CHAPTER V

EMPIRICAL ESTIMATION OF AN AGGREGATIVE MODEL

1. Introduction

This chapter presents the empirical results of a broad kind of an exercise, where unlike previous exercise, only three explanatory variables appear on the right hand side of the equations. They are : Expenditure on Physical Capital (EPK), Expenditure on Human Capital (EHK) and level of per capita income at the start of the period (PCI).*1 Such a model may help us to decide as to which kind of strategy should be given more emphasis to rapidly achieve the targeted level of basic welfare in the economy.

While searching for appropriate strategy to alleviate poverty and health related problems several approaches are currently advocated by major participants in the debate. Some emphasize general policies which promote economic growth on the ground, that this stimulates many changes, whose net result is the improvement in health, decline in

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*1 EHK includes; EPE, EOE, EMF and EOSC such as expenditure on flood relief, drought relif, employment and welfare etc. whereas the EPK includes EAG, EIM, ETC and EWPD. For further details of these categories, see, Appendix-A.

the poverty and fertility. They argue that a sound production base alone can provide a sustainable basis for any set of welfare programmes and hence should be given the first priority.

On the other hand, a more direct approach is advocated by those who support enhanced human resource investment. Among proponents of this view the anticipated impact is two fold : A stimulus to economic productivity and the direct effect on fertility and mortality as education changes perception and earning opportunities. Some of them have also demonstrated through empirical exercise that a planning strategy to ensure a better quality of life for the vast majority of the population is more effective in terms of improvement in the index of Birth Rate, Death Rate, IMR etc., than the stretegy for rapid economic growth (Rashid Rarukee, 1979).

However, this is not a debate which one can 'win' in any meaningful sense. At the policy level, it is seldom a question of exclusive choice. In policy debates, it is always a question of according priorities at the margin. Fast-growing societies can afford to finance good educational and health programmes and the latter are themselves important in assuring rapid growth. Thus, the policy problem is to assign relative <u>degrees of emphasis</u> to the different approaches.

The present chapter provides the estimates of a policy model which compares the impact of equivalent investment in physical capital and human capital on the rate of improvement in the welfare. The relative impacts of these expenditures on the rate of improvement in four individual components viz. health, female literacy, male literacy and general Economic and Social Conditions (GESC) are also estimated through OLS.

Impact parameters of above two expenditures viz. EPK and EHK are estimated separately for 1961-71 and 1971-81 and presented in section 2 of this chapter. Stability of these functions over time is tested with both the techniques viz., the 'Chow-test' and 'dummy variables'. Section 3 briefly discusses the technique of 'Chow-test', presents the required estimates of pulled regressions and gives the results of the Chow-test. Section 4 then discusses the technique of dummy variables and presents the empirical results for 1961-81 regressions including dummies. Section 5 then presents conclusion.

2. Regression Estimates of The Two Sub-Samples

Table 5-1 and Table 5.2 present the OLS estimates of five regressions viz. DMLR, DFLR, DHI, DGESC and DCWI for 1961-71 and 1971-81 respectively. Except the regression of DMLR for 1961-71 and DGESC for 1971-81, all other regressions are statistically significant, implying that expenditure

Table 5.1 : Results of Regressions, 1961-71.

Independent Variables	Dependent Variables									
	DMLR		DFLR		DHI		DGESC		DCWI	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
1	2	3	4	5	6	7	8	9	10	11
1) Constant term	-0.2125	-0.149	-0.3845	-0.388	-0.7431	-0.518	-2.8496*	-2.330	-1.5950*	-2.041
2) EHK	0.2661*	2.602	0.2223*	3.143	0.1778	1.733	-0.099	-1.134	0.1101**	1.971
3) EPK	-0.0898	-1.670	-0.0761**	-2.046	0.0970**	1.799	0.0714	1.554	0.0219	0.744
4) PCI	-0.0029	-0.636	-0.0017	-0.532	0.0003	0.062	0.0107	2.784	0.0037	1.520
R^2	0.3742		0.4739		0.5147		0.4412		0.5427	
$\bar{R}^2$	0.2177		0.3423		0.3934		0.3016		0.4284	
F	2.39	(3,12)	3.60*	(3,12)	4.24*	(3,12)	3.16**	(3,12)	4.75*	(3,12)

* Significant at 5% level; ** Significant at 10% level.

Table 5.2 : Results of Regressions, 1971-81.

