.99	31.68	32.39	33.12	33.86	34.62	35.40	36.19	37.00	37.83	38.68
	OPTIMAL	28.40	28.66	28.93	29.19	29.46	29.74	30.01	30.29	30.57	30.85	31.14	31.42
TEACHER/SCHOOL	ACTUAL	7.26	7.10	6.95	6.80	6.66	6.52	6.38	6.25	6.11	5.99	5.86	5.73
	OPTIMAL	7.16	7.19	7.22	7.24	7.27	7.30	7.33	7.35	7.38	7.41	7.44	7.46
NON-TEACHER/SCHOOL	ACTUAL	2.30	2.35	2.40	2.46	2.51	2.57	2.62	2.68	2.74	2.80	2.86	2.92
	OPTIMAL	1.53	1.50	1.46	1.42	1.38	1.35	1.32	1.28	1.25	1.22	1.19	1.16
PUPIL/SCHOOL	ACTUAL	219.93	220.10	220.27	220.44	220.61	220.78	220.95	221.12	221.29	221.46	221.64	221.81
	OPTIMAL	203.47	206.11	208.79	211.51	214.26	217.04	219.86	222.72	225.62	228.55	231.52	234.53

TABLE - 5.18(B)
KEY RATIOS FOR SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB

VARIABLES	YEAR	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-200	2000-01	2001-02	2002-03
		MALE											
PUPIL/TEACHER	ACTUAL	25.36	25.12	24.89	24.66	24.43	24.20	23.97	23.75	23.53	23.31	23.09	22.87
	OPTIMAL	27.97	28.08	28.18	28.29	28.39	28.50	28.61	28.72	28.87	29.06	29.26	29.46
TEACHER/SCHOOL	ACTUAL	10.98	11.20	11.43	11.66	11.89	12.13	12.38	12.63	12.88	13.14	13.40	13.67
	OPTIMAL	10.77	10.81	10.85	10.89	10.93	10.97	11.01	11.05	11.08	11.09	11.09	11.10
NON-TEACHER/SCHOOL	ACTUAL	2.99	3.13	3.27	3.41	3.57	3.72	3.89	4.06	4.25	4.43	4.63	4.84
	OPTIMAL	2.52	2.45	2.39	2.33	2.27	2.21	2.16	2.10	2.07	2.06	2.05	2.04
PUPIL/SCHOOL	ACTUAL	278.44	281.40	284.39	287.42	290.47	293.56	296.68	299.83	303.02	306.24	309.49	312.78
	OPTIMAL	301.26	303.52	305.79	308.09	310.39	312.72	315.07	317.43	319.80	322.19	324.58	326.99
		FEMALE											
PUPIL/TEACHER	ACTUAL	30.31	30.99	31.68	32.39	33.12	33.86	34.62	35.40	36.19	37.00	37.83	38.68
	OPTIMAL	28.40	28.66	28.93	29.19	29.46	29.74	30.01	30.29	30.57	30.85	31.14	31.42
TEACHER/SCHOOL	ACTUAL	7.26	7.10	6.95	6.80	6.66	6.52	6.38	6.25	6.11	5.99	5.86	5.73
	OPTIMAL	7.16	7.19	7.22	7.24	7.27	7.30	7.33	7.35	7.38	7.41	7.44	7.46
NON-TEACHER/SCHOOL	ACTUAL	2.30	2.35	2.40	2.46	2.51	2.57	2.62	2.68	2.74	2.80	2.86	2.92
	OPTIMAL	1.53	1.50	1.46	1.42	1.38	1.35	1.32	1.28	1.25	1.22	1.19	1.16
PUPIL/SCHOOL	ACTUAL	219.93	220.10	220.27	220.44	220.61	220.78	220.95	221.12	221.29	221.46	221.64	221.81
	OPTIMAL	203.47	206.11	208.79	211.51	214.26	217.04	219.86	222.72	225.62	228.55	231.52	234.53

TABLE 5.19(A)

MIX OF EXPENDITURE SHARES FOR SECONDARY EDUCATION : AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR PUNJAB

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL SECONDARY EDUCATION EXPENDITURE	*100.0%*	*100.0%*	*100.0%*	*100.0%*
MALE SECONDARY SCHOOLS				
TOTAL EXPENDITURE:	*68.3%*	*65.5%*	*67.1%*	*65.4%*
RECURRING EXPENDITURE:	*80.3%*	*83.2%*	*89.0%*	*81.3%*
TEACHERS	84.6%	86.2%	76.9%	86.6%
NON-TEACHERS	13.5%	11.8%	22.0%	11.8%
SCHOOLS	1.9%	2.0%	1.1%	1.5%
DEVELOPMENT EXPENDITURE :	*19.7%*	*16.8%*	*11.0%*	*18.7%*
FEMALE SECONDARY SCHOOLS				
TOTAL EXPENDITURE	*31.7%*	*34.5%*	*32.9%*	*34.6%*
RECURRING EXPENDITURE:	*74.3%*	*76.7%*	*72.3%*	*74.2%*
TEACHERS	82.0%	86.2%	69.2%	86.8%
NON-TEACHERS	15.2%	10.8%	28.4%	10.9%
SCHOOLS	2.8%	3.0%	2.4%	2.3%
DEVELOPMENT EXPENDITURE :	*25.7%*	*23.3%*	*27.7%*	*25.8%*

In a broad public policy framework, what is critical to note is that an *efficient and cost-effective* strategy certainly leads to higher efficiency gains in terms of student participation rates. However, if the enrollement rates are unequal, i.e., higher for boys and lower for girls, then, a prudent and *cost-effective* reallocation of resources could further enhance the participation rate for the latter group.

5.3.2.2 Ex-ante Optimal Expansion Paths and Estimated Efficiency Gain/Loss of Secondary Education Output for All Four Provinces Combined (National)

In this section, we briefly discuss the *ex-ante* simulation forecasts for the combined secondary school system and the results are reported in Tables 5.20-5.23, respectively.

At the national level, the actual combined (boys and girls) participation rate in the public secondary school system stands at only about 28 percent in 1991-92. The rate for girl students is far below the national average and is only about 15 percent as shown in Table 5.21. If a *cost-effective* optimization approach is adopted then, within the existing limited budget, an *efficient* reallocation of resources could have significantly increased the enrollment rates for females (over 22%) with a modest increase for boys (35.2% vs 32.8%) in 1991-92. Continuing with the *cost-effective* strategy, that is, adopting an accelerated school construction programme for girls (18,412 as opposed to 12293 as shown in Table 5.20) institutions, it is expected that the participation rates for both female and male students may be doubled reaching to over 42 percent for the former and 65 percent for the latter by the end of the perspective plan period 2002-03.

As far as the expenditure allocations are concerned, although recurring liabilities for secondary schools are slightly lower than that of the primary institutions, as a percentage of the total cost, these figures are still very high at about 80 percent. Thus, the crucial public policy issue that will

TABLE 5.19(B)

MIX OF EXPENDITURE SHARES FOR SECONDARY EDUCATION : AN EX-ANTE ACTUAL VS CONSTRAINT OPTIMAL FORECAST FOR PUNJAB

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL SECONDARY EDUCATION EXPENDITURE	*100.0%*	*100.0%*	*100.0%*	*100.0%*
MALE SECONDARY SCHOOLS				
TOTAL EXPENDITURE:	*68.3%*	*65.5%*	*67.1%*	*44.5%*
RECURRING EXPENDITURE:	*80.3%*	*83.2%*	*89.0%*	*95.3%*
TEACHERS	84.6%	86.2%	76.9%	85.7%
NON-TEACHERS	13.5%	11.8%	22.0%	12.7%
SCHOOLS	1.9%	2.0%	1.1%	1.5%
DEVELOPMENT EXPENDITURE :	*19.7%*	*16.8%*	*11.0%*	*4.7%*
FEMALE SECONDARY SCHOOLS				
TOTAL EXPENDITURE	*31.7%*	*34.5%*	*32.9%*	*55.5%*
RECURRING EXPENDITURE:	*74.3%*	*76.7%*	*72.3%*	*61.4%*
TEACHERS	82.0%	86.2%	69.2%	86.8%
NON-TEACHERS	15.2%	10.8%	28.4%	10.9%
SCHOOLS	2.8%	3.0%	2.4%	2.3%
DEVELOPMENT EXPENDITURE :	*25.7%*	*23.3%*	*27.7%*	*38.6%*

