



How Far Social Theory Of Fertility is Relevant? An Exploratory Study In The Indian Sub- Continent

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Abstract

There are three approaches namely theory of demographic transition, demand theory of fertility and social theory or synthesis model of fertility which are ever developed to explain the mechanism of demography and development relationship. Using National Family Health Survey dataset from 1st to 5th round, the present study of this paper aims to empirically verify the synthesis model or social theory of fertility in India where fifteen major states have been considered as units of analysis. With the application of the Path analytic technique the total effect of each explanatory variable included in this synthesis model to explain the variations of fertility has been decomposed into both direct and indirect effects which helps towards formulation of various policies which aim to reduce total fertility in Indian subcontinent. The present study concludes and confirms that the social theory of fertility is very much applicable in the heterogeneous socio-cultural structure of India at the disaggregate level. The most important socio-cultural factors which significantly increases the fertility is the preference of the parents for the boy-child over the girl. But even at this situation women empowerment measured by working women who are paid in cash is a significant determinant towards reducing fertility in India at sub-national level.

Index Terms- Social theory of fertility, Socio-cultural diversity, Preference for son, Working women paid in cash, Women empowerment, Demographic dividend.

I. INTRODUCTION

In order to formulate a development strategy relating to population, the understanding of the qualitative and quantitative character of population for a particular economy is essential. The interlinkage between demography and economic development is complex one that includes social, cultural and economic forces. It is quite evident that developed countries generally experience a lower level of fertility where as much higher level of fertility is experienced by developing countries. Government of India for the first time introduced family planning programme as early as 1951 with an aim to reduce the birth rate to that level required towards fulfillment of the target of population stabilization in the country. But the rate of reduction of fertility in India has been slow and not uniform across the states and rural-urban differential also prevails within a state. Diversified demographic, social and economic outcomes are the key features of India at the disaggregate level. Therefore, the study of demography-development interaction is vital in our country for formulation of appropriate population and development policies aiming to reduce fertility. The population transition theories so far emerged to explain population-development interaction in an economy are theory of demographic transition, household economic theory or demand theory of fertility and synthesis model or social theory of fertility.

India has been passing through the path of fertility decline during last four decades (1991, 2001 and 2011, 2021) but the pace at which the overall fertility declines is not uniform at all the states rather exhibits a wide scale of variations. Some major states have still been remaining at the 2nd stage of demographic transition; as a result whether India can reap the benefit of demographic dividend depends on these states. During 2001-2011 Children aged up to 18 years constituted nearly 45 percent of India's population (Chandrasekhar, Ghosh and Roychowdhury 2006, Dyson 2008). It is obvious that their wellbeing can secure national transformation. The age composition of India's population has been changing over time since 1970 creating a bulge of the population share belonging to the working age cohort and offering a boom in the demography of India termed 'Demographic Dividend' (Bloom and Williamson 1998, Bloom and Canning, 2004). This process is likely to continue up to 2025 due to continuous fall in the dependency ratio of children for which the overall dependency ratio has also been projected to fall to 48 and from 2025 onwards, it is expected to rise further to reach 50 by 2050 for rise in the dependency ratio of old people (UNPD, 2010).

Demographic change in India when tested, reveals that mortality transition appears to fit the pattern reasonably good (Visaria et al 1994, Dyson et al 2004, Dyson 2008). At the macro level, the theory of demographic transition of the 19th century was proposed by American economists explaining the effect of macro-developmental variables on fertility as outlined above but the pure economic theory of fertility was first developed by Becker (1960) depending on microeconomic foundation and assumption that couples would demand for higher order child birth if child caring activities are free of cost and opportunity cost of time for this is zero. Following Becker, the Chicago-Columbia School has stressed the demand for children as consumers good at the household level and has emphasized the substitution of quantity for quality of children as income increases (Becker and Lewis 1973, Wills 1974). Considering additional children as investments, Da-Vanzo (1971) and Schultz (1974, 1997) have argued that female going outside home for cash and sending children to schools are inclined to experience lower level of fertility. But the demand theory of fertility decisions is empirically valid mostly in developed countries. This theory has not yet been empirically justified

