Consumption Functions of India: During, Before and After Covid-19 Pandemic

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Abstract

Consumption is essential for living. It is the most important economic goal of every rich or poor individual living either in urban or rural households. A huge body of theoretical and empirical literature in the micro and macroeconomics analyses the level, growth and distribution of consumption among cross sections at a time or over the years or among generations. Distilled from seminal works Keynes (1936), Addo and Modigliani (1963) and Brumberg and Modigliani (1954), Samuelson (1958) Deaton (1972, 2008 and 2021), Banerjee, Duflo and Sharma (2021) and many other studies seven theories of consumption made popular in the literature; the Keynesian absolute income hypothesis for short run consumption, Kuznet's estimates of long run APC and Friedman's permanent income hypothesis, life cycle and cross section consumption, precautionary theory of consumption saving and investment, inequalities in wages, income and consumption, overlapping generation and general equilibrium theory consumption. The COVID-19 global pandemic seriously affected the consumption levels of individuals in every part of the world. Focus of this paper is on estimation of consumption functions of households located in rural and urban areas across twenty eight states of India. While the marginal propensity to consume (MPC) is 49.8 percent in India from macro time series for 1990-2020, it differs significantly at micro household levels. Estimated MPCs based on surveys of 178 thousand households covering all states are still positive and significant but are a lot lower than the MPCs at macro time series. Comparing cross section of consumption in 2020 with peak of COVID-19 to pre covid years 2017 to 2019 and post covid years 2021 and 2022 shows a significant rise in pre-cautionary saving among households during the pandemic. Even government transfers were saved rather than consumed. All other estimates are consistent to economic theories. Urban areas had higher MPCs than rural areas and the rural urban differences in MPCs are big across states. Bayesian analyses complement classical estimations of MPCs.

Key Words: Consumption functions, MPC, India
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1. Introduction

Consumption is essential for living for every individual. Better consumption is the most important economic goal of every individual from rich or poor households whether they are located in urban or rural areas. There is a huge body of theoretical and empirical literature in the micro and macroeconomics highlighting important factors that determine, level, growth, distribution of consumption in a particular time or over the years. More specifically Keynesian absolute income hypothesis for short run consumption, Kuznet's estimates of long run APC and Friedman's permanent income hypothesis, life cycle theory of consumption, precautionary theory of consumption saving and investment, overlapping generation and general equilibrium theory consumption and cross section theory of inequalities in wages, income and consumption are seven popular theories of consumption distilled from seminal works Keynes (1936), Ando and Modigliani (1963) and Brumberg and Modigliani (1954), Samuelson (1958) Deaton (1972, 2008 and 2021), Banerjee, Duflo and Sharma (2021) and many other studies. Recently consumption was the highly debated issue as the COVID-19 global pandemic had seriously affected consumption of individuals in every part of the world. Focus of this paper is on estimation of consumption function of households located in rural and urban areas in India and its twenty-eight states.

Studies on above theories of consumption applied for explaining patterns of consumption functions are reviewed in section 2. Data sources and variables are discussed and defined in section 3. Cross-section regression estimations of MPCs for pre-COVID-19 (August 2017, 2018 and 2019), peak of COVID-19 (August 2020) and after recovery phase of COVID-19 (August 2021) are compared across states with reference to theories outlined in sections 2 and 3 followed by conclusions of study in section 4.

2. A short review on theories of consumption

Literature on consumption increased substantially after the COVID-19 pandemic. Deaton (2021) looks into COVID-19 and income inequality globally; Banerjee, Duflo and Sharma (2021) examine the long-term effects of targeting the ultra-poor program in the context of pandemic; Hall, Jones and Klenow 2020 assess trading off consumption and COVID-19 deaths. Similarly Hoke and Känzig and Surico (2020) study consumption during time of COVID-19 using evidence from UK transaction data. In the context of India, studies such as Mishra, Gupta and Bhardwaj (2022) look into permanent inequality versus earnings instability and transmission of income shocks to consumption expenditure in India. Earlier Sen and Das (2018) carried out decomposition analysis of the sources of consumer expenditure inequality in India. We have found significant negative impact of COVID-19 in household consumption across India from estimates based on CMIE's Consumer Pyramids Household Survey. This is consistent to Gupta et al. (2021) who show more fall in levels of consumption than of income during Covid-19 in India using the same dataset.

Angus Deaton has been investigating the micro and macro aspects of consumption and inequality over 50 years. For instance, Deaton (1972) examined wealth effects on consumption in a modified life-cycle model. Campbell and Deaton (1989) investigated why consumption was so smooth. Deaton and Kozel (2005) looked into the data and dogma in the context of great Indian poverty debate. Then Deaton (2008) linked consumption to health issues for explaining the distribution of adult height, health, and inequality in India. Cotton, Garga and Rohan (2021) studied issues of consumption spending and inequality during the COVID-19 pandemic.

Literature on consumption is closely linked to the theory of saving and investment in Abel and Blanchard (1983) and in the dynamic general equilibrium analysis of life cycle optimisation in dynamic models of Auerbach and Kotlikoff (1987) or in income uncertainty, risk pooling, precautionary saving and consumption growth models of Blundell and Brugiavini (1995) or Banks, Blundell and Stoker (1995).

Some studies look into how the private saving and public policy relate to consumption (Bernheim and Scholtz (1992)) and others focus on consumption inequality and income uncertainty (Blundell and Preston (1996)) or earning uncertainty and aggregate wealth

accumulation (Caballero (1991)). Similarly non-expected utility preferences in a temporal framework is applied to explain consumption-savings behaviour by Chew and Epstein (1990) and social security and the retirement decisions were featured in Crawford and Lelien (1981). Davies (1981) connects uncertain lifetime to consumption and dissaving in retirement. Goodman and Webb (1994) focus on impacts of relative wage inequality on consumption. Many studies explain the growth in United Kingdom income and consumption inequality (Jonson and Webb (1993), Jenkins (1996)). Consumption is related to a life cycle analysis of social security in Imrohoroglu, Imrohoroglu and Joines (1995). It is related to precautionary saving in Kimball (1990) and precautionary saving and timing of taxes in Kimball and Mankiw (1989). Consumption is related to intergenerational transfers and savings or the effect of annuity insurance on savings and inequality in Kotlikoff (1988) and Kotlikoff, Shoven and Spivak (1986).

Dynamic programming models have been used to determine the process of consumption under uncertainty, dynamic consistency and non-expected utility models in Machina (1989 and 1987). The empirical failure of the life cycle model with perfect capital markets are studied in Pemberton (1997). While Perroni (1995) assesses the role of consumption evaluating the dynamic efficiency gains of tax reforms with endogenous human capital, Rust (1989, 1987) links consumption to the retirement behaviour of individuals. Consumption has distributive implications in the aging society in Weizsacker (1996). It relates to the economics of aging, pensions, the option value of work and retirement (Wise (1989), Stock and Wise (1997).

Distilled from above seminar works we find seven theories of consumption popular in the literature. The first and the most important theory is the Keynesian absolute income hypothesis for the short run consumption function. Here level of consumption expenditure in general is determined by the level of income, $\boldsymbol{C = C_0 + bY + e}$. Level of consumption at no income, called autonomous consumption, is C_0. The slope parameter *b* is the MPC, this shows how much consumption will change when income changes by one unit. Then the *e* term is a random shock, in the current context like the COVID-19 pandemic. The national consumption function is obtained by summing up such functions for all individuals in the economy. The average propensity to consume (APC) is higher than the marginal propensity to consume, APC

> MPC, at low level of income and APC < MPC at the higher level of income as shown in part (a) of Figure 1 in the appendix.

