Algorithm for calculating corporate marginal tax rate using Monte Carlo simulation

Sinha, Pankaj and Bansal, Vishakha

Faculty of Mangement Studies, University of Delhi

20 July 2012

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Pankaj Sinha and Vishakha Bansal
Faculty of Management Studies
University of Delhi

Abstract:

Simulated marginal tax rates involve complex calculations of simulating future (uncertain) incomes and mimicking corporate tax code. This paper develops two algorithms to calculate simulated marginal tax rate. The codes have been developed to forecast future taxable income of Indian companies and their Marginal Tax Rates (MTR) using Monte Carlo simulation in MATLAB. Loss carry forward and minimum alternate tax rules have been incorporated in both the algorithms. Further, a change is made in both the algorithms to incorporate loss carry backward feature to suit the needs of the country where such laws are applicable. The 10000 simulations in MATLAB suggest that MTR is company specific and it is dependent on the income pattern of the company. The MTR increases when loss carry backward rule is applied. In cases where the company actually pays zero tax in a year due to incurred losses, it is found that even in such cases MTR may be non zero. It is found that there is enough cross sectional and time series variations in MTR, therefore, the effect of tax rates on various policy issues of government and companies can be studied by taking MTR as an effective proxy for tax rates.

Key words: Marginal tax Rate, Corporate taxes, Loss carry forward, Alternate minimum tax, Loss carry backward, Tax code

JEL Codes: G17, G32, G38

1. Introduction:

Corporate Marginal tax rate (MTR) is defined as the present value of current and expected future taxes paid on an additional unit of income earned today. Various theories signal that corporate tax rates influence many policy issues of a company, for example, financing policy, determination of firm's weighted average cost of capital (WACC) and investment policies, corporate reorganisation and hedging, compensation policies, decisions regarding leverage buy outs (LBO) etc:.

In most of the countries, the statutory tax laws do not demonstrate enough variation in corporate tax rates over the years and across the firms. In the absence of variation in tax rates over time and across companies, we can only presume a similar policy for each company, which is not true; or we may end up with contradictory results. For a long period of time most of the empirical researches undertaken could not prove the stated theories for want of appropriate tax variable. It was only in the beginning of nineties that the methodology to calculate company specific Marginal tax rate (MTR) was developed by Shevlin (1990) and Graham (1996a). As has also been mentioned by Graham (1996a) "it is surprising that the marginal tax rate is almost never explicitly calculated. Instead, proxies are used to gauge a firm's tax status although these proxies are at best indirect and can be mis1eading. This could explain why most financial research fails to find that tax considerations are an important factor in corporate financial decisions." Plesko (2003) concluded that in comparison to generally used average tax rate measures, proxies used for marginal tax rate (mainly those based on simulation methods) perform better in estimating current year tax rates. Graham (1998) shows that simulated rates are highly correlated to the actual future tax rate.

The computation of MTR involves complex calculations of simulating future taxable income of companies and mimicking country's corporate tax code. Due to these complexities involved in computing MTR a very few researchers could employ it to study the above mentioned linkages.

Thus to solve the above problem in this paper we develop two computer algorithms, using MATLAB, for calculating simulated MTR of a company. The algorithms are based on the methodology described in Shevlin (1990), Graham (1996a), Graham (1996b) and Alworth and Arachi (2001). Here MTR is calculated by using 10,000 simulations of taxable incomes resulting

in a very high accuracy. The algorithms have been constructed considering the rules applicable for carry backward, forward losses and Minimum Alternate Tax (MAT). Since the algorithms can include different periods for carry backward and carry forward losses along with different MAT and regular tax rates, hence the algorithm can be used to calculate MTR of companies of many countries.

The section 2 reviews the literature and section 3 gives the theoretical framework for the calculation of MTR. Section 4 presents the data and the methodology which are used to calculate the MTR. Section 5 illustrates the findings and presents the comparative analysis of algorithm 1 and 2.

2. Review of literature:

2.1 Calculation of marginal tax rate

Shevlin (1990), for the first time, discussed a methodology to calculate firm specific marginal tax rate. Monte Carlo simulation was used to forecast future incomes and the net operating loss carry forward, backward rule was incorporated in calculating marginal tax rates. Graham (1996a) developed upon the methodology to further include other provisions of the federal tax code such as investment tax credits and alternate minimum tax rate. He used the marginal tax rate to study the relationship between taxes and corporate debt. Before this development only proxies or binary variable (dummies) were used to study any such linkages. Graham (1998) discussed in detail the methodology and limitations in calculating simulated corporate marginal tax.

Both Shevlin (1990) and Graham (1996a) uses historical income to calculate the drift and volatility required to measure manager's expectations. But as data is limited and using historical incomes further reduces the data values, Graham(1996b) and Alworth and Archi (2001) uses the entire horizon of the carry-forward sample for simulating the future incomes. We follow Graham (1996b) and Alworth and Archi (2001) for our research.

According to the federal tax code in 1996, losses could have been carried forward infinitely and thus Graham (1996a) and Graham (1998) simulate future income stream for 15 and 20 years respectively. Italian tax code allows 5 years of loss carry forward so Alworth and Arachi (2001)

simulates future income for 5 years. On the contrary we observed that the effect of Rs.1 change in income can go beyond the carry-forward period thus we forecast future taxable income for twice the number of years for which carry forward is allowed.

2.2 Importance of marginal tax rate:

Grady (1986) uses the concept of the marginal real effective tax rate on investments to study the policy change proposals of US and Canada to identify the effects on the burden and distribution of corporate tax based on various assumptions about the rate of inflation and the extent to which investment is debt financed.

Gogas (1997) discusses the problem where Canadian economy was facing a very high MTR, but already existing high debt situation was further pointing to an increase in tax rates. According to the author the problem could be solved only by identifying the taxation effects on labour and capital equilibrium and thus he proposes the use of MTR to study such effects.

Shackelford and Shevlin (2001) discuss in detail the scope for research in taxes and the problems faced therein, it also sheds light on the limitations due to lack of existing measurable variables and the need for more rigorous research in the area.