TABLE - 5.20

STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	154,260	166,989	180,768	90,007	97,434	105,474	114,177	123,598	133,797	144,838	156,789	169,727
	OPTIMAL	141,671	152,740	164,909	87,219	94,126	101,842	110,403	119,859	130,276	141,736	154,333	168,177
NON-TEACHING	ACTUAL	42,062	46,624	49,783	26,350	29,209	32,377	35,890	39,783	44,099	48,883	54,185	60,063
	OPTIMAL	48,559	50,834	53,292	27,368	28,678	30,129	31,713	33,431	35,282	37,272	39,407	41,696
SCHOOLS	ACTUAL	10,508	11,150	11,832	7,721	8,193	8,694	9,225	9,789	10,388	11,023	11,697	12,412
	OPTIMAL	10,803	11,604	12,482	6,577	7,072	7,623	8,233	8,905	9,644	10,453	11,339	12,311
		FEMALE											
TEACHING	ACTUAL	70,877	75,678	80,804	86,278	92,122	98,362	105,025	112,139	119,736	127,846	136,506	145,753
	OPTIMAL	68,002	73,315	79,156	85,553	92,540	100,162	108,467	117,514	127,367	138,098	149,788	162,526
NON-TEACHING	ACTUAL	22,492	25,070	27,944	31,147	34,717	38,696	43,132	48,076	53,586	59,728	66,575	74,205
	OPTIMAL	25,898	27,111	28,422	29,828	31,328	32,924	34,619	36,419	38,327	40,350	42,496	44,772
SCHOOLS	ACTUAL	4,725	5,154	5,622	6,133	6,690	7,297	7,960	8,683	9,471	10,331	11,270	12,293
	OPTIMAL	8,025	8,620	9,273	9,985	10,760	11,603	12,519	13,513	14,591	15,762	17,032	18,412

TABLE - 5.21
EFFICIENCY GAIN/LOSS IN SECONDARY EDUCATION : AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
ENROLLMENT	ACTUAL	2,696,806	2,892,085	3,101,504	3,326,087	3,566,932	3,825,218	4,102,206	4,399,251	4,717,806	5,059,427	5,425,786	5,818,673
	OPTIMAL	2,899,050	3,133,169	3,391,020	3,673,944	3,983,644	4,322,168	4,691,888	5,095,509	5,536,075	6,016,990	6,542,042	7,115,440
ENROLLMENT RATIO	ACTUAL	32.77%	34.27%	35.84%	37.49%	39.21%	41.01%	42.90%	44.87%	46.93%	49.09%	51.34%	53.70%
	OPTIMAL	35.22%	37.13%	39.19%	41.41%	43.79%	46.34%	49.06%	51.97%	55.07%	58.38%	61.90%	65.67%
EFFICIENCY		7.50%	8.34%	9.33%	10.46%	11.68%	12.99%	14.37%	15.83%	17.34%	18.93%	20.57%	22.29%
		FEMALE											
ENROLLMENT	ACTUAL	1,211,813	1,322,886	1,444,140	1,576,508	1,721,009	1,878,754	2,050,958	2,238,946	2,444,165	2,668,194	2,912,757	3,179,736
	OPTIMAL	1,818,838	1,978,238	2,154,673	2,349,305	2,563,559	2,799,111	3,057,889	3,342,082	3,654,153	3,996,863	4,373,292	4,786,872
ENROLLMENT RATIO	ACTUAL	14.98%	15.86%	16.80%	17.79%	18.84%	19.95%	21.12%	22.37%	23.69%	25.08%	26.56%	28.13%
	OPTIMAL	22.48%	23.72%	25.06%	26.51%	28.06%	29.72%	31.49%	33.39%	35.41%	37.58%	39.88%	42.35%
EFFICIENCY		50.09%	49.54%	49.20%	49.02%	48.96%	48.99%	49.10%	49.27%	49.51%	49.80%	50.14%	50.54%
		COMBINED											
ENROLLMENT	ACTUAL	3,908,619	4,214,971	4,545,644	4,902,595	5,287,941	5,703,972	6,153,164	6,638,197	7,161,971	7,727,621	8,338,543	8,998,409
	OPTIMAL	4,717,888	5,111,407	5,545,693	6,023,248	6,547,203	7,121,278	7,749,776	8,437,590	9,190,228	10,013,853	10,915,334	11,902,312
ENROLLMENT RATIO	ACTUAL	27.89%	28.96%	30.06%	31.21%	32.40%	33.99%	35.67%	37.43%	39.28%	41.22%	43.27%	45.41%
	OPTIMAL	33.66%	35.11%	36.68%	38.35%	40.12%	42.44%	44.93%	47.58%	50.40%	53.42%	56.64%	60.07%
EFFICIENCY		20.70%	21.27%	22.00%	22.86%	23.81%	24.85%	25.95%	27.11%	28.32%	29.59%	30.90%	32.27%

TABLE - 5.22
KEY RATIOS FOR SECONDARY EDUCATION : AN EX-ANTE FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	YEAR	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-200	2000-01	2001-02	2002-03
		MALE											
PUPIL/TEACHER	*ACTUAL*	17.48	17.32	17.16	17.00	16.84	16.68	16.53	16.37	16.22	16.07	15.92	15.77
	OPTIMAL	**20.46**	**20.51**	**20.56**	**20.61**	**20.66**	**20.71**	**20.76**	**20.81**	**20.86**	**20.91**	**20.96**	**21.01**
TEACHER/SCHOOL	*ACTUAL*	14.68	14.98	15.28	15.59	15.90	16.22	16.55	16.88	17.22	17.57	17.92	18.28
	OPTIMAL	**13.11**	**13.16**	**13.21**	**13.26**	**13.31**	**13.36**	**13.41**	**13.46**	**13.51**	**13.56**	**13.61**	**13.66**
NON-TEACHER/SCHOOL	*ACTUAL*	4.00	4.18	4.21	4.23	4.26	4.29	4.31	4.34	4.37	4.39	4.42	4.45
	OPTIMAL	**4.49**	**4.38**	**4.27**	**4.16**	**4.06**	**3.95**	**3.85**	**3.75**	**3.66**	**3.57**	**3.48**	**3.39**
PUPIL/SCHOOL	*ACTUAL*	256.64	259.37	262.13	264.91	267.73	270.57	273.45	276.36	279.29	282.26	285.26	288.29
	OPTIMAL	**268.36**	**270.01**	**271.67**	**273.34**	**275.02**	**276.71**	**278.41**	**280.12**	**281.85**	**283.58**	**285.33**	**287.08**
		FEMALE											
PUPIL/TEACHER	*ACTUAL*	17.10	17.48	17.87	18.27	18.68	19.10	19.53	19.97	20.41	20.87	21.34	21.82
	OPTIMAL	**26.75**	**26.98**	**27.22**	**27.46**	**27.70**	**27.95**	**28.19**	**28.44**	**28.69**	**28.94**	**29.20**	**29.45**
TEACHER/SCHOOL	*ACTUAL*	15.00	14.68	14.37	14.07	13.77	13.48	13.19	12.92	12.64	12.37	12.11	11.86
	OPTIMAL	**8.47**	**8.51**	**8.54**	**8.57**	**8.60**	**8.63**	**8.66**	**8.70**	**8.73**	**8.76**	**8.79**	**8.83**
NON-TEACHER/SCHOOL	*ACTUAL*	4.76	4.86	4.97	5.08	5.19	5.30	5.42	5.54	5.66	5.78	5.91	6.04
	OPTIMAL	**3.23**	**3.15**	**3.07**	**2.99**	**2.91**	**2.84**	**2.77**	**2.70**	**2.63**	**2.56**	**2.50**	**2.43**
PUPIL/SCHOOL	*ACTUAL*	256.47	256.67	256.87	257.06	257.26	257.46	257.66	257.86	258.06	258.26	258.46	258.66
	OPTIMAL	**226.65**	**229.49**	**232.37**	**235.29**	**238.24**	**241.23**	**244.26**	**247.33**	**250.43**	**253.58**	**256.76**	**259.99**

require serious consideration prior to formulating long-term policies for the public education sector will pertain to the recurring expenditure liabilities. The succcess and sustainability of the expanded school program in the sense of maintaining high enrollment ratios and quality teaching will depend on how much resources *PED* can provide on a regular basis to meet the recurring expenditure liabilities of the school system.