Then comes Kuznet's estimates of long run APC and Friedman's permanent income hypothesis where the focus is on long run relation between consumption and income. Because of lending and borrowing through the financial system, consumers can smooth out consumption despite fluctuations in their income in the short run. This is shown in panel (b) of Figure 1 in the appendix. Smoothing out consumption over time is also the main point of the micro-foundation theory of consumption, which emphasises on intertemporal substitution between current and future consumptions.

Fourthly, dynamic models of consumption is more explicitly stated in Ando and Modigliani (1963) and Brumberg and Modigliani (1954) theory of life cycle and cross section consumption. Individuals borrow for education in early phase of their life, save some fractions of their income after they start working in the middle phase of life and consume part of income in the retired phase of their life. In such empirical life cycle model current consumption depends more on expected permanent income than on current income or asset.

$$C_t = \frac{1}{T}\left[Y_t^1 + (N-1)\overline{Y}_t^{1e} + A_t\right]$$

MPC out of transient income is low (1/T) but high out of permanent income ((N-1)/T). An example of net of tax life time income (assuming that it grows by g each year) can be as follows:

$$V\left(Y_{Lt}^e - T_t^e\right) = (1-t)\left[1 + (1+g) + (1+g)^2 + \ldots + (1+g)^{36}\right]£40000$$

$$V\left(Y_{Lt}^e - T_t^e\right) = 0.75\left[1 + 1.03 + (1.03)^2 + \ldots + (1.03)^{36}\right]£40000$$

Apply sum of geometric series to calculate this sum $1 + X + X^2 + \ldots + X^n = \frac{1 - X^{n+1}}{1 - X}$.

Level of income and consumption varies per period for individuals depending on various factors such as the initial income, growth rate of it, the length of working and consumption life, tax rate as shown for hypothetical individuals A, B, C, D, E and F in the table below.

Table 1: Scenarios of consumption smoothing

Individuals	Initial income	tax rate	Growth	working life	Cons life	Life time y	Consumption per period
A	1000000	0.4	1.03	36	56	39,704,534	709010
B	50000	0.3	1.04	36	56	2,859,579	51064
C	40000	0.25	1.03	20	56	860,295	15362
D	40000	0.2	1.04	30	56	1,898,507	33902
E	20000	0.15	1.03	40	60	1,337,276	22288
F	10000	0.1	1.05	40	65	1,150,558	17701

A simple intertemporal model of consumption determines the optimal levels consumptions C_1, C_2 with W_1, W_2 endowments in period 1 and period 2 respectively. With logarithmic preference function $Max \quad U(C_1, C_2) = \ln C_1 + \beta \ln C_2$ subject to $C_1 + b \le W_1$ and $C_2 \le b(1+r) + W_2$ budget constraints in period 2 respectively inter-temporal consumption functions are given by $C_1 = \frac{1}{1+\beta}\Omega$ and $C_2 = (1+r)\frac{\beta}{1+\beta}\Omega$. Derivations and numerical examples are given in appendix 2.

Fifth, Hall (1988) has random walk theory of consumption, meaning consumption depends on past consumption and random factors and is very non-stationary.

Sixth one is the overlapping generation theory of consumption by Samuelson (1958) extends consumption hypothesis and analysis to various generations.

Finally, dynamic general equilibrium theory of consumption shows consumption an allocation process in decentralised markets guided by inter-temporal and intra-temporal process of optimisation over leisure, labour, saving, investment at different phases and locations of economic growth (Batabyal and Beladi (2016))

All of above theories have taken consumption in partial equilibrium framework. In addition we now introduce a simple general equilibrium model in which consumption is the result of the optimisation process of households and firms.

3. General Equilibrium Model of Consumption

Consider an economy consisting of a representative household and a representative firm. A representative household tries to maximise utility by consuming goods and services and from enjoying leisure subject to his budget constraints. The producer wants to maximise profit by selling goods produced using the labour supplied by the household. We follow Bhattarai (2006) model to derive a general equilibrium consistent consumption function that is based on optimisation by households and firms. In this model households maximise utility from consumption $Max \quad U = c^{\phi} l^{1-\phi}$ subject to 1) time constraints $l + h^s = 1$ and 2) resource budget constraint $pc = wh^s + \pi$ where *c* is consumption, *l* is leisure and h^s is labour supply, *p* is the price of the commodity, *w* is the wage rate π is the profit from owning the firm. Interior solution requires that $c \geq 0; l \geq 0; h^s \geq 0$.

Similarly representative **firm** maximizes profit, $Max \quad \pi = py - wh^d$ subject to technology constraint $y \leq \left(h^d\right)^{\alpha}$ where y is the output supplied by the firm and h^d is its demand for labour. Both output and labour supply (demand) need to be positive $y \geq 0; h^d \geq 0$ for an interior solution.

A competitive equilibrium in this economy is given by the real wage rate and price of commodity in which demands for goods and labour equal to their supplies. Given the prices and wage rate, the representative household maximises utility subject to its budget constraint and the representative firm maximises its profit subject to technology constraint. Solution of this model involves four stages: (1) derivation of households' demand for goods and leisure as well as the supply of labour (2) derivation of firm's demand for labour (3) Finding the equilibrium real wage that equates demand for and supply of labour in the market (4) finding the equilibrium price level that equates supply of goods by the representative firm and the demand for goods by the representative household for maximising its utility.

A competitive equilibrium is defined by the real wage rate where the demand for labour by firms is equal to the supply of labour by households, supply of labour and demand for leisure is equal to total endowment of time of households and the production of output is equal to the demand for consumption by the household. The real wage rate that clears the labour

market, $h^d = h^s$ can be solved for equilibrium real wage rate as a function of parameters in the production and consumption functions (see Appendix 3 for derivations).

$$\frac{w}{p} = \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}}$$

This is the equilibrium wage rate that clears demand and supply in the labour market giving equilibrium quantity of *l* and h^d.

$$\hat{h}^d = \hat{h}^s = \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}} \right)^{\frac{1}{\alpha-1}}$$

$$\hat{l} = 1 - \hat{h}^s = 1 - \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}} \right)^{\frac{1}{\alpha-1}}$$

It leads to equilibrium output

$$\hat{y} = \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}} \right)^{\frac{\alpha}{\alpha-1}}$$

Ultimately the consumption functions

$$c=\left(\frac{\phi}{1-\phi}\right)\left(1-\left(\frac{1}{\alpha}\frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}}+\phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}}\right)^{\frac{1}{\alpha-1}}\right)\frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}}+\phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}}$$

In a general equilibrium model consumption is determined by the price system that is an outcome of the preferences, endowments and technology in the economy. Parameters defining the preferences of households and the technology of the firms and endowments are the only arguments of the equilibrium prices. the relative wage rate, in a competitive equilibrium. Basis of all economic activities for maximizing utility from consumption. Production occurs because there is demand for products by the households. Firms demand for factors to produce output. They pay to labour according to its marginal product. The remuneration for labour services provides income to the households, which they use to demand consumption goods. Once equilibrium price is determined that determines all other quantities, such as demand for goods and leisure and supply of labour by households and demand for labour and supply of commodities by firms. Ultimate objective of all economic activities is maximization of utility through consumption.

4. Definition of data sources and variables

Empirical analysis is based on macro and micro household level data on consumption and income. Macro time series of consumption and income taken from the World Economic Outlook database of the International Monetary Fund (IMF) for estimating parameters of the macro consumption function. Then for estimation of the micro consumption functions at national, state, rural and urban areas are based on the household level data on total expenditure, total income, government transfer for 174,405 households in India from the Centre for Monitoring Indian Economy Pvt. Ltd. (CMIE, https://www.cmie.com/) database. Consumer Pyramids Household Survey provides anonymized record, at the level of individual households and members of households.

