DYNAMICS OF DEVELOPMENT COST STRUCTURE

By
Ali Naghi Mashayekhi
Associate Professor
Institute for Research in Planning and Development
P.O. Box 11365/193
Tehran, Iran
November 1990

ABSTRACT

A cost structure is presented for the development projects based on two kinds of cost: base cost and progress cost. The base cost is necessary to keep a project alive and ready for real progress. The progress cost is to make physical progress in the project. A dynamic model is made and simulated to show the behavior of this cost structure. The model shows that when development budget is not sufficient to pay for all the required expenses of on going development projects, total cost of development projects would increase and completion time of the projects would rise. Insufficiency of development budget occurs either by decline of government revenues or by start of too many new projects. In the face of insufficient budget, it becomes very crucial to decrease the starting rate of the new projects. By decreasing the number of starting projects, the behavior of the model in terms of completion time and unit cost of the projects improves considerably when budget insufficiency appears.

INTRODUCTION

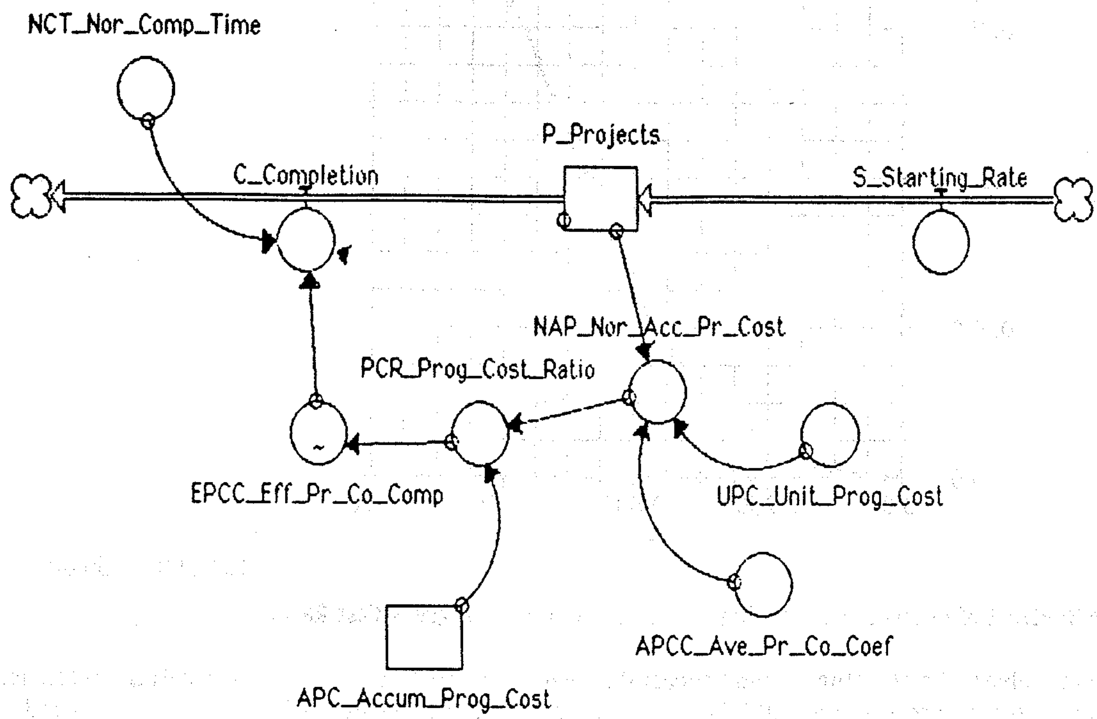
In developing countries, governments spent considerable fraction of their annual budget as development budget to execute development projects. Development projects are initiated to accelerate development process, to increase national investment, to construct new production or infrastructure capacity, and to satisfy some basic needs of the population such as education and medical services. In Iran, development budget constitute more than 25 percent of total annual budget of the government and currently is more than 1000 milliard Rials in each year. Effective and efficient management of development budget is very essential to the development process. Mismanagement of development budget leads to wasteful usage of scarce resources without resulting expected new capacity.

A cost structure for the development projects is proposed. Based on the cost structure of the development projects, this paper explains one aspect of development budget management which appears to have very dramatic effects on both efficiency and effectiveness. The paper presents a dynamic model for the cost structure of the development projects. Analysis of the model shows that when too many projects relative to the development resources starts or when development budget relative to the required budget for execution of on going development projects decreases, both efficiency and effectiveness of the development management drops considerably. The paper shows that maintaining the balance between on-going projects and development budget is essential to an effective and efficient management of development.

A COST STRUCTURE FOR DEVELOPMENT PROJECTS

Two kinds of cost can be recognized in the development projects which I call the *base cost* and the *progress cost*. The *base cost* refers to those expenditures in a project which are necessary to keep a project ready for the real progress. Expenditures related to the *base cost* include such items as salaries of project manager and his stuff (like secretaries, administrative, technical, and commercial employees, accountants, and guards), building and building services, construction machinery and equipment which are held in the project site, minimum charges made by consultants and contractors which are kept ready to provide the necessary services to the project as requested. The progress cost refers to those expenditures that generate real progress in the project. Expenditures related to the progress cost include the cost of such activities as engineering, construction, procurements, erection, commissioning and testing. During design and execution of development projects both base and progress costs occur and accumulate. When progress cost is accumulated to a certain required level, projects get completed. Completion of a development project requires that all necessary progress expenses are spent up to the level that project is finished.