Padovano and Galli (2002) study the relationship between taxes and economic growth. They argue that the main reason behind inconclusive empirical evidence regarding the above relationship lies in the wrong choice of tax rate indicators. Author also proposes the use of effective marginal tax rates to find out the relationship between taxes and economic growth.

Plesko (2003) highlights the importance and precision of financial statement based simulated MTR over other average tax measures to capture firm level tax based attributes as the author evaluates alternative measures of corporate tax rate.

Kotlikoff and Rapson (2005) compare the average and marginal tax rates on working and saving under current and proposed fair tax system. It also takes into account the corporate marginal tax rate to study the movement of capital flows based upon MTR under the proposed fair tax.

Rao and Stevens (2006) develop a theory of Weighted Average Cost of Capital (WACC) and MTR with debt depreciation and interest tax shields and further claims that as these variables are intertwined they must be calculated simultaneously. According to the authors WACC and MTR are central to any research on tax policy.

Ramb (2007) employs marginal tax rates developed by Graham (1996) to investigate the relationship between the investment behaviour of firms and taxes. In our paper also, the code developed is based on the calculation of MTR as in Graham (1996).

Thus above researches focus on both the ability and importance of MTR in the field of tax research to identify various relationships at the corporate and the economy level and also to evaluate various tax change proposals in the country. But the computation of MTR involves complex calculations of simulating future taxable income of companies and mimicking country's corporate tax code.

3. The Marginal Tax Rate:

To calculate marginal tax rate we need important sets of information: manager's expectation of future income flows, tax code treatment of business losses (BL) and minimum alternate tax (MAT).

3.1 Simulating manager's expectation of future income cash flows:

To apply loss carry-forward rule while calculating MTR we need a forecast of future income flows based on manager's expectation. The model proposed by Shevlin (1990) can be used to generate the proxy of manager's expectation. The model is based on the assumption that pre tax income follows a pseudo random walk with drift as given in the following equation:

$$\Delta TI_{it} = \mu_i + \varepsilon_{it} \qquad \text{(i)}$$

where, ΔTI_{it} is the first difference in pre-tax income of company i in the year t, μ_i is the sample mean of ΔTI_i and ε_{it} is a normally distributed random variable with mean zero and variance equal to variance of ΔTI_i over the number of years being considered.

3.2 Taxation in India:

In India there is a minor variation in the tax rates over time and across companies, moreover there is no progressive tax rate structure here. We have ignored the surcharge levied on the tax amount, as it will have a minimal impact on the marginal tax rate.

As per section 72 of the Indian Income tax Act (1961) business loss in any year can be carried forward to set off against the positive incomes of next 8 consecutive years. After 8 years it is considered to be lapsed even if not completely set off.

In most of the countries Alternate Minimum Tax (AMT) rule has been imposed to ensure that profitable firms pay at least some tax even if their taxable income become negative after adjustments. Higher of the two i.e. regular tax or AMT is paid. In India such tax is levied in the name of Minimum Alternate Tax (MAT) u/s 115JB of the Income Tax Act (1961). The method of arriving at taxable income for calculating regular tax and MAT is different, for simplicity we have ignored special adjustments required to calculate the book profit subject to MAT. The following example shows how MAT works:

Table 1: Taxable income of company (example)

Year	1997	1998	1999	2000	2001
Taxable income (in Rs.million)	-100	-200	-250	100	600

Using the information in table 1, suppose, we calculate the tax rate for year 2000 assuming 1997 as the base year (In India loss carry forward rule is applicable from 1997). After applying the carry forward rule, income of the year 2000 will reduce to a loss of 450 millions. Since the pre loss adjustment income is positive MAT would apply, assuming MAT rate of 10%, a company still has a tax liability of 10 million.

For the year 2001, as the losses could not be completely set off till 2000, Rs. 450 million would be carried to 2001; hence, the resulting taxable income is reduced to 150 million. Again assuming the MAT is 10% and regular tax rate is 30% of taxable income, a comparison of the two tax bills would be made. Here the regular tax liability would be Rs. 45 million (30% *150)

and AMT liability would be Rs. 60 million (10%*600). Thus although there is a positive taxable income the company would still pay the taxes according to MAT rate. Next section describes the data sources and methodology to calculate MTR.

4. Data and Methodology:

4.1 Data:

We have considered the taxable income of four domestic, non financial corporates with different income patterns to show how a marginal tax rate is calculated. The reason for choosing only non financial, domestic corporates is that the tax treatment of financial companies is relatively different and foreign companies are affected by the tax laws of the country of their origin. The taxable income data is taken from annual financial statements data set of CMIE PROWESS from the year 1989 to 2011.

Here we take one year fixed deposit rates of commercial banks as risk free rates to calculate the present value of tax bill. The rates are available on Reserve Bank of India website.

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4.2 Methodology:

We have developed two different algorithms to calculate Marginal Tax Rates which have different implications, using MATLAB version 2011.

Algorithm 1: Calculation of Marginal Tax Rate

In algorithm 1 we simulate the entire taxable income series of a corporate starting from 1989 till 2011 with an additional 16 year forecast of future income by drawing 39 random normal realizations, using model (i). By simulating entire taxable income series we try to overcome the problem of missing numbers and any manipulations made by the management. Given the carry-forward period of 8 years we forecast future income for 16 years (double the carry-forward period) to capture the effect of a rupee change which may go even beyond 8 years. Thus we arrive at a simulated taxable income series from 1989 – 2027. The simulations and forecasts are

based on the mean and variance of actual taxable income series from 1989 to 2011. We generate 10000 scenarios of income in this way.

Now to calculate MTR_{it} for, say, t=1989, we calculate the present value of taxes to be paid taking into account loss carry-backward, carry-forward and MAT provisions. Then we add a unit of income in the reference year and recalculate the present value of the tax bill. By taking the difference between these two present values, a single value of MTR is obtained. We repeat the process for each simulation and get 10000 MTR figures. Their average is used to arrive at the final single figure of MTR for the year 1989. Using the same taxable income series and applying similar rules, MTR is obtained for all the years from 1990 to 2011 simultaneously.

