

PARTICIPATORY APPROACH TO POVERTY MEASUREMENT IN BANGLADESH

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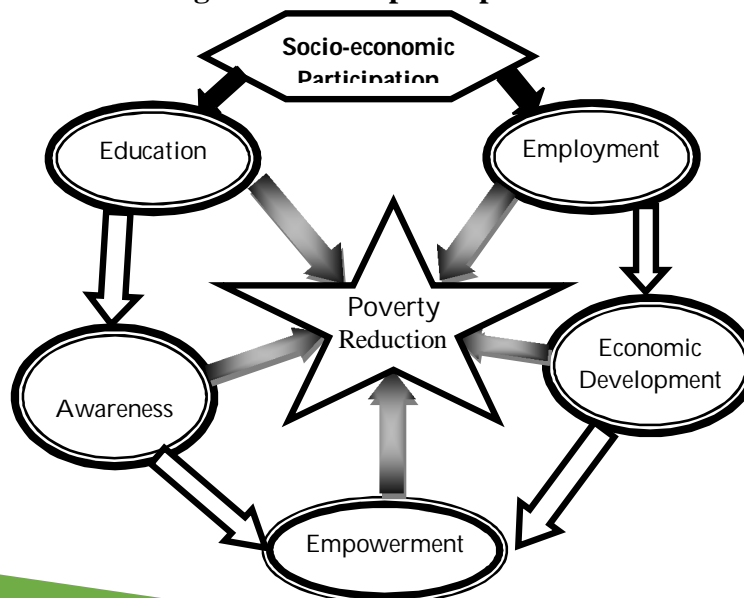
1 INTRODUCTION

The aim of the chapter is to assess poverty in Bangladesh using various components of participatory approach. Eradication of poverty as well as the participation of all groups of people in the development activities is one of the major challenges for Bangladesh. Participation of male along with female population in the creative and earning activities play a significant role in dynamic and socio-economic progress.

Participatory approach is an attempt to understand poverty dimensions within the social, cultural, economic and political environment of a country. Lack of participation of individuals or groups in a society excludes them from development activities (United Nations, 2009). Participation is a right of all citizens to strengthen social rights and empowerment. It contributes to enable, empower and conscientise the social transformation of endogenous and oppressed people through sharing, enhancing and analysing their knowledge of life and conditions (Cornwall, 2000). The participatory approaches are differentiated with self-determination and empowerment, increasing the efficiency of programmes and emphasising mutual learning. According to Moser (1998), “Participatory approach uses multiple, subjective indicators of poverty status that emerges out of the experience of the poor, collected through participatory techniques.” Participation aims to delineate about what it means to be poor, and the magnitude of poverty (Chambers 1994; 1997).

Participation of people reduces the incidence of poverty of the state. In addition, poverty occurs among the people due to the inability to participate in social and political life along with the lack of adequate income (Sen, 1979; 1985; 1987). The role of socio-economic participation in reducing poverty is shown here (Figure 4.1).

Figure 1: Social participation



Although the participatory methods are intended to determine the nature of projects and elicit the views of poor people to shape plans as well as to contribute to development strategies, in practice their impacts on projects or plans are often remote. Many people, who are born into poverty often, try to escape from it as they do not enjoy their basic needs in earlier life to accumulate crucial physical stature and cognitive capacity (Loury, 1981; Strauss and Thomas, 1998; Basu, 1999), because of their socio-economic exclusion and lack of awareness. This picture is quite frequent in those areas with less infrastructural facilities. Creating awareness and power of self-determination among the people is the aim of the participatory approach in this regard.

2 PARTICIPATION IN EMPLOYMENT

Participation of people in economic activities plays a vital role in reducing poverty. In this regard, the participation from both men and women is urgent. The involvement of women in employment than the men has been increasing during the last decade. During 1999-2000 to 2010, about 8 out of 10 in working aged men were involved in economic activities. However, a smooth increment was found in terms of women. In 1999-2000, 2 out of 10 working women were engaged in economic activities that increased to 3 out of 10 in 2010 (Table 1).

The number of women in working-age was 35.90 million in 1999-2000. Among them, only 7.9 million were employed in that year. Their participation in employment was 22.0 percent compared to the women in working-age. The rates of participation were 24.75 percent, 27.18 percent and 33.93 percent in the year 2002-2003, 2005-2006 and 2010 respectively.