in many developing countries. The family allocation of rights, duties, resource allocation among the spouses, gender bias measured by son preference, mother's age at marriage, education, behavior of the neighbor regarding family size, urbanization, couple protection rate etc affect the decision of the parents regarding the total number of children they would expect (Caldwell et al 1989, Jain 1989, Birdsall 1977, Borg 1989, Krishnaraj 1998, Bardhan and Udry 1999). The social theory or the synthesis model has been emerged to test the significant contribution of different social development parameters like women education and empowerment to explain the variation of fertility. The family allocation of rights, duties, kin and social institution do not reflect the actual reality. Both the economic and socio-cultural parameters have importance in determining fertility rate because the economic outcomes are determined in many cases by socio-cultural backgrounds at a large scale.

During last few years both in national and international level many social parameters have been empirically tested and found significant affecting fertility. Schmeer and Hays (2017) found that females with multi-partner fertility contribute to higher fertility in Nicaragua in low income setting. Sobotka et.al (2011) suggest that in the developed society during recession uncertainty causes postponement of births pushing fertility rates to a lower level than that of the normal situation. The job instability along with the rise in the unemployment are likely to be the main reasons for exerting downward pressure on fertility during the recession period because these two factors affect the young adults the most.

How the public provision of financial incentives can significantly influence the fertility level has been well investigated by Cohen et. al. (2013) in Israel using household level large dataset in a panel study framework. A consistent and significant contribution of the financial aid for the children affecting fertility has been found by them among the people of all age, religion, economic strata and ethnicity. Azarnert (2010) has shown that at the pre development era with low level of parental human capital, free basic education may contribute to reduction of poverty and fertility but at high level of development with high parental human capital endowment the free access to education crowds out private investment in education and raises fertility.

With the use of the Current Population Survey data, Bailey (2006, 2009) has estimated that the chance of the women of getting motherhood at age cohort 18-21 is likely to get reduced by 1 to 2 percent point of probability with their reach to the birth control pill before the age of 21 years.

The general consensus of the research of Browne and LaLumia (2014) suggests that if a young single woman gets access to legal birth control means, her probability of being mother at early age gets reduced although the study found no significant impact on lifetime. In Medellin of Columbia, from a theoretical study by Morales (2015) the incidence of strong peer effects were found significant causing high fertility of the women at a very early age. The study found that prevalence of teenage pregnancies among the individual's peer group is supposed to raise the probability of the individual to make fertility decision at a young age. But even at this situation, it has been found that education significantly contributes for postponing the child bearing activities and thereby reducing the incidence of teenage pregnancy as a result of peer effects.

Behrman et al (2006); Breierova and Duflo (2004); Osili and Long (2008) argued that promotion of public programmes towards utilization of effective contraceptive mechanisms is not a necessarily required for reduction in fertility. They found that the State neither played any role for the decline in fertility nor encouraged lower fertility as the only policy levers in Europe. Working on various settings of Guatemala,

Indonesia, and Nigeria their studies managed to draw a correlation of high extent between female education and higher age at birth causing lower fertility.

Pritchett's (1994a) argument in a highly acclaimed paper was that family planning programmes play minimum role on reduction of fertility. According to him variations in women's desired fertility account for ninety percent cross country variations in total fertility rate. Such findings are in high contrast and contradiction with the theoretical inference drawn to establish the fact that expansion of contraceptive usage has positive role in fertility reduction.

A major gap as highlighted by the other researchers is that he focused on the role of family planning programs only on the supply side and ignored the positive contribution of the same in reduction of desired family size. Regressions across the countries had been conducted by him with total fertility rate to be explained by other explanatory variables like couple protection rate and birth prevention initiatives where in each case, preferred fertility was considered to be the control variable (Pritchett 1994a, Table 3). However, Dasgupta (2014) has pointed out the gap of Pritchett's study and shown that for the reduction of desired family size, promotion of mass media turns out to be one of the fundamental components of family-planning programmes. Mass media contributes positively towards raising the usage of contraception and for reduction of fertility.

Dasgupta (2014) has documented a couple of means towards reduction of fertility in her study. She argued that media blasting actively support the family planning programmes to work in increasing both the demand for contraception and the access to those devices. Multiple studies find that family-planning programs effectively help to reduce fertility and these are impoverished in nature. Poor and uneducated women are mostly benefitted from the easier access to the birth control devices. In order to fetch multiple benefits for poor countries family planning programmes can work in a simplified, efficacious, and relatively economical way.