To model the cost structure of development budget, three state variables are considered: P as the number of projects under development, APC as accumulated progress cost, and ABC as accumulated base cost for the projects under development. Figure 1 Shows the structure around the development projects and corresponding equations.



P = P + dt * (S - C)
INIT(P) = 100
S = 25
C = (P/NCT)*EPCC
NCT = 4
EPCC = graph(PCR)
PCR = APC/NAP
NAP = UPC*P*APCC
UPC = 1
APCC = .5

Figure 1: Development Projects Starting and Completion Rate

Development Projects, P, is increased by starting rate of new projects, S, and is decreased by completion rate , C. Starting rate of new projects is assumed to be exogenous and constant. Completion rate is equal to the number of development projects divided by normal completion time, NCT, and multiplied by the effect of adequacy of progress cost on completion rate, EPCC. Normal completion time is assumed to be 4 years. Effect of adequacy of progress cost is a function of progress cost ratio, PCR, and is shown graphically in Figure 2. PCR is the ratio of accumulated progress cost, APC, to normal accumulated progress cost, NAP, for the number of projects under development. NAP is equal to the multiplication of unit project cost, UPC, number of projects, P, and accumulated progress cost coefficient, APCC. The unit project is defined such that unit progress cost, UPC, is 1 million rials per project. It is assumed that at the steady state on average about fifty percent of the progress cost of the projects under development is done. Therefore to obtain normal accumulated progress cost for the project under development, NAP, accumulated progress cost coefficient is set equal to .5. When accumulated progress cost, APC, decreases lower that normal accumulated progress cost, NAP, and progress cost ratio is less than one, then effect of adequacy of progress ~~cost on completion~~ rate, EPCC, becomes less than one, as shown in Figure 2, and completion rate decreases.

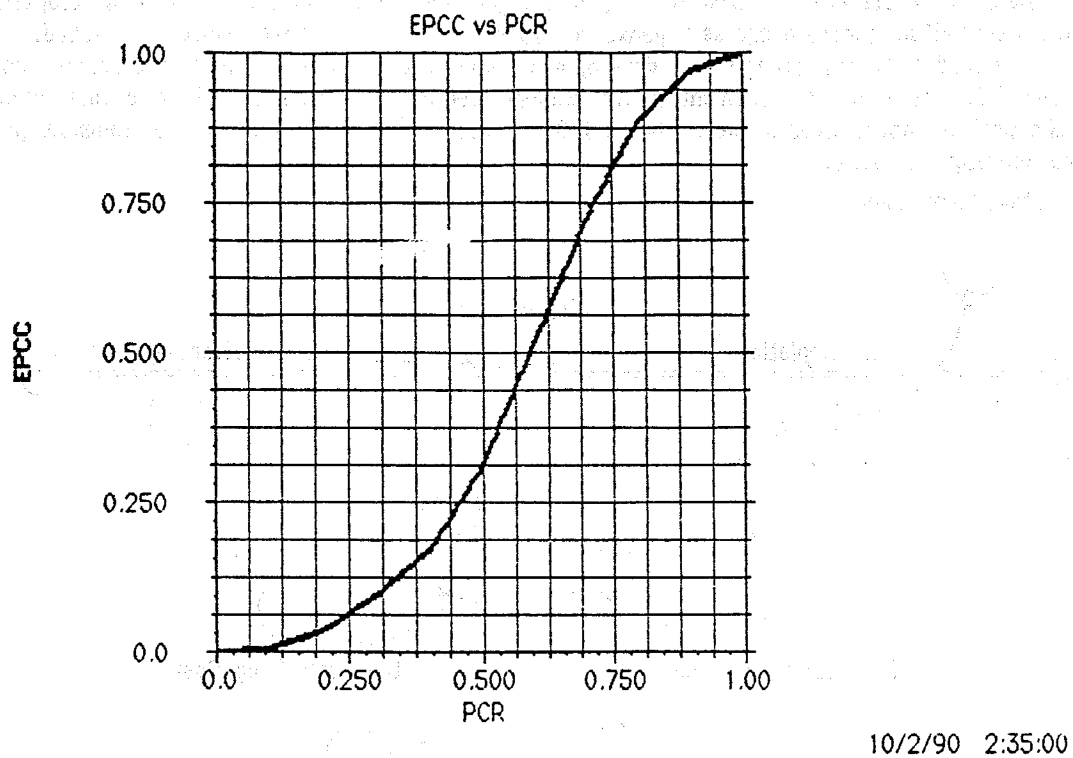
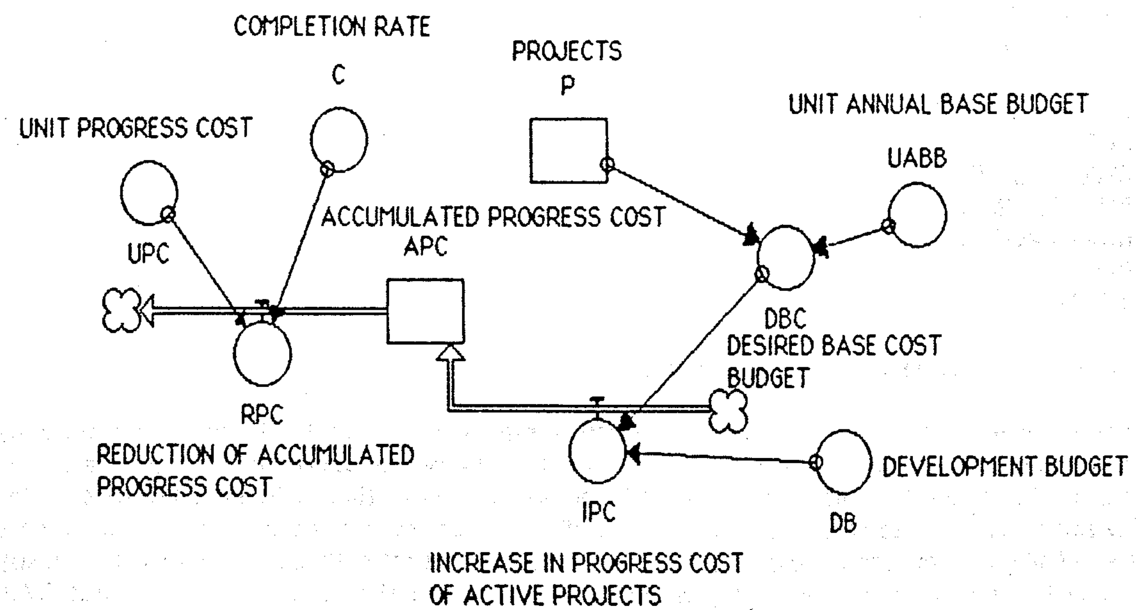