In 1999-2000, the number of men in working-age was 38.30 million. Among them, 31.1 million of them were involved in employment in that year which indicates that 81.20 percent men participated in economic activities among the labour force. After 5 years in 2005-2006, the employed men increased to 35.1 million and the rate of participation as employed men was 83.93 percent. The rate of participation decreased to 79.21 percent in 2010.

Though the employed women in the labour market are lower in number, the rate of increment is optimistic. Crisis of employment, lack of skill and lack of opportunities are liable for lower participation of women in employment.

Table 4.1 Population in employment and in working-age (in millions)

Year	Population in Working-age		Employed population		Percentage of employed population	
	Men	Wome	Men	Wome	Me	Women
1999-	38.3	35.90	31.1	7.9	81.2	22.00
2002-03	41.2	39.60	34.5	9.8	83.7	24.75
2005-06	43.0	41.58	36.1	11.3	83.9	27.18
2010	47.8	47.74	37.9	16.2	79.2	33.93

Source: Author's calculation based on Bangladesh Bureau of Statistics 2002, 2004, 2008 and 2011

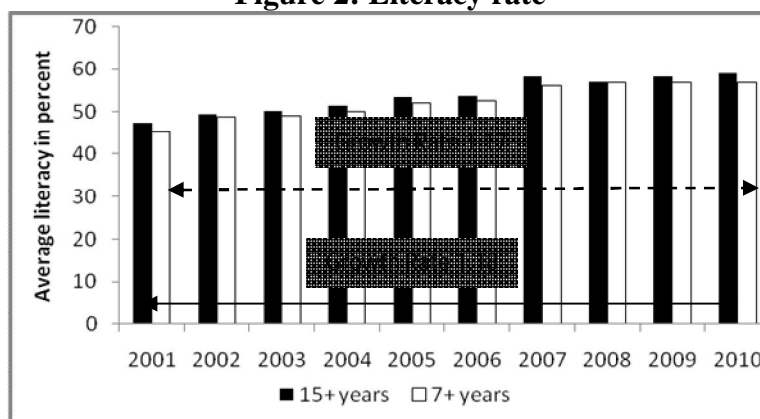
3 PARTICIPATION IN EDUCATION

Over the years, the participation in education is increasing in the country which has effected reduction of poverty. It is well known that an equal participation of educated is the precondition of a sustainable economy. The progress of a society depends on education. Since education ensures well-being of people, hence necessity of their participation in education is beyond doubt. Moreover, educated people find employment more readily and earn higher wages or, if self-employed, are more productive. Most importantly, it is possible for the educated people to avoid the vicious cycle of poverty easily. Furthermore, participation of people that ensures equality in educational attainment raises per capita rate of growth in real GDP.

3.1 Literacy Rate

Bangladesh has experienced a positive increment in case of literacy¹ for both male and female over the years. The country has also achieved positive improvement in female literacy. Various national and international initiatives have increased the literacy rate of population. Moreover, some active initiatives such as stipend, free tuition, national and international advocacy etc. have accelerated rate of literacy of women compared to that of men.

Figure 2: Literacy rate



Source: Author's calculation based on Ministry of Planning, 2011

Population of 7 Years and Above

The literacy rate of population for the age group of 7 years and above has increased in the country. Moreover, literacy rate of women of this age group has increased more than their counterparts. Average literacy rate for the age group of 7+ years increased from 45.2 percent in 2001 to 56.8 percent in 2010 with an annual increase of 1.17 percentage point (Figure 2). In this age group, literacy rate of women increased from 40.8 percent in 2001 to 53.9 percent in 2010 with an annual rate of increase of 3.57 percent, while, for male, the rate of increase was 2.28

¹ Literacy refers to the abilities to read and write text. Literacy is explicitly defined as the four strands of language-reading, writing, speaking and listening. A literate man can derive and convey meaning, and use their knowledge to achieve a derive purpose of goal that requires the use of language skills, be spoken or written.

percent per year during the same period (Figure 3). These higher rates of increase in female literacy compared to their counterparts have resulted in gender parity.