Couples in India are found to register strong preference for boy child over girl child similar to North Africa, Middle East countries, East and South Asia (Arnold 1996, 1997; Cleland, Verrall, and Vaessen 1983; UN 1981, 1985; Williamson 1976). It is also reported that women are found to be accorded low status in India (UN 1995). Children's welfare is highly affected by the parents' such preference for boy child which significantly affects society's demographic behaviours. A wide range of differentials across the regions of India have been noted in terms of degree of preference for boy child and demographic outcomes (Arnold, Choe, and Roy 1996; IIPS 1995).

Three major reasons have been found from various studies in support of the preference for boy child over daughter in Indian subcontinent. First of all, boy child is supposed to have economic utility than that of a girl child as he earns for family and provides support to his family (Bardhan 1988; Basu 1989; Dharmalingam 1996; Mamdani 1972; Miller 1981).

Indian wedding system also catalyzes the son preference. The parents of the boys through marriage of their sons have daughter-in-laws who provide additional support to them both economically (through dowry) and physically (by providing physical labor in the works of domestic fronts). Socio-cultural utility is another important factor to have preference for boy child in India. In patriarchal society of India having at least one boy child accords additional value to the family and having many sons is supposed to be much appreciated for the continuance of the lineage (J. Caldwell, Reddy, and P. Caldwell 1989; Dyson and Moore 1983; Kapadia

1966; Karve 1965). In heterogeneous religious structure of Indian society preference for sons also arises from an important religious custom which is done only by sons. Traditionally Hindus conduct the funeral of deceased persons by their sons. A strong preference for boy child creates hindrance in faster fertility decline. Even after reaching an overall family-size goal couples still carry on to welcome children in their lives until and unless they avail the satisfactory sex composition of their children. However, it is also true that numerous studies do not suggest consistently a highly robust fondness for sons on fertility (Arnold 1997, 1992; Bairagi and Langsten 1986; Das 1984, 1987, 1989; Haddad et al. 1996; Koenig and Foo 1992; Operations Research Group 1990; Parasuraman, Roy, and Surender 1994; Park 1986; Srinivas 1977). With the example of South Korea and China some studies demonstrated a dramatic fall in fertility where preference for boy child was widespread and enormous.

Indian economy has been characterized by the existence of diversity in respect of social, ethnic, cultural, social norms, habits, religion, caste, gender position etc. Such wide spread regional diversity has some impact on fertility. Social actions and activities are not independent of the economic actions and activities- the two kinds of concepts and their corresponding indicators or variables are interdependent. Deb, James and Sen (2002) have argued that the ineffectiveness of the conventional approach in explaining the fertility fall is the result of overemphasis on household level variables; choice regarding the quantity of the children and the usage of the contraception which are mostly designed at the level of community in the context of south Asian region. Hence, the impelling force behind a progressive decision like contraceptive acceptance often is the level of one's interaction within the community. O'Sullivan, Jane N. (2013) had reviewed the historical progress of the utilization of contraceptive mechanisms across the countries in the world especially the transition economies and has observed that development is not the best contraception, rather a case strongly supported by the data where the best development stimulus is contraception. Using pooling data from the districts of India for the year 1981 and 1991, Drèze and Murthy (2001) have shown that the education of the women is the most significant contributor towards fall in fertility over time. In their earlier study, Dreze, Guio and Murthy (1995) have shown that the direct better child health status, both the literacy rate and the labor force participation of the women can significantly bring down the total fertility. The same outcome is obtained by Rajan et al (1996). Using NFHS-1 data, Rangamuthia et al (1997) have explored the effect of the preference for the boy child on fertility in India. Based on the data set of both CBR and TFR across 594 districts in India, Rajan (2005), in one of his studies has observed a wide range of fertility differentials in India. Moreover, it has also been found that Northern India registers much higher fertility than that of the Southern and Western parts of India irrespective of the religion of the people in those regions.