The result generated by this method may be useful for companies to determine various policies that are dependent upon tax rates faced by them. This method reflects the behaviour of MTR over the years given the earning pattern of a particular company. Thus the MTR arrived by this method are more affected by the earning pattern than the tax policies.

Algorithm 2: Calculation of Marginal Tax Rate

Here, in order to estimate marginal tax rate MTR_{it} for t=1989 we obtain firm i's future taxable income forecasts for 1990 to 2005 by drawing 16 random normal realizations (for twice the carry-forward period as explained above), using model (i). As per algorithm 2 the simulations are undertaken only to capture the effect of loss carry-forward provisions. The forecasts are once again based on the mean and variance of actual taxable income series from 1989 to 2011. As in algorithm 1 we generate 10,000 simulations of future taxable income. Then the process mentioned in algorithm 1 is repeated to arrive at the final figure of MTR. This process is repeated independently for each year.

This MTR is very useful to study the impact of tax policy change on companies as well as the government revenues. Thus this method gives us a fruitful window to evaluate proposed changes in the tax policies. Hence the difference between two algorithms lies only in the period for which the income streams are simulated. The next section illustrates the algorithms.

5. Illustration:

To illustrate, we have considered four different companies with different income patterns over the years. The codes developed in MATLAB given in the Appendix (B) require the following inputs and steps to calculate MTR:

Inputs:

- Taxable income
- Regular tax rates
- Minimum Alternate Tax rates
- Risk free rate for the years
- Number of years losses can be carried forward
- Number of years losses can be carried backward

Table 2 shows the taxable income of the companies:

Table 2: Taxable income of companies

Company/ Year	Elecon Engineering Co. Ltd. (1)	Albert David Ltd. (2)	Yuken India Ltd. (3)	Super Sales India Ltd. (4)
1989	2	297	-6.7	1.7
1990	4.7	413.6	-18.8	2.4
1991	25.9	539.6	-34.4	2.2
1992	22.8	675	-16.3	-1.3
1993	2.2	441.7	-18.5	-2.6
1994	9.2	398.5	16.3	1
1995	17.8	158.1	81.4	2.1
1996	34.8	239.7	4.6	1.7
1997	42.2	976.9	0.5	-2.2
1998	11.1	1041	-79.7	-18.9
1999	6.6	702.1	-65.5	-20
2000	17.6	1664.3	-21.9	-7.3
2001	-40.2	2199.1	-21.9	-13.8
2002	1.7	2977.9	-16.2	-31.9
2003	6.8	4046	-28.7	-39.1
2004	31.8	5149.8	-25.3	-2
2005	34.8	6928.8	-26.3	7.5
2006	24.2	8548.7	-25.6	20.2
2007	38.9	10482	-36	11.7
2008	108.3	11885.1	-8	27.8
2009	233.4	10894.5	-17.4	22.2
2010	152.5	10361.1	-16.9	21.4
2011	15.1	11527.7	-12.1	17.1

Data source: Prowess database (CMIE)

Table 3 shows the tax rates of companies and risk free interest rates

Table 3: Corporate tax rates and risk free rate in the country

Year	Corporate tax rate	Minimum alternate tax rate	Risk free interest rate
1988-89	50	0	9
1989-90	50	0	9
1990-91	40	0	9
1991-92	45	0	12
1992-93	45	0	11
1993-94	45	0	10
1994-95	40	0	11
1995-96	40	0	12
1996-97	40	12	11
1997-98	35	10.5	10.5
1998-99	35	10.5	9
1999-2000	35	10.5	8.5
2000-01	35	7.5	8.5
2001-02	35	7.5	7.5
2002-03	35	7.5	4.25
2003-04	35	7.5	4
2004-05	35	7.5	5.25
2005-06	30	10	6
2006-07	30	10	7.5
2007-08	30	10	8.25
2008-09	30	15	8
2009-10	30	18	6
2010-11	30	18	8.25

Data source: Tax rates (Finance Act (1988 to 2011))

Risk free rates (RBI website)

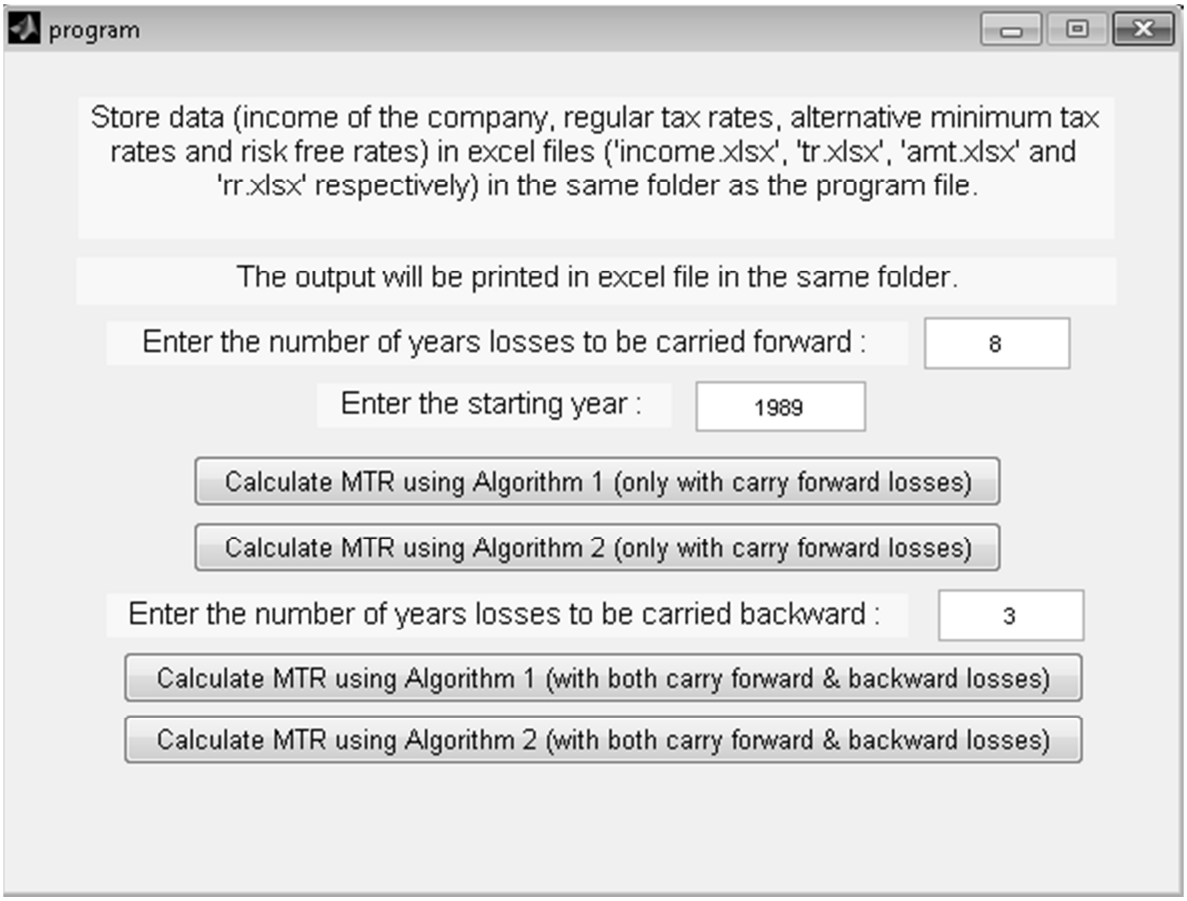
Table 4 shows the loss carry forward rule as applicable in India and the carry backward rule is assumed for illustration purposes.