Figure 3: Literacy rate (7+ years)

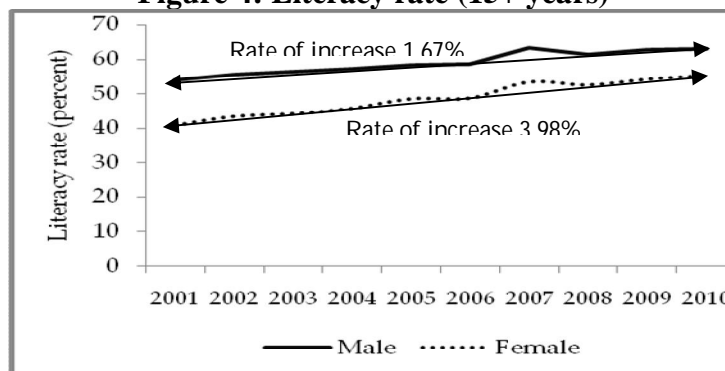


Source: Author's calculation based on Ministry of Planning, 2011

Population of 15 Years and Above

The adult literacy² rate is higher than the literacy rate of population aged 7+ years in the country. Moreover, in this age group, the literacy rate of women has increased with an accelerated pace than that of men. This higher rate of increase in women adult literacy over men has reduced the gender gap. For the age group of 15+ years, average literacy rate increased with an annual percentage point of 1.18 from 47.4 percent in 2001 to 59.2 percent in 2010 (Figure 2). Based on historical track record, the adult literacy rate of women increased from 40.8 percent in 2001 to 55.4 percent in 2010 with an increased rate of 3.98 percent per year (Figure 4.3). In order to achieve the target of adult literacy rate as 100 percent for women by 2015, the increase in the adult literacy by 16.1 percent is required from 2010. In case of men, the adult literacy rate increased to 62.9 percent in from 53.9 percent in 2001 with the increased rate of 1.67 percent (Figure 4).

Figure 4: Literacy rate (15+ years)



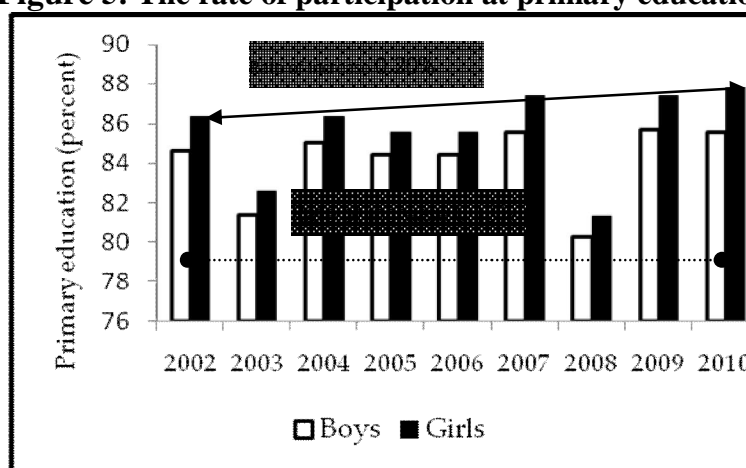
Source: Author's calculation based on Ministry of Planning, 2011

² Adult Literacy (15+ years) program offers not only instruction in reading, writing, and calculation but also provides information and skills to assist participants in obtaining employment, improving their productivity and reaching a better quality of life. These skills help participants to adapt to new workplace environments.

3.2 Participation in Primary Education

Bangladesh has achieved a significant progress in primary education though the rate of increase in the participation of children has been decreasing over the years. It is remarkable that the participation of girl was found higher than their counterparts between 2002 and 2010. The enrollment of girl at primary level increased from 86.4 percent in 2002 to 87.8 percent in 2010 with a rate of increase of 0.20 percent per year (Figure 5). On the other hand, the enrollment of boys increased to 85.6 percent in 2010 from 84.6 percent in 2002 with an annual rate of increase of 0.13 percent. To reduce the gender gap, some initiatives taken by the government and various NGOs have proved to be effective. Moreover, the progress of participation³ is a sign of poverty eradication from the country.