TABLE 5.23

MIX OF EXPENDITURE SHARES FOR SECONDARY EDUCATION : AN EX-ANTE ACTUAL VS OPTIMAL FORECAST FOR ALL PROVINCES COMBINED

VARIABLES	1991-92		2002-03	
	ACTUAL	OPTIMAL	ACTUAL	OPTIMAL
TOTAL SECONDARY EDUCATION EXPENDITURE	*100.0%*	*100.0%*	*100.0%*	*100.0%*
MALE SECONDARY SCHOOLS				
TOTAL EXPENDITURE:	*67.8%*	*65.6%*	*66.5%*	*65.4%*
RECURRING EXPENDITURE:	*88.9%*	*87.4%*	*91.0%*	*85.3%*
TEACHERS	85.0%	82.0%	82.8%	82.3%
NON-TEACHERS	13.5%	16.4%	16.3%	16.5%
SCHOOLS	1.5%	1.6%	0.9%	1.2%
DEVELOPMENT EXPENDITURE :	*11.1%*	*12.6%*	*9.0%*	*14.7%*
FEMALE SECONDARY SCHOOLS				
TOTAL EXPENDITURE	*32.2%*	*34.4%*	*33.5%*	*34.6%*
RECURRING EXPENDITURE:	*87.8%*	*82.2%*	*84.2%*	*79.4%*
TEACHERS	83.2%	79.9%	70.1%	80.3%
NON-TEACHERS	15.4%	17.7%	28.8%	17.9%
SCHOOLS	1.4%	2.4%	1.2%	1.8%
DEVELOPMENT EXPENDITURE :	*12.2%*	*17.8%*	*15.8%*	*20.6%*

CHAPTER SIX

POLICY RECOMMENDATIONS

Significance of education cannot be underscored in the growth and development process of a country. In his paper Lloyd-Ellis (1993)[1] writes:

> *Perhaps the most influential proposition that has come out of the post-war theories of economic growth is that the accumulation of human capital, in the form of educational expansion or otherwise, is a major determinant of overall GNP growth in both developed and less developed countries...(and) this expansion has contributed to aggregate economic growth and, where such investment programs have been well designed and implemented, the growth encouraged by them may well have offset any negative effect caused by increased taxation or debt burden.*

If Pakistan is to become another Asian Tiger, it must educate its masses without compromising expenditures on educational and other social services whenever there is a resource crunch. In this context, in recent years, Pakistan does have taken some positive initiative in the form of *Social Action Programme* (SAP) to revamp the public expenditure for social services including education, the allocations are still below the proposed 1993-94 *UNDP Human Development Report* target (3 percent of the *GDP* for education). Pertinent *public policy* issue that merits investigation in this regard particularly when the country is already experiencing high and increasing budgetary deficits are whether with limited funds can government produce better results for the public education system. This study therefore developed an optimization model and then using data empirically identified optimal *cost-effective* mix of inputs (teachers, schools), outputs (enrollments and other key education

---

1 Huw Lloyd-Ellis (1993): "Enterprise, Education and the Distribution of gains from Growth," *mimeograph*, University of Toronto. Paper was also presented at the *Macroeconomic Theory Conference*, University of Victoria, Canada, 1993.

ratios) and expenditure (both development and recurring) allocations. Broad policy recommendations and its implications derived from the present study are summarised below:

- If the *public education departments* in Pakistan were to pursue their past policies, they can, perhaps, achieve the stipulated target (100% enrollment rates) for male primary students by the end of the perspective plan period (2002-03). However, as far as female students are concerned, the participation rate can, at best, reach only a little over 60 percent. **On the other hand, if a *cost-effective efficient* approach is adopted, our study finds that, even with the same available resources, over 85 percent enrollment rates for female primary students can be achieved.**

- The *cost-effective* strategy to attain a higher participation rate for females at the primary school level will, of course, require **an expanded accelerated school construction programme for girls, while slowing down the growth of schools for boys at the same time.** Expansion of female schools should be widespread with smaller sizes covering larger areas, especially in remote rural villages. This strategy will be crucial in attracting female students particularly given the prevalent social customs. On the other hand, a programme of consolidation for boys schools has to be adopted in order to take advantage of the economies of scales by providing more teachers and erecting more classrooms on the same premises.

- At the secondary school level, given such low student participation rates and vast differences

(almost double) between boys and girls rates, the present policies or even a cost-effective strategy will still not achieve the desired targets for boys and certainly not for girls. What is suggested in this study is an alternative optimization approach whereby an additional constraints is imposed while maximizing student participation rates. **Under the alternative strategy, it has been proposed that, once a relatively modest participation rate for boys secondary school is achieved (say 70%), larger resources should be diverted towards female institutions.** Adopting this constrained optimization approach, our study finds that the female student participation rates can be improved significantly as compared to what could have been achieved either under the existing policies of the government or, for what matter, from the standard optimization strategy.

- In terms of allocation of resources between recurring and development outlays, it needs to be emphasised that the share of recurring expenditures, in relation to the total, is much greater for the school system and more so at the primary level (over 90%). Thus, the sustainability of the public school system critically depends on the availability of the recurring budget to meet expenses for teachers' salaries, books, etc. **Our study suggests that, prior to the formulation of any accelerated (such as SAP) school construction programme, the policy makers should ensure the steady inflow of recurring outlays.**

TECHNICAL APPENDICES

TECHNICAL APPENDIX A

ALGEBRAIC SOLUTION FOR AN EXTENDED OPTIMIZATION EDUCATION SYSTEM

The purpose of this technical appendix is to derive optimal solution for an extended EDUCATION system based on maximization of the Education Welfare Function (EWF) for a given fixed total expenditure on education system. The *EWF* is a composite weighted index of Male Enrollment and Female Enrollment. Total cost on the other hand, consist of expenditures on recurring and development outlays for male and female schools. Since the producer [Public Education Department (*PED*)] is assumed to act as *monopsonist*, input supply for education staff (teachers, non-teachers) are assumed to be infinite. It should be noted that the unit development cost in this framework is simply the long run smoothed expenditure on additional schools at a given point in time. The basic optimization problem in this context simply involves the maximization of *EWF* with respect to the input prices of the personnel and infrastructure (teaching, non-teaching and *Schools*) subject to available budget.