Figure 2: Effect of Progress Cost on Completion Rate Versus Progress Cost Ratio

Figure 3 Shows the structure around accumulative progress cost, APC, and corresponding equations. Increase in accumulated progress cost, IPC, is the difference between development budget, DB, and desired



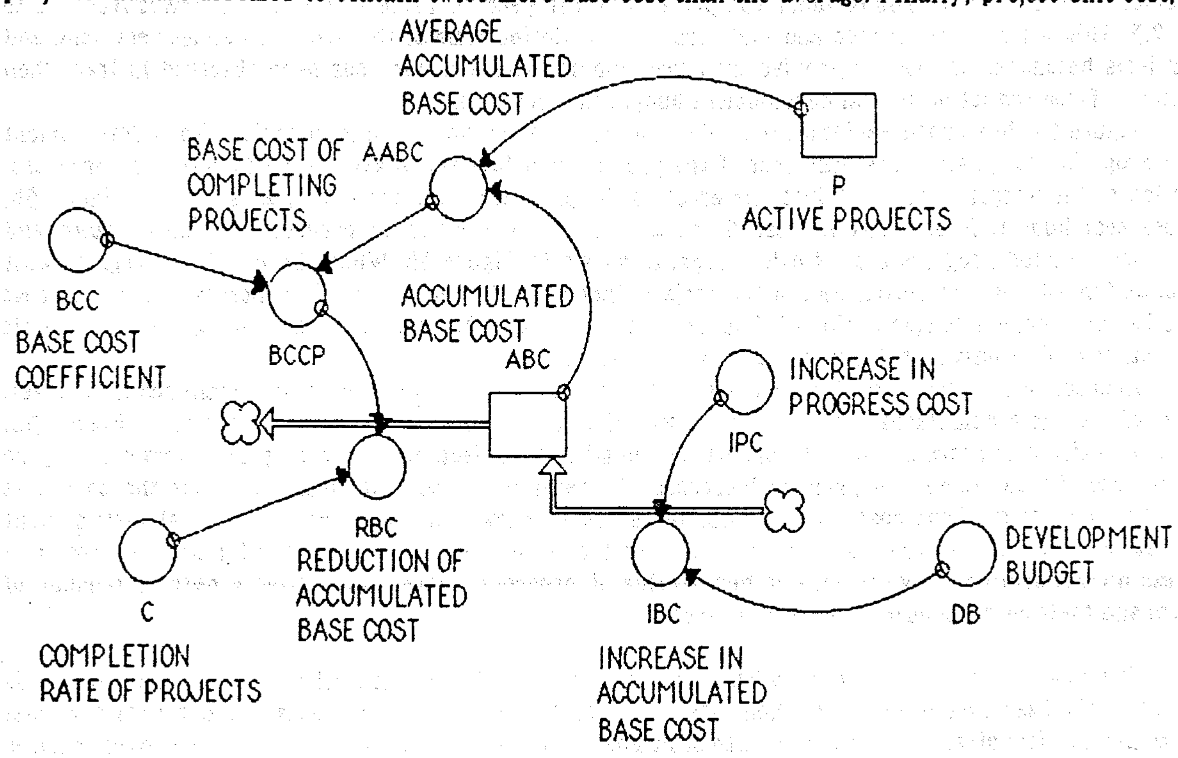
APC = APC + dt * (IPC - RPC)
INIT(APC) = 50
IPC = MAX((DB-DBC),0)
DBC = P*UABB

RPC = UPC*C

Figure 3: Accumulated Progress Cost and Corresponding Equations.

based cost budget, DBC, if such difference is greater than zero and otherwise IPC will be zero. Therefore, it is assumed, in the model, that the development budget is used first to finance the base cost of the projects to keep them ready for progress and then the remaining budget is used to finance the progress cost. Desired based cost budget, DBC, is the number of active projects, P, times unit accumulated based budget, UABB, which indicates the necessary annual base budget for each unit of project. Reduction of accumulated progress cost, RPC, is completion rate of the progress, C, times unit progress cost, UPC, that indicates the necessary progress cost of each unit of project to get completed.