Figure 5: The rate of participation at primary education



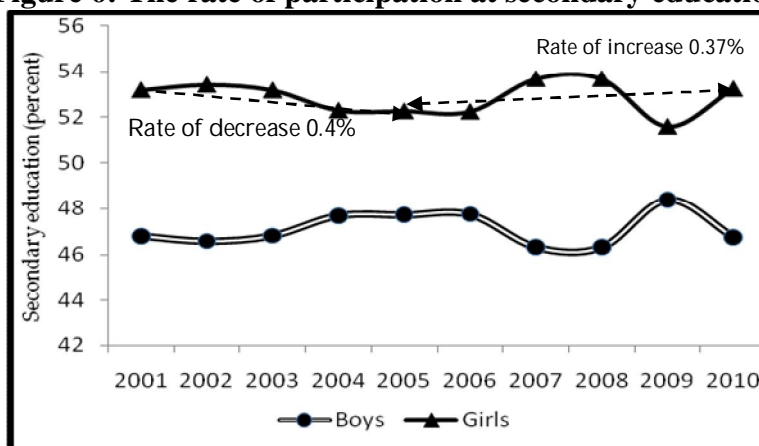
Source: Author's calculation based on Ministry of Planning, 2011

3.3 Participation in Secondary Education

A combined effect of various programmes improved the condition of female participation at secondary education in the country. In the last decade between 2001 and 2010, the participation rates of both boys and girls at secondary education have fluctuated a little bit whereas the rate was slightly higher for the girls. In secondary education, participation of girls was 53.20 percent in 2001 which decreased annually by 0.43 percent from 2001 to 2005 and increased by 0.37 percent from 2005 to 2010 (Figure 6). During 2001 to 2010, with an annual rate of increase of 0.01 percent, the participation of female has increased from 53.20 percent in 2001 to 53.25 percent in 2010.

³ Participation is a very important determinant of educational achievement of a country. The net participation appeared to be main predictor of basic education in Bangladesh.

Figure 6: The rate of participation at secondary education

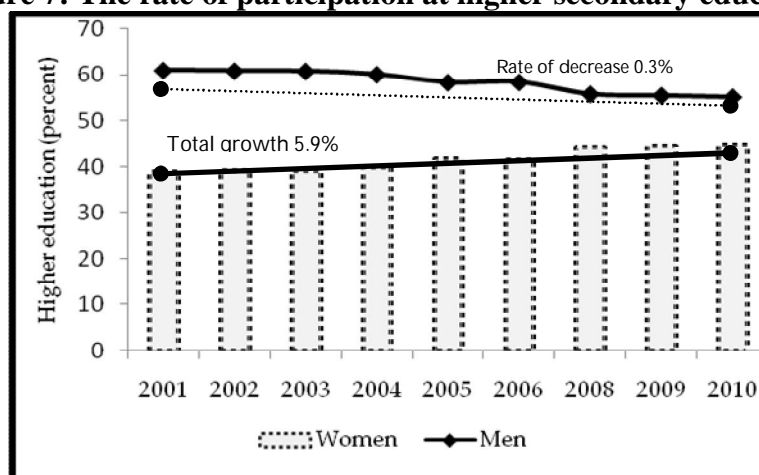


Source: Author's calculation based on Ministry of Education 2009, 2010 and 2011

3.4 Participation at Higher Secondary Education

Bangladesh has a significant track record in achieving gender equality regarding the higher secondary education in the early years. Between 2001 and 2010, the participation of women at higher secondary education increased by 5.93 percentage point from 38.97 percent in 2001 to 44.90 percent in 2010 (Figure 7). The participation of women in higher secondary level increased from 41.64 percent in 2005 to 44.90 percent in 2010 with a rate of increase of 1.57 percent per year. The effect of reducing gender gap in higher secondary education has been reflected in the alleviation of poverty reported by Bangladesh Bureau of Statistics, 2010.

Figure 7: The rate of participation at higher secondary education



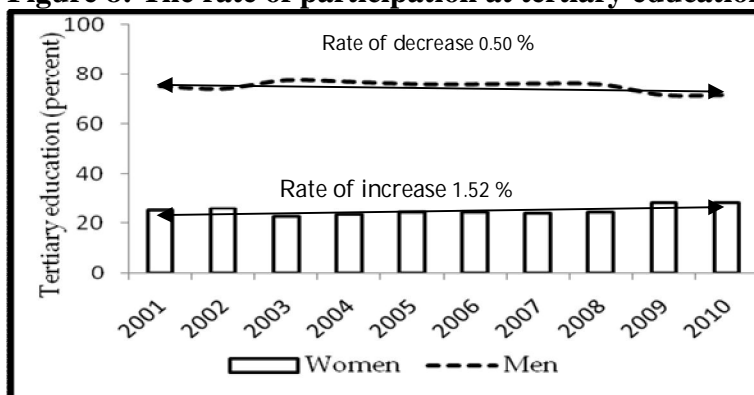
Source: Author's calculation based on Ministry of Education 2009, 2010 and 2011