This optimization problem of the combined public education system thus can be written as:

$$Max: \quad E_T = E_m^{\delta}\, E_f^{(1-\delta)} \qquad (1)$$

$$Where \quad E_m^{\delta} = \Phi_{10}\, T_m^{\Phi_{11}}\, N_m^{\Phi_{12}}\, S_m^{\Phi_{13}}\, Z_m^{\Phi_{14}}$$
$$E_f^{(1-\delta)} = \Phi_{20}\, T_f^{\Phi_{21}}\, N_f^{\Phi_{22}}\, S_f^{\Phi_{23}}\, Z_f^{\Phi_{24}}$$

$$Subject\ to \quad \overline{C} = C_m + C_f \qquad (2)$$
$$C_m = W_T\, T_m + W_N\, N_m + m\, S_m + c(S_m - S_{m-1})$$
$$C_f = W_T\, T_f + W_N\, N_f + m\, S_f + c(S_f - S_{f-1})$$

The Lagrange equation for the above problem can be written as:

$$\mathcal{L}(T_m, N_m, S_m, T_f, N_f, S_f, \lambda) = E_T - \lambda(\overline{C} - C_m - C_f)$$

$$\mathfrak{L}(T_m,\ N_m,\ S_m,\ T_f,\ N_f,\ S_f,\ \lambda) = \left(\Phi_{10}\ T_m^{\Phi_{11}}\ N_m^{\Phi_{12}}\ S_m^{\Phi_{13}}\ Z_m^{\Phi_{14}}\right)^{\delta} \left(\Phi_{20}\ T_f^{\Phi_{21}}\ N_f^{\Phi_{22}}\ S_f^{\Phi_{23}}\ Z_f^{\Phi_{24}}\right)^{(1-\delta)} - \lambda\Big[\overline{C} - (W_T\ T_m + W_N\ N_m + m\ S_m + c(S_m + S_{m-1})) - (W_T\ T_f + W_N\ N_f + m\ S_f + c\ (S_f - S_{f-1}))\Big]$$

The first order conditions for the above system can be written as:

$$\frac{\partial \mathfrak{L}}{\partial T_m} = \Phi_{11}\delta\ \frac{E_T}{T_m} - \lambda\ W_T = 0$$

$$\frac{\partial \mathfrak{L}}{\partial N_m} = \Phi_{12}\delta \frac{E_T}{N_m} - \lambda\ W_N = 0$$

$$\frac{\partial \mathfrak{L}}{\partial S_m} = \Phi_{13}\delta \frac{E_T}{S_m} - \lambda\ (\ m + c\ ) = 0$$

$$\frac{\partial \mathfrak{L}}{\partial T_f} = \Phi_{21}\ (\ 1 - \delta\ )\ \frac{E_T}{T_f} - \lambda\ W_T = 0$$

$$\frac{\partial \mathfrak{L}}{\partial N_f} = \Phi_{22}\ (\ 1 - \delta\ )\ \frac{E_T}{N_f} - \lambda\ W_N = 0$$

$$\frac{\partial \mathfrak{L}}{\partial S_f} = \Phi_{23}\ (\ 1 - \delta\ )\ \frac{E_T}{S_f} - \lambda(m + c) = 0$$

$$\frac{\partial \mathfrak{L}}{\partial \lambda} = \overline{C} - W_T T_m - W_N N_m - m\ S_m - c(S_m - S_{m-1}) - W_T T_f - W_N N_f - m\ S_f - c(S_f - S_{f-1})$$

Solving simultaneously the above equations, we can get the optimal solution for teachers, non-teachers and *schools for male and female* :

$$T_m^* = \frac{\Phi_{11}\,\lambda\,\Delta}{W_T}$$

$$N_m^* = \frac{\Phi_{12}\,\lambda\,\Delta}{W_N}$$

$$S_m^* = \frac{\Phi_{13}\,\lambda\,\Delta}{(m + c)}$$

$$T_f^* = \frac{\Phi_{22}\,(1 - \lambda)\,\Delta}{W_T}$$

$$N_f^* = \frac{\Phi_{21}\,(1 - \lambda)\,\Delta}{W_N}$$

$$S_f^* = \frac{\Phi_{23}\,(1 - \lambda)\,\Delta}{(m + c)}$$

where Δ is defined as:

$$\Delta = \frac{\overline{C} + c\,(S_{m-1} + S_{f-1})}{\delta\,(\Phi_{11} + \Phi_{12} + \Phi_{13}) + (1 - \delta)\,(\Phi_{21} + \Phi_{22} + \Phi_{23})}$$

CONSTRAINED OPTIMIZATION:

The constrained optimization problem of the Education system assumes that the Enrollment in Male Education is sufficient and it is more than that of the desired target level. Thus, additional resources are not needed in Male Education system. In order to derive optimal solution for the constrained strategy we adopt the follwing steps.

- Compute input demand functions for teachers, non-teachers and schools as in the standard optimal case.

- Compute Optimal Enrollment for male by substituting optimal teachers, non-teachers, schools and other variables.

$$E^* = \alpha_0 T^{*\alpha_1} N^{*\alpha_2} S^{*\alpha_3} Z^{*\alpha_4}$$

E^* : Optimal Enrollment, T^*: Optimal Teachers, N^*: Optimal Non-Teachers, S^*: Optimal Schools, Z^*: Other Variables

- Calculate desired enrollment at a given point of time by multiplying population of the related age group with desired optimal ratio.

$$\hat{E} = rP_t$$

$\hat{E}$: Desired Enrollment, P_t : Population at time t, r is the desired enrollment ratio

- If the optimal enrollment (step 2) is higher than the desired enrollment, compute excess enrollment.

- Since the Enrollment function is Cobb-Douglas type, growth in Enrollment must be equal to the growth rate of individual component times the elasticitiy.

$$\dot{E} = \alpha_1 \dot{T} + \alpha_2 \dot{N} + \alpha_3 \dot{S} + \alpha_4 \dot{Z}$$

- Compute required growth rate in enrollment by subtracting previous year optimal enrollment from desired level of enrollment and divide by previous year enrollment.

- Subtract growth rate in other variables times its elasticity from required growth rate to compute net growth rate in demand variables times elasticity.

- Compute optimal values for teachers, non-teacher and schools by applying net growth rate times elasticities to the previous year optimal values of teachers, non-teachers and schools.

- Compute expenditure required for this constrained optimal values for teachers, non-teacher and schools and subtract from the total expenditure to calculate total funds available for female education.

- Distribute this available fund into each inputs (teachers, non-teachers and schools) by their corresponding shares and then compute new (constrained) optimal values for teachers, non-teachers and schools.

- Compute optimal enrollment for female by substituting these constrained optimal input values and other variables values into optimal function for female enrollment.

TECHNICAL APPENDIX B
THE ANALYSIS OF EDUCATION DATA
ASSUMPTIONS & METHODOLOGY

This appendix elaborates that how variables are used in the Public Education model and the methodology and assumptions made for its analysis. This appendix also describes the problem and limitation in handling of the data. The Public Education model forecast the optimal mix of expenditure and enrollment for the year up to 2002-3. Time series data from 1972 to 1991 was collected on the variable used in the model. The study based on the primary and secondary levels of education which also been studied by gender.

Definition of Each Level

In Pakistan, there are three types of public education institutions for grade one to ten. They are primary schools, middle schools and secondary schools. A primary school is an institution consisting of grades one to five (I-V) of the educational system. Primary school is the only institution where the mix of three is not available. In our analysis, we have included Mosque Schools in the total stock of primary schools. A middle school is an institution consisting of grades six to eight (VI-VIII) of the educational system. Middle schools may have primary section in it. Primary schools upgraded to middle schools and middle schools upgraded to secondary schools. Those primary schools that upgraded to middle school consist eight classes from grade one to eight (I to VIII) of the educational system. By definition, secondary level consisting grades nine and ten (XI-X) of the educational system. Most of the secondary schools in Pakistan consist grade six to ten (VI-X) of the educational system. Secondary school may have primary and middle section in it.

Data Source

Two sources, Estimates of Charged Expenditures and Demand for Grants (current expenditure) for Punjab, and Punjab Development Statistics have been used to collect the data for the variables of Production Function. The data was collected for the time-series from 1972-1991.

Data Collection

The data collection process was started with assumption that all the data is correct and any inconsistency in the data is just printing or calculation error. Later, it has revealed that the data was in poor state. It was inconsistent, misprinted and erroneous. Different methodology has adopted to overcome this problem.

The data on total number of posts, salaries and recurring expenditure was collected from Estimates of Charged Expenditures and Demand for Grants of Punjab, and the data on number of enrolment, schools and teachers all by gender was collected from Punjab Development Statistics.

Assumptions & Methodology

Assumptions

1. It was assumed that total number of primary schools reported in Development Statistics is authentic and it includes those primary institutions which exist in middle and high schools.

2. Wage rates of primary teaching and non-teaching staff assumed to be same for the primary, middle and secondary level.

3. Except the total number of schools, all the data includes the middle level and we have to separate it and added it into two heads primary stage and secondary stages.