Figure 4 Shows the structure around accumulative base cost, ABC, and corresponding equations. Increase in accumulated base cost, BCB, is the difference between development budget, DB, and the rate of increase in progress cost of active progress. Reduction of accumulated base cost is base cost of completing projects, BCCP, times the completion rate, C. Base cost of completing projects, BCCP, indicates the base cost of completing unit projects and is average accumulated base cost, AABC, times base cost coefficient, BCC. Average accumulated base cost, AABC, is accumulated base cost, ABC, divided by active projects, P. Base cost coefficient, BCC, is to adjust average accumulated base cost for the base cost carried on by the completing projects that are assumed to contain twice more base cost than the average. Finally, project unit cost, PUC,



ABC = ABC + dt * (BCB - RBC)
INIT(ABC) = 20
BCB = DB-IPC
RBC = BCCP*C
BCCP = AABC*BCC
AABC = ABC/P
BCC = 2
PUC = BCCP+UPC

Figure 4 : Accumulated base cost and corresponding equations.

that indicates completing projects unit cost, is the sum of unit progress cost, UPC, and base cost of completing projects, BCCP.

DYNAMIC BEHAVIOR OF DEVELOPMENT COST:

Assume that in each year a number of new development projects starts and adequate development budget is provided to finance all the projects and finish them during a normal time of 4 years. The model presented in the previous section starts under such equilibrium conditions and then in year 5 development budget is reduced by 20 percent. However, the starting rate of new projects is kept constant as it was before the budget reduction. In fact due to the growth of population and a huge amount of unsatisfied basic needs, there are a lot of socio-political pressures to start new development projects in different parts of the country in spite of reduction in available budget. Due to those pressures, in the real world, there is a resistance against the reduction of starting rate of the new projects. If the development management yields to such pressures, starting rate will remain at least constant. In order to examine the consequences of top management yielding to such pressures, the starting rate is kept constant.

Figures 5a through 5c show the behavior of the model under the above conditions. Figure 5a shows that the model starts from equilibrium and then in year 5 development budget is reduced 20 percent from 35 to 28 billion Rials. As the result of such disturbance, actual completion time of development projects increases from 4 years at the beginning of the simulation to about 500 years in year 24. Projects under development increases from 100 to about 400 project units in year 24. Project unit cost increases from 1.4 to about 2.5. This behavior is strange and undesirable. Completion time of the projects become very long and the projects become much more expensive than they should. Such behavior has been observed in Iran when the country faced reduction in real development budget in recent years.

Figure 5b shows some variables to explain the reasons for undesirable behavior. When development budget drops in year 5, since the base cost of the project must be paid to keep projects ready for progress, reduction of the budget is completely transferred to the progress cost. Therefore, as shown in Figure 5b, progress cost budget, PCB, drops in year 5. As a result, accumulation of progress cost slows down and average accumulated progress cost, AAPC, drops, as shown in Figure 5b. When the required progress cost can not be funded, the completion time of the projects increases. As completion time increases, the base cost should be paid during a longer period of time for each project and therefore the total cost to complete a unit of project, or project unit cost, increases as shown in Figure 5a.

In order to complete a project, accumulated progress cost should reach to a certain required level. Decline of average accumulated progress cost causes the completion rate to drop, as shown in Figure 5b. When completion rate decreases below starting rate, number of projects under development, shown in Figure 5a, increases. As the number of projects increases, the necessary base cost rises and since the base cost budget has a priority, base cost budget, BCB, increases as shown in Figure 5b. Since total development budget is constant, rise of base cost budget decreases the amount of budget available for progress cost and progress budget declines, Figure 5b. Further decline of progress budget intensifies growth of number of projects and their corresponding required base cost.

The growth of base cost budget with a growing trend continues until all the development budget is allocated to the base cost in year 18. Then after, base cost budget remains constant and progress budget becomes zero. In fact after year 18 that growth of number of projects continues and base cost budget remains constant, development budget is not enough to cover even the base cost. Under such condition, completion rate is approaching to zero and completion time increases with a growing trend and becomes very large as it is shown in Figure 5b.

A NEW STATRTING RATE POLICY

In order to improve the undesired behavior of the previous section a new starting rate policy is examined. According to the new policy, starting rate is not constant, but it is determined by budget availability. The equation of the new starting rate policy is as follows:

S=25*EBAS
EBAS=graph(BA)
BA=DDB/DB

Where S is starting rate, EBAS is effect of budget availability on starting rate, BA is budget availability, and DDB is desired development budget, and DB is development budget. As is indicated in the above equation, effect of budget availability is a function of budget availability. The graphical shape of the function is shown in Figure 6. When budget availability is zero, according to the new policy, EBAS is zero and no new project starts. When budget availability is one or greater than one, indicating no budget shortage, effect of budget availability on starting rate is one and starting rate of new projects is 25 projects per year.

Figures 7a through 7b show the behavior of the model under the new policy. Figure 7a shows that the model starts from the same equilibrium as before, and then in year 5 development budget is reduced 20 percent from 35 to 28 billion Rials as it did in the previous run. As the result of such disturbance under the new policy, actual completion time of development projects remains almost the same and does not increase as it did in the previous run. Projects under development decreases from 100 to about 90 project units in year 24, while in the previous run it increased to 400 project units. Project unit cost increases only very slightly above initial value of 1.4. This behavior under new policy is much better than the behavior in the previous section. Neither completion time nor project unit cost increases as they did before. The new policy improves the behavior of the model considerably.