3.5 Participation in Tertiary Education

Bangladesh has experienced a daunting gender inequality in higher studies. During the last decade (2001 to 2010), the country has experienced a little increase in participation of women at higher education. Women participation at tertiary education was only 24.86 percent in 2001 that increased to 28.26 percent in 2010. In higher studies, there was only 3.4 percentage point

increment during this decade with a rate of increase of 1.52 percent per annum (Figure 8). This little increment of women education at higher level might have impact on reducing poverty.

Figure 8: The rate of participation at tertiary education



Source: Author's calculation based on Ministry of Education 2009, 2010 and 2011

4 PARTICIPATION IN MICROCREDIT PROGRAM

Participation of people in microcredit program helps them to earn and consume more, accumulate assets, invest in children's schooling and therefore, to be lifted out of poverty. Mainly, women are involved in the microcredit programs. Therefore, net worth of households increases and both the poverty and the debt-asset ratio decreases. The rates of poverty reduction, however, vary that means this rate is higher for the participants (Khandker and Samad, 2013). According to Mahtab (2007), access to population on microcredit program in different government and non-government organisations has a positive role on women empowerment, increment of income of female and poverty alleviation. Although numerous people have participated in microcredit programs for many years, some critics argue that participants in microcredit program in the country are trapped in poverty and debt. Study of Ahmed (2007) has showed that some microcredit loan borrowers have been benefitted from their finance, however; a remarkable number of people could not develop themselves, in this regard.

Furthermore, some studies also reveal that only non-poor borrowers are the beneficiaries from microfinance and enjoy significant positive impacts. According to a study of Hulme and Mosley (1996), a vast majority of poor starting with incomes below the poverty line actually ended up with less incremental income after getting microloans, compared with a control group whose members did not obtain such loans. Khandker (2005) found marginal improvements for microcredit borrowers. According to Yunus (2003), microcredit is not a miracle cure that can eliminate poverty in one fell swoop. It, however, can end for many and reduce its severity for others. Combined with other innovative programmes that unleash people's potential, microcredit is an essential tool searching for a poverty-free world. Thus, there is agreement about the requirement to harmonise the microfinance in order to reduce poverty.

Microcredit is not the solution of global poverty; neither is for health, or education, or economic growth. The solution must include a broad array of empowering interventions.

4.1 Role of Microcredit in Employment Generation

Microcredit program has been contributing to generate employment at a small scale over the years. Generating the employment among their participants is very low (Table 2). Most of the respondents, from the Unnayan Onneshan survey 2012, have argued that microcredit programmes have created employment for only four persons out of ten. Among the total respondent (325), 21.23 percent have pointed out that they have been self-employed through the training of microcredit programme; 13.54 percent are involved with small business/shop keeping and 3.08 percent have got job due to the programme.

Table 2: Frequency distribution of employment types

Types of Employment	No. of Respondents	Percentage
Job*	10	3.08
Small Business/Shop keeping	44	13.54
Self employed through training	69	21.23
Others	8	2.46
No employment creation	194	59.69
Total	325	100.0

**Job includes nurture and nourishing of forestry of the NGOs, and cleaning and looks after their organisation*

Source: Unnayan Onneshan Field Survey, 2012

5 DETERMINANTS OF POVERTY

To identify the associated factors of poverty, a logistic regression analysis is applied. The determinants such as education of household head, their occupation, capacity building training received by any family members, income source of female members, female participation in decision making of the family and participation of women with social or political activities are statistically significant i.e., highly effect on reducing the poverty of respondents (Table 3). The relative odds ratio for each category along with β value, standard error of β value, 95 percent confidence interval and its statistical significance are also presented in Table 3.

Educational status of household head is an important determinant for the alleviation of poverty. In this logistic regression analysis, respondents up to primary studies are considered as reference category. The odds ratio for the respondents who passed six to SSC is 134.74 and for the respondents having education HSC and above is 2065.58 as compared with the reference category. That means, education having six to SSC are 134.74 times, and HSC and higher studies have 2065.58 times higher possibility to root out poverty than that of the respondents having studies up to primary level. It is because naturally educated people have better opportunity in obtaining a job and they possess more managing capacity at any circumstances.

