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T. Wiatr MSc.

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CAPITAL EXPENDITURE AND RECEIPTS ANALYSIS IN CONSTRUCTION PROJECT MANAGEMENT (DESCRIPTION OF THE MODEL)

T. Wiatr

Poznań University of Technology

1. Problem outline

Traditional project planning in construction industry focuses on the issues of the production process, highlighting elements such as rhythm, continuity, and uniformity. This situation is reflected in an informal and unofficial two-stage management structure of many organisations. It assumes the existence of a higher level of management, specialising in the issues of economy and finance, and a lower (separated) level of management specialising in the issues of technology and production. In this arrangement financial planning is highly general, with little relationship to the complex issues of technology and engineering. Today, in the age of integrated information systems, such an approach to management of project seems truly obsolete.

The approach needs changing by integrating the production planning and the financial planning into one system of management [1]. Looking at it from the theoretical standpoint, the problem can be presented as the question of optimum technological-economic control. The article focuses on the relations between what is spent and received relation to the value of works and project schedule (Fig 1). These relations may be a source of risk, especially in cash flow forecasting [2, 3]. It is very important problem because the extent of risk and uncertainty associated with construction projects is considerable and should not be underestimated [4].

2. Decomposition and systematisation

The project schedule is a basis of the production process in construction industry. The financial schedule (schedule of payments and cash flows) closely related to the schedule of works is a source of integration between the production planning and the financial planning (Fig 1). Cash events (inflows and outflows) reflecting receipts and expenditure are elements of the financial schedule. These events define the discrete character of distribution of the receipts and expenditure. Discrete form of expenditure is in the opposition to actual knowledge [3, 5] because cumulative expenditure are not continuous here (only value of works has a continued form of an S-curve). Proposed name of the model is IVO (Inflow-Value-Outflow) according to these features.

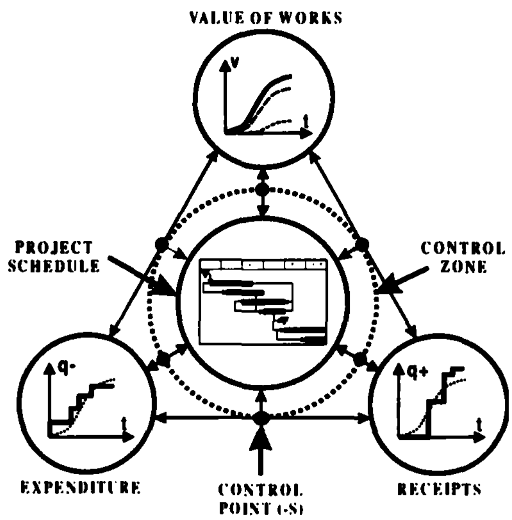

Fig 1. Ideograph of project control (simplified model)

A discrete distribution reflects the project cash flow and it is a basis for financial control. The control embraces four principal quantitative elements: every scheduled receipt should be characterised by quoting the amount received (Q+) and the time when the amount was received (T+). Similarly, every scheduled amount spent should be characterised by quoting the amount spent (Q-) and the time when the amount was spent (T-). Taking the four highlighted parameters into consideration, it has been assumed that each one may be known (answer = 1), or unknown (answer = 0). Basing on the above-defined dichotomy, a systematisation of simple cash flows has been worked out (Fig 2) and described (Table 1).

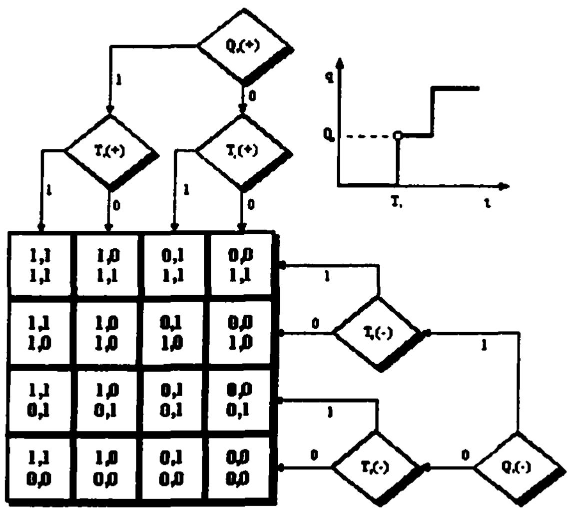

Fig 2. Dichotomic systematisation of simple cash flows

The scope of the classification contains fourteen cases and two extreme cases. The first occurs when the amounts of receipts and expenditure are precisely defined and is, therefore, a deterministic case reflected in the table by four positive answers (1,1/1,1). The other extreme case refers to the situation whereby the dates and amounts of receipts and expenditure are unknown, and it has been reflected in the table by means of four negative answers (0,0/0,0).