Table 4: Loss carry backward and carry forward rules

Number of years losses can be carried forward	8 years (India)
Number of years losses can be carried backwards	3 years (assumption)

One can use the following form to input the data for calculating MTR:

Figure 1: Form to calculate marginal tax rate

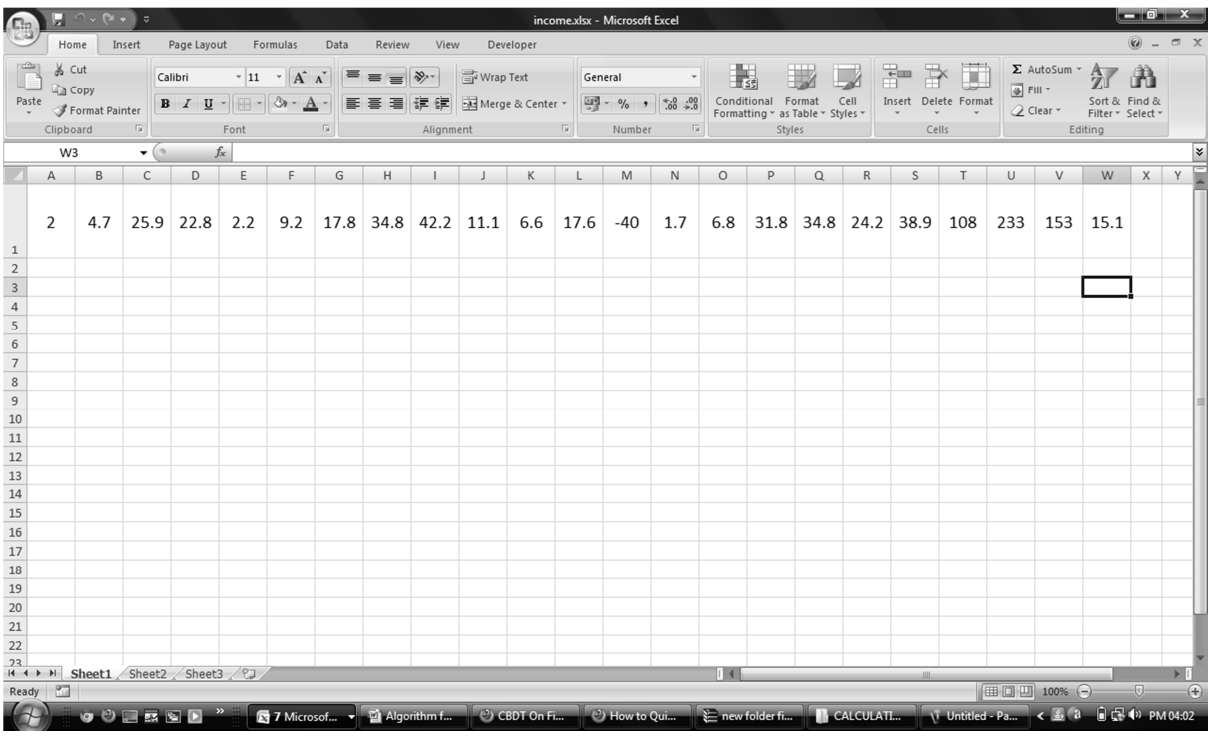


STEPS:

Step 1:

To calculate MTR the first step is to fill in the required information in the respective excel files as mentioned in the above form (figure 1) .The user has to provide the necessary detail in the first row of each file. For example the data related to income for 23 years of Elecon Engineering Co. Ltd (table 1) has been posted in the first row of file named "income.xlsx" as shown in the figure 2 below:

Figure 2: Data entry for income in "income.xlsx"



Similarly all other rates are to be entered in their respective files as mentioned on the form (see figure1). Precaution has to be taken to fill equal number of years data for each variable that is, if the user is filling in 23 years of taxable income data then respective 23 years of tax rates, minimum alternate tax rates and risk free rates for each year are to be filled in the input files, else the program will not work.

Step 2:

All the excel files have to be taken to the same folder as the link to this program.

Step 3:

The next step is to fill in all the details in figure 1, as per the respective tax rules of the country. Starting year of the income stream is to be mentioned and in case the user is not applying the carry backward rule the respective space has to be left blank.