Figure 7b shows some variables to explain the reasons for the desirable behavior. When development budget drops in year 5, budget availability decreases and as a result, under the new policy, starting rate, shown in Figure 7a, drops and becomes less than completion rate until about year 8. As starting rate becomes less than completion rate, projects under development, shown in Figure 7a, decreases and so does the base cost budget, shown in Figure 7b. When the base cost budget falls, more fund is available for the progress cost budget and, as shown in Figure 7b, progress cost budget starts to rise after its initial drop in year 5. Therefor, decline of completion rate, that starts in year 5 due to drop of progress budget, slows down and reaches a new equilibrium around year 12. At the new equilibrium, completion rate becomes proportional to the stable progress cost.

SUMMARY AND CONCLUSION

In development projects, two kinds of cost can be identified: base cost and progress cost. The base cost is necessary to keep a project alive and ready for real progress. The progress cost is to make physical progress in the project. A dynamic model of the cost structure of development projects was presented. The model shows that when development budget is not sufficient to pay for all the required expenses of on going development projects, if starting rate of the new projects does not respond, then total cost of development projects would increase and completion time of the projects would rise. Insufficiency of development budget occurs either by decline of government revenues or by start of too many new projects. It is very crucial to have a policy under which the starting rate of the new projects is responsive to the availability of the budget.

Under such responsive policy, when development budget falls and decreases budget availability, starting rate of new projects falls and the number of projects under development decreases. As the number of projects under development falls, the base budget cost decreases and more fund becomes available for progress cost. Higher progress cost increases completion rate. In addition, as the number of projects under development drops, budget availability increases and starting rate rises after its initial drop and reaches to a new equilibrium below its initial value and proportional to new lower development budget. Under the new policy, system adjusts the starting rate of the new projects in accordance with the available budget. Such adjustment does not let the number of projects to increase and use up available budget to pay for the base cost by lowering the progress cost budget and not making any real progress in the development budget.

LIST OF EQUATIONS:

```
ABC = ABC + dt * ( BCB - RBC )
INIT(ABC) = 20
ABCCP = ABCCP + dt * ( RBC )
INIT(ABCCP) = 0
ACC = ACC + dt * ( CC )
INIT(ACC) = 0
ACP = ACP + dt * ( C )
INIT(ACP) = 0
APC = APC + dt * ( PCB - RPC )
INIT(APC) = 50
APCCP = APCCP + dt * ( RPC )
INIT(APCCP) = 0
P = P + dt * ( S - C )
INIT(P) = 100
AABC = ABC/P
ACCP = (APCCP+ABCCP+ACC)/ACP
ACT = P/C
APCC = .5
BA = DB/DDB
BCB = DB-PCB
BCC = 2
BCCP = AABC*BCC
C = (P/NCT)*EPCC
CC = (ABC+APC)*I
DB = 35*(1+STEP(-.2,4))
DBC = P*UABB
DDB = DBC+(UPC*P)/NCT
I = .12
NAP = UPC*P*APCC
NCT = 4
PCB = MAX((DB-DBC),0)
PCR = APC/NAP
PUC = BCCP+UPC
RBC = BCCP*C
RPC = UPC*C
S =IF STSP=0 THEN 25 ELSE 25*EBAS
STSP = 1
UABB = .1
UPC = 1
EBAS = graph(BA)
(0.0,0.0),(0.200,0.0),(0.400,0.0400),(0.600,0.200),(0.800,0.560),(1.00,1.00),(1.20,1.36),(1.40,1.61),(1.60,1.
80),(1.80,1.91),(2.00,1.99)
EPCC = graph(PCR)
(0.0,0.0),(0.100,0.00500),(0.200,0.0350),(0.300,0.0950),(0.400,0.170),(0.500,0.315),(0.600,0.520),(0.700,0.
725),(0.800,0.885),(0.900,0.970),(1.00,1.00)
```