Keynesian consumption function of India

First let us describe our estimation of the macro consumption function. First, observe the consumption time series as given in the following Figure 4.1; as expected, consumption and GDP are positively related, both are increasing over time.

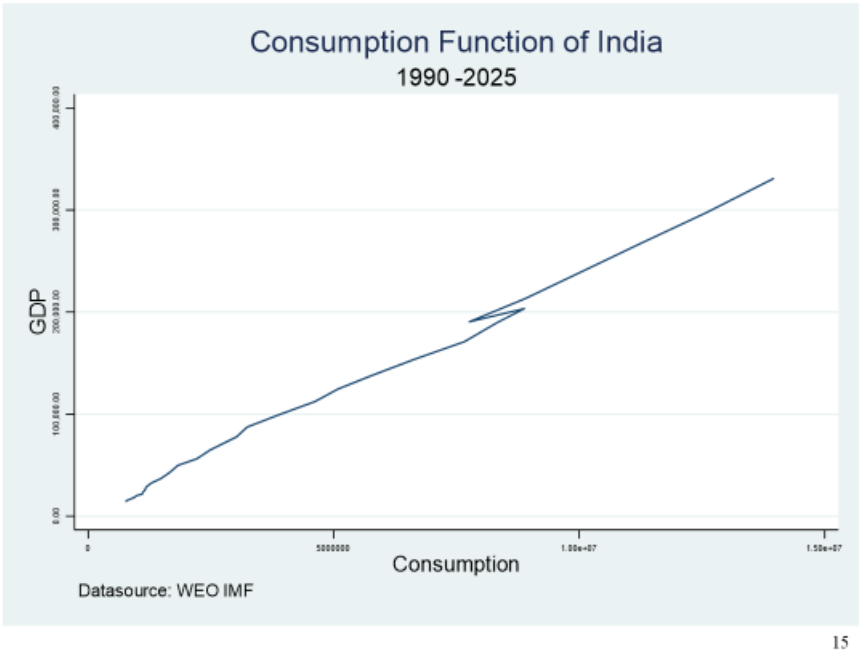


Figure 4.1: Macro consumption function of India, 1990-2025

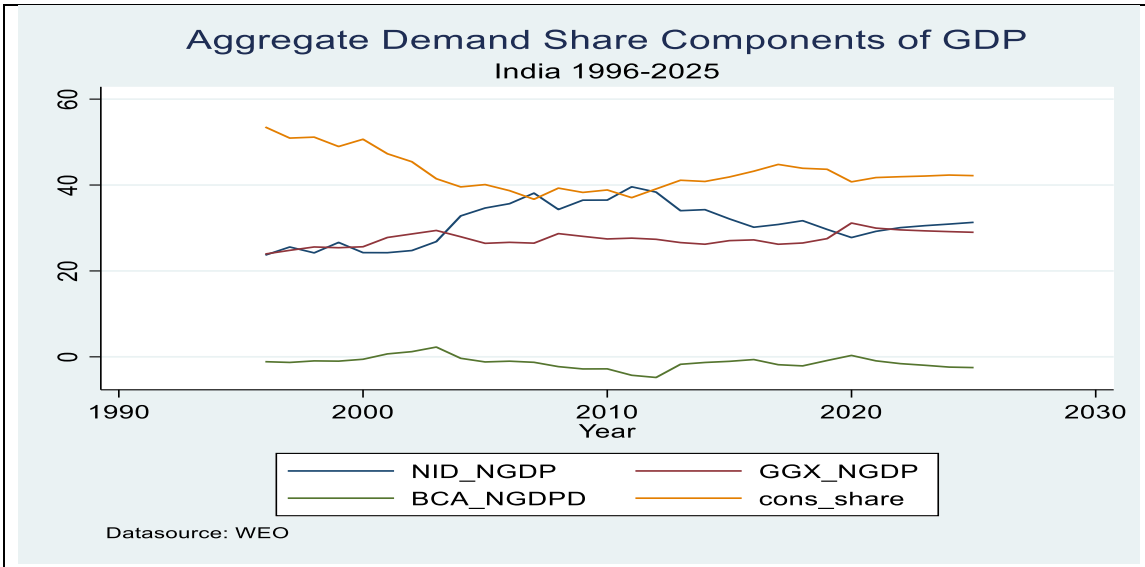


Figure 4.2: Share of consumption in GDP of India, 1990-2025

Share of consumption in India is slightly above 40 percent GDP, and it has remained the major component of the GDP also for every year in our study period. Investment share came close of the share of consumption in 2010 but has remained around 30 percent of GDP in recent years close to the share of exports.

With this data we estimated four consumption functions. The first two estimations generate biased estimates of the marginal propensity to consume because of autocorrelation in error terms in the regression for consumption function. The estimation in the differences of consumption and income as presented in column (3) matches the share of consumption series as presented above. The equation shows that the MPC is 49.8 percent.

Table 4.1: Consumption Function of India at National Level, 1990-2021

VARIABLES	(1) levels	(2) logs_elasticity	(3) differences	(4) C_change_Y
NGDPD	41.97*** (0.687)			
Lgdp		0.954*** (0.0167)		
dgdp			49.80*** (2.527)	
NGDP				3.868*** (0.801)
Constant	-72.53 (1,392)	4.274*** (0.188)	-88,754** (37,644)	10,894 (117,833)
Observations	30	30	29	29
R-squared	0.993	0.991	0.935	0.463
DW-stat	0.424	0.214	1.879	1.932

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The final column of table 4.1 shows that change in consumption is roughly 3.9 percent of GDP.

Micro consumption functions of Indian households

Our second contribution of this study is to estimate parameters of micro consumption functions of India using data on around 178,677 households from the "Consumer Pyramids Household Survey" during the peak period of Covid-19 in August 2020 as well as pre- covid-19 August 2017, 2018 2019 and post-COVID-19 for year August 2021. By comparing the results across these years, we hope to find out how consumption behaviour changed during

the covid-19 pandemic in comparison to pre and post COVID-19 periods. Household level data was taken through the CMIE. We do this analysis using descriptive statistics, cross-section regressions, quantile regressions and Bayesian estimation of parameters of those consumption functions. More specifically we focus on estimated values of propensity to consume during the peak COVID-19 peak pandemic compared to other pre- and post Covid-19 years and to measure the propensity of consumption government transfers.

Pandemic had resulted in loss of employment especially in unorganized sector across India. This led to fall in income and consumption expenditure, and a sharp decline in GDP (Gupta et al. 2021). Consumption expenditure being the largest component of India's GDP, any fall in consumption expenditure leads to a decline in GDP. Indian government took immediate steps to provide relief to poor and vulnerable sections with free ration and also income transfers to support and sustain a subsistence level of consumption during the recession.

Table 4.2: Summary of Data for Consumption Function of India, August 2021

VARIABLES	(1) All India (sd)	(2) India Rural (sd)	(3) India Urban (sd)	(4) 5St_Rural (sd)	(5) 5St_Urban (sd)
TOTAL_EXP	12,311	11,128	12,840	10,280	11,746
	(6,265)	(4,952)	(6,702)	(3,612)	(5,237)
TOTAL_INCOME	22,286	17,481	24,433	15,703	23,214
	(19,838)	(20,462)	(19,168)	(19,508)	(17,239)
GOV_TRANSFER	251.7	376.1	196.2	299.1	91.20
	(797.8)	(953.1)	(710.5)	(773.3)	(332.8)
Observations	134,436	41,520	92,916	14,258	27,792

Note : Rupees per month; standard deviations in ()s indicate dispersion around the mean. Five states for columns (4) and (5) are Maharashtra, Madhya Pradesh, Bihar, West Bengal and Karnataka (MMBBK).