Step 4:

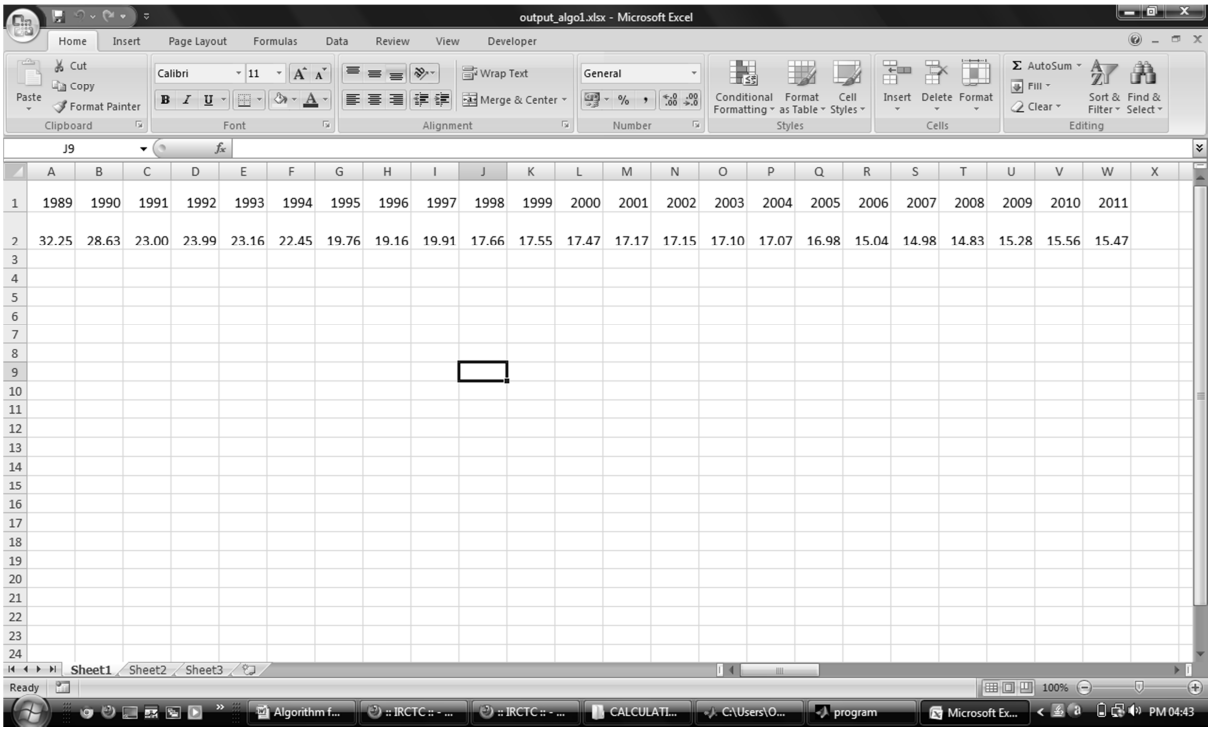
Final step is to click the appropriate button. It is important to mention that algorithm 1 simulates both past and future incomes and algorithm 2 simulates only the future incomes. The output will be generated in the same folder in different files respectively as mentioned in table 5.

Table 5: Output files for different algorithm

Algorithm	Output file
Algorithm 1(only carry forward)	"output_algo1.xlsx"
Algorithm 2 (only carry forward)	"output_algo2.xlsx"
Algorithm 1 (both carry forward and carry backward)	"output_carryback_algo1.xlsx"
Algorithm 2 (both carry forward and carry backward)	"output_carryback_algo2.xlsx"

The output will be generated with respective years as shown in figure 3. It shows the calculated marginal tax rate for Elecon Engineering Co. Ltd. from 1989 to 2011 by using Algorithm 1 without carry backs.

Figure 3: MTR output according to ‘algorithm 1 without carry back ward’ generated in “output_algo1.xlsx”



1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
32.25	28.63	23.00	23.99	23.16	22.45	19.76	19.16	19.91	17.66	17.55	17.47	17.17	17.15	17.10	17.07	16.98	15.04	14.98	14.83	15.28	15.56	15.47

Other results will be obtained in the same manner in the respective files.

5.2 Results

Table 7, 8, 9 and 10 as given in Appendix (A), show MTR for the above mentioned companies calculated using the data given in table 2 and 3.

5.3 Observations:

A comparative analysis of the results based on Algorithm 1 and 2 are given in table 6 and are discussed below.

1) During the times of profit when companies faced regular tax rate, MTR is always found to be lower than regular tax rate as per algorithm 1 and it is equal or higher as per algorithm 2. MTR is constantly found to be higher than tax rate faced by the companies, when companies incurred losses or paid MAT.

2) Results show that there is enough cross sectional variation in MTR (between the companies). MTR calculated according to algorithm 1, is found to be more stable, even after applying the carry backward rule.

Table 6: Comparative analysis of MTR Results as per different algorithms:

Basis Of Comparison		**MTR when calculated as per Algorithm 1 (Company's point of view)**	**MTR when calculated as per Algorithm 2 (Government's point of view)**
Tax rate faced by the company	**Regular corporate tax rate**	Lower than the regular tax rate	Higher than or Equal to the regular tax rate
	MAT	Higher than MAT	Higher than MAT
	Zero	Higher (non zero)	Higher (non zero)
Stability over the years		More Stable	Comparatively Less Stable
Company Specific		Yes	Yes
Whether Dependent on the Income Pattern or Statutory Laws		More on Income Pattern	Both
When Carry-backward Rule also exists		No Specific Pattern	Generally Higher

3) MTR calculated as per algorithm 1 is more dependent on the income pattern and thus takes care of missing information or manipulations by the company.
4) An important observation is when calculations are made as per algorithm 1, implementation of a carry-back rule does not bring much difference to the resulting MTRs but in case of algorithm 2 MTRs are mostly found to be higher than earlier ones.

6. Conclusion:

Our methodology to calculate marginal tax rate is an improvement over the existing ones because of the following reasons:

1) We forecast the income stream for twice the number of years for which losses can be carried forward. The purpose behind this is to integrate the effect of a rupee change which can go even beyond the carry-forward period.
2) The algorithms are built in to perform 10000 simulations resulting in higher accuracy.
3) Algorithms developed in this paper can be used in many countries where similar rules apply with difference only in the number of years for carry-forward and backward of losses.
4) The algorithm 1 and 2 are important developments to calculate MTR of companies of various countries.