4. It was assumed that teachers/school ratio for primary stage is 1:2.3, in middle level it is 1:8 and in secondary level it is 1:12.

5. It was assumed that teaching/non-teaching ratio for primary level is 1:2.3, in middle level it is 2:8, and in secondary level it is 3:12.

6. In the analysis of primary schools, it was assumed that development costs incur only in primary schools' construction and no new mosque, middle and high schools have constructed from development cost.

The methodology for filtering the primary schools data from middle and secondary is as follows:

Primary Stage

Primary level has taken as primary stage of education that also includes mosques schools. Since, High schools and middle schools also offered primary education and we have to filtered the data (teachers, non-teachers etc.) from high and middle schools to get exact size of primary stage data.

Methodology

1. In budget documents, the reported total number of primary teaching staff is the summation of primary and middle school teachers. The methodology for separating the primary school teachers from middle school is based on teacher/school ratio for primary and middle each and the geometric mean of the two ratios for every year. It was assumed that in pure primary schools the teacher/school ratio is approx. 1:2.3 and in the middle schools it is 1:8. The geometric mean of the two revealed that in total number of middle school teachers, the share of primary teacher is 70% (class I to V) and the share of middle school (VI to VIII) is 30%. Time series estimation revealed that the teachers/school ratio of pure primary schools remains constant which crossed checked our computation. So, the equation for the total number of teaching staff for primary education has become:

TOTAL TEACHING STAFF PRIMARY = TOTAL BUDGETED - MIDDLE TEACHERS

2. The non-teaching staff for primary education has computed from primary schools data by taking the teachers/non-teacher ratio. It was assumed that in primary stage the teacher/non-teacher ratio is 2.3:1 and in middle it is 8:2. By taking the geometric mean of the two ratios for every year we filtered the primary school non-teaching staff and middle school non-teaching staff from the data. The equation for primary school non-teaching staff has become:

TOTAL NON-TEACHING STAFF PRIMARY = TOTAL BUDGETED - MIDDLE NON-TEACHING STAFF PRIMARY

3. The wage rates of the teaching and non-teaching staff assumed to be same in all three levels and the share of total recurring expenditure has added accordingly in the primary and secondary levels.

4. The share of unit cost of primary schools and secondary schools from the middle schools data was according to the same 70% for primary and 30% for secondary ratios.

5. The share of middle school teaching, non-teaching, unit cost and recurring expenditure has added up in the secondary school data.

Secondary Stage

Secondary level has taken as secondary stage offering (VI to X) Classes. The primary school data in the secondary stage has been filtered by assuming 1:2 teachers/school ratio of teaching staff for primary schools and 1:12 ratio for secondary schools and teachers/non-teaching staff ratio for the non-teaching staff. It was assumed that teacher/non-teachers ratio for primary is 1:2.3 and for secondary school it is 3:12. By using these ratios the primary schools data has been filtered from the secondary schools data. It has revealed from the time series data the share of primary schools teaching and non-teaching staff in the secondary school data is approx. 20%. The unit cost on schools and total recurring expenditures has been adjusted accordingly.

TABLE - C.1

EXPENDITURE ON STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: A HISTORICAL SIMULATION FOR PUNJAB BETWEEN 1981-1992 IN CURRENT PRICES (IN '000 RUPEES)

VARIABLES	YEARS	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
TEACHING	ACTUAL	351,754	400,869	452,418	610,739	747,933	919,926	1,045,807	1,260,711	1,585,752	1,751,886	1,852,338
	OPTIMAL	343,600	383,371	452,426	555,623	678,761	886,344	1,048,994	1,253,411	1,587,463	1,902,248	2,127,120
NON-TEACHING	ACTUAL	17,869	19,202	34,077	52,746	60,840	72,304	77,000	92,980	227,475	241,911	267,729
	OPTIMAL	45,381	50,634	59,754	73,384	89,648	117,064	138,546	165,545	209,665	251,240	280,940
REC. EXPENDITURE	ACTUAL	6,598	6,720	7,087	8,081	9,128	14,240	16,257	16,774	17,893	18,671	18,803
ON SCHOOLS	OPTIMAL	5,511	5,603	5,874	6,948	8,036	12,285	14,083	14,783	17,001	18,361	18,352
DEV. EXPENDITURE	ACTUAL	27,546	(14,299)	70,094	80,495	113,574	418,830	149,686	169,611	204,856	172,332	48,117
ON SCHOOLS	OPTIMAL	18,012	(13,622)	51,458	119,171	139,395	321,084	140,436	203,180	483,151	333,038	5,045
		FEMALE										
TEACHING	ACTUAL	208,447	239,617	272,696	362,997	442,640	577,688	673,515	824,406	1,120,897	1,308,877	1,326,950
	OPTIMAL	190,169	212,180	250,399	307,515	375,667	490,555	580,575	693,712	878,596	1,052,816	1,177,274
NON-TEACHING	ACTUAL	10,589	11,478	20,540	31,350	36,006	45,405	49,589	60,802	160,792	180,738	189,428
	OPTIMAL	25,932	28,934	34,145	41,934	51,227	66,894	79,169	94,597	119,809	143,566	160,537
REC. EXPENDITURE	ACTUAL	4,096	4,185	4,364	4,947	5,421	7,548	8,680	9,206	10,684	11,747	11,963
ON SCHOOLS	OPTIMAL	3,936	4,002	4,196	4,963	5,740	8,775	10,059	10,559	12,143	13,115	13,109
DEV. EXPENDITURE	ACTUAL	18,507	(6,398)	33,733	43,305	32,499	76,407	91,641	146,424	324,586	266,107	70,654
ON SCHOOLS	OPTIMAL	12,866	(9,730)	36,756	85,122	99,568	229,346	100,311	145,128	345,108	237,884	3,604
		COMBINED										
TOTAL EXPENDITURE	ACTUAL	645,407	661,374	895,009	1,194,660	1,448,041	2,132,348	2,112,175	2,580,915	3,652,934	3,952,269	3,785,981
	OPTIMAL	645,407	661,374	895,009	1,194,660	1,448,041	2,132,348	2,112,175	2,580,915	3,652,934	3,952,269	3,785,981

TABLE - C.2(A)

EXPENDITURE ON STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB IN CURRENT PRICES('000 RUPEES)

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	1,852,338	2,187,099	2,582,358	3,049,050	3,600,084	4,250,702	5,018,902	5,925,934	6,996,887	8,261,387	9,754,410	11,517,258
	OPTIMAL	2,127,120	2,506,791	2,975,385	3,550,581	4,254,586	5,115,200	6,167,173	7,453,948	9,029,904	10,963,212	13,339,521	16,266,689
NON-TEACHING	ACTUAL	267,729	350,957	460,059	603,077	790,554	1,036,313	1,358,470	1,780,776	2,334,364	3,060,045	4,011,318	5,258,311
	OPTIMAL	280,940	331,086	392,975	468,945	561,926	675,592	814,532	984,484	1,192,629	1,447,971	1,761,823	2,148,431
REC. EXPENDITURE	ACTUAL	18,803	20,879	23,184	25,743	28,585	31,741	35,245	39,136	43,456	48,254	53,581	59,496
ON SCHOOLS	OPTIMAL	18,352	20,326	22,673	25,427	28,634	32,352	36,656	41,634	47,398	54,077	61,833	70,856
DEV. EXPENDITURE	ACTUAL	48,117	329,588	389,492	460,282	543,940	642,802	759,633	897,697	1,060,856	1,253,668	1,481,525	1,750,795
ON SCHOOLS	OPTIMAL	5,045	304,729	414,818	542,419	693,684	876,079	1,098,830	1,373,489	1,714,654	2,140,905	2,676,010	3,350,497
		FEMALE											
TEACHING	ACTUAL	1,326,950	1,596,763	1,921,437	2,312,129	2,782,262	3,347,988	4,028,745	4,847,922	5,833,665	7,019,842	8,447,209	10,164,806
	OPTIMAL	1,177,274	1,387,406	1,646,754	1,965,101	2,354,740	2,831,054	3,413,278	4,125,456	4,997,683	6,067,689	7,382,879	9,002,947
NON-TEACHING	ACTUAL	189,428	252,756	337,257	450,007	600,451	801,191	1,069,041	1,426,438	1,903,318	2,539,627	3,388,663	4,521,545
	OPTIMAL	160,537	189,192	224,557	267,968	321,101	386,053	465,447	562,562	681,502	827,412	1,006,756	1,227,675
REC. EXPENDITURE	ACTUAL	11,963	13,316	14,823	16,500	18,367	20,445	22,758	25,333	28,199	31,389	34,941	38,894
ON SCHOOLS	OPTIMAL	13,109	14,519	16,195	18,162	20,453	23,109	26,183	29,739	33,855	38,627	44,166	50,611
DEV. EXPENDITURE	ACTUAL	70,654	220,355	261,049	309,258	366,370	434,029	514,183	609,140	721,633	854,900	1,012,778	1,199,812
ON SCHOOLS	OPTIMAL	3,604	217,664	296,299	387,442	495,489	625,771	784,879	981,063	1,224,753	1,529,218	1,911,436	2,393,212
		COMBINED											
TOTAL EXPENDITURE	ACTUAL	3,785,981	4,971,713	5,989,658	7,226,046	8,730,612	10,565,210	12,806,977	15,552,376	18,922,378	23,069,112	28,184,424	34,510,917
	OPTIMAL	3,785,981	4,971,713	5,989,658	7,226,046	8,730,612	10,565,210	12,806,977	15,552,376	18,922,378	23,069,112	28,184,424	34,510,917

