Optimal Sales Taxation in India

- Final Paper

Course: MACS 30250 Instructor: Dr. Richard W. Evans

Abstract: India has very recently seen a major economic reform through implementation of GST, Goods and Services Tax across the whole nation. The tax reform through GST scheme removes multiple taxes like central taxes, state taxes, duties like excise duty, counter vailing duty, etc., and instead places a uniform tax, Goods and Services Tax (GST). Motivated by this economic reform, my research looks at the problem of optimal sales taxation in India. Using "large data" methods from current research work, the study aims to find if the current tax rates- 5%, 12%, 18% and 28%, employed under GST scheme are optimal or not. I create a type space of different possible tax policies and then calculate total societal utility and the amount of tax revenue generated for a given policy. Removing the dominated policies, I obtain optimal tax policies, that provides higher level of societal utility and generates larger tax revenue.

Submitted by- Nipun Thakurele

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1. Introduction

India has very recently seen a major economic reform through GST (Goods and Services Tax) policy under which multiple taxes like central taxes, state taxes, duties like excise duty, etc., were removed. Now, there is a uniform taxation policy in India in the form of Goods and Services Tax (GST). The comparative advantage from price differentials due to different taxes across states has vanished. There are six different tax rates under GST scheme: Nil, 3%, 5%, 12%, 18% and 28%. The homogenization of the tax rates across the nation makes the study of optimal taxation policy much more relevant in today's time.

This study aims at answering the research question "Are the tax rates under the current GST scheme optimal? If not, can I find the optimal tax rates based on the categorization of goods under the current scheme?" I accomplish this task by dividing the solution method into three parts. In the first part, I estimate the income distribution of the households using the generalized method of moments (GMM). Next, I solve the constrained regression problem to find the minimum consumption levels. Then I find the societal utility and the amount of tax revenue generated for a given tax policy by solving the household and policy maker's problem. At last, I construct a type space, and iterate over each taxation policy in the type space. For each policy, I calculate the level of societal utility and the total taxes generated. Removing the dominated tax policies, I find the optimal taxation policy from the frontier obtained through the iteration step.

The taxation problem has been widely studied in the economics literature. Ramsey (1927), Diamond and Mirrlees (1971 a, b) and Deaton (1977) all looked at the variations of the taxation problem in an economy. Ramsey (1927) considered the problem of a policy maker with a constraint on the total amount of tax revenue generated. Diamond and Mirrlees (1971 a, b) and Deaton (1977) also considered the taxation problem involving multiple goods and a policy maker with a constraint on the total amount of tax revenue. However, they extended the work of Ramsey by considering multiple consumers with identical preferences but different wage levels. Some current examples are the studies on optimal commodity taxation by Kaplow (2010), Saez (2002) that focus on elasticities of demand of commodities. Einav et al. (2014) and, Ellison and Ellison (2009) have studied taxation where the commodities are purchased on the Internet.

This study builds up on the current research work of Backer et al. (2014), which looks at the optimal taxation problem in a non-convex setup and develops a large data solution method to find the optimal taxation policy. Backer et al. (2014) broaden the scope of the taxation problem by considering heterogenous agents and incorporating uncertainty. They also use minimum consumption levels for different categories in their model like Balcer et al. (1983). The solution method developed in Backer et al. (2014) follows a large data approach making the problem tractable even when it involves high-dimensional heterogeneity.

I find that the tax rates under current GST scheme are inefficient. They aren't generating enough of either societal utility or tax revenue. I find the optimal tax rates that maximize the tax revenues and also the level of societal utility. In general, both of the optimal tax policies charge taxes above the rate of 50% for all the consumption categories. Hence, there does exists an optimal taxation policy and implementation of which would result in higher societal utility for Indian households along with an increase in the amount of tax revenue.

The remaining sections in the paper are as follows: Data section contains information on the data collection process and the variables of interest. Model section provides the theory underlying our research question. Next, I explain the solution methods employed in our study under Computational Methods section. Results section looks at the estimates and the solutions required to answer our research question. At the end, there are Conclusion and Bibliography sections.