To conclude, since the manual calculations suffer from lack of precision and are subject to errors due to the complexities in calculating MTR, the algorithms developed in this paper are of high use for corporate, academicians and government. The algorithms can directly be used to generate MTR by simply filling in the appropriate details. Since MTR calculated according to algorithm 1 remains more stable even after applying the carry backward rule, corporate decisions based on these MTRs are predicted to be more appropriate. MTR calculated using algorithm 2 are expected to better suit the studies undertaken to review government policies.

Acknowledgement: We are thankful to Lavleen Goyal, a third year B.Tech student of IIT Guwahati and Tanmay Sinha, a third year student of JIIT Noida for helping us in implementing the above algorithms in MATLAB.

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Appendix (A):

Table 6: MTR for Elecon Engineering Co. Ltd. calculated as per different methods

Elecon Engineering Co. Ltd.					
Year	Marginal tax rate (MTR)				Without simulation (Actual tax rate faced by the company)
	Algorithm 1 without carry back	Algorithm 2 without carry back	Algorithm 1 with carry back (3 years)	Algorithm 2 with carry back (3 years)	
1989	33.01	50.00	34.50	55.98	50.00
1990	29.26	50.00	29.38	54.69	50.00
1991	23.28	40.00	23.18	42.87	40.00
1992	24.28	45.00	23.91	46.80	45.00
1993	23.46	45.00	23.37	46.95	45.00
1994	22.71	45.00	22.74	47.00	45.00
1995	20.04	40.00	20.18	41.76	40.00
1996	19.53	40.00	19.83	41.16	40.00
1997	20.35	40.00	20.30	40.93	40.00
1998	17.89	35.00	17.96	36.07	35.00
1999	17.85	35.00	17.84	36.33	35.00
2000	17.81	35.00	17.86	36.42	35.00
2001	17.55	15.86	17.53	18.48	0.00
2002	17.46	23.80	17.27	26.14	7.50
2003	17.27	24.77	17.24	36.44	7.50
2004	17.18	7.50	17.22	35.84	7.50
2005	17.06	35.00	17.12	35.61	35.00
2006	15.00	30.00	14.90	30.44	30.00
2007	14.89	30.00	14.93	30.41	30.00
2008	14.80	30.00	14.80	30.22	30.00
2009	15.08	30.00	15.15	30.06	30.00
2010	15.41	30.00	15.44	30.03	30.00
2011	15.38	30.00	15.44	30.38	30.00

Table 7: MTR for Albert David Ltd. calculated as per different methods

Albert David Ltd.					
Year	Marginal tax rate (MTR)				Without simulation (Actual tax rate faced by the company)
	Algorithm 1 without carry back	Algorithm 2 without carry back	Algorithm 1 with carry back (3 years)	Algorithm 2 with carry back (3 years)	
1989	45.55	50.00	46.82	53.90	50.00
1990	45.11	50.00	44.89	51.79	50.00
1991	37.86	40.00	37.31	40.83	40.00
1992	42.18	45.00	41.72	45.45	45.00
1993	42.48	45.00	42.00	45.37	45.00
1994	42.71	45.00	42.44	45.30	45.00
1995	38.42	40.00	38.24	40.30	40.00
1996	38.53	40.00	38.45	40.24	40.00
1997	38.97	40.00	38.83	40.15	40.00
1998	34.35	35.00	34.26	35.07	35.00
1999	34.46	35.00	34.37	35.05	35.00
2000	34.54	35.00	34.44	35.03	35.00
2001	34.59	35.00	34.54	35.01	35.00
2002	34.64	35.00	34.63	35.00	35.00
2003	34.71	35.00	34.70	35.00	35.00
2004	34.75	35.00	34.72	35.00	35.00
2005	34.79	35.00	34.76	35.00	35.00
2006	29.87	30.00	29.86	30.00	30.00
2007	29.90	30.00	29.88	30.00	30.00
2008	29.91	30.00	29.89	30.00	30.00
2009	29.93	30.00	29.93	30.00	30.00
2010	29.96	30.00	29.94	30.00	30.00
2011	29.96	30.00	29.95	30.00	30.00

Table 8: MTR for Yuken India Ltd. calculated as per different methods

Yuken India Ltd.					
Year	Marginal tax rate (MTR)				Without simulation (Actual tax rate faced by the company)
	Algorithm 1 without carry back	Algorithm 2 without carry back	Algorithm 1 with carry back (3 years)	Algorithm 2 with carry back (3 years)	
1989	31.94	26.00	33.51	27.24	0.00
1990	28.09	19.68	28.24	19.93	0.00
1991	22.30	17.91	22.03	17.57	0.00
1992	23.19	16.01	22.82	16.34	0.00
1993	22.39	14.10	22.24	14.50	0.00
1994	21.55	13.80	21.46	13.94	0.00
1995	19.06	40.00	18.80	42.41	40.00
1996	18.51	40.00	18.23	41.90	40.00
1997	19.13	40.00	18.88	42.04	40.00
1998	16.84	10.32	16.61	10.94	0.00
1999	16.70	9.11	16.59	9.24	0.00
2000	16.56	9.36	16.59	9.61	0.00
2001	16.18	9.09	16.01	9.48	0.00
2002	16.11	9.10	15.90	9.16	0.00
2003	15.96	8.38	15.93	8.51	0.00
2004	15.80	6.75	15.77	7.06	0.00
2005	15.59	6.27	15.59	6.19	0.00
2006	13.66	5.64	13.58	6.00	0.00
2007	13.61	5.23	13.60	5.10	0.00
2008	13.54	4.19	13.56	4.40	0.00
2009	13.94	4.10	13.78	4.11	0.00
2010	14.20	4.24	14.00	4.15	0.00
2011	14.19	3.88	13.98	3.94	0.00