TABLE - C.2(B)

EXPENDITURE ON STAFF AND INFRASTRUCTURE IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB IN CURRENT PRICES('000 RUPEES)

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	1,852,338	2,187,099	2,582,358	3,049,050	3,600,084	4,250,702	5,018,902	5,925,934	6,996,887	8,261,387	9,754,410	11,517,258
	OPTIMAL	2,127,120	2,506,791	2,975,385	3,550,581	4,254,586	5,115,200	6,122,457	7,014,800	8,035,907	9,202,954	10,535,655	12,056,317
NON-TEACHING	ACTUAL	267,729	350,957	460,059	603,077	790,554	1,036,313	1,358,470	1,780,776	2,334,364	3,060,045	4,011,318	5,258,311
	OPTIMAL	280,940	331,086	392,975	468,945	561,926	675,592	812,065	959,227	1,133,036	1,339,053	1,583,723	1,874,724
REC. EXPENDITURE	ACTUAL	16,803	20,879	23,184	25,743	28,585	31,741	35,245	39,136	43,456	48,254	53,581	59,496
ON SCHOOLS	OPTIMAL	18,352	20,326	22,673	25,427	28,634	32,352	36,421	39,458	42,749	46,317	50,185	54,380
DEV. EXPENDITURE	ACTUAL	48,117	329,588	389,492	460,282	543,940	642,802	759,633	897,697	1,060,856	1,253,668	1,481,525	1,750,795
ON SCHOOLS	OPTIMAL	5,045	304,729	414,818	542,419	693,684	876,079	994,659	463,427	534,828	617,749	713,834	825,136
		FEMALE											
TEACHING	ACTUAL	1,326,950	1,596,763	1,921,437	2,312,129	2,782,262	3,347,988	4,028,745	4,847,922	5,833,665	7,019,842	8,447,209	10,164,806
	OPTIMAL	1,177,274	1,387,406	1,646,754	1,965,101	2,354,740	2,831,054	3,446,627	4,456,375	5,768,510	7,464,405	9,648,712	12,455,923
NON-TEACHING	ACTUAL	189,428	252,756	337,257	450,007	600,451	801,191	1,069,041	1,426,438	1,903,318	2,539,627	3,388,663	4,521,545
	OPTIMAL	160,537	189,192	224,557	267,968	321,101	386,053	469,995	607,688	786,615	1,017,873	1,315,733	1,698,535
REC. EXPENDITURE	ACTUAL	11,963	13,316	14,823	16,500	18,367	20,445	22,758	25,333	28,199	31,389	34,941	38,894
ON SCHOOLS	OPTIMAL	13,109	14,519	16,195	18,162	20,453	23,109	26,438	32,124	39,077	47,518	57,721	70,023
DEV. EXPENDITURE	ACTUAL	70,654	220,355	261,049	309,258	366,370	434,029	514,183	609,140	721,633	854,900	1,012,778	1,199,812
ON SCHOOLS	OPTIMAL	3,604	217,664	296,299	387,442	495,489	625,771	898,314	1,979,277	2,581,656	3,333,242	4,278,860	5,475,880
		COMBINED											
TOTAL EXPENDITURE	ACTUAL	3,785,981	4,971,713	5,989,658	7,226,046	8,730,612	10,565,210	12,806,977	15,552,376	18,922,378	23,069,112	28,184,424	34,510,917
	OPTIMAL	3,785,981	4,971,713	5,989,658	7,226,046	8,730,612	10,565,210	12,806,977	15,552,376	18,922,378	23,069,112	28,184,424	34,510,917

TABLE - C.3

EXPENDITURE ON PERSONNELS AND INFRASTRUCTURE IN PRIMARY EDUCATION: AN EX-ANTE ACTUAL VS OPTIMAL FORECAST, ALL PROVINCES COMBINED IN CURRENT PRICES ('000 RUPEES)

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	3,272,137	3,863,488	4,561,710	5,386,116	6,359,512	7,508,823	8,865,841	10,468,104	12,359,932	14,593,658	17,231,070	20,345,122
	OPTIMAL	3,619,321	4,243,423	5,011,944	5,951,783	7,096,487	8,487,658	10,176,757	12,227,368	14,718,078	17,746,107	21,431,912	25,925,024
NON-TEACHING	ACTUAL	472,940	619,962	781,997	986,383	1,244,187	1,569,372	1,979,548	2,496,929	3,149,534	3,972,706	5,011,026	6,320,724
	OPTIMAL	478,024	560,452	661,955	786,085	937,272	1,121,011	1,344,100	1,614,935	1,943,897	2,343,825	2,830,630	3,424,060
REC. EXPENDITURE	ACTUAL	42,672	47,382	52,613	58,422	64,871	72,033	79,985	88,815	98,620	109,507	121,596	135,020
ON SCHOOLS	OPTIMAL	31,227	34,408	38,193	42,623	47,760	53,682	60,487	68,297	77,255	87,535	99,343	112,926
DEV. EXPENDITURE	ACTUAL	591,367	747,969	883,914	1,044,567	1,234,419	1,458,777	1,723,913	2,037,238	2,407,510	2,845,080	3,362,179	3,973,262
ON SCHOOLS	OPTIMAL	161,978	460,793	637,131	837,136	1,069,514	1,344,528	1,674,538	2,074,668	2,563,653	3,164,901	3,907,857	4,829,749
		FEMALE											
TEACHING	ACTUAL	1,963,282	2,362,483	2,842,854	3,420,900	4,116,482	4,953,500	5,960,710	7,172,720	8,631,171	10,386,174	12,498,028	15,039,291
	OPTIMAL	2,003,146	2,348,561	2,773,906	3,294,069	3,927,615	4,697,572	5,632,419	6,767,348	8,145,854	9,821,745	11,861,687	14,348,441
NON-TEACHING	ACTUAL	280,267	373,964	498,986	665,805	888,394	1,185,398	1,581,695	2,110,480	2,816,046	3,757,493	5,013,681	6,689,831
	OPTIMAL	273,156	320,258	378,260	449,191	535,584	640,578	768,057	922,820	1,110,798	1,339,329	1,617,503	1,956,606
REC. EXPENDITURE	ACTUAL	15,684	17,458	19,434	21,632	24,080	26,804	29,837	33,213	36,971	41,154	45,810	50,993
ON SCHOOLS	OPTIMAL	22,305	24,577	27,280	30,445	34,114	38,344	43,205	48,783	55,182	62,525	70,960	80,662
DEV. EXPENDITURE	ACTUAL	66,506	288,902	342,255	405,460	480,339	569,045	674,133	798,628	946,114	1,120,838	1,327,828	1,573,044
ON SCHOOLS	OPTIMAL	115,699	329,138	455,094	597,954	763,938	960,377	1,196,099	1,481,906	1,831,181	2,260,644	2,791,326	3,449,820
		COMBINED											
TOTAL EXPENDITURE	ACTUAL	6,704,855	8,321,609	9,983,763	11,989,286	14,412,285	17,343,752	20,895,662	25,206,126	30,445,899	36,826,610	44,611,217	54,127,287
	OPTIMAL	6,704,855	8,321,609	9,983,763	11,989,286	14,412,285	17,343,752	20,895,662	25,206,126	30,445,899	36,826,610	44,611,217	54,127,287