2. Data

The data used in this study is IHDS (India Human Development Society) Survey II. The IHDS is a nationally-representative survey of 41,554 households collected from 1503 villages and 971 urban neighbourhoods across India. The survey is jointly organized by the National Council of Applied Economic Research (NACER) (India) and the University of Maryland (United States). The data is very much accessible from their website (https://ihds.umd.edu). "IHDS-II public data files are available from the Data Sharing for Demographic Research program of ICPSR, the Inter-university Consortium for Political and Social Research, at ICPSR Study 36151 (IHDS-II)."[1]

An important feature of IHDS Survey II is that it develops upon the previous survey, IHDS I. As there are households which are common to both the surveys, the study of economic changes in India becomes feasible. The researchers interview each household from the sample, covering range of topics like health, employment, education, marriage, economic status, etc. Within IHDS II data, there are multiple files catering to different topics at different levels: Household, Individual, Medical facilities, Wages, etc. This study uses the files and data available under the "Household" category.

Sample:

IHDS II sample had 42,152 households in total, out of which around 83% of the households were a part of IHDS I survey. In terms of geographic reach, IHDS II sample was spread across 33 states and union territories, hundreds of districts and thousands of villages and urban blocks from multiple towns and cities. The sample weights are provided with the data.

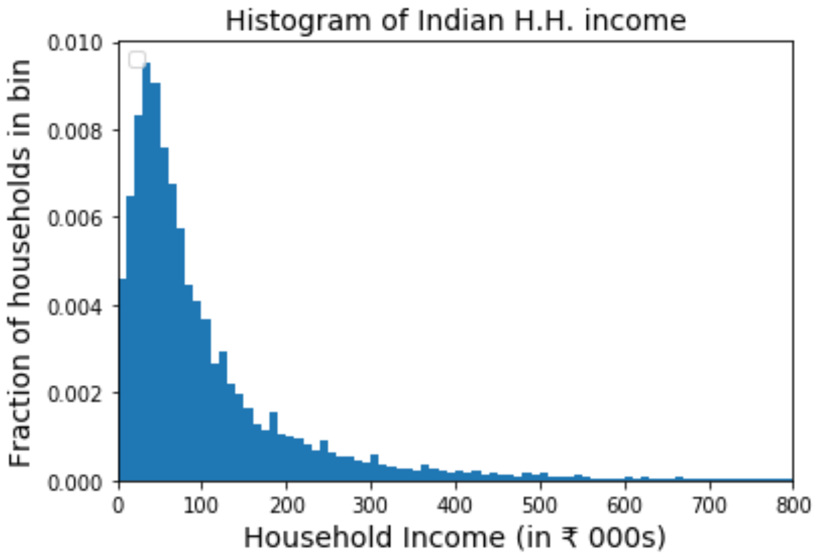
Variables of Interest:

Income: The survey had questions designed to measure household income, categorised into 8 different types: farm income, wage and salary income, etc. Crop failures and high cost of agricultural expenditures result in negative income for around 11% of the households. The data on households corresponding to negative income have been removed from this study.

[1] https://ihds.umd.edu/IHDS-II

Descriptive Summary: The average annual income is Rs. 129469, with the minimum income of Rs. 0, and maximum income of Rs. 11360000.

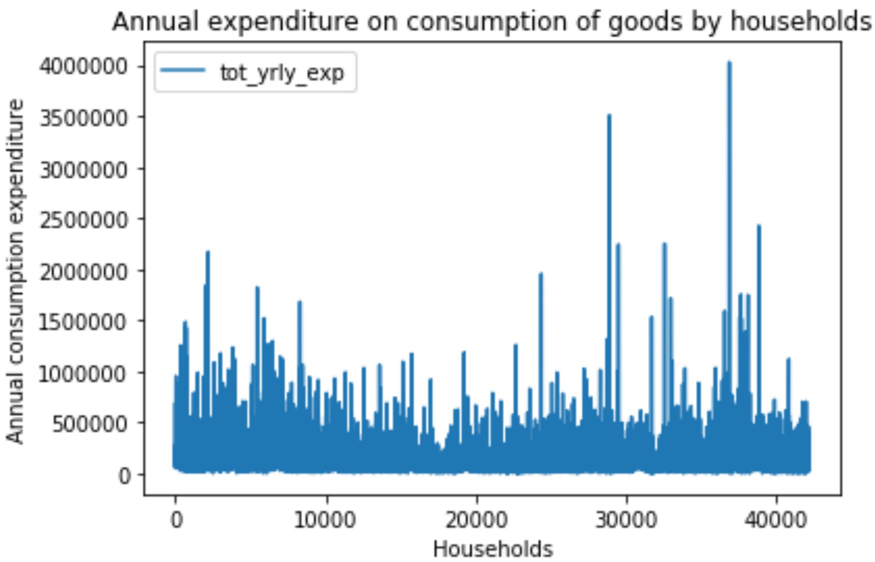
count	41700.000
mean	129469.631
std	217085.488
min	0.000
25%	40000.000
50%	74600.000
75%	145200.000
max	11360000.000