II. Research Gaps: Scope and Broad Objective of the Study:

India exhibits differential demographic outcomes at disaggregate level. Although at the aggregate level, India did experience a fall in Total Fertility Rate (TFR), rate of decline is very slow and not uniform across the states and sub-states. Numerous studies have explored

the state level causes of higher order births in India considering explanatory variables like income, infant mortality rate, female labour force participation rate etc. At the state level (macro level), unit of analysis is state but only fifteen major states do not reveal the actual factors affecting fertility. However, a panel study can be carried out to capture both time and space, thereby in the regression model of fertility one can extend the

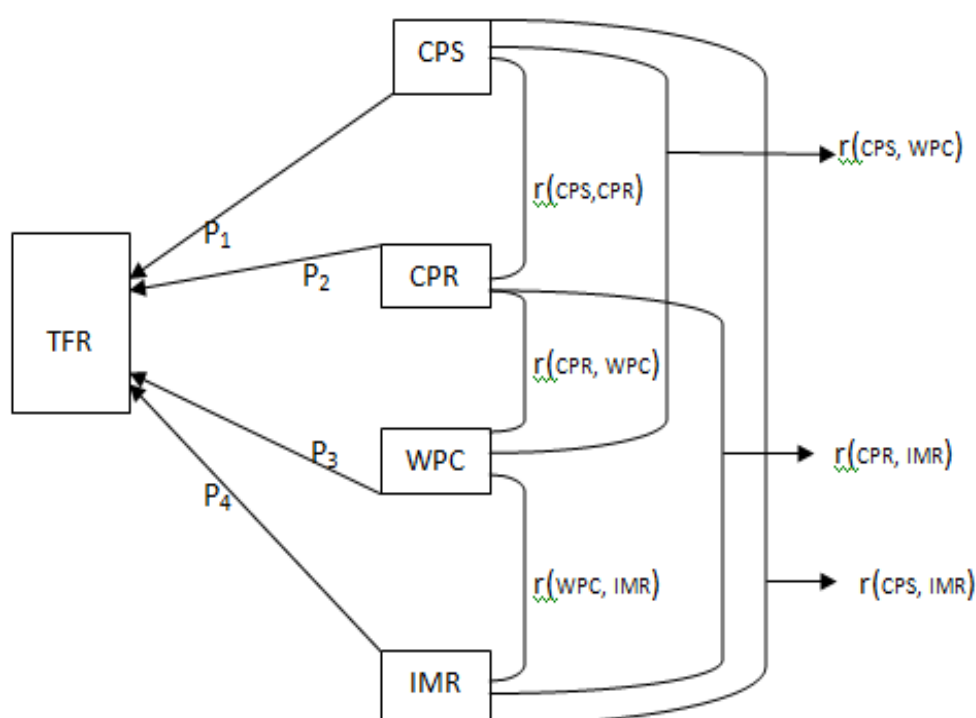
number of observations in one hand and the state specific heterogeneity on the other. The findings of the most of the earlier studies are based on pooling instead of panel. The earlier studies did not consider the 4th and the 5th round NFHS data at the state level. Using 1st, 2nd, 3rd, 4th and 5th round data of National Family and Health Survey conducted in 1992-93, 1998-99, 2005-06, 2015-16 and 2019-21 respectively, in my present study my broad objective is to check the validation of social theory or the synthesis model of fertility towards exploring the fertility determinants in India at the state level. My present study also differs from the earlier studies mainly on the methodological aspect where I have applied Path Analytic tool to capture the effect of some selected socio-cultural and development parameters to explain the variation of the fertility, where Path Analytic Approach is a standardized multiple regression technique. Multiple regression of socio-economic variables generally suffers from the problem of multicollinearity. Path analysis helps to decompose the total correlation between direct and indirect effects.

Keeping in mind the importance of economic as well as social variables in fertility determination, the following four socio-cultural variables have been included in my study to check whether they can significantly explain the variation in total fertility rate (TFR).

1. Percentage of couples who prefer boy child or sons over girl child or daughters (CPS)
2. Percentage of couples using protection in their reproductive behaviour (CPR)
3. Percentage of women who work outside and paid in cash (WPC)
4. Infant Mortality Rate (IMR)

The causal inter-relation between total fertility rate and above mentioned four socio-cultural variables have been depicted by formulation of the following structure:

Fig.1 Causal Inter-Relationship among Fertility and Socio-Cultural Variables



Where, TFR be the dependent variable. The arrows starting from each explanatory variable denotes the direct effect.