Independent Variables	Dependent Variables									
	DMLR		DFLR		DHI		DGESC		DCWI	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
1	2	3	4	5	6	7	8	9	10	11
1) Constant term	0.5071	0.7026	-0.3918	-0.6424	0.4461	0.4396	-0.5582	-0.585	0.0193	0.0439
2) EHK	0.1183*	2.785	0.1393*	3.880	0.1836*	3.118	0.1000	1.779	0.1292*	4.998
3) EPK	-0.6936	-0.0372	-0.0372*	-2.075	-0.0961*	-3.220	-0.0472	-1.682	-0.0468*	-3.623
4) PCI	-1.066	-0.0020	-0.0020	-0.981	-0.0020	-0.591	0.0008	0.2497	-0.0014	-0.9552
R^2	0.4448		0.6021		0.5603		0.3256		0.7282	
$\bar{R}^2$	0.2934		0.4936		0.4404		0.1416		0.6540	
F	2.94*	(3,11)	5.55*	(3,11)	4.673*	(3,11)	1.770	(3,11)	9.82*	(3,11)

* Significant at 5% level.

variables do have significant relationships with the improvement in socio-economic variables.

It follows from Table 5.1 and Table 5.2 that during both the periods, government efforts on human capital increased the index of composite welfare (CWI) and literacy (FLR, MLR) at an increasing rate. During 1971-81, government effort on human capital also increased the index of health at an increasing rate. Whereas effort on physical capital (EPK) had a decclerating impact on the index of female literacy. What is more interesting to point out is that during 1971-81 the EPK had negative impact on disparity reduction rate in FLR, health as well as composite welfare index implying that government effort on physical capital had started yielding diminishing returns, in terms of these social output indexes.

However, the most relevant question which would arise here is that have all the functions such as DMLR, DFLR, DHI, DGESC and DCWI structurally changed between 1961-71 and 1971-81 or some of them remained the same during both the periods? The most pertinent question from the policy purpose is; whether the estimated relationship between government expenditure and improvement in socio-economic indexes during 1961-71 is significantly different from that of 1971-81 or the difference between them is insigni-

ficant, so that it may be attributed to chance etc. This could be tested through various ways. One of the techniques of testing the stability of functions over time is the technique of 'Chow test' which is carried out and discussed in the next section.

3. 'Chow-Test' and Some Results

As already mentioned, one of the techniques for testing the stability of the function over a period of time is the 'Chow-Test'. Suppose the regression coefficients for 1961-71 sample are denoted by b's and for 1971-81 are denoted by B's then we can test whether b's are statistically the same as B's. Here the null hypothesis to be tested is; H_0 : bi = Bi, indicating that there is no difference between the coefficients obtained from the two samples. In order to accept or reject this hypothesis we are required to perform, the F^{**} test as suggested by 'Chow'.*2 The stated F can be calculated by the following formula :

$$F^{**} = \frac{\left[\sum e_p^2 - \left(\sum e^2{}_1 + \sum e_2^2\right)\right] / K}{\left(\sum e_1^2 + \sum e_2^2\right) / \left[(N_1 + N_2) - 2K\right]}$$

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*2 For discussion on this, see, A. Koutsoyiannis, THEORY OF ECONOMETRICS, Macmillan Ltd., 1981.

Where

$\sum e_p^2$ = Residual sum of squares (RSS)

$\sum e_1^2$ = RSS of the regression of the first sample (1961-71)

$\sum e_2^2$ = RSS of the second sample (1971-72)

K = Total number of coefficients to be estimated including the intercept.

N_1 = Number of observation of 1st sample

N_2 = Number of observation of 2nd sample

Thus the Chow-test involves the following steps.

(a) The first step is to pull together both the samples viz. 1961-71 and 1971-81 and from this compute a pulled regression equation and estimate the unexplained variation in Y (RSS). That is we calculate $\sum e_p^2$.

(b) We then perform regression analysis on each sample separately and obtain the unexplained variations of the two samples and form a total unexplained variation viz. $\sum e_1^2 + \sum e_2^2$, with $N_1 + N_2 - 2K$ degrees of freedom.

(c) We substract the above sum of rasidual variations from the 'pooled' rasidual variance viz. $\sum e_p^2$ and obtain

$$\sum e_p^2 - (\sum e_1^2 + \sum e_2^2)$$

(d) We then calculate the F^{**} ratio as per the above formula compare the calculated F^{**} with the theoretical value of F at given level of significance and appropriate degrees of freedom.