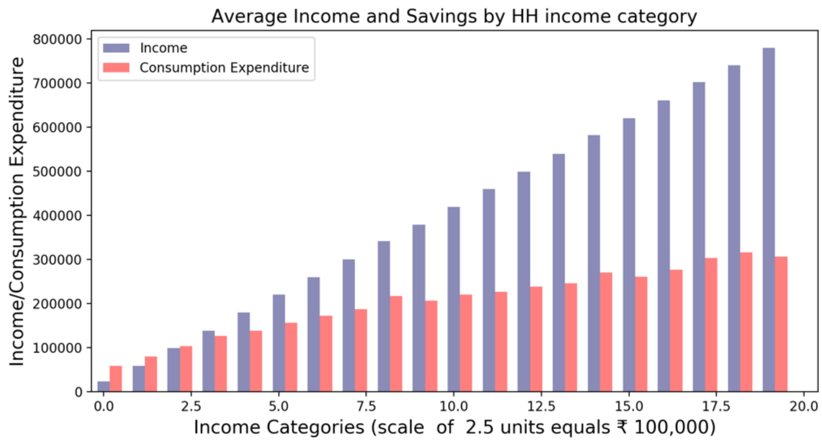
Consumption/Expenditure: The survey had questions about household consumption that were designed to estimate consumption expenditures of a household. It is an important variable as total expenditure is a good measure of household's current economic level. The survey had questions about both, frequently purchased goods like rice, pulses, etc, and also, goods like transport equipment, furniture, etc. which are purchased annually.

Descriptive Summary: The average monthly consumption expenditure is Rs. 9178, with minimum expenditure of Rs. 0 and maximum expenditure of Rs. 340063.

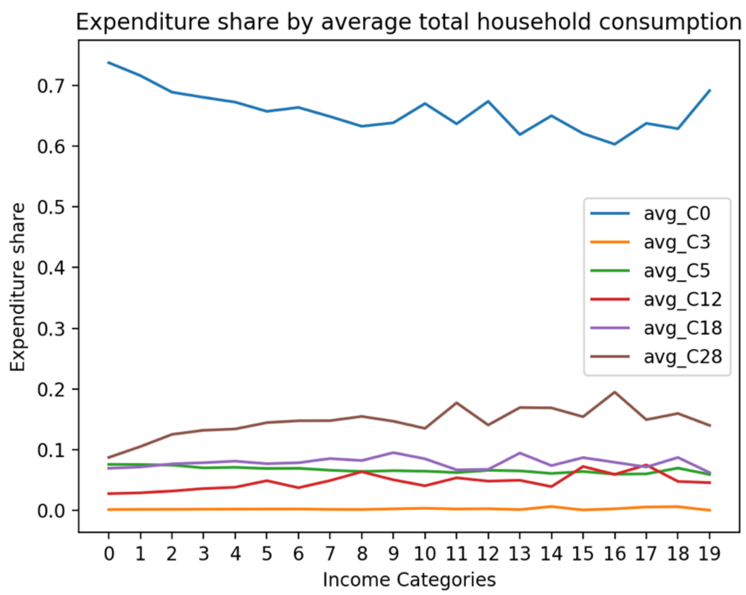
count	41700.000
mean	9178.887
std	9606.792
min	0.000
25%	4363.542
50%	6766.083
75%	10844.125
max	340063.333



The following chart shows the average level of income and consumption expenditures for different income categories. As expected, the households with lower level of income do not have negative savings (the difference between the bar for income and consumption expenditures). With an increase in the level of income, savings grow.



