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MANAGEMENT OF SCALE-UP RESEARCH PROJECTS FOR DEVELOPING NOVEL ADSORPTIVE MATERIALS BASED ON BIO-WASTE RECYCLING AND PROCESSING

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Introductory Analysis

This work deals with the application of project management methods in biomass research for developing novel adsorptive materials based on bio-waste recycling and processing. For this purpose, we have designed a methodological framework, under the form of an algorithmic procedure, including the following activity stages and decision nodes (denoted by a Latin letter in parenthesis or a number in brackets, respectively), interconnected as shown in the corresponding diagram of Fig.1.

(A): GIS-aided waste biomass recording (per species) in the wider region under consideration.

(B): Selection of proper waste bio-species per sub-region, occurring in adequate quantities to form reliable raw bio-waste material for a downstream biomass-to-energy industrial unit.

(C): Bio-waste collection.

(D): Bio-waste transportation.

(E): Bio-waste storing.

(F): Waste biomass modification/processing.

(G): Product logistics.

(H): Product utilization.

(I): Waste logistics.

(J): Waste recycle.

(K): Waste incineration.

(L): Waste disposal.

[I]: Are there proper bio-waste species?

[II]: Are the respective bio-waste species adequate in quantity and supply rate in the long-run in order to support production within the downstream unit higher than the breakeven point (on condition of market availability)?

[III]: Is the waste going to recycle or incineration or disposal (denoted by r, i, d, respectively) stage?

[IV]: Is the waste going to incineration or disposal stage?