Table 5.3 : Results of Pulled Regressions 1961-81

Independent variables	Dependent Variables									
	DMLR		DFLR		DHI		DGESC		DCWI	
	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value
1	2	3	4	5	6	7	8	9	10	11
1) Constant term	0.4210	0.636	0.2379	0.4520	1.9708**	1.932	-1.6138*	-2.20	0.0812	0.179
2) EHK	0.1354*	3.836	0.1026*	3.65	0.0482	0.8847	0.0683**	1.754	0.0742*	3.062
3) EPK	-0.0351	-1.471	-0.0421*	-2.217	-0.0248	-0.675	-0.0214	-0.808	-0.0245	-1.496
4) PCI	-0.0021	-0.886	0.0009	-0.4718	-0.0004	-0.116	0.0040	1.508	0.0010	0.571
R^2	0.3860		0.3663		0.3345		0.3030		0.3708	
$\bar{R}^2$	0.3178		0.2958		-0.0795		0.2256		0.3009	
F	5.66* (3,27)		5.20* (3,27)		0.311 (3,27)		3.91* (3,27)		5.30* (3,27)	

* Significant at 5% level. ** Significant at 10% level.

If calculated F^{**} is statistically significant, we reject the null-hypothesis of equal coefficients and accept that the two functions differ significantly (or the two samples give the different relationship). However, if the stated F^{**} is statistically insignificant we infer that the function has remained statistically the same for both the periods. This needs to be carried out for each of the regressions considered in the model.

Table 5.3 presents the estimates of pulled regressions of the two periods and Table 5.4 gives values of stated F^{**} for each function.

Table 5.4 : Results of the Chow-Test for Structural Constancy, 1961-81

Dependent Variables	Residual Sum of Squares			Calculated F-value	Degrees of Freedom
	Pulled Regression (1961-81)	Regression I (1961-71)	Regression II (1971-81)		
1	2	3	4	5	6
1) DMLR	180090	116382	39135.0	0.909	4, 23
2) DFLR	114046	55690.9	27942.8	2.091	4, 23
3) DHI	428272	117128	77377.7	6.911*	4, 23
4) DGESC	221049	85027.4	68370.6	2.536	4, 23
5) DCWI	84960.2	34724.2	14484.1	4.178*	4, 23

* Significant at 5% level.

Table 5.4 reveals that out of five, for three functions the calculated F^{**} is statistically insignificant, for rest of the two functions it is, statistically significant at 5 percent level of significance. Thus the 'Chow-test' of these functions suggests that functions between government expenditure variables and endogenous variables of DMLR, DFLR and DGESC, have almost remained the same during 1961-81, whereas the functions between government expenditure variables and endogenous variables of DHI and DCWI have changed between 1961-71 and 1971-81 possibly due to change in several factors.

In nutshell, we may conclude from the above exercise that :

(i) the functions of DMLR, DFLR and DGESC have remained stable between the two periods namely 1961-71 and 1971-81 and

(ii) the function of DHI and DCWI have structurally changed between the two sub periods due to several factors.

However, the major limitation with the Chow-test is, that it only indicates whether the function has changed or not. It does not indicate anything regarding the way the function has changed.*3 The change in function between the two periods may occur due to any of the following :

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*3 See, Damodar Gujrati, BASIC ECONOMETRICS, McGraw-Hill, Kogakusha Ltd., 1978.

(i) Only the intercept of the two regressions viz. regressions of 1961-71 and 1971-81 change, the slope coefficient remaining constant. That is the regressions may differ in their location.

(ii) The intercept (location) of the two regressions remain the same but the slopes may change.

(iii) The two regressions may completely change in the sense that their slopes as well as intercept between the two sub-periods have changed.

Now, for the policy decisions it is imperative to detect the causes of change in the function and thereby learn the changing role of various policy instruments. Moreover, if our interest is to measure the impact of change in other factors like $Z_1, Z_2, Z_3 \ldots$ etc., then we must measure the change in intercept coefficients over a period. For this purpose we need to introduce dummy variables on the right hand side of the equations which would not only indicate the statistical change in the function but would also measure the change in each coefficient of the function.