The respondents whose household head of the family are service holders are 11.56 times more likely to report no poverty in their family than the respondents whose household head of the family are farmer or labour. Service holder of household head is positive at 5 percent level of significance however, in case of businessmen or shopkeeper it is not statistically significant.

Capacity building training for family members is also found to be significantly associated with experiencing no poverty in the family for the population under this study. Income sources of female members in the family have been found as highly significant in reducing poverty.

In the logistic regression model, the women who have participated in decision making are 3.00 times more likely to report no experiencing poverty in their family than those who are not. The social and political participation of women has a positive effect in removing poverty among the population.

Table 3: Binary logistic regression analysis of poverty alleviation, controlling for selected covariates

Covariates	B	SE (β)	Odds Ratio	95 Percent CI
Education of household head				
Up to primary [®]	1.00	...
Six to SSC	4.90	1.14	134.74*	14.5-1256.3
HSC and higher	7.63	1.62	2065.58*	86.1-49153.6
Occupation of household head				
Farming/Labour [®]	1.00	...
Service	2.45	1.26	11.56**	0.9-135.9
Business/Shop keeping	1.27	1.03	3.55	0.5-26.9
Received capacity building training				
No [®]	1.00	...
Yes	4.32	1.07	74.92*	9.1-615.5
Any income source of female members				
No [®]	1.00	...
Yes	2.04	0.27	7.71*	4.6-13.1
Women's participation in decision making				
No [®]	1.00	...
Yes	1.09	0.23	3.00*	1.9-4.7
Women's involvement with social/political activity				
No [®]	1.00	...
Yes	2.16	0.26	8.69*	5.3-14.4

Note: [®] means reference category; * $p < 0.01$ and ** $p < 0.05$

Source: Unnayan Onneshan Field Survey, 2012

7 CONCLUSIONS

The participation of people in development activities is increasing over the years. However, the rate of reduction of poverty is not matching at the similar pace in Bangladesh. The participation of population in income generating activities increased from 39.0 million in 1999-2000 to 54.1 million in 2010 with an annual rate of increase of 3.87 percent, whereas the rate of poverty declined from 49.8 percent to 31.5 percent with the decrease rate of 3.67 percent per year during the same period. The employed population is increasing but they are compelled to go for multiple and informal employment just to maintain their livelihoods as the nation is facing higher inflationary pressure and unexpected natural disasters. Measures should be taken to wipe out the barriers (legal and regulatory) for full participation of distressed or backward people, especially for women in the labour force. It is also evident that job crisis and lack of skills are the more influential factors responsible for the required participation in employment and lesser reduction of incidence of poverty.

Results from the binary logistic regression analysis point out that capacity building training, employment of the women, and participation of female in decision making are significant determinants in reducing the poverty. Attention is more required in terms of participation at higher education for all especially the women and distressed groups.

Finally, the right of every citizen to participate challenges existing socio-cultural relations. The participatory approach enables, empowers and conscientises the endogenous people by means of sharing, enhancing and analysing their knowledge of daily lives. Conscientisation does not come easily for the poor and exploited people, as they are a part of the “culture of silence” which means that they are not even aware of the fact that they have ‘zero’ voice. Therefore, there should be more focus on the development of critical consciousness among the participants which would allow them to take action against poverty.

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Appendix A

Data Sources and Methods

A total of 325 households, divided equally from each of three different char areas of *Sirajgonj, Shariatpur and Gaibandha* districts have been selected to monitor the state of livelihood by using a pre-designed questionnaire during the month of December, 2013 under the supervision of Unnayan Onneshan. The households have been selected using the stratified sampling technique considering their position compared to the orthodox poverty line⁴ to maintain the comparability with the national statistics. The data have been edited, compiled, computerized and processed by using SPSS 16.0 program. Secondary data have also been collected from different Household, Income and Expenditure Survey, Labour Force Survey and others survey of Bangladesh Bureau of Statistics (BBS), related journals and books to explain the scenario of informal labour force in Bangladesh.