Figures in Table 4.2 clearly show that level of average income and consumption is significantly higher in urban than rural areas whereas variance of these is higher in rural areas than in urban areas. Therefore, the government transfers seem much higher in rural areas than in the urban areas. Also note that the sample size is much larger for urban than rural areas. Banerjee, Duflo and Sharma (2021) have argued that effects of such transfer becomes visible after seven to ten years *…" big-push" program providing a large asset transfer to the poorest Indian households. In a randomized controlled trial that follows these households over ten years, we find positive effects on consumption (0.6 SD), food security (0.1 SD), income (0.3 SD), and health (0.2*

SD). These effects grow for the first seven years following the transfer and persist until year ten. One main channel for persistence is that treated households take better advantage of opportunities to diversify into more lucrative wage employment, especially through migration..."

Similarly Sen and Das (2018) observed *".. that the inequality in consumer expenditure has increased in both the rural and the urban parts of India during the post-reform period. Non-food expenditure is more unevenly distributed, and it has been found to be more pro-rich in nature. Expenditure on cereals and pulses still exhibits higher inequality-reducing effect in rural and urban India. Education and health-care expenses have been inequality-increasing in the country. Contribution of expenditure on miscellaneous consumer services, durable goods, education and health care to the overall expenditure inequality is significantly higher."*

4.3: Micro Consumption Function of India in Covid-19 pandemic, August 2020

	(1)	(2)	(3)	(4)	(5)
VARIABLES	India_all	India_rural	India_urban	5State_rural	5State__urban
TOTAL_INCOME	0.170***	0.0776***	0.214***	0.0432***	0.162***
	(0.000725)	(0.00113)	(0.000908)	(0.00151)	(0.00155)
GOV_TRANSFER	-0.327***	-0.0534**	-0.265***	-0.195***	-0.0911
	(0.0180)	(0.0242)	(0.0245)	(0.0381)	(0.0801)
Constant	8,606***	9,791***	7,668***	9,660***	7,991***
	(22.19)	(31.17)	(28.86)	(39.10)	(45.78)
Observations	134,436	41,520	92,916	14,258	27,792
R-squared	0.293	0.102	0.377	0.055	0.285

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

We ran cross section OLS regressions to estimate MPC from the micro level data. In general, signs of the MPC coefficients with respect to income are as expected and they are significant for all India as well as rural and urban areas across the states and the country as a whole. In contrast, government transfers had negative coefficients on consumption in contrary to our expectations during the Covid-19 panic period. Such things happen only when households raise pre-cautionary saving or are under the Ricardian equivalence illusion. They are saving more for precautionary causes from government transfer in anticipation of uncertainty of future income or in anticipation of increase in taxes. It seems during the peak period of COVID-19 pandemic and the lock-down associated with it, this was a natural reaction from households in depressed mood. There was significant amount of excess capacity of production both in public and private sectors due to various phases of lock-down. In order to ascertain such behaviour of pre-cautionary saving in India during Covid-19 period, we

estimate the marginal propensity to consume from the public spending for post and pre covid-19 years 2021, 2019, 2018 , 2017 and 2022 as shown in Tables 4.4, 4.5 and 4.6, where the marginal effect on consumption out of the public transfer received from the government were found to be positive and significant. Lastly in Table 4.3 the estimated value of the constant term in these regressions indicating the value of autonomous consumption were reasonably close to each other at the national level (column 1) across rural and urban areas of all India (columns 2 and 3) or across rural and urban area of five MMBBK states (columns 4 and 5).

4.4: Micro Consumption Function of India, Pre and Post Covid-19 August 2019 and 2021

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	2019M1	2019M2	2019M3	2021M1	2021M2	2021M3
TOTAL_INCOME	0.248***		0.247***	0.262***		0.261***
	(0.000717)		(0.000717)	(0.000672)		(0.000672)
GOV_TRANSFER		0.790***	0.426***		1.184***	0.608***
		(0.0263)	(0.0203)		(0.0253)	(0.0187)
Constant	6,288***	10,980***	6,226***	4,845***	9,043***	4,774***
	(20.97)	(20.77)	(21.15)	(17.39)	(18.42)	(17.47)
Observations	174,405	174,405	174,405	178,677	178,677	178,677
R-squared	0.406	0.005	0.408	0.461	0.012	0.464

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.5: Micro Consumption Function of India, Pre-Covid-19 August 2017-18

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	2018M1	2018M2	2018M3	2017M1	2017M2	2017M3
TOTAL_INCOME	0.228***		0.227***	0.288***		0.286***
	(0.000761)		(0.000762)	(0.000822)		(0.000821)
GOV_TRANSFER		0.502***	0.155***		2.024***	1.141***
		(0.0219)	(0.0178)		(0.0419)	(0.0321)
Constant	6,550***	10,959***	6,533***	4,939***	9,266***	4,893***
	(23.52)	(22.57)	(23.60)	(19.85)	(20.07)	(19.81)
Observations	173,181	173,181	173,181	168,165	168,165	168,165
R-squared	0.341	0.003	0.341	0.422	0.014	0.426

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

There is significant heterogeneity average consumption levels among 28 provinces in India as shown by the coefficients to state in Table 4.7. States such as Delhi, Goa, Himachal Pradesh Jammu & Kashmir, Jharkhand and Uttar Pradesh in general had higher average consumption levels compared to the base state Andra Pradesh. In contrast Bihar, Chhattisgarh, Madhya

Pradesh, Puducherry and Tripura had lower level of consumption than of Andhra Pradesh. Many other states had average level of consumption lower in some years and higher in other years. Therefore level of consumption significantly differs across states of India because differences in income, public transfers and state specific factors. Convergence in level of income and consumption across states requires policies that bring uniformity in various socio-economic factors which seems very difficult in case of India. These finding are similar to those that focus on determinant of saving (Athukorala and Sen (2004)) or inequality and deprivation (Mallick (2008)).

4.6: Micro Consumption Function of India, Post-Covid-19 July 2022

VARIABLES	(1) 2022M1	(2) 2022M2	(3) 2022M3
TOTAL_INCOME	0.311***		0.308***
	(0.000734)		(0.000735)
GOV_TRANSFER		2.126***	0.971***
		(0.0389)	(0.0278)
Constant	4,362***	8,997***	4,306***
	(19.41)	(22.34)	(19.41)
Observations	178,677	178,677	178,677
R-squared	0.501	0.016	0.504

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

We further investigate whether the consumption patterns vary across income quantiles of the households in India and present the results in Table 4.8. We observe that the MPC steadily increases by quantile groups. MPC was 0.21 for top quantile against 0.033 for the bottom quantile. Normal expectation would have been just opposite but the result shows the precautionary savings must be higher in lower quantiles than in the upper quantiles.