III. Methodology: A Path Analytic Technique

Path analytic approach has been employed in this current study to check the practical relevance of social theory of fertility in India at the disaggregate level. The mechanism of path analysis is basically a standardized multiple regression technique which in a regression model, aims to decompose the total correlation of endogenous variable with all its exogenous variables into two segments: direct effect and indirect effects (Wright 1921, Duncan 1966, Sumangala and Nagarajan 1993, Halder 2007). Direct effect is captured by standardized multiple regression co-efficient which can be expressed as $\delta Y/\delta X$; where Y and X denote dependent and exogenous variable respectively. On the other hand, indirect effects are determined by considering all the exogenous variables which are used to be incorporated of regression model of path analysis. In my present study I have included total four number of socio cultural explanatory variables (which possess a high degree of correlation with total fertility rate as depicted from the Table-1 of the Appendix) for empirical verification of social theory of fertility in India's sub-national level. One more advantage of employing path model in this study is that it takes care of the emergence of multicollinearity as total correlation is decomposed into its direct and indirect effects. Direct effect is mainly the marginal effect. Therefore, the level of significance can easily be tested by transforming the variables into their standardized forms.

Following the methodology of path analysis (as graphically depicted in Fig.1 and outlined in the appendix), four structural equations have been constructed given by equation 1,2,3,4.

$$r(TFR, CPS) = P_1 + r(CPS, CPR).P_2 + r(CPS, WPC).P_3 + r(CPS, IMR).P_4 + u_i \dots \dots (1)$$

$$r(TFR, CPR) = P_2 + r(CPS, CPR).P_1 + r(CPR, WPC).P_3 + r(CPR, IMR).P_4 + v_i \dots \dots (2)$$

$$r(TFR, WPC) = P_3 + r(WPC, CPR).P_2 + r(WPC, SP).P_1 + r(WPC, IMR).P_4 + w_i \dots \dots (3)$$

$$r(TFR, IMR) = P_4 + r(IMR, WPC).P_3 + r(IMR, CPR).P_2 + r(IMR, CPS).P_1 + x_i \dots \dots (4)$$

where, $r(Y, X_i)$ =total effect, assuming Y =TFR is Dependent variable and X_i be the exogenous variable, P_i stands for direct effect, where $i=1,2..4$; $\sum r(X_i, X_j).P_j$ stands for the sum of the indirect effects, where $i \neq j$.

IV. Data Source

The present paper uses the dataset of National Family and Health Survey of five rounds conducted by ministry of health and family welfare, Govt. of India in 1992-93, 1998-99, 2005-06, 2015-16 and 2019-21 respectively. Data of TFR and four exogenous variables (CPS, CPR, IMR and WPC) are drawn from 1st, 2nd, 3rd, 4th and 5th round's NFHS reports, IIPS, Mumbai.

V. Findings and Discussion:

With the help of the path analytic tool empirical verification of the synthesis model or the social theory of fertility has been done in this current paper, finding of which are summarized in the following Table 1.

Guided by the correlation matrix depicted in the table 1 of the appendix, all the four socio-cultural exogenous variables have been included in the model of path analysis in my present study as all the four variables exhibit a significant association with the dependent variable, TFR.

Table-1: Decomposition of Total Effect into Direct and Indirect Effects

R=0.906, R ² =0.821, Adj. R ² =0.804, F= 49.17, N=75. Collinearity statistics: Variance Inflating Factor (VIF): CPS=3.389; CPR=3.242, WPC=4.197, IMR=2.890		
Direct Impact of Exogenous Variable	Indirect Impact of Exogenous Variable via others	Total Impact
$P_1 = \delta TFR / \delta CPS = 0.577^{**}$	$r(CPS, CPR).P_2 = 0.0416$ $r(CPS, WPC).P_3 = 0.2387$ $r(CPS, IMR).P_4 = 0.0202$	$r(TFR, CPS) = 0.878$
$P_2 = \delta TFR / \delta CPR = -0.0529$	$r(CPR, CPS).P_1 = -0.4546$ $r(CPR, WPC).P_3 = -0.2400$ $r(CPR, IMR).P_4 = -0.0181$	$r(TFR, CPR) = -0.766$
$P_3 = \delta TFR / \delta WPC = -0.3105^*$	$r(WPC, CPS).P_1 = -0.4437$ $r(WPC, CPR).P_2 = -0.0408$ $r(WPC, IMR).P_4 = -0.0207$	$r(TFR, WPC) = -0.816$
$P_4 = \delta TFR / \delta IMR = 0.0287$	$r(IMR, WPC).P_3 = 0.407$ $r(IMR, CPR).P_2 = 0.033$ $r(IMR, CPS).P_1 = 0.2462$	$r(TFR, IMR) = 0.716$