Table 9: MTR for Super Sales India Ltd. calculated as per different methods

Super Sales India Ltd.					
Year	Marginal tax rate (MTR)				Without simulation (Actual tax rate faced by the company)
	Algorithm 1 without carry back	Algorithm 2 without carry back	Algorithm 1 with carry back (3 years)	Algorithm 2 with carry back (3 years)	
1989	34.71	50.00	36.30	55.68	50.00
1990	31.16	50.00	31.13	54.14	50.00
1991	25.05	40.00	24.85	43.14	40.00
1992	26.46	25.37	26.31	0.00	0.00
1993	25.75	24.31	25.60	0.50	0.00
1994	25.13	22.12	24.98	47.82	0.00
1995	22.39	25.88	22.17	42.17	0.00
1996	21.92	40.00	21.99	41.99	40.00
1997	22.76	19.49	22.69	1.76	0.00
1998	20.23	14.40	20.02	16.06	0.00
1999	20.17	11.95	20.00	12.45	0.00
2000	20.21	12.68	19.96	13.51	0.00
2001	19.99	11.59	19.79	12.20	0.00
2002	20.05	11.01	19.86	11.04	0.00
2003	20.00	8.78	19.84	8.66	0.00
2004	19.89	8.24	19.77	8.40	0.00
2005	19.73	14.16	19.70	14.12	7.50
2006	17.36	16.21	17.27	16.38	10.00
2007	17.39	10.00	17.22	15.12	10.00
2008	17.36	14.11	17.27	14.14	10.00
2009	17.72	18.83	17.72	18.89	15.00
2010	18.15	25.24	18.07	26.58	18.00
2011	18.17	18.00	18.15	26.13	18.00

Appendix (B):

MATLAB Main Code:

```
function varargout = program(varargin)
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
'gui_Singleton',  gui_Singleton, ...
'gui_OpeningFcn', @program_OpeningFcn, ...
'gui_OutputFcn',  @program_OutputFcn, ...
'gui_LayoutFcn',  [], ...
'gui_Callback',   []);
if nargin && ischar(varargin{1})
   gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end


function program_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);

function varargout = program_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_Callback(hObject, eventdata, handles)

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function edit2_Callback(hObject, eventdata, handles)

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function pushbutton1_Callback(hObject, eventdata, handles)
J=get(handles.edit1,'String');
J=str2double(J);
```

```
Y=get(handles.edit2,'String');
Y=str2double(Y);
[num] = xlsread('income.xlsx');
p=num(1,:);
Ntemp=length(p);
N=Ntemp+2*J;
p=diff(p);
mu=mean(p);
sig=std(p);
[num] = xlsread('tr.xlsx');
tr=num(1,:);
temp=tr(Ntemp)*ones(1,2*J);
tr=[tr temp];
[num] = xlsread('amt.xlsx');
amt=num(1,:);
temp=amt(Ntemp)*ones(1,2*J);
amt=[amt temp];
[num] = xlsread('rr.xlsx');
rr=num(1,:);
temp=rr(Ntemp)*ones(1,2*J);
rr=[rr temp];
p=zeros(1,N);
mtr=zeros(1,N-J);
sum=zeros(1,N-J);
for z=1:10000
    p=randn(1,N);
    p=mu+sig*p;
    p=cumsum(p);
    n=b(p,tr,amt,J,N);
for i=1:N-J
        pnew=p;
        pnew(i)=pnew(i)+1;
        nnew=b(pnew,tr,amt,J,N);
        npv=n(i);
        nnewpv=nnew(i);
for j=i+1:N
            r=1;
for k=i:(j-1)
                r=r/(1+rr(k)/100);
end
            npv=npv+n(j)*r;
            nnewpv=nnewpv+nnew(j)*r;
end
        mtr(i)=(nnewpv-npv)*100;
end
    sum=sum+mtr;
end
sum=sum/10000;
years=linspace(Y,Y+N-J-1,N-J);
xlswrite('output_algo1.xlsx',years,'A1:CV1');
xlswrite('output_algo1.xlsx',sum,'A2:CV2');
```

```
function pushbutton2_Callback(hObject, eventdata, handles)
J=get(handles.edit1,'String');
J=str2double(J);
Y=get(handles.edit2,'String');
Y=str2double(Y);
[num] = xlsread('income.xlsx');
p=num(1,:);
Ntemp=length(p);
N=Ntemp+2*J;
pp=diff(p);
mu=mean(pp);
sig=std(pp);
[num] = xlsread('tr.xlsx');
tr=num(1,:);
temp=tr(Ntemp)*ones(1,2*J);
tr=[tr temp];
[num] = xlsread('amt.xlsx');
amt=num(1,:);
temp=amt(Ntemp)*ones(1,2*J);
amt=[amt temp];
[num] = xlsread('rr.xlsx');
rr=num(1,:);
temp=rr(Ntemp)*ones(1,2*J);
rr=[rr temp];
pp=zeros(1,N);
mtr=zeros(1,N-J);
for i=1:N-J
for z=1:10000
        pp=randn(1,N);
        pp=mu+sig*pp;
        pp=cumsum(pp);
if(i<=Ntemp)
            pp=[p(1:i) pp((i+1):N)];
end
        n=b(pp,tr,amt,J,N);
        pp(i)=pp(i)+1;
        nnew=b(pp,tr,amt,J,N);
        npv=n(i);
        nnewpv=nnew(i);
for j=i+1:N
            r=1;
for k=i:(j-1)
                r=r/(1+rr(k)/100);
end
            npv=npv+n(j)*r;
            nnewpv=nnewpv+nnew(j)*r;
end
        mtr(i)=mtr(i)+(nnewpv-npv)*100;
end
end
```

```
mtr=mtr/10000;
years=linspace(Y,Y+N-J-1,N-J);
xlswrite('output_algo2.xlsx',years,'A1:CV1');
xlswrite('output_algo2.xlsx',mtr,'A2:CV2');

function edit3_Callback(hObject, eventdata, handles)

function edit3_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function pushbutton3_Callback(hObject, eventdata, handles)
J=get(handles.edit1,'String');
J=str2double(J);
Y=get(handles.edit2,'String');
Y=str2double(Y);
JJ=get(handles.edit3,'String');
JJ=str2double(JJ);
[num] = xlsread('income.xlsx');
p=num(1,:);
Ntemp=length(p);
N=Ntemp+2*J;
p=diff(p);
mu=mean(p);
sig=std(p);
[num] = xlsread('tr.xlsx');
tr=num(1,:);
temp=tr(Ntemp)*ones(1,2*J);
tr=[tr temp];
[num] = xlsread('amt.xlsx');
amt=num(1,:);
temp=amt(Ntemp)*ones(1,2*J);
amt=[amt temp];
[num] = xlsread('rr.xlsx');
rr=num(1,:);
temp=rr(Ntemp)*ones(1,2*J);
rr=[rr temp];
p=zeros(1,N);
mtr=zeros(1,N-J);
sum=zeros(1,N-J);
for z=1:10000
    p=randn(1,N);
    p=mu+sig*p;
    p=cumsum(p);
    n=bb(p,tr,amt,J,N,JJ);
for i=1:N-J
        pnew=p;
        pnew(i)=pnew(i)+1;
        nnew=bb(pnew,tr,amt,J,N,JJ);
```

```
        npv=n(i);
        nnewpv=nnew(i);
for j=i+1:N
            r=1;
for k=i:(j-1)
                r=r/(1+rr(k)/100);
end
            npv=npv+n(j)*r;
            nnewpv=nnewpv+nnew(j)*r;
end
        mtr(i)=(nnewpv-npv)*100;
end
    sum=sum+mtr;
end
sum=sum/10000;
years=linspace(Y,Y+N-J-1,N-J);
xlswrite('output_carryback_algo1.xlsx',years,'A1:CV1');
xlswrite('output_carryback_algo1.xlsx',sum,'A2:CV2');

function pushbutton4_Callback(hObject, eventdata, handles)
J=get(handles.edit1,'String');
J=str2double(J);
Y=get(handles.edit2,'String');
Y=str2double(Y);
JJ=get(handles.edit3,'String');
JJ=str2double(JJ);
[num] = xlsread('income.xlsx');
p=num(1,:);
Ntemp=length(p);
N=Ntemp+2*J;
pp=diff(p);
mu=mean(pp);
sig=std(pp);
[num] = xlsread('tr.xlsx');
tr=num(1,:);
temp=tr(Ntemp)*ones(1,2*J);
tr=[tr temp];
[num] = xlsread('amt.xlsx');
amt=num(1,:);
temp=amt(Ntemp)*ones(1,2*J);
amt=[amt temp];
[num] = xlsread('rr.xlsx');
rr=num(1,:);
temp=rr(Ntemp)*ones(1,2*J);
rr=[rr temp];
pp=zeros(1,N);
mtr=zeros(1,N-J);
for i=1:N-J
for z=1:10000
        pp=randn(1,N);
        pp=mu+sig*pp;
```

```
        pp=cumsum(pp);
if(i<=Ntemp)
            pp=[p(1:i) pp((i+1):N)];
end
        n=bb(pp,tr,amt,J,N,JJ);
        pp(i)=pp(i)+1;
        nnew=bb(pp,tr,amt,J,N,JJ);
        npv=n(i);
        nnewpv=nnew(i);
for j=i+1:N
            r=1;
for k=i:(j-1)
                r=r/(1+rr(k)/100);
end
            npv=npv+n(j)*r;
            nnewpv=nnewpv+nnew(j)*r;
end
        mtr(i)=mtr(i)+(nnewpv-npv)*100;
end
end
mtr=mtr/10000;
years=linspace(Y,Y+N-J-1,N-J);
xlswrite('output_carryback_algo2.xlsx',years,'A1:CV1');
xlswrite('output_carryback_algo2.xlsx',mtr,'A2:CV2');
```