4.7: Micro Consumption Functions across states of India from 2017 to 2021

VARIABLES	(1) 2021M	(2) 2020M	(3) 2019M	(4) 2018M	(5) 2017M
TOTAL_INCOME	0.143***	0.252***	0.226***	0.208***	0.268***
	(0.000678)	(0.000691)	(0.000747)	(0.000770)	(0.000821)
GOV_TRANSFER	-0.452***	0.125***	0.508***	0.144***	1.177***
	(0.0168)	(0.00983)	(0.0201)	(0.0173)	(0.0313)
Assam	-1,496***	-371.0***	-1,895***	-619.4***	4.777
Bihar	(148.5)	(122.5)	(165.9)	(200.3)	(167.9)
Chandigarh	-1,248***	1,528***	749.4***	-585.2***	-620.1***
Chhattisgarh	(79.34)	(71.30)	(95.88)	(110.4)	(91.12)
Delhi	8,517***	852.7***	6,257***	8,913***	3,418***
Goa	(232.8)	(224.3)	(303.6)	(351.5)	(309.4)
Gujarat	1,373***	978.2***	1,026***	395.6***	-1,208***
Haryana	(95.02)	(84.98)	(115.0)	(132.5)	(109.6)
Himachal Pradesh	7,888***	3,524***	3,889***	3,826***	1,985***
Jammu & Kashmir	(145.4)	(136.0)	(186.2)	(214.8)	(176.9)
Jharkhand	2,135***	1,245***	4,670***	7,577***	7,241***
Karnataka	(204.4)	(151.4)	(205.3)	(237.5)	(195.6)
Kerala	2,326***	1,202***	3,032***	1,746***	1,367***
Madhya Pradesh	(80.08)	(71.70)	(96.93)	(111.4)	(92.62)
Maharashtra	4,503***	2,616***	3,251***	3,434***	1,814***
Meghalaya	(87.25)	(82.05)	(111.9)	(128.2)	(105.4)
Odisha	-92.38	4,360***	4,832***	3,142***	6,390***
Puducherry	(164.9)	(140.0)	(190.1)	(219.6)	(182.0)
Punjab	3,146***	-848.9***	-3,257***	4,140***	3,630***
Rajasthan	(147.0)	(105.3)	(142.6)	(164.9)	(135.9)
Sikkim	447.3***	1,927***	1,303***	507.4***	628.9***
Tamil Nadu	(98.16)	(85.63)	(115.7)	(133.3)	(110.5)
Telangana	-2,072***	-284.8***	488.2***	-1,151***	774.8***
Tripura	(83.37)	(70.67)	(95.25)	(109.6)	(90.59)
Uttar Pradesh	2,669***	3,586***	3,562***	1,499***	4,082***
Uttarakhand	(95.05)	(84.63)	(115.1)	(132.7)	(109.2)
West Bengal	1,650***	2,399***	584.3***	-631.7***	-789.7***
Assam	(79.75)	(71.41)	(96.42)	(112.1)	(93.01)
Bihar	343.7***	919.9***	2,177***	1,504***	876.4***
Chandigarh	(70.50)	(62.22)	(83.91)	(96.38)	(80.17)
Chhattisgarh	5,147***	-58.49	4,082***	3,676***	-2,034***
Delhi	(203.5)	(153.3)	(208.6)	(239.7)	(99.00)
Goa	-131.9	-425.7***	1,179***	-1,131***	-2,228***
Gujarat	(94.87)	(77.17)	(104.1)	(119.9)	(189.3)
Haryana	4,347***	3,577***	3,850***	-1,852***	4,736***
Himachal Pradesh	(143.4)	(146.6)	(199.3)	(230.1)	(99.68)
Jammu & Kashmir	5,103***	5,650***	5,739***	6,599***	837.7***
Jharkhand	(84.56)	(77.78)	(104.9)	(120.8)	(88.58)
Karnataka	2,159***	3,605***	3,318***	1,887***	-721.3***
Kerala	(77.09)	(69.22)	(93.27)	(107.6)	(89.23)
Madhya Pradesh	72.27	-695.7***	-1,126***	-3,386***	-1,734***
Maharashtra	(463.3)	(170.5)	(231.3)	(267.1)	(103.6)
Meghalaya	-437.7***	642.1***	1,638***	-537.4***	-2,013***
Odisha	(78.15)	(68.89)	(92.79)	(107.2)	(189.3)
Puducherry	77.31	1,018***	-474.6***	-812.5***	-539.3***
Punjab	(90.18)	(79.88)	(108.2)	(125.0)	(78.09)
Rajasthan	1,250***	2,568***	2,454***	5,920***	2,256***
Sikkim	(161.6)	(143.9)	(195.2)	(225.6)	(148.5)
Tamil Nadu	-2,113***	1,114***	459.9***	-820.3***	-1,027***
Telangana	(67.52)	(61.26)	(82.21)	(94.28)	(89.58)
Tripura	12,074***	6,469***	6,671***	4,506***	
Uttar Pradesh	(128.2)	(115.5)	(156.6)	(180.4)	
Uttarakhand	66.53	-1,269***	706.3***	328.0***	
	(84.06)	(69.63)	(93.63)	(108.4)	
Urban	621.2***	961.6***	677.4***		
	(28.25)	(23.89)	(32.18)		
Constant	8,056***	2,293***	4,565***	6,150***	4,769***
	(65.23)	(54.95)	(73.89)	(81.57)	(67.59)
Observations	134,436	174,405	174,405	173,181	168,165
R-squared	0.452	0.558	0.448	0.387	0.471

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.8: Consumption Function of India by income quantiles, August 2020

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	QSt_Rural	QSt_Rural	QSt_Rural	QSt_Urban	QSt_Urban	QSt_Urban
TOTAL_INCOME	0.0325***	0.0392***	0.0528***	0.114***	0.153***	0.212***
	(0.00171)	(0.00246)	(0.00314)	(0.00224)	(0.00271)	(0.00349)
GOV_TRANSFER	-0.00264	-0.135***	-0.251***	-0.332***	0.200**	0.579***
	(0.0407)	(0.0313)	(0.0883)	(0.0852)	(0.0930)	(0.116)
Maharashtra	1,361***	1,734***	2,457***	1,805***	2,277***	2,966***
	(85.14)	(76.96)	(147.7)	(53.45)	(68.69)	(89.79)
Mpradesh	2,250***	3,028***	4,035***	2,763***	3,318***	3,746***
	(84.67)	(93.40)	(133.7)	(60.08)	(72.59)	(105.2)
Bihar	918.9***	380.0***	-200.4**	1,580***	1,252***	929.9***
	(55.23)	(66.88)	(90.03)	(46.29)	(61.53)	(80.45)
WBengal	650.6***	854.7***	1,567***	1,986***	2,047***	2,254***
	(96.94)	(95.97)	(149.6)	(62.01)	(72.54)	(103.8)
o.Karnataka	-	-	-	-	-	-
Constant	6,530***	7,884***	9,408***	5,017***	5,675***	6,451***
	(58.10)	(75.81)	(109.7)	(66.45)	(76.42)	(94.28)
Observations	14,258	14,258	14,258	27,792	27,792	27,792

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

We observe heterogeneity in consumption across states as shown both in quantile regression in Table 4.8 or state dummy regression in Table 4.7.

We apply Bayesian estimation to find the distribution of parameters of consumption in the next sections to reconcile alarming degree of heterogeneity in the MPC coefficients across states or quantile groups.

5. Bayesian Estimation of the parameters of the consumption function

Due to parameter uncertainty, the Bayesian model is becoming increasingly popular in recent years (see Lancaster(1979, 2004)). Bayesian regard true parameter to be a random variable, priors are updated frequently upon arrival of the new data. Thus in Bayesian analysis the value of true parameter θ, such as the MPC of the consumption function, is unknown like in the classical approach but it is not fixed. Instead θ has a probability distribution and it is updated continuously based on sample information and priors. The prior density is given by f(θ) and this may represent all available information up to that point.

$$f(\theta_1) = \int_{-\infty}^{\infty} f(\theta)(d\theta_2 d\theta_3 \dots d\theta_n)$$

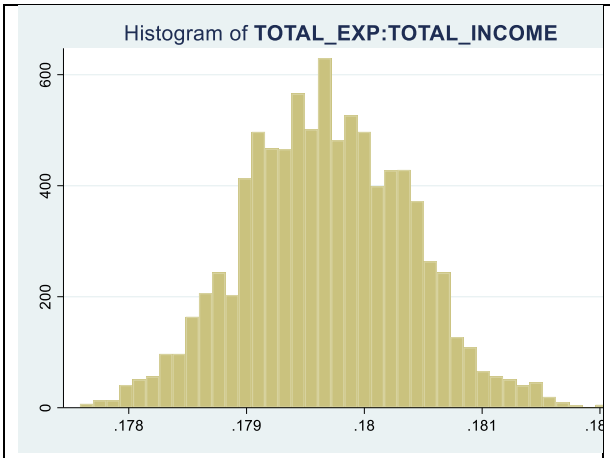
The sample density of variable y is treated as conditional on the random variable θ given by f(y/θ). The joint density of y and θ is result of the product of prior density and the sample likelihood function.