TABLE - C.4

EXPENDITURE ON STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: A HISTORICAL SIMULATION IN CURRENT PRICES FOR PUNJAB 1981-1992(IN '000 RUPEES)

VARIABLES	YEARS	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
		MALE										
TEACHING	ACTUAL	300,243	323,482	359,421	485,455	632,748	722,094	910,922	1,116,557	1,416,186	1,637,222	1,848,371
	OPTIMAL	293,989	317,311	370,548	458,850	568,178	685,977	851,953	1,071,967	1,324,323	1,568,285	1,872,982
NON-TEACHING	ACTUAL	28,076	31,949	39,381	61,493	93,508	100,254	135,599	177,321	235,965	252,134	294,078
	OPTIMAL	40,089	43,270	50,529	62,570	77,479	93,542	116,175	146,177	180,589	213,857	255,407
REC. EXPENDITURE	ACTUAL	10,443	10,979	12,453	15,771	19,764	21,963	25,303	28,906	32,393	36,529	42,465
ON SCHOOLS	OPTIMAL	8,857	9,310	10,368	13,201	17,503	19,733	23,551	28,183	33,601	38,486	43,866
DEV. EXPENDITURE	ACTUAL	25,917	(37,946)	98,204	179,627	106,414	170,271	224,764	276,910	183,556	233,190	535,800
ON SCHOOLS	OPTIMAL	28,303	(32,389)	60,124	157,646	194,404	184,026	301,876	422,234	448,079	324,094	437,896
		FEMALE										
TEACHING	ACTUAL	143,341	156,112	177,204	235,083	324,543	351,894	413,092	572,711	681,992	726,406	769,107
	OPTIMAL	142,540	153,848	179,660	222,473	275,480	332,595	413,068	519,742	642,096	760,381	908,112
NON-TEACHING	ACTUAL	12,866	14,451	17,586	26,435	43,624	46,892	59,816	103,841	121,382	126,089	142,416
	OPTIMAL	17,818	19,231	22,457	27,809	34,435	41,574	51,634	64,968	80,262	95,048	113,514
REC. EXPENDITURE	ACTUAL	4,990	5,312	5,921	7,248	9,475	10,533	12,994	15,988	19,920	23,089	26,740
ON SCHOOLS	OPTIMAL	6,456	6,786	7,557	9,622	12,758	14,384	17,166	20,542	24,491	28,052	31,973
DEV. EXPENDITURE	ACTUAL	32,806	(10,581)	34,899	55,964	91,858	82,065	212,967	289,340	368,648	229,773	323,950
ON SCHOOLS	OPTIMAL	20,630	(23,608)	43,824	114,906	141,699	134,134	220,034	307,761	326,600	236,229	319,178
		COMBINED										
TOTAL EXPENDITURE	ACTUAL	558,683	493,757	745,067	1,067,076	1,321,935	1,505,966	1,995,456	2,581,574	3,060,042	3,264,432	3,982,927
	OPTIMAL	558,683	493,757	745,067	1,067,076	1,321,935	1,505,966	1,995,456	2,581,574	3,060,042	3,264,432	3,982,927

TABLE - C.5(A)

EXPENDITURE ON STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS STANDARD OPTIMAL FORECAST FOR PUNJAB IN CURRENT PRICES('000 RUPEES)

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	1,848,371	2,216,770	2,658,595	3,188,481	3,823,978	4,586,136	5,500,200	6,596,447	7,911,187	9,487,968	11,379,018	13,646,974
	OPTIMAL	1,872,982	2,212,487	2,626,998	3,131,346	3,743,621	4,485,864	5,384,915	6,473,447	7,791,237	9,386,722	11,318,915	13,659,741
NON-TEACHING	ACTUAL	294,078	371,942	470,422	594,976	752,509	951,753	1,203,750	1,522,470	1,925,577	2,435,417	3,080,247	3,895,811
	OPTIMAL	255,407	301,703	358,227	427,002	510,494	611,709	734,307	882,743	1,062,441	1,280,008	1,543,488	1,862,692
REC. EXPENDITURE	ACTUAL	42,465	48,861	56,219	64,685	74,426	85,634	98,531	113,369	130,442	150,085	172,687	198,693
ON SCHOOLS	OPTIMAL	43,966	50,527	58,499	67,994	79,264	92,613	108,405	127,070	149,126	175,186	205,980	242,380
DEV. EXPENDITURE	ACTUAL	535,800	417,392	492,595	581,348	686,093	809,709	955,598	1,127,773	1,330,970	1,570,777	1,853,791	2,187,798
ON SCHOOLS	OPTIMAL	437,896	439,353	564,651	711,756	886,093	1,094,192	1,343,954	1,644,971	2,008,933	2,450,114	2,985,982	3,637,945
		FEMALE											
TEACHING	ACTUAL	769,107	909,806	1,076,243	1,273,128	1,506,030	1,781,539	2,107,449	2,492,979	2,949,038	3,488,526	4,126,707	4,881,635
	OPTIMAL	908,112	1,072,721	1,273,696	1,518,228	1,815,089	2,174,964	2,610,868	3,138,641	3,777,569	4,551,138	5,487,959	6,622,905
NON-TEACHING	ACTUAL	142,416	181,121	230,346	292,950	372,567	473,823	602,599	766,373	974,657	1,239,548	1,576,432	2,004,873
	OPTIMAL	113,514	134,090	159,212	189,779	226,886	271,871	326,358	392,330	472,196	568,892	685,995	827,863
REC. EXPENDITURE	ACTUAL	26,740	31,627	37,408	44,245	52,332	61,898	73,211	86,593	102,420	121,140	143,282	169,471
ON SCHOOLS	OPTIMAL	31,973	36,828	42,639	49,560	57,774	67,505	79,015	92,620	108,696	127,691	150,137	176,668
DEV. EXPENDITURE	ACTUAL	323,950	390,429	473,663	574,642	697,147	845,769	1,026,075	1,244,820	1,510,198	1,832,151	2,222,740	2,696,597
ON SCHOOLS	OPTIMAL	319,178	320,239	411,568	518,791	645,863	797,544	979,593	1,199,001	1,464,289	1,785,861	2,176,449	2,651,658
		COMBINED											
TOTAL EXPENDITURE	ACTUAL	3,982,927	4,567,948	5,495,491	6,614,455	7,965,083	9,596,262	11,567,414	13,950,824	16,834,488	20,325,613	24,554,905	29,681,851
	OPTIMAL	3,982,927	4,567,948	5,495,491	6,614,455	7,965,083	9,596,262	11,567,414	13,950,824	16,834,488	20,325,613	24,554,905	29,681,851

TABLE - C.5(B)

EXPENDITURE ON STAFF AND INFRASTRUCTURE IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS CONSTRAINED OPTIMAL FORECAST FOR PUNJAB IN CURRENT PRICES('000 RUPEES)