The consumption categories are mapped to the different tax rates under GST scheme. Hence, we have split total consumption expenditure of any household into six categories: ‘C0’, ‘C3’, ‘C5’, ‘C12’, ‘C18’, and ‘C28’. Note: ‘Cx’ represents consumption category that is charged x% tax rate. The following graph shows the expenditure shares for all the categories of goods varied with the income levels. Most of the consumption categories except ‘C0’ follow the expected trend: the percentage of share would increase with an increase in the level of income.



The table below lists some types of goods that fall under different tax rates categories.

Consumption category	**Types of goods**	**Consumption category**	**Types of goods**
C0	Rice, Wheat, Sugar, Kerosene, Pulses, etc.	**C12**	Telephone, Crockery, Household items, etc.
C3	Jewellery items, Gold, Silver, etc.	**C18**	Personal care, Soap, Furniture/Fixtures, etc.
C5	Paan, Tobacco, Coffee, etc.	**C28**	Transport equipment, Diesel, Petrol, CNG, etc.

3. Model

To solve for the optimal taxation policy, I solve for the household problem and the policy maker's problem. Households are considered heterogenous with respect to their annual wages. Backer et al. (2014) considered the consumers/households heterogeneous with respect to wages as well as η, the elasticity of substitution among different consumption goods. However, I took η to be equal to 4.1 and now the households are heterogenous in terms of their wages only. The model doesn't involve any production or labour decisions.

Given a tax policy (tax rates on different categories of consumption goods), households maximize their utility maintaining a minimum consumption level. On the other hand, the policy maker solves for the optimal tax schedule that maximizes societal welfare, subject to a given level of total revenue. The given level of tax revenue is not calculated within our model and is considered an exogenous variable in our model. Also, there is a natural 1-1 mapping between consumption categories of goods and tax rates in a given tax policy. All the goods that fall under a given tax slab/rate are clubbed together to form one category.

Prior to implementation of the Goods and Services tax (GST) scheme in India, there were multiple tax categories: central taxes, state taxes, duties like excise duty, counter vailing duty, etc. In the form of GST scheme, India implemented "one nation, one tax" policy across the whole country. For any nation, the question of finding optimal tax policy is always relevant but for India it is all the more opportune, with the homogenization of tax rates across different states as a result of GST. Next, I will provide details on the household and policy maker's problem.

Household problem:

Consider an economy in which households are characterized by type θ = (η, w). The six different goods consumption categories are obtained by mapping goods to their tax rates under GST scheme (there are currently six different tax rates under it). The total household consumption is defined as:

$$C \equiv \left(\sum_{i=1}^{6} \alpha_i (c_i - \bar{c}_i)^{\frac{\eta}{\eta-1}} \right)^{\frac{\eta}{\eta-1}} \quad \forall \eta \geq 1 \tag{1}$$

where η is the elasticity of substitution among different consumption goods, $\alpha_i \in [0, 1]$ is the weight on the consumption of good of type i, with $\sum_i \alpha_i = 1$, and $\bar{c}_i \geq 0$ is a minimum level of consumption for good of type i. The constant relative risk aversion (CRRA) utility function is defined as:

$$u(C) = \frac{C^{1-\gamma} - 1}{1-\gamma} \quad \forall\gamma \geq 1 \tag{2}$$

In the above function, $\gamma \geq 1$ is the CRRA (coefficient of relative risk aversion) and C is the aggregated consumption of a household calculated through equation (1). Households are characterized by their types θ = (η, w), hence, the heterogeneity among them arises either due to different elasticity of substitution among goods or different incomes or nominal wages. Hence, the type space in general is $\Theta = [1, \infty) \times (0, \infty)$, with $\eta \geq 1$ and $w \in (0, \infty)$. The household incomes are estimated using gamma distribution:

$$f(y; a, b) = \frac{1}{b^a \Gamma(a)} y^{a-1} e^{-\left(\frac{y}{b}\right)} \quad y \, \epsilon \, [0, \infty), and\ a, b > 0 \tag{3}$$