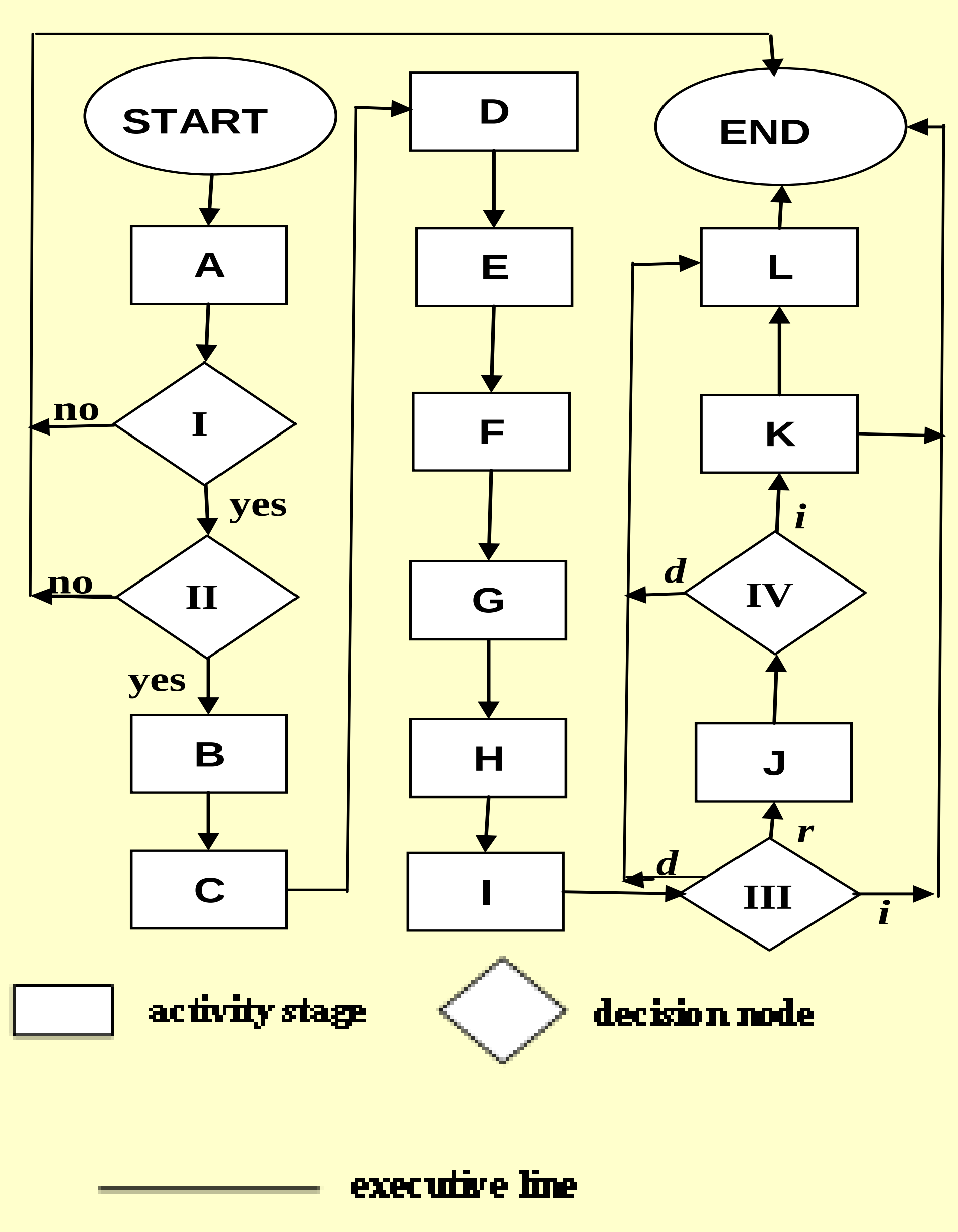

Figure 1: The methodological framework we have designed under the form of an algorithmic procedure for applying a project management approach in developing waste-to-energy processes and novel materials based on bio-waste recycling