$$p(\theta/y) = p(y/\theta)p(\theta)$$

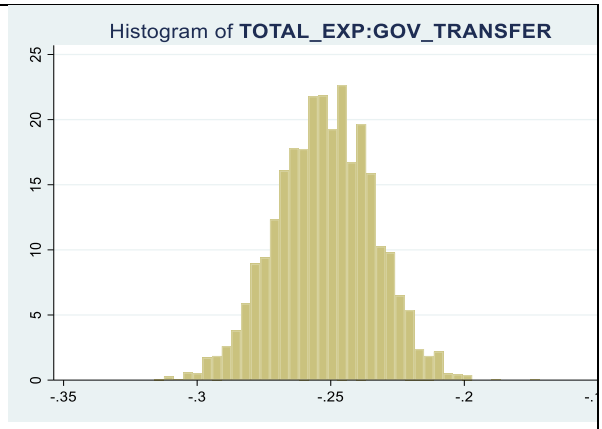
True parameters of a model are unknown both in the classical and Bayesian models but there is one major difference. True parameters have a given density function in the classical models but such density keeps changing when new information arrives in the Bayesian model. The Bayesian estimation of the consumption function

$$C_h = C_{0.h} + b.(Y_h - T_h) + d.TR_h + e_h$$

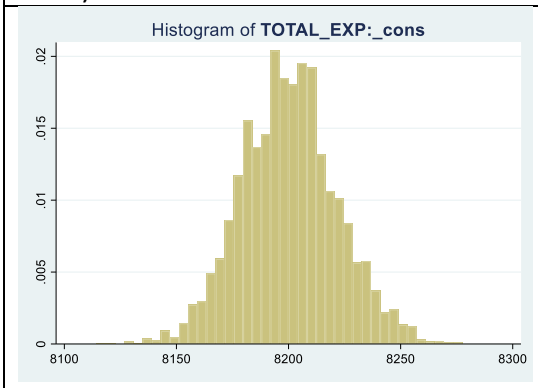
The Bayesian estimation generates the distribution of the consumption function parameters as presented in Figures 4.3



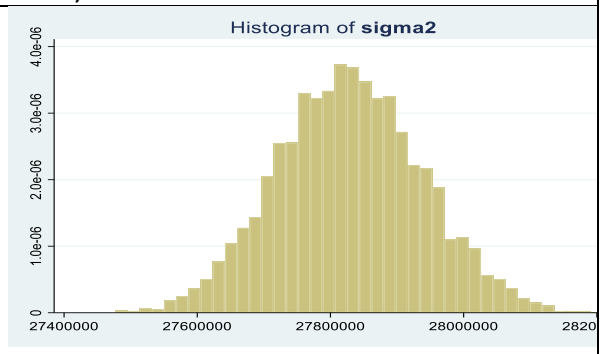
a) MPC



b) MPG



c) Autonomous consumption



d) Variance of consumption

Figure 5.1: Bayesian estimation of consumption function of India

We have studied Bayesian distributions for model parameters in all other scenarios but only Figure 5.1 could be reported here for space reasons. Any way the major point we want to make here is that while thinking about the relations between income and public transfers in consumption, it is important to consider that MPCs estimated from the macro or micro data could be subject to changes in the distributions upon arrival of new data. While the mean and variance of these MPC parameters may be better understood using their Bayesian distributions, the classical estimates can still be a good starting point for any empirical analysis of consumption function as discussed above.

6. Conclusions

Consumption is essential for living for every individual. Better consumption is the most important economic goal of every individual from rich or poor households whether they are located in urban or rural areas. There is a huge body of theoretical and empirical literature in

the micro and macroeconomics discussing important factors that determine level, growth, distribution of consumption in cross sections or over the years. COVID-19 global pandemic had seriously dampened consumption of individuals in every part of the world. Focus of this paper is to find how MPC differed in Covid-19 pandemic compared to normal years before or after the Covid-19 pandemic. Cross sections of consumption functions for rich and poor households located in rural and urban areas in India and its twenty-eight states were estimated for every year from 2017 to 2021. Households allocated most of public transfers for pre-cautionary savings and MPCs were lower at the peak of the pandemic across all cross sections.

This study finds that the marginal propensity to consume to be close to 50 percent in India based on time series data consumption and GDP for 1990-2020. At micro household level data still shows positive and significant impact of income in consumption but the MPC is a lot lower than at the macro level. Generally government transfers have positive effects on consumption but it had negative and significant effect during the pandemic, as consumers raised their precautionary savings during that period. Urban areas have higher consumption levels than those in rural areas. There are big differences in MPCs and autonomous consumption across states. Policies aiming to enhance the consumer welfare should assess these differences.

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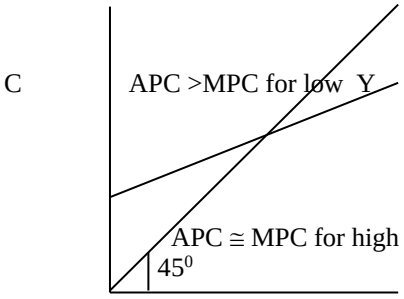
Appendix 1

Figure A1 Theories of consumption

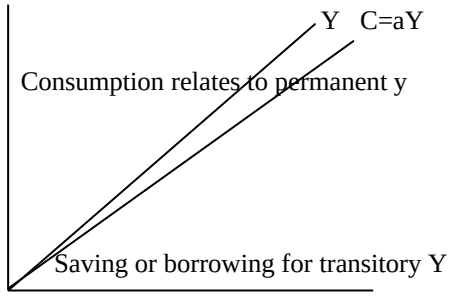
Keynesian absolute income hypothesis (short run)



APC declines with income

(a)

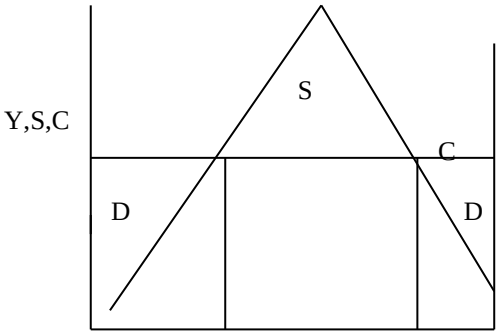
Kuznets long rung estimates of APC



APC is constant in the long run

(b)

Modigliani-Addo-Brumberg life cycle hypothesis

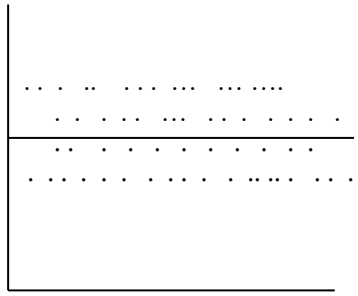


Smooth consumption and erratic income over life

(c)

Random walk hypothesis

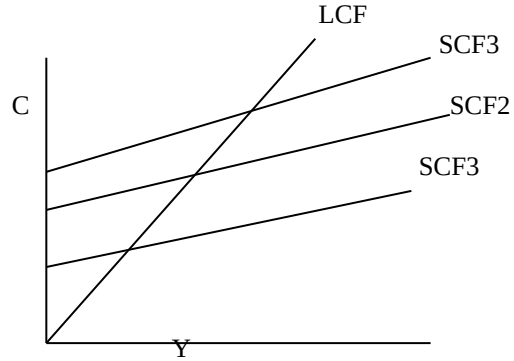
C is a stochastic process with unit root.