I assume the joint density over different types of households as $f(\eta, w) = f(\eta) f(w)$, where $\eta \sim U[\eta_{min}, \eta_{max}]$ where U denotes the Uniform distribution and $w \sim G(a, b)$ where G denotes the Gamma distribution. Upon normalizing the marginal cost of each good to 1 and assuming the perfectly competitive equilibrium, the prices of each good are determined by:

$$\mathrm{p}_i = (1 + \tau_i) \tag{4}$$

Now, for a household with a nominal wage of w, the problem is to maximize utility (2) subject to the following budget constraint:

$$(1 + \tau_i) \leq \mathrm{w} \tag{5}$$

Hence, the household's optimization problem is:

$$\max_{\boldsymbol{c}} u(\boldsymbol{c};\ \eta, w, \boldsymbol{\tau})\ s.t. w \geq \textstyle\sum_{i=1}^{6} (1 + \tau_i) c_i\ and\ c_i \geq \overline{c_i}\ \forall\ i \tag{6}$$

In the above equation, $\boldsymbol{c}\ and\ \boldsymbol{\tau}$ are the vectors where $\boldsymbol{c}$ represents the consumption bundle $(c_1, c_2, \dots, c_6)$ while $\boldsymbol{\tau}$ represents the tax policy $(\tau_1, \tau_2, \dots, \tau_6)$.

The solution to household problem provides us with a consumption basket $(c_i)_{i=1}^{6}$that maximizes the total utility subject to the given budget constraint. Thus, I can obtain household consumption functions $c_i(\eta, w, \tau)$ for different levels of elasticity of substitution among goods, nominal wages, and tax-policies. Note: there exists tax schedules such that $(1 + \tau_i) \leq \mathrm{w}$

requirement is not met or minimum consumption levels are around zero, to deal with such scenarios, I used the same functional variations of equations (1) and (2) as employed by Backer et al. (2014).

Policy maker's problem:

Given a minimum level of total tax revenues, the policy maker solves for the optimal tax policy (tax-schedule for the different categories of consumption goods), such that total societal utility is maximized. The policy maker solves the following problem:

$$\max_{\boldsymbol{c}} \int_{\eta} \int_{w} f(\eta) f(w) u(\boldsymbol{c}(\eta, w, \boldsymbol{\tau}))\, d\eta dw \;\; s.t. \int_{\eta} \int_{w} f(\eta) f(w) \sum_{i=1}^{6} \tau_i c_i(\eta, w, \boldsymbol{\tau})\, d\eta dw \;\geq\; \bar{R}$$

where $\boldsymbol{\tau}$ refers to the tax schedule for the six different goods categories (I mapped goods categories to the six tax slabs under GST scheme). $\bar{R}$ is the exogenous variable which captures the minimum amount of total tax revenues to be generated.

The above maximization problem is non-convex as the individual household demand functions cannot be aggregated. Upon solving the above optimization problem, I will obtain a tax policy τ as a functional distribution of household types characterized by $f(\eta, w)$. Note: In our analysis, there is no heterogeneity among households on the basis of η.

4. Computational methods

I employed the following computational methods: GMM (Generalized Method of Moments), 'nnls' (non-negative least squares) solver and 'slsqp' (sequential least squares programming). GMM, 'nnls' solver and 'slsqp' method were used to estimate the income distribution of households, solve the constrained regression (to find the minimum consumption levels and expenditure shares for each categories), and to obtain the optimal consumption bundle in household problem (for a given tax policy), respectively.

GMM (Generalized Method of Moments)

Generalized method of moments (GMM) is a general estimation principle wherein I derive the estimates using the moment conditions. It was first formalized by Hansen (1982), and one of its key strengths is the ability to find robust estimates using minimal assumptions, and with partial specification of the model. For identification, one needs the same number of moment conditions as the number of parameters to be estimated. Briefly, moment can be defined as a data summarizing statistic, for example, mean and standard deviation are the two commonly used moments.

GMM estimates the parameters such that the model moments are almost identical to the corresponding data moments. GMM was used to estimate the distribution of Indian households using two moments, mean and standard deviation. The parameter vector $\widehat{\theta_{GMM}}$, is estimated by choosing θ such that the distance between the data moments, $m(x)$, and the model moments, $m(x|\theta)$, is minimized:

$$\widehat{\theta_{GMM}} = \theta: min_{\theta}||m(x) - m(x|\theta)|| \qquad (7)$$

The moment error function, $e(x|\theta)$ is taken as the (vectorized) difference between the model moments and the moments obtained from the data. Finally, the GMM estimator is:

$$\widehat{\theta_{GMM}} = \theta: min_{\theta} e(x|\theta)^T W e(x|\theta) \qquad (8)$$

where W is a R X R weighing matrix in the above criterion function.