Implementation

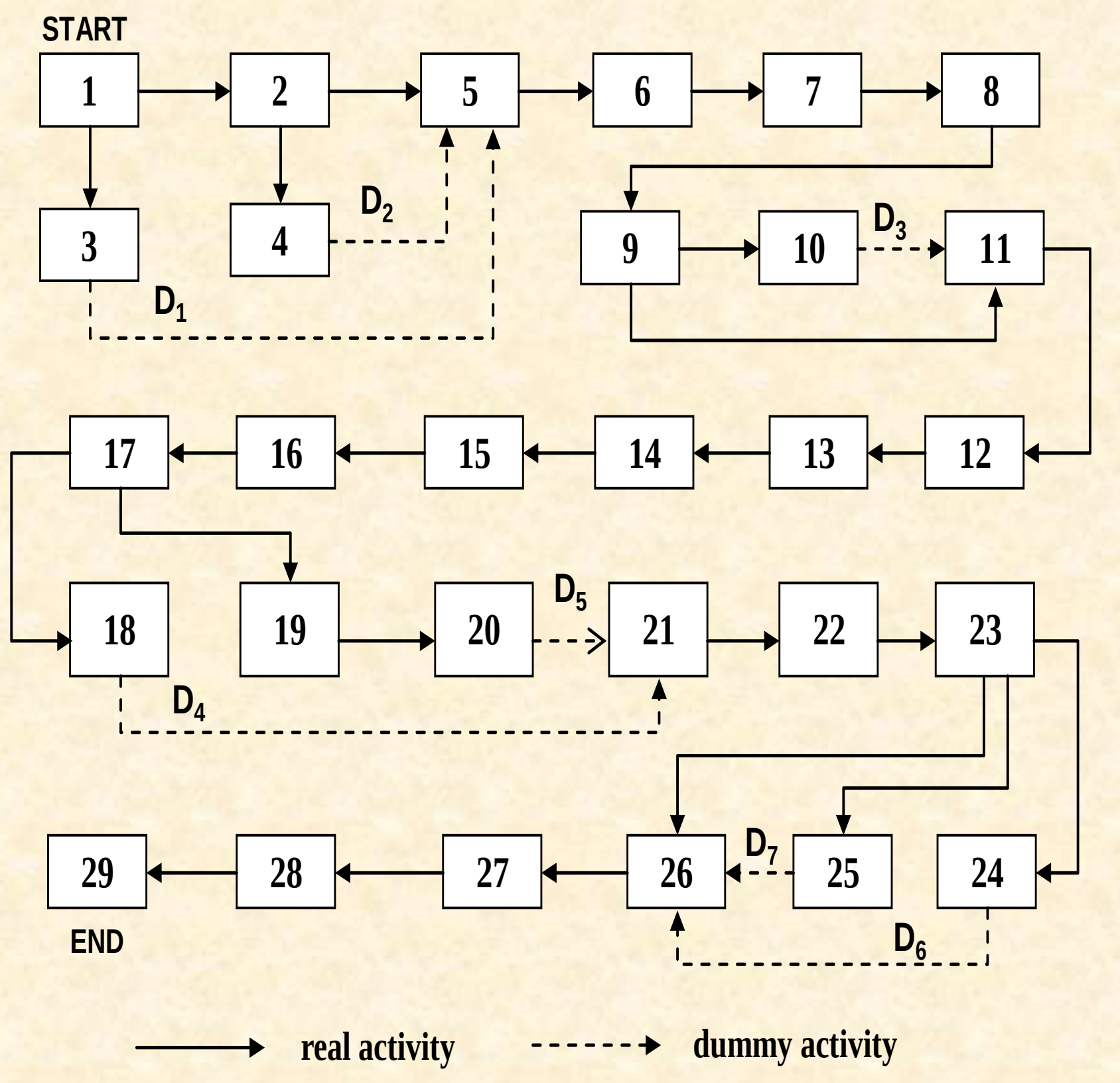

Figure 2. Arrow/network diagram representing the activities that take place within stage (F), i.e., biomass processing, of a R&D project for developing novel adsorptive materials based on bio-waste recycling. Each arrow represents a unique activity with its head indicating the direction of progress of the project. Each event (boxed number) represents a point in time that signifies the completion of some activities and the beginning of new ones. The dummy activities, D_1, D_2, D_4, D_5, D_6, D_7 are used to establish correct precedence activities; D_3 is used to identify activities (namely, 'collection of biomass modification methods', 'selection of criteria for comparative evaluation of biomass modification methods') that have common start and end events.

Table II: Fuzzy and stochastic duration per activity. Centr. : Crisp number obtained by defuzzification with the centroid method for fuzzy-CPM. Var. : Variance of earliest expected duration (Exp.) for PERT.

Activity	Centr.	Exp.	Var.
1,2	12.167	11.933	0.538
1,3	14.033	14.167	0.360
2,4	3.567	3.483	0.047
2,5	5.567	5.683	0.123
5,6	11.767	11.883	0.267
6,7	27.367	27.283	0.967
7,8	4.867	4.783	0.123
8,9	1.633	19.367	0.810
9,10	7.933	7.967	0.160
9,11	9.400	9.300	0.321
11,12	24.000	23.900	1.604
12,13	2.600	2.550	0.014
13,14	6.100	6.100	0.054
14,15	50.500	49.600	2.668
15,16	4.033	4.017	0.023
16,17	37.266	37.083	1.480
17,18	10.5	10.35	0.340
17,19	15.366	15.333	0.284
19,20	4.233	4.166	0.04
19,21	5.666	5.633	0.04
21,22	8.166	8.283	0.146
22,23	57.366	57.133	1.69
23,24	6.866	6.983	0.100
23,25	12.533	12.516	0.613
23,26	28.6	28.65	1.322
26,27	22.9	22.5	1.69
27,28	7.133	7.066	0.134
28,29	13.1	12.8	0.64

Table III: Earliest time, variance of earliest time, scheduled time (Earl., VET, Sched., respectively) and probability (Pr.) of [Earl. > Sched.] per event.

Event	Earl.	VET	Sched.	Pr.
1	0.000	0.000	0	0.000
2	11.930	0.538	12	0.464
3	14.170	0.360	26	0.000
4	15.420	0.047	15	0.973
5	16.620	0.660	18	0.319
6	29.500	0.927	30	0.302
7	56.780	1.894	59	0.054
8	61.570	2.017	63	0.156
9	80.930	2.827	79	0.875
10	88.900	0.160	87	1.000
11	90.230	3.148	91	0.333
12	114.130	4.752	116	0.196
13	116.680	4.766	119	0.144
14	122.780	4.820	126	0.071
15	172.380	7.488	175	0.169
16	176.400	7.511	180	0.094
17	213.480	8.991	219	0.033
18	223.830	0.340	228	0.000
19	228.820	9.275	231	0.237
20	232.980	0.040	232	1.000
21	234.450	9.315	237	0.202
22	242.730	9.462	245	0.231
23	299.870	11.152	296	0.877
24	306.850	0.100	300	1.000
25	312.380	0.614	310	0.999
26	328.520	12.475	337	0.008
27	351.020	14.165	350	0.606
28	358.080	14.299	362	0.150
29	370.880	14.939	375	0.143

Discussion and Concluding remarks

The project completion time *X* (considered as the independent/stochastic variable) optimization is achieved by minimizing total cost *C* consisted of two conflict partial variables C_1 and C_2, representing cost of stage (F) and cost of the rest downstream stages, respectively: the higher the cost C_1, due to performing more scale-up effort, the lower the cost C_2, due to producing lower-cost of higher-quality product. X_{opt} is estimated at $C_{min}=(C_1+C_2)_{min}$ as an equilibrium point of this tradeoff, allowing for sensitivity/ robustness analysis to examine the influence/impact of endogenous and exogenous factors, like the accumulation of experience in the time course (known as 'learning by doing') and the increase of oil prices in the long run, respectively. C_1 a stepwise function, corresponding to five scale-up levels of experimentation: Lab, Bench, Pre-pilot, Pilot, Prototype