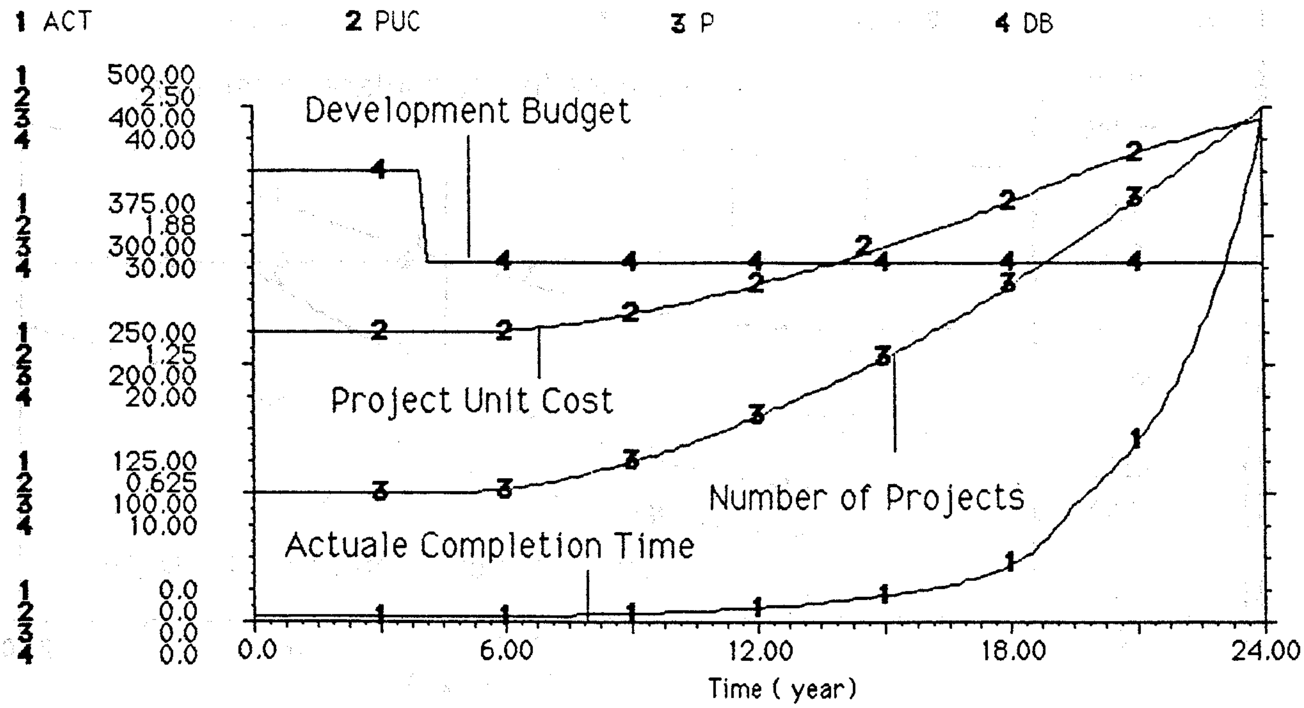


Figure 5a: The base run of cost dynamics

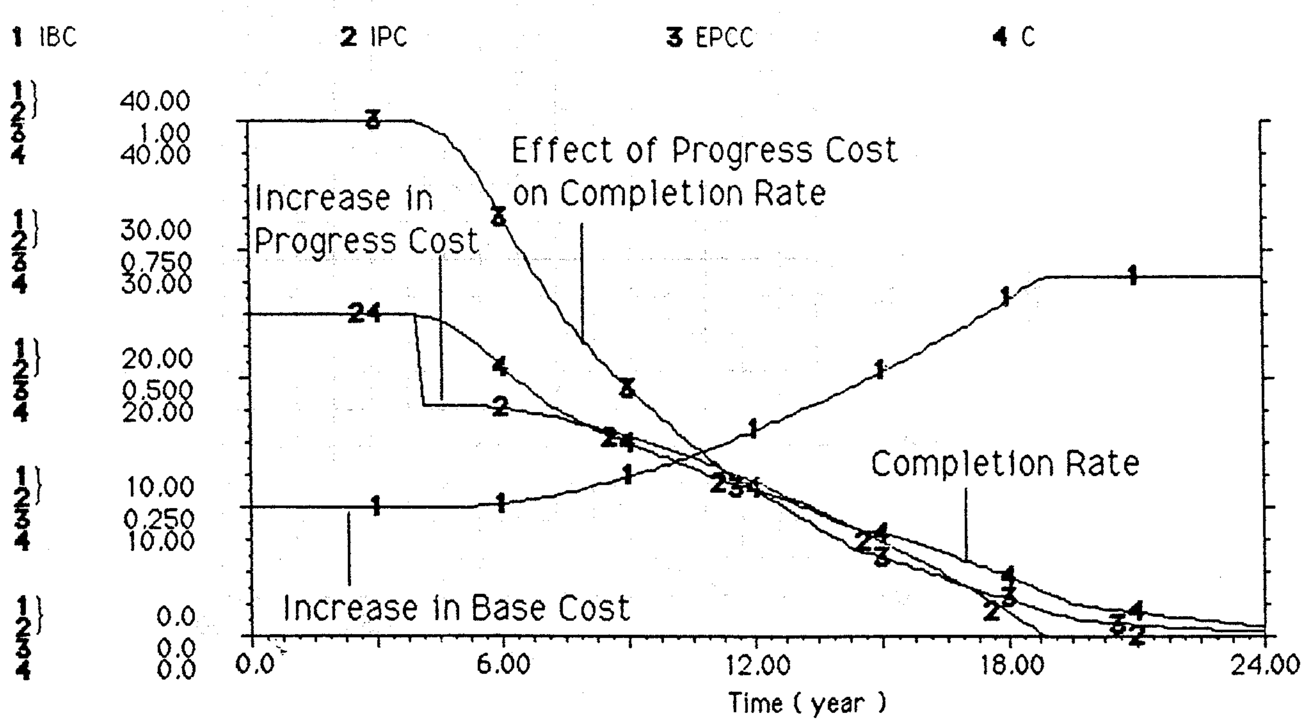


Figure 5b: The base run of cost dynamics.