NNLS (non-negative least squares)

Non-negative least squares is a type of constrained least squares optimization problem wherein the coefficients are non-negative. Mathematically, non-negative least squares problem takes the following form:

$$argmin_x \left|\left|Ax - y\right|\right|^2 \ subject\ to\ x \ \geq 0 \qquad (9)$$

Any non-negative constrained regression problem can be formulated in terms of a non-negative least squares problem. I used nnls solver (scipy.optimize package) in Python to solve for the minimum consumption levels and expenditure shares for a given type of consumption good and a given level of income.

$$c_{i,j} = \bar{c}_i + \alpha_i AVGTOTEXP_j + \varepsilon_{i,j} \ \forall\ i,j \qquad (10)$$

where $c_{i,j}$ corresponds to the average consumption level of good type i by the average household in the jth income category, α_i is the share of expenditure on good type i, and $AVGTOTEXP_j$ is the average total consumption expenditure by households in the jth income category. $\varepsilon_{i,j}$ is an i.i.d (independent and identically distributed) random variable with mean zero. The constraints were that both $\bar{c}_i$ and α_i should be non-negative for each type of good i.

SLSQP (Sequential Least Squares Programming)

Sequential least squares programming is a type of sequential quadratic programming methods. These are iterative methods to solve constrained nonlinear optimization problems. These methods require both the criterion (objective function in the minimization/maximization problem) and the constraints to be twice continuously differentiable. Mathematically, non-linear optimization problems are of the form:

$$min_x\ f\ (x)\ s.t.\ b(x) \geq 0\ and\ c(x) = 0 \qquad (11)$$

I employed the SLSQP solver from scipy package available in python ('SLSQP' is a method under optimize.minimize) to find the optimal consumption levels for each household (characterized by the level of $w\ and\ \eta$) under a given tax policy. The constraints in our optimization problem were the budget constraint and the non-negative consumption level:

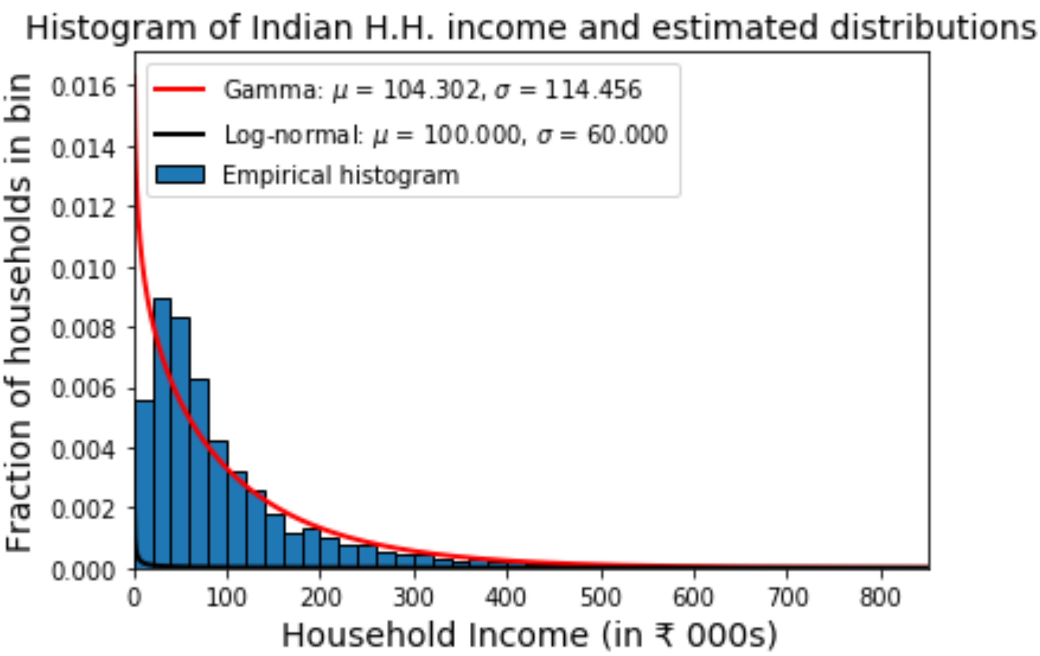
$$w \ \geq \sum_{i=1}^{6} (1 + \tau_i) c_i \ and\ c_i \ \geq \bar{c}_i \ \forall\ i \qquad (12)$$