Function for calculating tax with only carry forward losses :

```
function [n] = b(p,tr,amt,J,N)
    v=p;
    c=zeros(1,J);
    l=zeros(1,N);
for i=1:N
for j=J:-1:1
            c(j+1)=c(j);
end
        c(1)=0;
if(v(i)<=0)
            c(1)=v(i);
            v(i)=0;
else
for j=J+1:-1:1
if(c(j)<0)
if(-c(j)>=v(i))
                        c(j)=c(j)+v(i);
if(p(i)>0)
                            l(i)=p(i);
end
                        v(i)=0;
else
                        v(i)=c(j)+v(i);
                        c(j)=0;
```

```
end
end
end
end
end
for i=1:N
if(l(i)==0 && p(i)>0)
            l(i)=p(i);
end
end
    v=(v.*tr)/100;
    l=(l.*amt)/100;
    n=max(v,l);
end
```

Function for calculating tax with both carry forward & backward losses :

```
function [n] = bb(p,tr,amt,J,N,JJ)
    v=p;
    c=zeros(1,J);
    l=zeros(1,N);
    bck=zeros(1,JJ);
for i=1:N
if(v(i)<0)
for j=1:JJ
if(-v(i)>bck(j))
                    v(i)=v(i)+bck(j);
                    bck(j)=0;
else
                    bck(j)=bck(j)+v(i);
                    v(i)=0;
end
end
end
for j=J:-1:1
            c(j+1)=c(j);
end
        c(1)=0;
if(v(i)<=0)
            c(1)=v(i);
            v(i)=0;
else
for j=J+1:-1:1
if(-c(j)>=v(i))
                    c(j)=c(j)+v(i);
if(p(i)>0)
                        l(i)=p(i);
end
                    v(i)=0;
```

```
else
                    v(i)=c(j)+v(i);
                    c(j)=0;
end
end
end
for j=1:(JJ-1)
                bck(j)=bck(j+1);
end
if(l(i)==0 && p(i)>0)
            l(i)=p(i);
end
        v(i)=v(i)*tr(i)/100;
        l(i)=l(i)*amt(i)/100;
        n(i)=max(v(i),l(i));
if(v(i)==n(i))
            bck(JJ)=100*v(i)/tr(i);
else
            bck(JJ)=0;
end
end
end
```