The Economics of Tobacco and Tobacco Taxation in Bangladesh

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Annex. Econometric Model of Demand for Cigarettes in Bangladesh

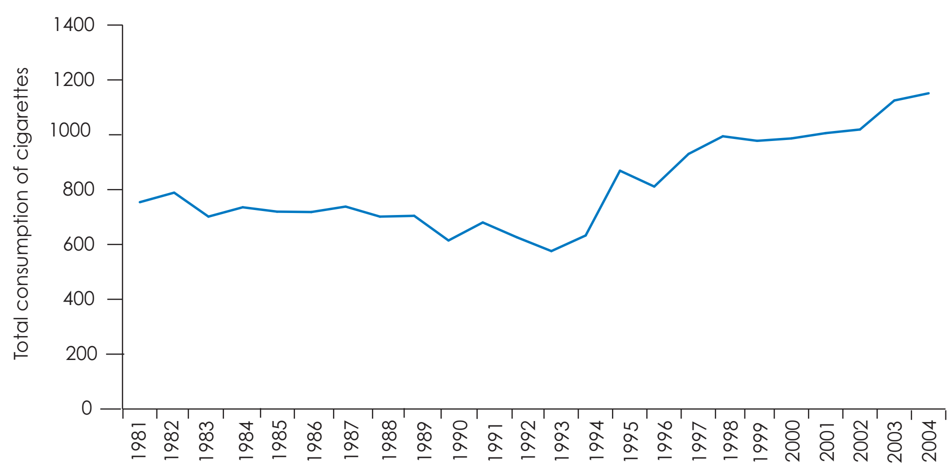
In this annex we provide more details on our estimation of cigarette demand in Bangladesh. We focus on cigarettes given the lack of reliable historical data on biri and smokeless tobacco product prices and consumption over time. Our data cover the period from 1981 through 2004, given the data available at the time this project began.

Graphs A.1-A.3 show trends in cigarette consumption, the real price of cigarettes and real per capita GDP over time. These figures suggest that the variables may not be stationary in their levels.

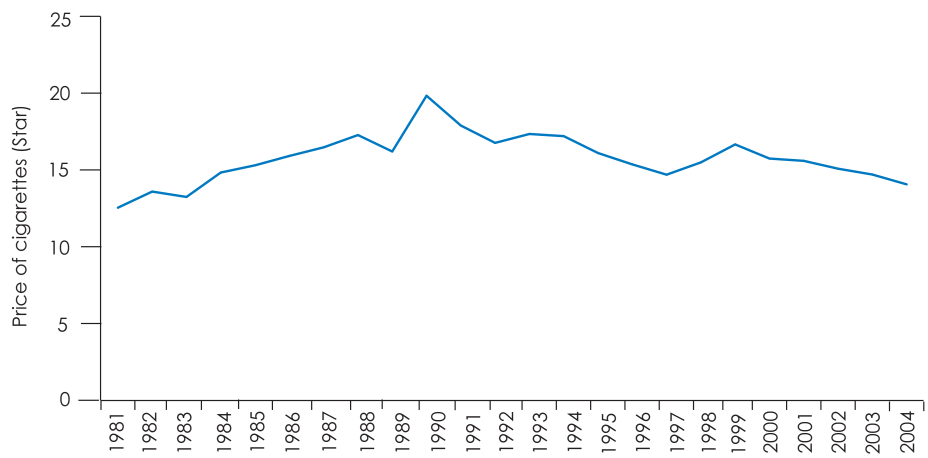
In Table A.1, we present the results from tests for the stationarity of the variables. From the results shown in Table A.1, it is clear that all the variables are nonstationary in their level and are stationary in first differences according to the Phillips-Perron (PP) test. The same result holds for the Augmented Dickey-Fuller (ADF) test except for the GDP per capita. In empirical literatures, the PP test is preferred to ADF test. Thus, we argue that all data are integrated of first order.

The estimated coefficients of the long-run demand equation for cigarettes are presented in Table A.2. All coefficients are of expected signs; those for price and income are statistically significant. However, as the data series used in this equation are non-stationary and the long-run equation is run on the level of the variables,

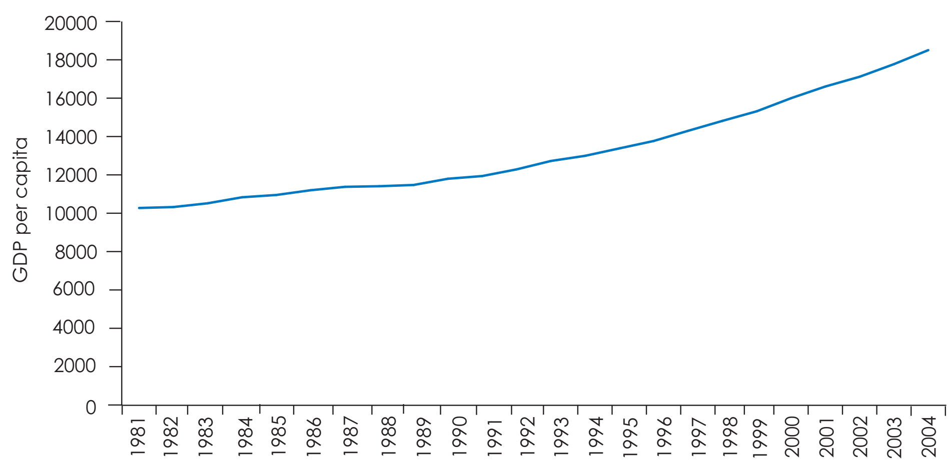
Graph A.1: Cigarette Consumption, Bangladesh, 1981-2004