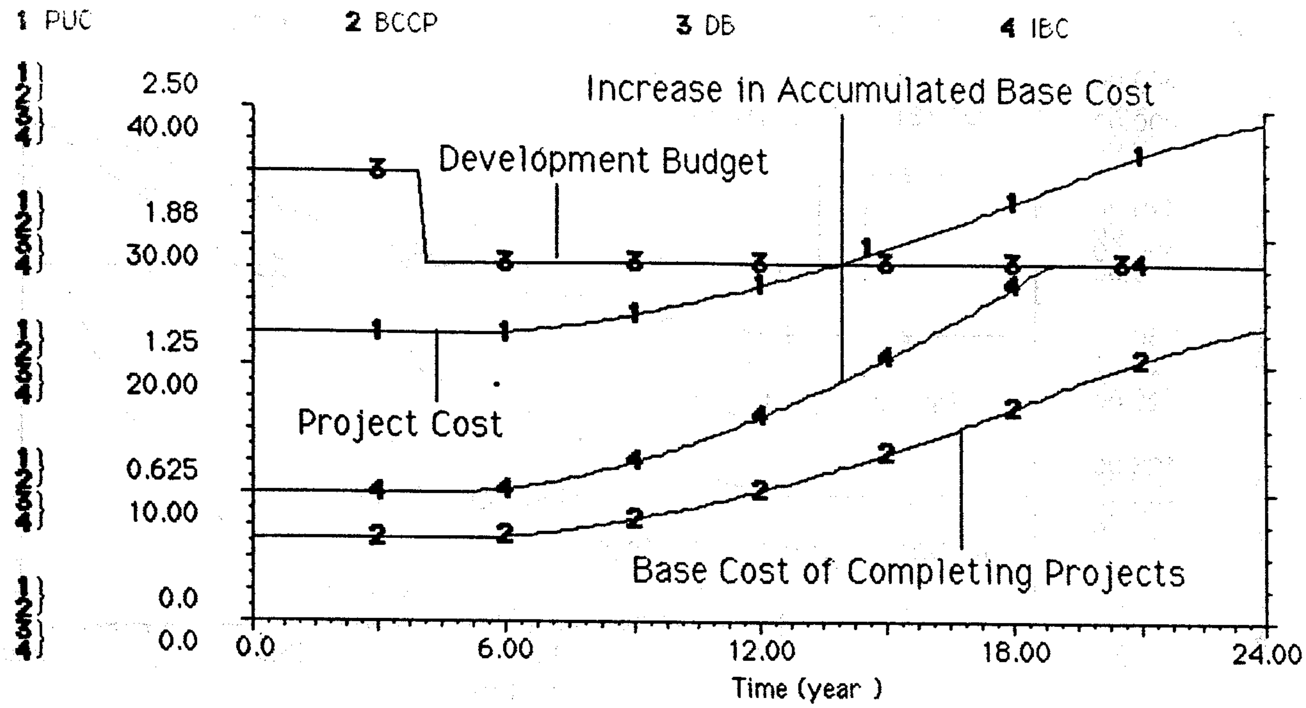


Figure 5c: The base run of cost dynamics.

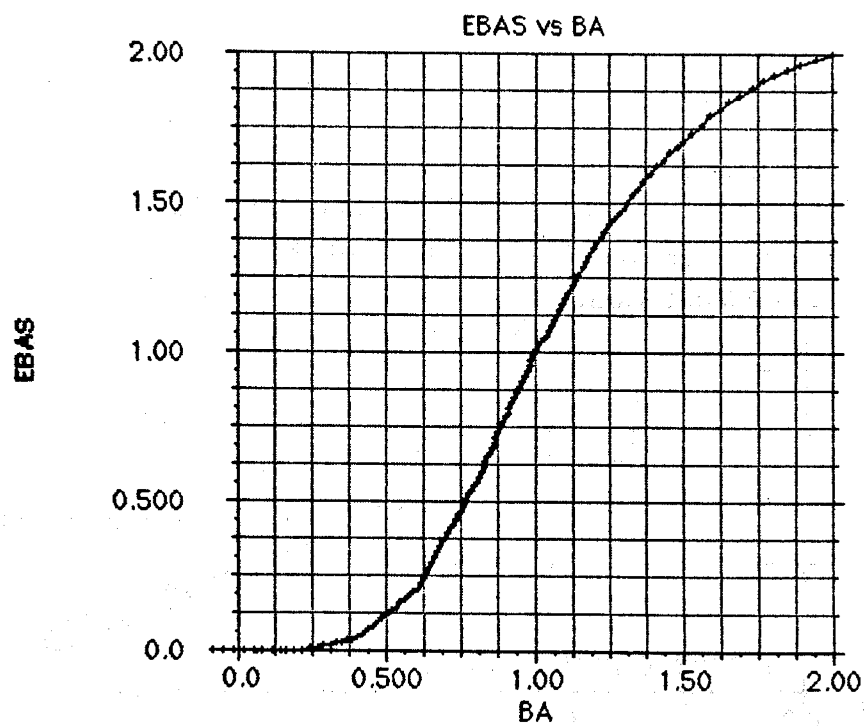


Figure 6: Effect of Budget Availability on Starting Rate Versus Budget Availability.