4. The Technique of Dummy Variables

As already noted above, we are interested in knowing, which parameters of the functions have changed between the two sub-periods and by how much. For this purpose the

econometric technique of 'dummy variable' is often used. A dummy variable is defined to be a variable(s) which we construct to describe the development or variation of the variable under consideration (See, Gujarati, 1978). For estimating the structural change in the impact of a variable we introduce the dummy variable for that particular variable and arbitrarily assign it the values zero and one respectively for two periods. For the sake of illustration let us consider the two regressions, one for 1961-71 and the other for 1971-81.*4 They can be written as :

1961-71 $Y_i = \alpha_0 + B_1 x_i + U_i$ with N_1 observations

1971-81 $Y_i = \alpha_0 + B_1 x_i + U_i$ with N_2 observations

We now want to measure the changes in intercept and slope coefficients between these two periods. We therefore, introduce one dummy for α_0 which will measure the change in location (intercept) and one for B_1 which will measure the change in, the slope over a period. We then 'pull' all the N_1 and N_2 observations together and estimate the following regression.

$$Y_i = \alpha_0 + \alpha_1 D_i + B_1 X_i + B_2 (D_i X_i) + U_i \quad \text{---- (1)}$$

where,

Y_i = dependent variable

X_i = Independent variable

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*4 See, Damodar Gujrati, op. cit.

$D_i^* = 0$ for period 1961-71

$D_i^* = 1$ for period 1971-81

Assuming that $E(U_i) = 0$ we obtain

$$E(Y_i/D_i = 0, X_i) = \alpha_0 + B_1 X_1 \quad \text{---- (2)}$$

$$E(Y_i/D_i = 1, X_i) = (\alpha_0 + \alpha_1) + (B_1 + B_2)X_i \quad \text{--- (3)}$$

which are respectively the estimated regression equations for 1961-71 and 1971-81. α_1 is the differential intercept and B_2 is the differential slope coefficients indicating by how much the slope coefficient of 1961-71 function differs from the slope coefficient of a 1971-81 function. What is important to point out is that if the t values of α_1 and B_2 (dummies) are statistically insignificant at a given level of significance, we infer that their corresponding parameters in the equation have not changed over a period.

5.4.2 Empirical Results With Dummy Variables : The exercise as shown above is carried out for each of the five regressions considered for the model and presented in Table 5.5 of this section.

From the regressions of Table 5.5, we may obtain the impact coefficients for both the periods. As can be seen, all the regressions are fitted very well to the data as indicated by the statistically significant F ratio of each one of them. It can be inferred from Table 5.5 that the function of DMLR

Table 5.5 : Results of Pulled Regressions with Dummy Variables, 1961-81.

Independent variables	Dependent Variables									
	DMLR		DFLR		DHI		DGESC		DCWI	
	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value
1	2	3	4	5	6	7	8	9	10	11
1) Constant term	-0.2125	-0.178	-0.3845	-0.439	-0.7431	-0.5563	-2.8496*	-2.402	-1.5950*	-2.374
2) EHK	0.2661*	3.116	0.2223*	3.550	0.1778**	1.862	-0.0991	-1.168	0.1101*	2.292
3) EPK	-0.0898	-1.100	-0.0761*	-2.311	0.0970**	1.933	0.7142	1.602	0.0219	0.866
4) PCI	-0.0029	-0.7622	-0.0017	-0.6013	0.0003	0.066	0.0167*	2.870	0.0037*	1.767
Dummy Variables :										
1) Constant term	0.7196	0.4629	-0.0073	-0.0064	1.1892	0.684	2.2914	1.484	1.6143**	1.846
2) EHK	-0.1478	-1.427	-0.0830	-1.093	0.0851	0.073	0.1990**	1.935	0.0191	0.328
3) EPK	0.0750	1.400	0.0389	0.9895	-0.1931*	-3.22	-0.1186*	-2.229	-0.6860*	-2.277
4) PCI	0.0003	0.0606	-0.0003	-0.0906	-0.0023	-0.406	-0.0988**	-1.994	-0.0051**	-1.821
R^2	0.4698		0.5353		0.5610		0.5163		0.6356	
$\bar{R}^2$	0.3085		0.3938		0.4274		0.3691		0.5247	
F	2.912* (7,23)		3.78* (7,23)		4.19* (7,23)		3.51* (7,23)		5.73* (7,23)	

* Significant at 5% level. ** Significant at 10% level.