5. Results

To build up our model to answer the research question, I divided our solution method into three parts: estimating households income distribution, obtaining the minimum consumption levels and expenditure shares for each categories, and then finding the total societal utility and the amount of tax revenue generated for a given tax policy. Each of the three solution steps and their results are discussed below.

Estimating income distribution of households:

I employed GMM method of estimation and found gamma distribution to yield a better fit, given the real data of household incomes. The next best estimate was obtained using log-normal distribution. The mean level of household income was ₹ 104,000 for the beta distribution while it was ₹ 100,000 for the log-normal distribution. The standard deviation in the case of beta distribution was ₹ 114,000 while it was ₹ 60,000 for the log-normal distribution. Due to higher standard deviation, the beta distribution estimates the level of household incomes better than the log-normal distribution.



Minimum consumption levels for different consumption categories:

Using the 'nnls' solver, I obtained the minimum consumption levels for each type of consumption good. Consumption categories were grouped into six categories based on the percentage of tax charged. Under GST scheme, there are six different tax rates: Nil, 3%, 5%, 12%, 18% and 28%. I also found out the values of α_i, the share of expenditure on good type i. The results are tabulated below:

Consumption Category (i)	**Tax rates (corresponding to category i)**	$\bar{c}_i$	α_i
C0	Nil	7024	0.6154
C3	3%	0	0.0048
C5	5%	1550	0.0578
C12	12%	0	0.0663
C18	18%	385	0.0772
C28	28%	0	0.1785

The minimum consumption level is highest for the consumption category which doesn't get taxed. It also has the highest share of expenditure among all the consumption categories. The minimum consumption level and the share of expenditure is the lowest for the luxury good which are charged 3% tax rate. One of the important observations is seen for the consumption category C28 (attracting a tax rate of 28%). Though the minimum consumption level of this category is zero, their share of expenditure is the second highest, next to the C0 category (nil tax rate). One possible explanation of this result is that goods like transport equipment, CNG, diesel and petrol fall under C28 category, which are not essential goods for the lower income households. Note: the values of α_i for all the consumption categories sum to 1.

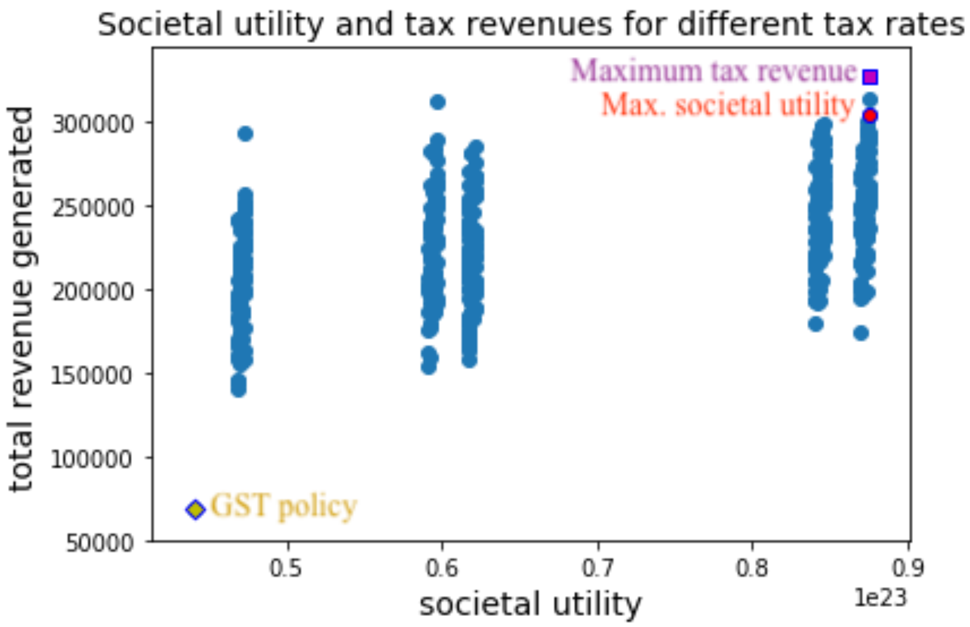
Optimal taxation policy:

Now I get to the essential part of this paper, that is, our research question "Are the tax rates under the current GST scheme optimal? If not, can I find the optimal tax rates based on the categorization of goods under the current scheme?". To answer our question, I did the groundwork in the form of estimating the income distribution of households and finding the minimum consumption levels and the share of expenditures for each type of consumption category. Now, to find the optimal tax policy I use the following algorithm:

Algorithm to find the optimal tax policy:

- Generate the type space the type space $\Theta = \{\eta\} \times (0, \infty)$, where $\eta = 4.1$ and $w \in (0, \infty)$. I will consider all the wages reported in the dataset that are above ₹ 100.
- Generate sample space for tax policies: $\boldsymbol{\tau}$ $(\tau_1, \tau_2, \ldots, \tau_6)$. In addition to the GST tax policy, I randomly generated tax policies in the space $[0, 1]^6$.
- Next, for each tax policy and each type of household (characterized only by wages as $\eta = 4.1$ is same for everyone), I computed the optimal consumption bundle by solving the household problem.
- From the given tax policy and the optimal consumption of the households, I found the total level of societal utility and the total amount of revenue generated by aggregating over all the households.
- At last, I drop the tax policies which are dominated, that is, the policies which achieve lower levels of societal utility as well as amount of tax revenue collected.
- From the remaining tax policies, I identify the ones which are efficient (achieveing higher level of societal utlity and a minimum amount of tax revenue).

I calculated the following levels of societal utility and tax revenues for around 700 different tax policies.



As seen in the above plot, current GST tax policy (0, 0.03, 0.05, 0.12, 0.18, 0.28) is inefficient as it generates the lowest amount of tax revenues and also the societal utility. I obtain two different tax policies, one which generates highest amount of tax revenues (0.67, 0.74, 0.85, 0.81, 0.74, 0.81) and the other which generates the highest level of societal utility (0.67, 0.30, 0.85, 0.81, 0.92, 0.68). Hence, India can improve on both the fronts, amount of tax revenue generated and the level of societal utility by revising its taxation policy.

6. Conclusion

I answered the research question about finding the optimal taxation policy in India, and if the current GST policy is efficient? I used the income and consumption expenditure data at the level of households provided by IHDS (India Human Development Society). The data is from a nationally-representative survey of 41,554 households collected from 1503 villages and 971 urban neighbourhoods across India. The research study, after data collection, can be broken down into three parts: estimation of households income distribution, obtaining the minimum consumption levels and expenditure shares for each categories, and then finding the optimal consumption bundle by solving household problem and calculating the total amount of tax generated, for a given tax policy.

The computational methods used in this study are GMM (Generalized Method of Moments), 'nnls' (non-negative least squares) solver and 'slsqp' (sequential least squares programming) method to estimate the income distribution, solve the constrained regression (to find the minimum consumption levels and expenditure shares for each categories), and to obtain the optimal consumption bundle in household problem (for a given tax policy), respectively. The optimal tax policy is obtained using the large data approach to eliminate the dominated tax policies from a large type space (varying over different tax policies and income levels). The limitations of the study are not being able to estimate the income distribution through Generalized Gamma distribution, and iterating over a large type space to find the optimal taxation. However, these can be overcome using grid computing or advanced processing systems.

I find that the tax rates employed in the current GST scheme are inefficient as they yield lower level of societal utility and also generates lower amount of tax revenues. If we increase the tax rates for all the categories above 50%, then we not only obtained higher levels of societal utility but also higher amount of tax revenue was generated. Through implementation of GST (Goods and Services tax) policy, India has seen a major economic reform, however, she can benefit further by revising the tax schemes for each consumption category. This revision of tax schemes promises a higher level of societal utility as well as larger amount of tax generated.

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