Within the same activity at a certain scale-up level, the duration *T* can be compressed by increasing the allocated resources and, consequently, the corresponding expenditure *E*. Evidently, there is a limit, called 'crash time', beyond which no further reduction in the duration can be effected because of technical constraints. We can determine optimal duration T_{opt} at $T_{min}=(T_1+T_2)_{min}$, where T_1 is the indirect expenditure due to fiscal policy at both, macroeconomic and microeconomic/sectoral levels, and E_2 is the direct expenditure for the resources to be used. E_1 is an increasing function of *T* with an increasing rate (i.e., $dE_1/dT>0$ and $d^2E_1/dT^2>0$), since risk and consequently the corresponding cost of money increases disproportionally in the region of high *T*-values. On the contrary, is a decreasing function of *T* with an increasing algebraic or decreasing absolute rate (i.e., $dE_2/dT<0$ and $d^2E_2/dT^2>0$ or $d|dE_2/dT|/dT<0$) because of the validity of the Law of Diminishing Returns. The T_{opt}-value is determined at $d(E_1+E_2)/dT=0$ or $ME_1=ME_2$, where $ME_1=dE_1/dT$ and $ME_2=|dE_2/dT|$ are the marginal values of E_1 and E_2, respectively.

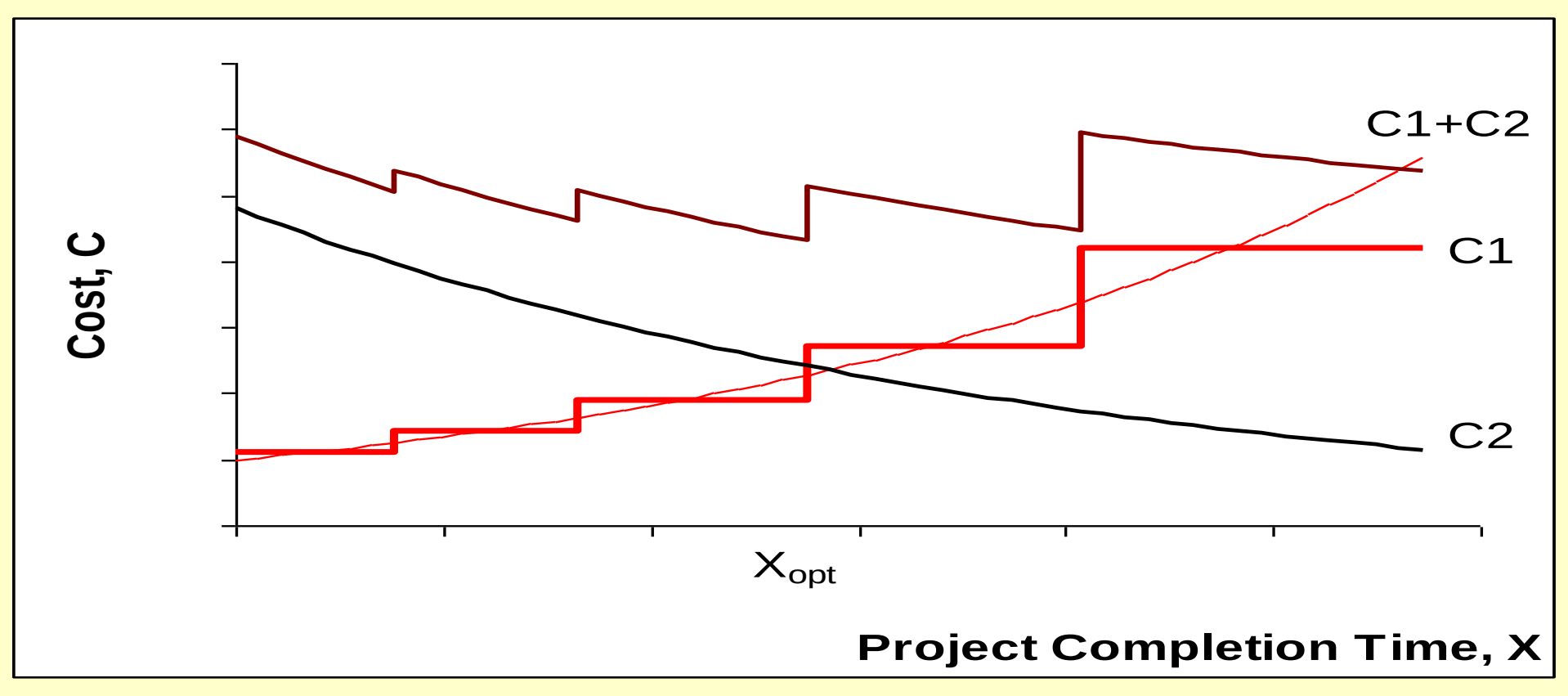

Figure 3. Dependence of cost C on project completion time X and determination of X_{opt} at $C_{min}=(C_1+C_2)_{min}$

Figure 4: Adsorption columns (top) of stainless steel at lab/bench scale and (bottom) of polymethyl-methacrylate (PMMA) at Pre-pilot (in the right hand side) and pilot scale, adsorbing methylene blue on modified biomass.