and DFLR have remained more or less stable between the two periods, since all the dummies are statistically insignificant. This was also indicated by the Chow-test (See, Table 5.4). However, an interesting problem arises in case of DGESC. The Chow-Test for this function suggests that it has statistically remained the same between the two periods whereas the test with dummies gives the contradictory result. The dummy variables for all the three explanatory variables viz. EHK, EPK and PCI are statistically significant in case of DGESC function implying that impact of these variables on the DGESC has changed over a period. This only suggests that an overall type of test like the Chow-test should be used with caution. On the other hand, the test with dummies not only separately measure the changes in coefficients but improves the relative precision of the estimated parameters, since 'pulling' increases the degrees of freedom and hence should be preferred over the other.

5.4.3 Analysis of Regression Results : As has been mentioned, empirical exercise with dummy variables may help us to throw some light upon the changing role of government expenditures on physical as well as human capital. The exercise of Table 5.5 imply the following :

i. The functions of DMLR and DFLR have almost remained stable between the two periods viz. 1961-71 and 1971-81.

ii. Expenditure on human capital had a positive impact on DMLR, DFLR, DHI and DCWI during both the periods implying that government efforts on human capital development had accelerating impact on these indexes.

iii. During 1961-71 the expenditures on physical capital (EPK) had a positive impact on DHI but during 1971-81 the impact of EPK on the same has significantly declined as suggested by the negative and significant dummy of EPK.

iv. Similar interesting result arises in case of DGESC. For 1961-71 the impact of EHK on DGESC was statistically insignificant but has become positive and statistically significant during 1971-81. On the other hand, the impact of EPK on DGESC was insignificant during 1961-71 but has actually declined (has become negative) during 1971-81. This is indicated by the positive and negative dummies of the two variables EHK and EPK respectively.

v. In the function of DCWI also the impact coefficient of EHK turns out to be positive and statistically remained the same between both the periods. However, the impact of EPK on DCWI appears to have declined and become negative during 1971-81.

vi. The impact of PCI on DGESC and DCWI was positive and statistically significant (though not substantial in magnitude) during 1961-71, but during 1971-81 the impact

of PCI has substantially declined, as suggested by the negative and significant dummies of PCI in both these regressions.

vii. One additional point which needs to be noted is that during 1961-71 the intercept coefficient of DCWI was negative and significant, suggesting that assuming the value of all other variables zero, the welfare of the poors would have actually declined. This may imply that basic factors in the system such as socio-cultural-demographic factors were working against during 1961-71. This lends further support to those, who argue that, but for government efforts during 1961-71, poverty and inequality would have increased and the welfare would have actually declined. However, during 1971-81 the situation appears to be slightly better. The dummy of intercept variable is positive and significant making the ultimate value of intercept coefficient non-negative during 1971-81. This is indicative of the fact that after 1961-71, improvement in the socio-cultural, demographic and other structural factors, was such that they helped to enhance the welfare of the poors rather than reducing it.

5. Conclusion

The empirical exercise of an aggregative model, where only three variables viz. EHK, EPK and PCI appear as explanatory variables, appears to yield quite satisfactory results. Almost all the regressions are statistically significant implying that such a model fits the existing data quite well.

It follows from the above analysis that at existing level of welfare and development, additional government efforts on development of human capital would increase the level of basic welfare (welfare of the masses) at an increasing rate. For the period 1971-81 it is unequivocally true that the marginal returns to the government efforts on human capital are increasing. On the other hand, it is equally true that marginal returns to the government efforts on physical capital are decreasing. The EPK has negative and significant impact on all the variables except DMLR.

The above results clearly suggest that government efforts on physical capital, on margin may improve various social output indexes, but at a decreasing rate. Thus, if the policy problem is to tilt the balance on margin, then the present study suggests tilting the balance in favour of investment in human capital vis-a-vis physical capital to

efficiently achieve some minimum (projected) welfare level for the poors.

But, expenditure on human capital has several components like health, education, social welfare services etc. and the policy problem could be that between these components which must be accorded higher priority at the margin? In order to find out this, we need to consider the disaggregated data on these expenditures. This is considered in the subsequent chapter. EHK and EPK are disaggregated in to eight different expenditures mentioned earlier. Looking to the size of the sample we thought it worthwhile to stop at that level of disaggregation only. The empirical exercise with such disaggregated expenditure variables is carried out in the subsequent chapter.