Note: ** Significant at 1 percent level, * Significant at 5 percent level. Source: Author's estimation.

The empirical findings of the path model which has been reported in tabular form above, suggests that couples having bias for boy child over girl child have profound and significant on fertility. Although at present the value of the total fertility rate in India is not more than three, the desire to have at least one boy child is very strong and persisting in many states of India. As a consequence, couples carry on activities of bearing child in expectation of a son until and unless a desired composition of children is achieved by them (IIPS, 2007). The total fertility rate increases accordingly. The logic behind the preference for boy child can well be explained from the relative cost benefit analysis of having sons and daughters. The societal structure of India is mainly patriarchal in many of the states. Moreover, poverty is another issue for parents' gender preference in favour of sons. In destitute situation parents send their children for work to engage them in economic contribution of the family. Boy child is better option than girl child in this regard. All these kind of socio-economic and religious factors lead to create couples' preference for son. In my present study, the result of path analysis reveal that the direct effect of couples' preference for sons (CPS) is found to be much stronger than that of the indirect effects through other exogenous variables which the model has incorporated.

It is observed that couples using protection in their reproductive behaviour (CPR) directly reduces the TFR but its influence is not found to be strong and significant. Infant mortality rate (IMR) is revealed to be another factor that increases the fertility rate. Death and demise of infants leads to increase the number of child bearing of the women. In this present study result of path analysis suggests that IMR directly as well as indirectly raises the TFR but its indirect effect is much stronger than the direct effect. Indirect Impact of IMR is found to be highest through the exogenous variable CPS; which again reflects the true picture of strong gender bias of the Indian societies that consequently aggravate the total fertility rate (TFR).

But even at this patriarchal and diversified socio-economic and cultural backdrop of India, empowerment of women is proved to be a significant contributor for reduction of fertility at the disaggregate level which is prominent from the result reported in Table 1 of my present study. Women working outside and paid in cash (WPC) appears to be the most significant predictor for reducing total fertility rate (TFR). It is also found that all the indirect effects of WPC have been found estimated to be negative even through couples' bias for son (CPS)- which is quite interesting result and also supports the earlier findings. The logic behind this result is quite clear. Since opportunity cost of time of child bearing and rearing activities are high, women participating in workforce want to have less number of child which reduces the TFR.

VI. Concluding Observations and policy Implications:

Among the three theories of population-development inter-relationship the social theory of fertility or synthesis model has been examined in this paper at Indian backdrop.

While examining the application of this theory of fertility or synthesis model it has been found that the theory does hold good in heterogeneous socio-cultural society structure of India. Couples' preference for boy child is an important and significant predictor for explaining the variation of total fertility rate. Additionally, more interesting result comes out is that this synthesis model of fertility is also highly applicable in Indian sub-continent even if the level of income is very low where women participate in the work force of unorganized sector and paid in cash.

Therefore, from the view point of policy prescription, more and more women employment opportunities in unorganized sector can be suggested where the scope of formal sector job in India is severely restricted.

Future demographic dividend largely depends on the quick fertility decline of India along with attainment of quality of future human resource. But various studies confirm that Bihar, Uttar Pradesh, Madhya Pradesh which are among major states of India have still been remaining at the 2nd stage of demographic transition. Moreover, the social environment prevailing in these states are not conducive towards small family norms, therefore, India at an early date will reap the benefit of the window of opportunity of demographic advantage at the aggregate level if the above states are capable to reduce their fertility at a faster rate. In this regard empowerment of women can be one of the possible means of reduction of total fertility rate of India at the disaggregated level which can be made working either by raising female education or by raising employment opportunities of the women even at the unorganized sector, where scope of the formal sector job is highly restricted in heterogeneous societal structure of India.