Change in consumption occurs only because of unanticipated change in income.

(d)

Reconciliation of Keynesian theory and Keynesian finding: Permanent income hypothesis



SCF1-SCF3 are short run consumption functions, and LCF is the long run consumption function. APC varies with income in the short run but it is constant in the long run.

How can short run APC vary but long run APC be constant?

Permanent income hypothesis: Simple model

Consumption is function of permanent income

$$C = kY_t^P$$

Income has permanent and transitory components

$$Y_t = Y_t^P + Y_t^t$$

Permanent income function can be estimated as:

$$Y_t^P = Y_{t-1} + \varphi\left(Y_t - Y_{t-1}^P\right)$$

Consumption depends only on permanent income, therefore APC is low for years with positive transitory income $\frac{C_t}{Y_t} = \frac{C_t}{Y_t^P + Y_t^t}$ and it is high with negative transitory income.

Appendix 2: Intertemporal and life cycle models of consumptions and numerical examples.

1. A Simple Inter temporal model

$$Max \quad U(C_1, C_2) = \ln C_1 + \beta \ln C_2 \qquad (1)$$

Subject to $C_1 + b \le W_1$: budget in period 1

$C_2 \le b(1+r) + W_2$: budget in period 2 (2)

C_1, C_2 are consumption in period 1 and period 2 respectively and W_1, W_2 are endowments in period 1 and period to respectively. To form an inter temporal budget constraint first by solving the second period budget constraint for b and substituting it in the period 1 constraint.

$$C_1 + \frac{C_2}{1+r} = W_1 + \frac{W_2}{1+r} \qquad (3)$$

A Lagrangian function for this maximisation problem is

$$L = \ln C_1 + \beta \ln C_2 + \lambda \left[C_1 + \frac{C_2}{1+r} - W_1 - \frac{W_2}{1+r} \right] \quad (4)$$

Where λ is shadow value of income in terms of utility. Derivative of L with respect to C_1, C_2 and λ give three first order conditions of maximisation as following:

$$\frac{\partial L}{\partial C_1} = \frac{1}{C_1} - \lambda = 0 \qquad (5)$$

$$\frac{\partial L}{\partial C_2} = \frac{\beta}{C_2} - \frac{\lambda}{1+r} = 0 \qquad (6)$$

$$\frac{\partial L}{\partial \lambda} = C_1 + \frac{C_2}{1+r} - W_1 - \frac{W_2}{1+r} \qquad (7)$$

Solution of the model

Define $\Omega = W_1 + \frac{W_2}{1+r}$.

To find allocation between period 1 and period 2 solve (5) and (6) for C_2 and substitute it then in (7).

$$\frac{\partial L / \partial C_1}{\partial L / \partial C_2} = \frac{C_2}{\beta} \frac{1}{C_1} = 1 + r \; ; C_2 = (1+r)\beta C_1 \quad (8)$$

If the consumer has same preference for today and tomorrow (β =1) and if the rate of interest is equal to zero $C_1 = C_2$. Consumption smoothing over period implies

$C_1 + C_2 = \Omega$ or $C_1 = \frac{1}{2}\Omega$ and $C_2 = \frac{1}{2}\Omega$ (9)

If $\beta < 1$ and the interest rate is greater than zero $r > 0$ then

Given intertemporal budget $C_1 + \frac{C_2}{1+r} = W_1 + \frac{W_2}{1+r} = \Omega$ Using result in (8)

$$C_1 + \frac{(1+r)\beta C_1}{1+r} = W_1 + \frac{W_2}{1+r} = \Omega \Rightarrow C_1 = \frac{1}{1+\beta}\Omega \qquad (10)$$

$$C_2 = (1+r)\beta C_1 \Rightarrow C_2 = (1+r)\beta\frac{1}{1+\beta}\Omega \Rightarrow C_2 = (1+r)\frac{\beta}{1+\beta}\Omega \qquad (11)$$

Results:

(1) Lower the subjective discount rate higher will be consumption today.
(2) Higher the interest rate higher will be consumption tomorrow.
(3) Consumption will be higher for higher the level of wealth, Ω.

(a) If the real interest rate is 5%, what is its wealth (i) in terms of today's consumption? (ii) in terms of tomorrow's consumption? Compute the household's permanent income.

$Y_t = 1000$; $Y_{t+1} = 1500$

Wealth in terms of today: $W_1 = Y_1 + \frac{Y_2}{1+r} = 1000 + \frac{1500}{1+0.05} = 2428.57$

Wealth in terms of tomorrow $W_2 = Y_1(1+r) + 1500 = 1000(1.05) + 1500 = 2550$

Permanent income: $W_1 = 2428.57 = Y_P + \frac{Y_P}{1+r} = Y_P\left(1 + \frac{1}{1.05}\right) = \frac{2.05}{1.05}Y_P$ $Y_P = \frac{1.05}{2.05}W_1 = \frac{1.05}{2.05}(2428.57) = 1243.9$

(b) If today's income unexpectedly increases by 200, what is the change in the permanent income?

$\Delta Y_P + \frac{\Delta Y_P}{1+r} = 200$; $\Delta Y_P = \frac{1.05}{2.05}(200) = 102.4$

$Y_P = \frac{1.05}{2.05}(W_1 + \Delta W_1) = \frac{1.05}{2.05}(2428.57 + 200)$

$= 1243.9 + 102.4 = 1346.3$

(b) If income goes up by 200 permanently, what is the effect on permanent income?

$Y_P + \Delta Y_P = 1243.9 + 200 = 1443.9$

c. If the interest rate is 10%

Wealth in terms of today: $W_1 = Y_1 + \frac{Y_2}{1+r} = 1000 + \frac{1500}{1+0.1} = 2363.64$

Wealth in terms of tomorrow $W_2 = Y_1(1+r) + 1500 = 1000(1.1) + 1500 = 2600$

Permanent income: $W_1 = 2363.64 = Y_P + \frac{Y_P}{1+r} = Y_P\left(1 + \frac{1}{1.1}\right) = \frac{2.1}{1.1}Y_P$

$Y_P = \frac{1.1}{2.1}W_1 = \frac{1.1}{2.1}(2363.64) = 1238.09$;

If income increased unexpected by 200; it will increase permanent income by $\Delta Y_P = \frac{1.1}{2.1}(200) = 104.2 \qquad Y_P = 1238.09 + 104.2 = 1342.29$

If income increases permanently by 200, then $Y_P = 1238.09 + 200 = 1438.09$

Appendix 3: Derivation of General Equilibrium Model of Consumption

We follow Bhattarai (2006) model to derive the general equilibrium consistent consumption in this section. The **household** maximisation problem can be stated as the following:

$$Max \quad U = c^{\phi} l^{1-\phi}$$

Subject to:

i. $l + h^s = 1$ time constraint

ii. $pc = wh^s + \pi$ budget constraint

iii. $c \geq 0; l \geq 0; h^s \geq 0$ non-negativity constraint

where *c* is consumption, l is leisure and h^s is labour supply, *p* is the price of the commodity, *w* is the wage rate π .is the profit from owning the firm.

Maximisation problem for the representative **firm** can be states as

$$Max \quad \pi = py - wh^d$$

subject to:

i. $y \le \left(h^d\right)^{\alpha}$ technology constraint

ii. $y \ge 0; h^d \ge 0$ non-negativity constraint

where y is the output supplied by the firm and h^d is its demand for labour.