3. Interpretation of the model

In practical terms, the dates of some payments (cash events) may be defined rigidly by appropriate law regulations (for example, national terms of taxes – vat and so on) or by contract. In such cases, it must be mandatorily assumed that the date is known (answer = 1). A similar situation occurs in case of amounts which may be fixed at a certain level and, therefore, it should be assumed that the amounts are known (answer = 1).

Description of the simple cash flows (abbreviations: rec. – receipts, exp. – expenditure)

Q-	T-	Q+	T+	Explanation of the simple cash flows
group 1				**all parameters known**
1	1	1	1	known amounts and dates of receipts and expenditure
group 2				**one parameter unknown**
0	1	1	1	known amounts and dates of receipts and expenditure dates, unknown expenditure amounts
1	0	1	1	known amounts and dates of receipts and amounts of expenditure, unknown expenditure dates
1	1	0	1	known dates of receipts and amounts and expenditure dates, unknown amounts of receipts
1	1	1	0	known amounts of receipts and amounts and expenditure dates, unknown dates of receipts
group 3				**two parameters unknown**
0	0	1	1	known amounts and dates of receipts, unknown amounts and expenditure dates
0	1	0	1	known dates of receipts and expenditure, unknown amounts of receipts and expenditure
0	1	1	0	known amounts of rec. and exp. dates, unknown amounts of rec. and exp. dates
1	0	0	1	known dates of rec. and amounts of exp., unknown amounts of rec. and exp. dates
1	0	1	0	known amounts of receipts and expenditure, unknown dates of receipts and expenditure
1	1	0	0	known amounts and expenditure dates, unknown amounts and dates of receipts
group 4				**three parameters unknown**
1	0	0	0	known amounts of expenditure, unknown expenditure dates and amounts and dates of receipts
0	1	0	0	known expenditure dates, unknown amounts and dates of receipts and amounts of expenditure
0	0	1	0	known amounts of rec., unknown amounts of expenditure and dates of receipts and expenditure
0	0	0	1	known dates of receipts, unknown amounts of expenditure and amounts and expenditure dates
group 5				**all parameters unknown**
0	0	0	0	unknown dates and amounts of receipts and expenditure

It results from an evident assumption that all amounts and dates of receipts and expenditure have been defined by a contract and, therefore, in the financial schedule (schedule of all payments) which is part of the contract. This is a basis of a traditional planning practice included in contract regulations (only in solid, detailed agreements). In such a case, the contract becomes a basis for further analyses targeted at the sensitivity analysis of the plan to changes of parameters during the life cycle of project. In this case sensitivity analysis helps finding a searching value in effect of change of a single variable within a project by analysing that effect on the project plan [4] in day-to-day management [6] without probability calculations [7] or with them.

In a wider sense, the simulation may serve the purpose of optimisation of the plan before the contract is signed (like a decision support system in strategic decision-making [6]), like a tool for teaching theoretical concepts [6] or management game. It corresponds with all features of simulation in the branch of construction management [8]. Presented problems are included in general area of the Project Time Management, Project Cost Management and Project Risk Management [9].

4. Simulation and sensitivity analysis

Normally the knowledge of the four above-mentioned parameters (amount spent, date of expenditure, amount received, date of receipt) gives a determinist model. It must be stated that the opposite lack of knowledge of a certain parameter (answer = 0) does not mean that it is completely undefined. In practice, the value of each of the listed parameters may differ within certain limits (in an estimated range) and it defines probability of parameters. In this situation we have probable amounts and dates and a model enabling to calculate the expected risk related to financial schedule.