Appendix B

Mathematical Equation

$$P_l = P_b (1 + ry)$$

$$\Rightarrow r = \frac{1}{y} \left(\frac{P_l}{P_b} - 1 \right)$$

Where,

P_l = Value of the launch year;

P_b = Value of the base year;

y = Number of years between launch year and base year;

r = Rate of growth

Then, a projection using this method could be computed as:

$$P_t = P_l (1 + rz)$$

Where,

P_t = Value of the target year;

P_l = Value of the launch year;

z = Number of years between target year and launch year;

r = Rate of growth

Appendix C

Development of Logistic Regression Analysis

⁴ Daily income is less than USD 1.25 according to World Bank poverty line criteria

When we examine each independent variable individually, it can only provide a preliminary idea of how important each variable is by itself. So, the relative importance of all the variables has to be examined simultaneously by some multivariate methods. There are varieties of multivariate statistical techniques that can be used to predict a binary dependent variable from a set of independent variables.

Multiple regression analysis and discriminate analysis are two related techniques but these techniques are applicable only when the dependent and independent variables are measured in interval scale under the assumption that they are normally distributed with equal variances. However, in most applications, dependent variable may be dichotomous one and one or more explanatory variables are qualitative or measured in nominal or ordinal scales and the assumption of normality is violated. To overcome this problem, a very interesting and appropriate technique is the linear logistic regression method. Cox is the pioneer of logistic regression model. Subsequently this model was illustrated by Wolker and of success. This model expresses a qualitative dependent variable as a function of several independent variables, both qualitative and quantitative (Fox, 1984). Duncan (1967) and Cox himself (Cox, 1970). More recently Lee (1980) and Fox (1984) have further illustrated the Cox's model. The logistic regression method does not require any distributional assumption. This regression is useful when the dependent variable is dichotomous. Since it does not require any distributional assumptions, unlike many other multivariate techniques (i.e. the variables are normally distributed with equal variances), it can appropriately handle situations in which the independent variables are qualitative or measured in nominal and ordinal scale. The logistic regression model can be used not only to identify risk factors but also to predict the probability.

Let Y_i denote dichotomous dependent variable for the i th observation and $Y_i = y_i = 1$, if the i th individual is a success and $Y_i = y_i = 0$, if the i th individual is a failure.

So that, $p_i = E\{y_i = 1 | X_i\} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_i)}}$ where X_i is explanatory variable and

$$1 - p_i = E\{y_i = 0 | X_i\} = 1 - \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_i)}}$$

$$= \frac{e^{-(\beta_0 + \beta_1 X_i)}}{1 + e^{-(\beta_0 + \beta_1 X_i)}}$$

$$= \frac{1}{1 + e^{(\beta_0 + \beta_1 X_i)}}$$

Therefore, we can write

$$\frac{p_i}{1 - p_i} = \frac{1 + e^{(\beta_0 + \beta_1 X_i)}}{1 + e^{-(\beta_0 + \beta_1 X_i)}}$$

$$= e^{(\beta_0 + \beta_1 X_i)} \dots \dots \dots (1)$$

Now if we take natural log of the equation (1) we obtain

$$L_i = \log_e \left(\frac{p_i}{1-p_i} \right) = \beta_0 + \beta_1 X_i \dots \dots \dots (2)$$

Here, $p_i/(1-p_i)$ given in (1) is simply the odds ratio and L_i given in (2) is known as log odds.

Instead of single explanatory variable, we can count two or more explanatory variables. Let $X_{i1}, X_{i2}, \dots, X_{ik}$ be the vector of k independent explanatory variables for the i th response. The logarithm of the ratio p_i and $(1-p_i)$ gives the linear function of X_{ij} and the model (2) becomes,

$$L_i = \log_e \left(\frac{p_i}{1-p_i} \right) = \sum_{j=0}^k B_j X_{ij} \dots \dots \dots (3)$$

Where we consider $X_{i0} = 1$ and β_j is the parameter relation to X_{ij} .

The function (3) is a linear function for both the variables X and parameter β . L is called the logit and hence the model (3) is called logistic regression model.

