

# Mutual Debt Cut within a Group of Countries, an improved algorithm

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**Abstract :** In a recent paper [1], inspired by the economic crisis in Greece and the EU where the debate focuses on the National Debts, we investigated the possibility of a circulation of Debts within a group of countries. A transfer table was used for the purposes of the circulation. The concept is that the poorest country is granted a “catalytic” fund in order to buy some of its debt from other countries. A circulation algorithm was introduced which led to a result where all countries had reduced their debts on similar but equal amounts. The initial amount remains intact. In the present paper a different algorithm is introduced. In the first stage the “richest” country receives the initial capital. The transfer criteria differ and as a result we obtain a balanced solution where every country have erased the same amount of debt and of other countries possessed debt.

**Keywords – Mutual debt cut, transfer table, algorithm, analysis.**

## I. THE MUTUAL DEBT CUT PROCEDURE

We consider a group of countries as in table 1 where we denote the debt of one country to another. In the (i,j) cell we denote by  $d_{ij}$  the debt of the  $i$ -Country to the  $j$ -Country

**Table 1:** Debt of one country to another.

	Input Values					Outcomes
	C1	C2	C3	C4	C5	Current Debt
C1	0	31	25	16	8	80
C2	11	0	23	10	7	51
C3	4	22	0	10	0	36
C4	13	25	22	0	11	71
C5	22	90	112	43	0	267
Debt Possession	50	168	182	79	26	0

On the column to the right of the table we denote the Total Debt  $D_i = \sum_{j=1}^n d_{ij}$  of every country to the rest of the group and below the table we denote the total amount of other countries debt  $P_j = \sum_{i=1}^n d_{ij}$  that every country processes. We also denote as  $M$  the minimum amongst the total Debts and Possess of every country i.e.  $M = \min_{\substack{i=1..n \\ j=1..n}} \{P_i, D_j\}$  among the countries. In our example  $M = 26$ .

We call the “richest” the country that currently has the minimum total debt to other countries and the “poorest” the country that currently has the maximum total debt to other countries. We pick the “richest” country  $C_j$  and we grant it with a deposit equal to  $M$  under the restriction that the whole amount should be used to reduce the country’s debt starting with the “poorest” country.

In our example  $C_3$  is the richest country thus we transfer to it the whole deposit amount,  $M = 26$ . No country is allowed to exceed that amount. Thus in columns next to the table 2 of the debts we write each country’s Current Debt, available deposit, the used deposit and the remaining.

**Table 2:** Available deposit for reducing debt.

	Input Values					Outcomes			
	C1	C2	C3	C4	C5	Current Debt	Deposit	Used Credit	Remaining Deposit
C1	0	31	25	16	8	80			26
C2	11	0	23	10	7	51			26
C3	4	22	0	10	0	36	26		26
C4	13	25	22	0	11	71			26
C5	22	90	112	43	0	267			26

$C_1$  is the poorest among the countries that possess debt of  $C_3$ . Thus  $C_1$  has to buy as much of its debt  $C_3$  as possible. After the first step the results appear in table 3:

**Table 3:** The results since  $C_1$  bought  $C_3$ 's debt.

	Input Values					Outcomes			
	C1	C2	C3	C4	C5	Current Debt	Deposit	Used Credit	Remaining Deposit
C1	0	31	25	16	8	80	4		26
C2	11	0	23	10	7	51			26
C3	0	22	0	10	0	32	22	4	22
C4	13	25	22	0	11	71			26
C5	22	90	112	43	0	267	0		26

Notice that the sum of the available deposit of a country and the cut to its debt should not exceed the maximum allowance (26 in our example). If a country exceeds its limits it is excluded and we proceed with the rest of the countries. This is achieved after several iterations of the procedure and it is shown in the table 4.

**Table 4:** The results after several iterations of the algorithm in which if a country exceeds its limits of using the deposit.

	Input Values					Outcomes			
	C1	C2	C3	C4	C5	Current Debt	Deposit	Used Credit	Remaining Deposit
C1	0	31	25	16	8	80	4		26
C2	11	0	23	10	7	51	12		26
C3	0	10	0	0	0	10	0	26	0
C4	13	25	22	0	11	71	10		26
C5	22	90	112	43	0	267	0		26

As we see the C3 country has reach the maximum of the available credit. The iterations proceed with the remaining countries up to the point where according to the restrictions there are no moves available. That is shown in table 5:

**Table 5:** The C3 country has reach the maximum of the available credit.

	Input Values					Outcomes			
	C1	C2	C3	C4	C5	Current Debt	Deposit	Used Credit	Remaining Deposit
C1	0	31	25	0	0	56	2	24	2
C2	6	0	23	10	0	39	14	12	14
C3	0	10	0	0	0	10	0	26	0
C4	13	11	22	0	0	46	1	25	1
C5	5	90	112	43	0	250	9	17	9

At this point all countries cannot receive further deposit otherwise they will exceed  $M$ .

Thus we must insert a new criterion to proceed. We count the differences between the current and the initial Debt possession of each country and the differences between the current and the initial debts as shown in Table 6. At this stage we will transfer capital from the country of the maximum deposit to the country with the minimum possession difference.

Notice that the initial richest country has used all the deposit to eliminate its debt without cutting any of the debts in its possession. All other countries at this stage have cut the maximum of 26 monetary units (MU) of their possession. According to the new criterion we will transfer 14 MU from  $C_2$  to  $C_3$

**Table 6:** The appliace of the new criterion.

	Input Values					Outcomes			
	C1	C2	C3	C4	C5	Current Debt	Deposit	Used Credit	Remaining Deposit
C1	0	31	25	0	0	56	2	24	2
C2	6	0	23	10	0	39	14	12	14
C3	0	10	0	0	0	10	0	26	0
C4	13	11	22	0	0	46	1	25	1
C5	5	90	112	43	0	250	9	17	9
Current Debt Possession	24	142	182	53	0				
Initial Debt Possession	50	168	182	79	26				
Difference	-26	-26	0	-26	-26				

After few 4 iterations all available deposit of  $C_1, C_2, C_4, C_5$  are transferred to  $C_3$  and thus we obtain the solution in the final Table 7 where all countries have cut the same amount  $M = 26$  of their debt and the debt they possess.

**Table 7:** The representation of solution.

	Input Values					Outcomes		
	C1	C2	C3	C4	C5	Current Debt	Initial Depth	Remaining Deposit
C1	0	31	23	0	0	54	80	-26
C2	6	0	9	10	0	25	51	-26
C3	0	10	0	0	0	10	36	-26
C4	13	11	21	0	0	45	71	-26
C5	5	90	103	43	0	241	267	-26
Current Debt Possession	24	142	156	53	0	0		
Initial Debt Possession	50	168	182	79	26			
Difference	-26	-26	-26	-26	-26			

**II. SUMMARY AND CONCLUSIONS**

While we kept the same example as in [1] the introduction of new criteria led to a faster and more fair algorithm. The new algorithm consists of only two phases with straightforward conditions

- Initial Step: We grant the “richest country” with a deposit capital  $M$  that is the minimum amongst the total Debt and Debt Possess of every country.
- Phase One: Transfer of deposit capital from the current richest country with available deposit to its poorest creditor under the condition that every country’s deposit and used deposit should not exceed  $M$ . We repeat until there are no moves available.
- Transfer capital from the country with the maximum available deposit to the country with the minimum possession difference

At the end of the procedure all countries have exchanged the same amount of debt they possess for their own debt. No actual capital is spent. The present algorithm provides a formula for a fair debt cut via a circulation of debts among a group of countries within a transfer table.

REFERENCES

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