Moreover, in many cases, a given parameter may be only relatively constant (answer – 1) by way of its dependence on other relatively constant parameters (technical and organisational in particular). The reason is that, in practice, the amounts and dates of receipts and expenditure may be directly dependent on the schedule of works (in many cases). The variability of production parameters effects in delays of partial amounts and partial terms, and all those factors define indirectly the variability of the financial schedule. If many technological and organisational factors come into play, their influence on the distribution of the cash flows may be critical. In this situation we are in need of simulation of work's schedule. In such a case, the risk related to the schedule of works combines (multiplies) with risk of financial schedule according to the probability rules.

If, on top of this, there is some influence of factors which are external to a given project organisation (instability on the construction industry market, inflation etc), the analysis of the variability may be crucial from the point of view of the project success (for example, in lump sum contracts or BOT projects and in developing firms). In these most complex cases value of work may be in a probabilistic form but value of works has a continuous form (cash events are discrete). This case is a combination of discrete-event simulation and continuous simulation.

5. Computers and software

Four cash flow parameters have been discussed above, constituting a basis of a common denominator for individual cases, and presenting them as simple cash flows. Although their number (16 cases) is not big, it must be stated that, in practice, they never occur in pure form. In modelling the complex cases, we must associate (combine) simple cases, using the principle of superposition and (in such a situation) the number of existing parameters in the simulation will grow very fast. Specialist software and a fast computer, with technical characteristics reflecting the complexity of the modelled (simulated) projects, are necessary for analyses - especially in connection with complex risk analysis.

At present there is no single software on the market, which might serve the purpose of carrying out such analyses, and therefore, it is necessary to join together a number of specialist software packages. Good example is the proposition of computer program prepared by Navon [10] but the discussed product is directed only to contracts based on the detailed bills of quantities (BOQ) [10] and this software is not available. Similar specialised systems in Poland are used in practice with the database of cost calculation software. They are too rigid (not flexible) for general research (in all aspects of modelling projects and contracts) because these systems focuse on automatic integration of the cost items with the schedule items [10], [11], not on complex analyses. These systems are very useful for practical cases of particular contracts but less universal in all aspects of the research.

In the practice of all types of building and engineering projects (and in the process of real modelling these projects), the recommended software is the world-famous Primavera Project Planner+Monte Carlo for Primavera. What can be used both for theoretical and practical purposes, is difficult CA SuperProject+Predict, or popular MS Project+@Risk for Project packages.

A possible alternative for special cases is Polish program Planista and modules prepared with adoption of genetic algorithms (GA). Taking into account the analyses of test schedules/model schedules for research purposes the recommended software packages is MS Excel+@Risk in dynamic connection with the latest software listed above (and not listed older Pertmaster Advance) or with the optional usage of the software written individually.

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KAPITALO IŠLAIDŲ IR ĮPLAUKŲ ANALIZĖS VALDANT STATYBOS PROJEKTUS MODELIO APRAŠYMAS

T. Wiatr

Santrauka

Aprašytas bendrasis projektų valdymo modelis piniginių srautų ir gamybos bei finansinių planų priklausomybės požiūriu. Šiame modelyje grynieji pinigai yra diskretaus pobūdžio, bet darbų vertė yra tęstinės S-kreivės formos. Nuomonė, kad išlaidos yra diskretaus pobūdžio, prieštarauja nusistovėjusiai nuomonei. Pagal šią savybę siūlomas ir modelio pavadinimas – IVO (angl. *Inflow-Value-Outflow*). Modelis leidžia analizuoti problemas naudojant specialią programinę įrangą. Modelis gali būti pagrindu jautrumo analizei atlikti, atsižvelgiant į pavienius projektų kintamuosius dydžius. Antra vertus, modelis gali būti modeliavimo ir galimos rizikos vertinimo įrankis. Straipsnyje išryškintas gamybos ir finansų planavimo integravimas į vieną valdymo sistemą. Ši sistema tiesiogiai sukoncentruota į projektą, bet netiesiogiai į statybinę firmą (projektų portfelis).

Tomasz A. WIATR, MSc. Institute of Structural Engineering, Poznan University of Technology, Piotrowo 5, 60-965 Poznan, Poland. E-mail: tomasz.wiatr@put.poznan.pl

Member of SPMP (Polish Association of Project Management – associate in IPMA). Doctoral student. Research interests: construction project management, computer modelling of projects, making the optimal bar charts and networks, methodical organisation of building sites, planning of formworks and scaffoldings, consulting.