Interpretation of the Parameters

Interpretation of the parameters in logistic model is not so straight forward as in linear regression model. So, it is relevant to present a little discussion about it. Since the logit transformation

$$L_i = \log_e \frac{p_i}{(1-p_i)}$$

is linear in parameter, we can interpret the parameters using arguments of linear regression. Thus the interpretation may be described as follows:

We have, $p_i = \frac{e^{\beta_0 + \beta_1 X_1 + \dots + \beta_k X_k}}{1 + e^{\beta_0 + \beta_1 X_1 + \dots + \beta_k X_k}}$ is a linear in parameter.

i.e. $L_i = \log_e \left(\frac{p_i}{1-p_i} \right) = \beta_0 + \beta_1 X_1 + \dots + \beta_k X_k$

So, arguing analogously as in the case of linear model we can say that β_j ($j=1,2,\dots, k$) represent the rate of change in $\log_e \left(\frac{p_i}{1-p_i} \right)$ for one unit change in X_j (other variables remaining constant).

The interpretation of the parameters in logistic regression has another interesting aspect. In fact, this is the proper interpretation for the parameters of qualitative variable coefficient. To describe this, we first consider that the independent variable (X_j) is dichotomous. This case is not only the simplest but also it gives the conceptual foundation for all other situations. The description is given below.

We have $\text{Log}_e \frac{p_i}{1-p_i} = \beta_0 + \beta_1 X_1 + \dots + \beta_j X_j + \beta_k X_k$

Now if X_j is a dichotomous variable taking values 0 and 1, then the odds ratio 'O' (say) for $X_j = 1$ against $X_j=0$ is (keeping all other X 's fixed)

$$\begin{aligned}
 O &= \frac{p_i(Y_i = 1 | X, X_j = 1)}{1 - p_i(Y_i = 1 | X, X_j = 1)} \bigg/ \frac{p_i(Y_i = 1 | X, X_j = 0)}{1 - p_i(Y_i = 1 | X, X_j = 0)} \\
 &= \frac{e^{\beta_0 + \beta_1 X_1 + \dots + \beta_j X_j + \dots + \beta_k X_k}}{e^{\beta_0 + \beta_1 X_1 + \dots + 0 \cdot \beta_j + \dots + \beta_k X_k}} \\
 &= e^{\beta_j} \\
 \Rightarrow \text{Log}_e O &= \beta_j
 \end{aligned}$$

So, we can directly estimate the coefficients of a logistic regression model as $\log_e \hat{O}$ and hence can interpret. In a qualitative independent variable has m categories, we introduce only (m-1) dummy variables and the remaining one is taken as reference category.

Estimation of the Parameters

In order to estimate the unknown parameters we cannot use the standard OLS method, Because in that case we must face some special problem as non-normality of the disturbance terms, heteroscedastic variance of the disturbance terms, non-fulfillment of the axiom i.e. $0 \leq P_i = E(Y_i | X) \leq 1$ and questionable value of R^2 as a measure of goodness of fit.

To eliminate the above problem, Cox suggested the maximum likelihood estimation method in place of standard OLS method and proposed the following function.

$$\begin{aligned}
 L(\beta_0, \beta_1, \dots, \beta_k) &= \frac{\prod_{i=1}^n \exp(Y_i \sum_{j=0}^k \beta_j X_{ij})}{\prod_{i=1}^n \{1 + \exp(Y_i \sum_{j=0}^k \beta_j X_{ij})\}} \\
 &= \frac{\exp\{\sum_{i=1}^n (Y_i \sum_{j=0}^k \beta_j X_{ij})\}}{\prod_{i=1}^n \{1 + \exp(Y_i \sum_{j=0}^k \beta_j X_{ij})\}} \\
 &= \frac{\exp\{\sum_{j=0}^k (\beta_j \sum_{i=1}^n X_{ij} Y_i)\}}{\prod_{i=1}^n \{1 + \exp(Y_i \sum_{j=0}^k \beta_j X_{ij})\}} \\
 &= \frac{\exp\{\sum_{j=0}^k \beta_j t_j\}}{\prod_{i=1}^n \{1 + \exp(Y_i \sum_{j=0}^k \beta_j X_{ij})\}}, \text{ where } t_j = \sum_{i=1}^n X_{ij} Y_i, j = 0, 1, \dots, k
 \end{aligned}$$

The log-likelihood function is given by

$$\log_e L(\beta_0, \beta_1, \dots, \beta_k) = \sum_{j=0}^k \beta_j t_j - \sum_{i=1}^n \log_e \{1 + \exp(Y_i \sum_{j=0}^k \beta_j X_{ij})\}$$

In order to estimate the parameter of this function, the logistic regression procedure of statistical package SPSS for windows base 16.0 version may be used.

MEASURING MULTIDIMENSIONALITY

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