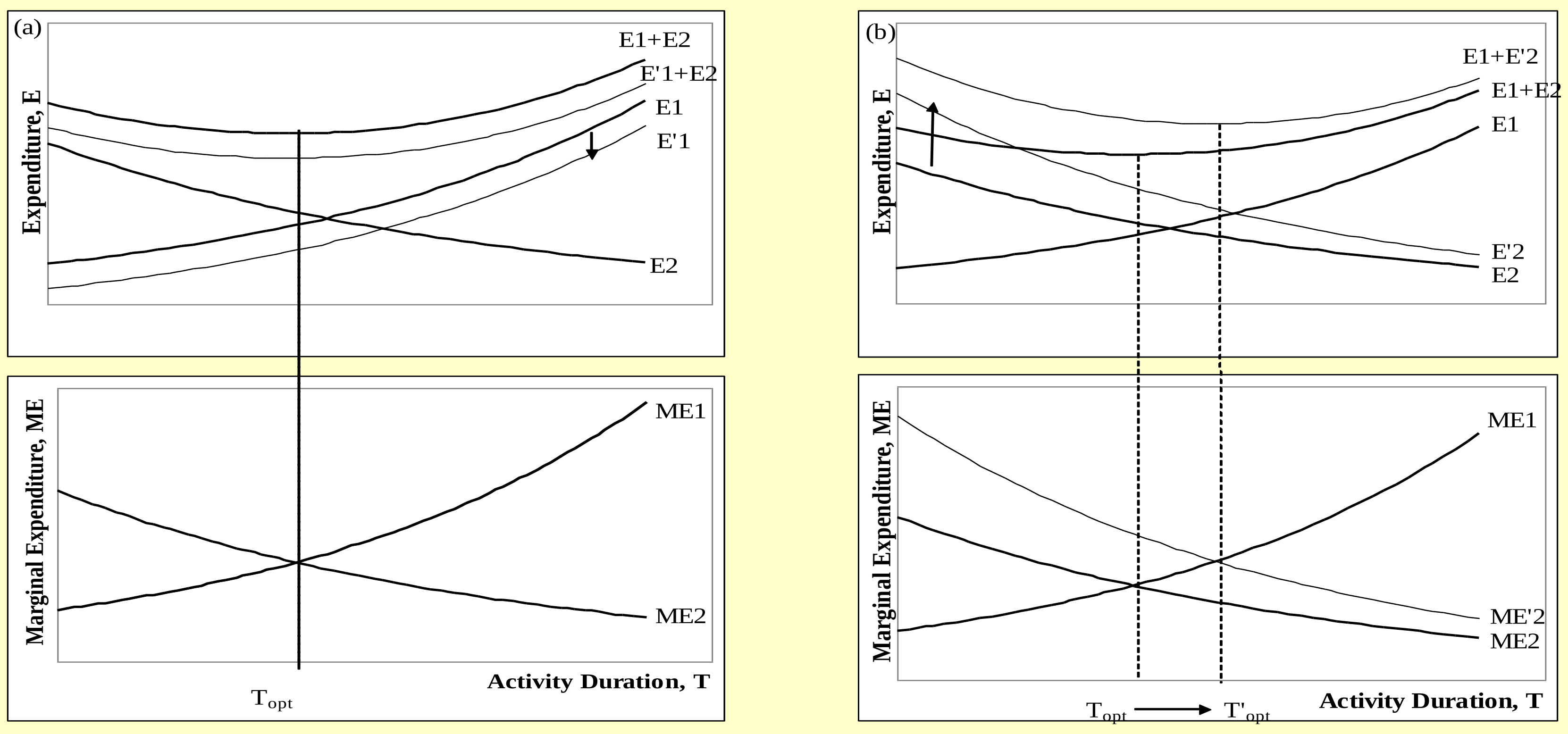

Figure 5: Dependence of Expenditure E on Activity Duration T during compression, and sifting of T_{opt}, when (a) the rate of interest dicreases and (b) law clauses become stricter.

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