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	1,848,371	2,216,770	2,658,595	3,188,481	3,823,978	4,586,136	5,500,200	6,596,447	7,911,187	9,487,968	11,379,018	13,646,974
	OPTIMAL	1,872,982	2,212,487	2,626,998	3,131,346	3,743,621	4,485,864	5,384,915	6,473,447	7,521,876	8,483,777	9,567,022	10,785,569
NON-TEACHING	ACTUAL	294,078	371,942	470,422	594,976	752,509	951,753	1,203,750	1,522,470	1,925,577	2,435,417	3,080,247	3,895,811
	OPTIMAL	255,407	301,703	358,227	427,002	510,494	611,709	734,307	882,743	1,038,420	1,198,842	1,384,507	1,600,371
REC. EXPENDITURE	ACTUAL	42,465	48,861	56,219	64,685	74,426	85,634	98,531	113,369	130,442	150,085	172,687	198,693
ON SCHOOLS	OPTIMAL	43,866	50,527	58,499	67,994	79,264	92,613	108,405	127,070	144,193	159,052	175,433	193,492
DEV. EXPENDITURE	ACTUAL	535,800	417,392	492,595	581,348	686,093	809,709	955,598	1,127,773	1,330,970	1,570,777	1,853,791	2,187,798
ON SCHOOLS	OPTIMAL	437,896	439,353	564,651	711,756	886,093	1,094,192	1,343,954	1,644,971	1,135,253	490,793	553,840	624,638
		FEMALE											
TEACHING	ACTUAL	769,107	909,806	1,076,243	1,273,128	1,506,030	1,781,539	2,107,449	2,492,979	2,949,038	3,488,526	4,126,707	4,881,635
	OPTIMAL	908,112	1,072,721	1,273,696	1,518,228	1,815,089	2,174,964	2,610,868	3,138,641	3,965,088	5,194,724	6,771,460	8,778,987
NON-TEACHING	ACTUAL	142,416	181,121	230,346	292,950	372,567	473,823	602,599	766,373	974,657	1,239,548	1,576,432	2,004,873
	OPTIMAL	113,514	134,090	159,212	189,779	226,886	271,871	326,358	392,330	495,636	649,341	846,433	1,097,373
REC. EXPENDITURE	ACTUAL	26,740	31,627	37,408	44,245	52,332	61,898	73,211	86,593	102,420	121,140	143,282	169,471
ON SCHOOLS	OPTIMAL	31,973	36,828	42,639	49,560	57,774	67,505	79,015	92,620	114,092	145,748	185,250	234,183
DEV. EXPENDITURE	ACTUAL	323,950	390,429	473,663	574,642	697,147	845,769	1,026,075	1,244,820	1,510,198	1,832,151	2,222,740	2,696,597
ON SCHOOLS	OPTIMAL	319,178	320,239	411,568	518,791	645,863	797,544	979,593	1,199,001	2,419,929	4,003,336	5,070,960	6,367,238
		COMBINED											
TOTAL EXPENDITURE	ACTUAL	3,982,927	4,567,948	5,495,491	6,614,455	7,965,083	9,596,262	11,567,414	13,950,824	16,834,488	20,325,613	24,554,905	29,681,851
	OPTIMAL	3,982,927	4,567,948	5,495,491	6,614,455	7,965,083	9,596,262	11,567,414	13,950,824	16,834,488	20,325,613	24,554,905	29,681,851

TABLE - C.6

EXPENDITURE ON PERSONNELS AND INFRASTRUCTURE IN SECONDARY EDUCATION: AN EX-ANTE ACTUAL VS OPTIMAL FORECAST, ALL PROVINCES COMBINED IN CURRENT PRICES ('000 RUPEES)

VARIABLES	YEARS	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
		MALE											
TEACHING	ACTUAL	4,018,574	4,819,518	5,780,097	6,932,131	8,313,776	9,970,797	11,958,080	14,341,448	17,199,847	20,627,954	24,739,318	29,670,120
	OPTIMAL	3,690,616	4,408,271	5,272,996	6,313,982	7,566,526	9,073,270	10,885,724	13,066,097	15,689,533	18,846,824	22,647,703	27,224,851
NON-TEACHING	ACTUAL	639,360	808,645	985,160	1,200,207	1,462,194	1,781,370	2,170,217	2,643,944	3,221,078	3,924,193	4,780,787	5,824,362
	OPTIMAL	738,123	881,654	1,054,599	1,262,796	1,513,305	1,814,654	2,177,145	2,613,219	3,137,907	3,769,365	4,529,541	5,444,970
REC. EXPENDITURE	ACTUAL	69,054	79,453	91,419	105,186	121,026	139,252	160,223	184,351	212,114	244,057	280,811	323,099
ON SCHOOLS	OPTIMAL	70,992	82,685	96,442	112,606	131,583	153,854	179,989	210,656	246,648	288,897	338,504	396,771
DEV. EXPENDITURE	ACTUAL	589,950	678,730	801,020	945,343	1,115,670	1,316,686	1,553,920	1,833,897	2,164,319	2,554,275	3,014,491	3,557,626
ON SCHOOLS	OPTIMAL	646,869	846,431	1,032,049	1,253,096	1,517,466	1,834,623	2,215,955	2,675,210	3,229,018	3,897,533	4,705,211	5,681,760
		FEMALE											
TEACHING	ACTUAL	1,846,392	2,184,166	2,583,731	3,056,392	3,615,519	4,276,932	5,059,341	5,984,883	7,079,740	8,374,887	9,906,965	11,719,317
	OPTIMAL	1,771,496	2,115,970	2,531,038	3,030,712	3,631,932	4,355,170	5,225,148	6,271,727	7,530,976	9,046,476	10,870,897	13,067,928
NON-TEACHING	ACTUAL	341,897	434,817	552,991	703,283	894,421	1,137,506	1,446,656	1,839,827	2,339,854	2,975,777	3,784,532	4,813,089
	OPTIMAL	393,666	470,216	562,453	673,491	807,096	967,816	1,161,144	1,393,717	1,673,550	2,010,328	2,415,755	2,903,984
REC. EXPENDITURE	ACTUAL	31,051	36,726	43,439	51,378	60,769	71,877	85,014	100,553	118,932	140,670	166,382	196,793
ON SCHOOLS	OPTIMAL	52,737	61,423	71,643	83,650	97,747	114,292	133,706	156,488	183,224	214,609	251,460	294,744
DEV. EXPENDITURE	ACTUAL	308,750	453,374	550,027	667,285	809,541	982,123	1,191,498	1,445,509	1,753,671	2,127,529	2,581,088	3,131,339
ON SCHOOLS	OPTIMAL	480,531	628,778	766,665	930,871	1,127,261	1,362,863	1,646,138	1,987,299	2,398,699	2,895,310	3,495,300	4,220,736
		COMBINED											
TOTAL EXPENDITURE	ACTUAL	7,845,029	9,495,429	11,387,885	13,661,204	16,392,916	19,676,542	23,624,949	28,374,412	34,089,554	40,969,342	49,254,372	59,235,745
	OPTIMAL	7,845,029	9,495,429	11,387,885	13,661,204	16,392,916	19,676,542	23,624,949	28,374,412	34,089,554	40,969,342	49,254,372	59,235,745

REFERENCES:

Lockheed, M.E., A.M. Verspoor and Associates (1991): ***Improving Primary Education in Developing Countries,*** Oxford University Press.

Rostow, W.W. (1960): ***The States of Economic Growth: A Non-Communist Manifesto,*** Cambridge University Press.

Tan, J. and A. Mingat (1992): ***Education in Asia: A Comparative Study of Cost and Financing,*** The World Bank.

Urquidi, V.L. (1971): ***The so-called Social Aspects of Economic Development,*** in ed., A. B. Mountjoy, Developing the Underdeveloped Countries, MacMillan Press, 76-86.

World Development Report (1991): ***The Challenge of Development,*** Oxford University Press

Canadian International Development Agency (CIDA) commissioned study (1992): ***A Study on Imporving the Efficiency of Spending in the Social Sector and Increasing Resource Mobilisation in the Provinces***

Michael P. Todaro (1985): ***Economic Development in the Third World: Education and Development,*** by Orient Longman Limited

Bureau of Statistics : ***Punjab Development Statistics,*** Government of Punjab (various issues)

Finance Division, Economic Advisory Wing: ***Economic Survey,*** Government of Pakistan (various issues)

Demand for Grants Current Expenditure, Government of Pakistan (various issues)

Human Development Report: (1994)