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Appendix:**Table 1: Zero-order correlation matrix**

		TFR	CPS	CPR	WPC	IMR
TFR	Pearson Correlation	1.000	.878	-.766	-.816	.716
	Sig. (2-tailed)	.	.000	.000	.000	.000
CPS	Pearson Correlation	.878	1.000	-.788	-.769	.706
	Sig. (2-tailed)	.000	.	.000	.000	.000
CPR	Pearson Correlation	-.766	-.788	1.000	.773	-.633
	Sig. (2-tailed)	.000	.000	.	.000	.000
WPC	Pearson Correlation	-.816	-.769	.773	1.000	-.793
	Sig. (2-tailed)	.000	.000	.000	.	.000
IMR	Pearson Correlation	.716	.706	-.633	-.793	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	.

Assumptions of the Path Model

- 1)The set of variables considered in the Path analysis are linearly additive and a symmetrical relationship exists among the variables,
- 2)The correlation exist in both dependent and independent variables and among the independent variables itself in the system and
- 3)The dependent variable (Y) is the result of independent variables like $X_1, X_2, X_3, \dots, X_n$ and other disturbance (random) term designated by R such that $r(Y, R) \neq 0$ but $r(X_i, R) = 0$ and $E(R) = 0$. Direct path coefficient is the ratio of the standard deviation of the cause variable (X_i) to the effect (Y) variable. Symbolically, $P_i = \sigma_{X_i} / \sigma_Y$ for $i=1, 2, 3, \dots, n$ and path coefficient for the residual factor is $h = \sigma_R / \sigma_Y$.

Following the above assumptions, a linear additive function is considered as

$$Y = \sum_{i=1}^n X_i + R \quad \dots\dots\dots(1)$$

For α^{th} observation, $Y_\alpha = \sum_{i=1}^n X_{i\alpha} + R_\alpha$ $Y_\alpha = \sum_{i=1}^n X_{i\alpha} + R_\alpha$, where $\alpha = 1, 2, 3, \dots, p$ and

$$\bar{Y} = \sum_{i=1}^n \bar{X}_i \quad \dots\dots\dots(2)$$

$$r_{X_i Y} = \frac{\text{Cov}(X_i, Y)}{\sigma_{X_i} \cdot \sigma_Y} \quad \dots\dots\dots(3), \text{ for } i = 1, 2, 3, \dots, n.$$

Solving the system of equations (3), we get

$$r_{X_i Y} = P_i + \sum_{j=1}^n r_{ij} P_j \quad \dots\dots\dots(4), \quad 1 \leq i \leq n \text{ and } j \neq i$$

This represents n equations and n unknowns. That is, P_i for $i=1, 2, 3, \dots, n$

This set of structural equations can be solved. As shown by Haldar(2007), for each equations in the left handside(LHS) in equations (4) for every $i=1, 2, 3, \dots, n$, the total effect could be divided into two parts i.e.,

direct effect(P_i) and indirect effects($\sum_{j=1}^n r_{ij}P_j$). The path coefficients relating to the random component can be estimated as:

$$\sigma_Y^2 = \sum_{i=1}^n \sigma_{x_i}^2 + \sigma_R^2 + 2r_{12}\sigma_{x_1}\sigma_{x_2} + \dots + 2r_{(n-1)n}\sigma_{(n-1)}\sigma_n \quad \dots\dots\dots(5)$$

by taking the variance of equation (1).

Dividing equation (5) by σ_Y^2 , we get

$$1 = \sum_{i=1}^n P_i^2 + h^2 + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^n r_{ij}P_iP_j, \text{ since } h^2 = \frac{\sigma_R^2}{\sigma_Y^2} \text{ and } P_i^2 = \frac{\sigma_{x_i}^2}{\sigma_Y^2}.$$

Now solving for 'h', we get

$$h = \sqrt{1 - \sum_{i=1}^n P_i^2 - 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^n r_{ij}P_iP_j} \quad \dots\dots\dots(6)$$

This is the path coefficient for the residual term R .