Graph A.2: Real Cigarette Prices, Star Brand, Bangladesh, 1981-2004



Graph A.3: Real Per Capita GDP, Bangladesh, 1981-2004



theses coefficients are argued to be super consistent. So, it is difficult to draw inference using the t-values.

To statistically establish the long-run relationship we need to see if the variables are cointegrated. The ADF test has been used to test for cointegration. The critical values used to test the residual based test for cointegration differs from those for univariate ADF tests (see Harris, 1995: 54 and 158).* If the univariate ADF test is used to test for cointegration, there is

* Harris, RID. Using Cointegration Analysis in Econometric Modelling, Prentice Hall, 1995.

Table A.1: Test of Stationarity of Variables and the Order of Integration

Variable	Test	In level form	In first difference form
CONS	ADF	0.37	-3.09**
	PP		-5.27***
RPRC	ADF	-1.85	-3.44**
	PP		-5.95*
RINC	ADF	3.64	-2.89
	PP		-3.81**

*Note: *** implies significant at 1% level, ** implies significant at 5% level, * implies significant at 10% level. MacKinnon critical values are used for rejection of hypothesis of a unit root.*

Table A.2: Long-run Demand Equation for Cigarettes for Bangladesh: 1981-2004

Dependent variable: CONS			
Independent variables	**Coefficient**	**t-value**	**Prob-value**
Constant	283.46	0.67	0.67
Trend	-10.69	-1.01	0.325
RPRC	-29.41	-2.43	0.025
RINC	0.09	2.83	0.009
Adj. R2 = 0.86		DW = 1.29	

tendency to over-reject the null hypothesis of no cointegration as the residuals are calculated to have the smallest possible sample variance. Also, the distribution of the test statistic under the null hypothesis is affected by the number of regressors in the cointegrating equation. Based on the MacKinnon critical values for cointegration, the hypothesis of no cointegration cannot be rejected even at 10% level of significance. The MacKinnon critical value at 10% level for the cointegrating equation of 3 variables with trend using 24 observations is -4.23, which is greater than the calculated ADF statistic of -2.7.

Even though we cannot reject the hypothesis of no cointegration, we can estimate an error-correction model (ECM) using the residual from the long-run equation. The ECM captures the short-run dynamics as deviations from the long run equilibrium tend to partially revert to equilibrium position in the following period. The ECM is based on stationary data (as all the regressors are in first difference form) and includes the lagged residuals (of the long-run equation) as an explanatory variable.

Table A.3 presents the estimated coefficients of the ECM for cigarette demand. Since, all the variables used in the ECM are stationary, the standard tests for statistical inference are applicable. All the coefficients are of expected signs and are statistically significant. Given the fact that the short-run demand equation is estimated in first difference form, a high explanatory power is not expected. The coefficient of -0.65 on the lagged residual of the long-run equation indicates that, on average, about 65% of the deviation from the long-

Table A.3: Error-correction Model for Cigarette Demand for Bangladesh: 1982-2004

Dependent variable: CONS			
Independent variables	**Coefficient**	**t-value**	**Prob-value**
Constant	-4.28	-0.25	0.802
D(RPRC)	-20.98	-2.39	0.027
D(RINC)	-0.07	1.74	0.097
Residual(-1)	-0.65	-2.27	0.035
Adj. R2 = 0.36		DW = 1.94	

Table A.4: Diagnostic Test on the Error-correction Model

Test name	Purpose	LM statistic	F statistic
Breusch-Godfrey	Residual serial correlation	0.02 (0.88)	0.02 (0.9)
Ramsey's RESET	Functional form	1.14 (0.29)	0.93 (0.35)
Jarque-Bera	Normality	0.03 (0.99)	n/a
White	Heteroscedasticity	5.75 (0.02)	6.99 (0.02)

run equilibrium will be compensated for in the following year and to achieve the long-run equilibrium outcome it will take roughly one and a half years.

Various diagnostic tests are used to check for the statistical acceptability of the estimated regression equation. In Table A.4, the results of some of the important tests are given. The test statistics show that there is no problem with residual serial correlation, the functional form of the equation and the normality of the residuals. However, the estimated equation suffers from heteroscedasticity. To rectify the problem of heteroscedasticity, we have used the adjusted White's heteroscedasticity-consistent variance-covariance matrix to calculate the t-values for the coefficients; these are presented in Table A.3. Thus, we argue that the error-correction model of cigarette demand is free from statistical inconsistency.