A competitive equilibrium in this economy is given by the real wage rate and price of commodity in which demand for goods are equal to supply of goods, demand for labour equals supply of labour. Given the prices and wage rate the representative household maximises utility subject to its budget constraint and the representative firm maximises its profit subject to technology constraint. Solution of this model involves four stages: (1) derivation of households demand for goods and leisure as well as the supply of labour (2) derivation of firm's demand for labour (3) Finding the real wage that equates demand for and supply of labour in the market (4) finding the price level that equates supply of goods by the representative firm and the demand for goods by the households that maximises its utility.

No we form a Lagrangian maximisation problem for this household. To make problem simpler, from time constraint define $l = 1 - h^s$ and substitute it into the utility function $U = c^{\phi}\left(1 - h^s\right)^{1-\phi}$.

Desired Lagrangian is:

$$L(c, l, \lambda) = c^{\phi}\left(1 - h^s\right)^{1-\phi} + \lambda\left[wh^s + \pi - pc\right] \qquad (2.1)$$

It has three choice variables (c, l, λ), λ is shadow price of income; necessary first order conditions for utility maximisation are:

1. $\frac{\partial L(c, l, \lambda)}{\partial c} = \phi c^{\phi-1}\left(1 - h^s\right)^{1-\phi} - \lambda p = 0$ => the first term if marginal utility from consumption.

2. $\frac{\partial L(c,l,\lambda)}{\partial h^s} = (1-\phi)c^{\phi}\left(1-h^s\right)^{-\phi}(-1)+\lambda w = 0$

3. $\frac{\partial L(c,l,\lambda)}{\partial \lambda} = wh^s + \pi - pc = 0$

Now derive its demand for consumption goods. Demand for consumption goods can be derived by dividing FOC (2) by FOC (1) and solving for c

$$\frac{\frac{\partial L(c,l,\lambda)}{\partial h^s}}{\frac{\partial L(c,l,\lambda)}{\partial c}} = \frac{(1-\phi)c^{\phi}\left(1-h^s\right)^{-\phi}(-1)}{\phi c^{\phi-1}\left(1-h^s\right)^{1-\phi}} = \frac{w}{p} \quad (2.2)$$

marginal rate of substitution between leisure and consumption should be equal to the real wage rate to optimise.

or, $c = \left(\frac{\phi}{1-\phi}\right)\left(1-h^s\right)\frac{w}{p}$: Thus, consumption depends on real wage rate and the work efforts.

Now using this solution in the budget constraint $wh^s + \pi = pc$

$$h^s\frac{w}{p} + \frac{\pi}{p} = c = \left(\frac{\phi}{1-\phi}\right)\left(1-h^s\right)\frac{w}{p} \quad (2.3)$$

Now derive its demand for leisure. Equation (2.3) can be solved for the households' labour supply

$$h^s\frac{w}{p} + \frac{\pi}{p} = \left(\frac{\phi}{1-\phi}\right)\left(1-h^s\right)\frac{w}{p} \Rightarrow h^s\left(1+\frac{\phi}{1-\phi}\right)\frac{w}{p} = \left(\frac{\phi}{1-\phi}\right)\frac{w}{p} - \frac{\pi}{p}$$

$$h^s\left(\frac{1}{1-\phi}\right)\frac{w}{p}=\left(\frac{\phi}{1-\phi}\right)\frac{w}{p}-\frac{\pi}{p}\frac{1-\phi}{1-\phi} \Rightarrow h^s\,\frac{w}{p}=\phi\frac{w}{p}-\frac{\pi}{p}(1-\phi)$$

Labour supply, leisure and consumption all are functions of the real wage rate

$$h^s=\frac{\phi\frac{w}{p}-\frac{\pi}{p}(1-\phi)}{\frac{w}{p}}\text{; leisure } l=1-h^s=1-\frac{\phi\frac{w}{p}-\frac{\pi}{p}(1-\phi)}{\frac{w}{p}} \qquad (2.4)$$

Consumption $c=\left(\frac{\phi}{1-\phi}\right)\left(1-h^s\right)\frac{w}{p} = c=\left(\frac{\phi}{1-\phi}\right)\left(1-\frac{\phi\frac{w}{p}-\frac{\pi}{p}(1-\phi)}{\frac{w}{p}}\right)\frac{w}{p}$ (2.5)

Now write the Lagrangian function for the firm's optimisation problem.

Substitute the technology function for y in the profit function

$$\pi=py-wh^d=p\left(h^d\right)^\alpha-wh^d$$

Firms want to maximise profit by choosing labour to employ. This implies

$$\frac{\partial\pi}{\partial h^d}=p\alpha\left(h^d\right)^\alpha-w=0 \Rightarrow h^d=\left(\frac{1}{\alpha}\frac{w}{p}\right)^{\frac{1}{\alpha-1}}$$

Now from the profit function

$$\frac{\pi}{p}=y-w\frac{h^d}{p}=\left(h^d\right)^\alpha-\frac{w}{p}h^d=\left(\frac{1}{\alpha}\frac{w}{p}\right)^{\frac{\alpha}{\alpha-1}}-\frac{w}{p}\left(\frac{1}{\alpha}\frac{w}{p}\right)^{\frac{1}{\alpha-1}}=\left(\frac{w}{p}\right)^{\frac{\alpha}{\alpha-1}}\left[\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}}-\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right] \quad (2.6)$$

real profit is also function of the real wage rate.

a. Derive firm's demand for labour

As derived above $h^d=\left(\frac{1}{\alpha}\frac{w}{p}\right)^{\frac{1}{\alpha-1}}$

b. Define a competitive equilibrium for this economy

A competitive equilibrium is defined by the real wage rate were the demand for labour by firms is equal to the supply of labour by households , supply of labour and demand for leisure is equal to total endowment of time and the production of output is equal to the demand for consumption by the household.

- Labour market clearing: $h^d = h^s$

$$h^d = \left(\frac{1}{\alpha}\frac{w}{p}\right)^{\frac{1}{\alpha-1}} = h^s = \frac{\phi\frac{w}{p} - \frac{\pi}{p}(1-\phi)}{\frac{w}{p}}$$

Substituting the expression for real profit

$$h^d = \left(\frac{1}{\alpha}\frac{w}{p}\right)^{\frac{1}{\alpha-1}} = h^s = \frac{\phi\frac{w}{p} - \left(\frac{w}{p}\right)^{\frac{\alpha}{\alpha-1}}\left[\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} - \left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right](1-\phi)}{\frac{w}{p}} \qquad (2.7)$$

Two sides of the labour market in (2.7) can be solved for equilibrium real wage rate as a function of parameters in the production and consumption functions.

$\frac{w}{p} = \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}}\right]^{\alpha-1}}$ This is the equilibrium wage rate that demand and supply in the labour market.

c. Compute the real wage that brings goods and labour market in equilibrium.

d. What is the equilibrium quantity of c or y?

Equilibrium output

$$\hat{y} = \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}} \right]^{\alpha-1}} \right)^{\frac{\alpha}{\alpha-1}}$$

e. What is the equilibrium quantity of *l* and h^d ?

$$\hat{h}^d = \hat{h}^s = \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}} \right]^{\alpha-1}} \right)^{\frac{1}{\alpha-1}}$$

leisure $\hat{l} = 1 - \hat{h}^s = 1 - \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}} \right]^{\alpha-1}} \right)^{\frac{1}{\alpha-1}}$

$$c = \left(\frac{\phi}{1-\phi} \right) \left(1 - \left(\frac{1}{\alpha} \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}} \right]^{\alpha-1}} \right)^{\frac{1}{\alpha-1}} \right) \frac{\phi^{\alpha-1}}{\left[(1-\phi)\left(\frac{1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} + \phi\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha-1}} \right]^{\alpha-1}}$$