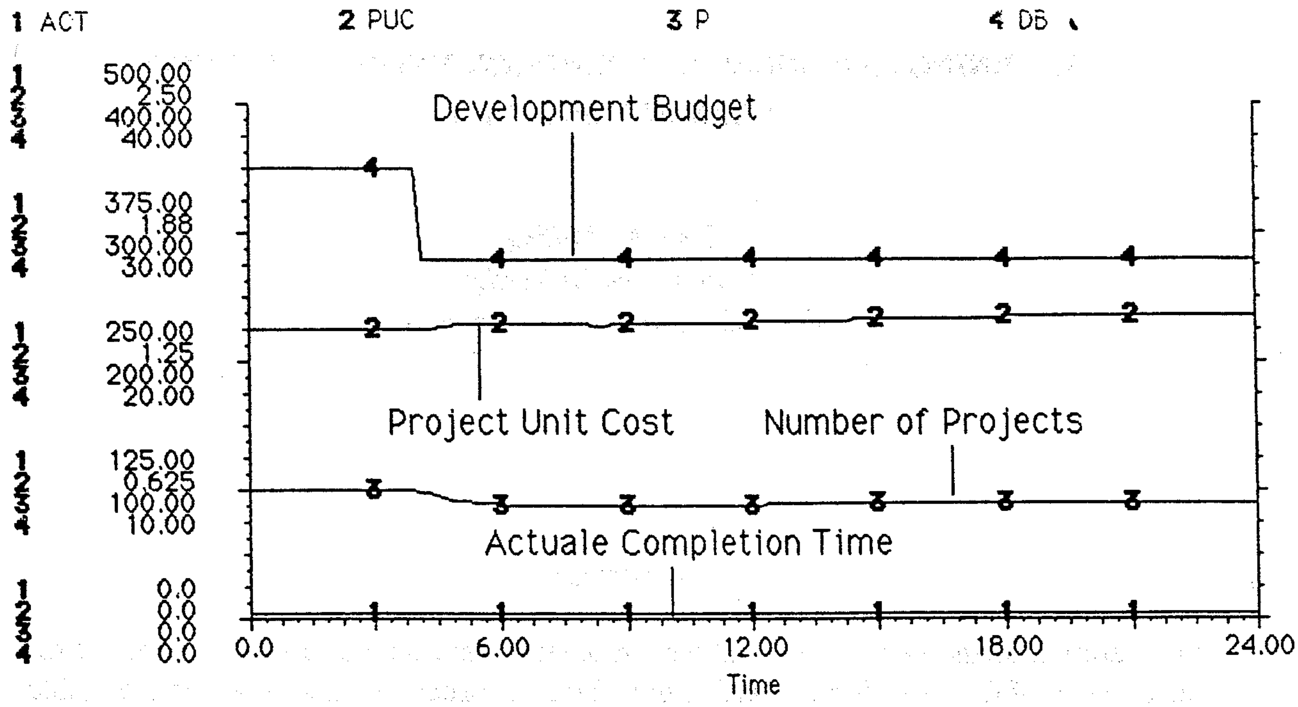


Figure 7a: New Starting Rate Policy.

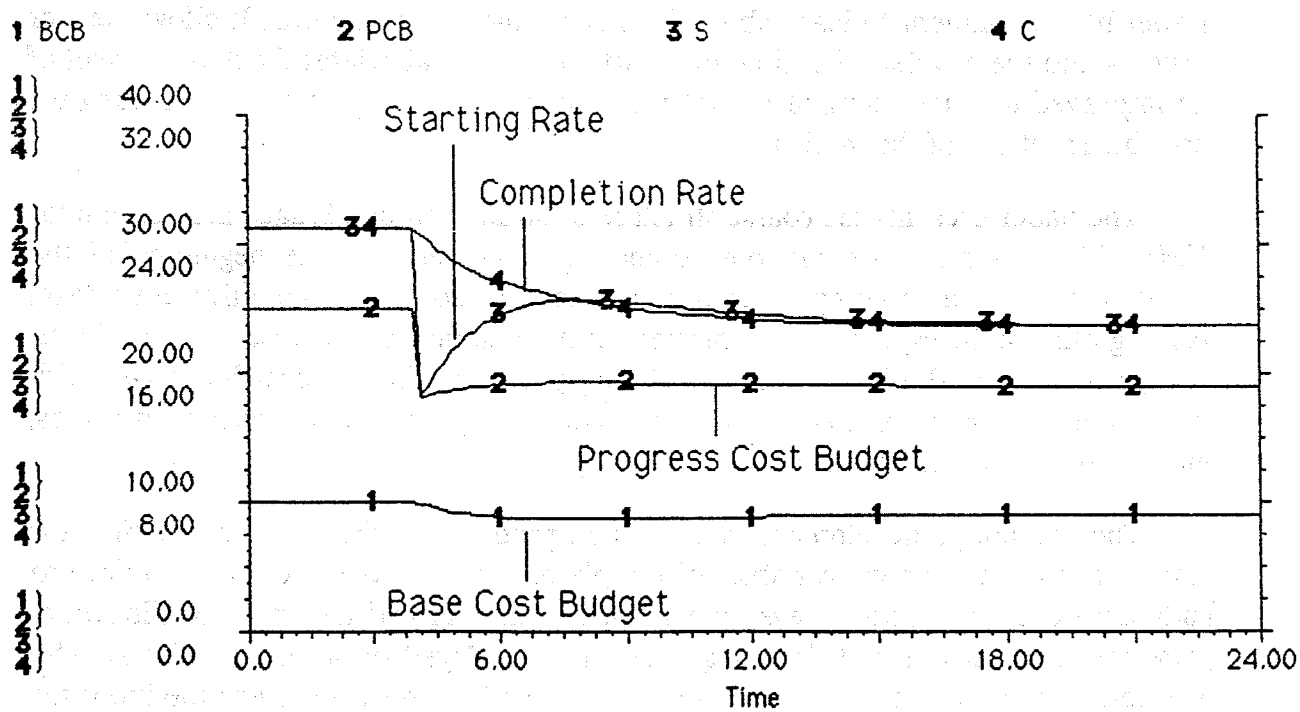


Figure 7b: New Starting Rate Policy.