

Thus, we had an excellent opportunity to study a hypothetical model of the dependence of the number of users who are ready to make a purchase on the amount of the deposit, from which funds are allocated for marketing, which is engaged in attracting the most users.

References

1. Sterman, J. D. (2000). *Business Dynamics: System Thinking and Modeling for a Complex World*. New York, Irwin. McGraw- Hill. 982 p.
2. Wheat, D. I. (2007). *The Feedback Method: A System Dynamics Approach to Teaching Macroeconomics*. PhD thesis, University of Bergen.
3. Romer, D. (2012). *Advanced macroeconomics*. University of California, Berkeley.

Mordas Olena, Orlovska Oleksandra
Master students, NaUKMA

SYSTEM DYNAMICS APPROACH IN PROJECT MANAGEMENT

Engineering and construction industry is expected to continue to grow very fast. E&C companies have been considered as active participants in building smart, sustainable future. Project Management of Construction projects has evolutionized during this century due to digitalization of operating activity, automation of construction sites and a raise of qualified workers capable to cope with digital tools.

In today's world project management covers several stages that include key processes such as procurement of materials and equipment, post-ordering services, subcontractor services, quality estimation, solutions provision, work supervision, financial planning, cost estimates, cash flow planning and lots of other day-to-day operational activities.

Numerous delays in procurement works, pandemic-induced supply shortages, unexpected losses or repairs, uncertain future in Covid-19 world, consequently work force losses and drastic decrease in labour productivity are the key shocks that experienced major E&C companies recently.

Complexity of construction projects means that there are so many factors that influence the project, that construction processes appear to be highly dynamic and uncertain.

System dynamics approach may become a very useful tool for adapting the business and project management to new challenges. Limited supply, tariff uncertainties, mistakes or short-sightedness of initial project costs estimations are the main drivers for E&C firms to plan, manage and execute projects better.

We believe that System dynamics application may help to adjust the business and include all vital components such as quality supervision, reworks and delays during project execution, actions control and goal adjustment.

Besides for being complex and highly dynamic as mentioned above, Project Management System Dynamics models include a lot of interdependent variables, involve multiple feedback processes and non-linear relationships.

In general, any project management model may be described through the flow of tasks – from work to be done to the work really done. Work being done depends on human resources, labour productivity and quality of the works execution. The feedback structure of the model gives us the information about what should be redone. In practice this information is usually received both from quality control managers and from the customer.

The most important phases of Project Management SD model can be expressed through main sub-models: Process Management module, Project Control module, Goal Management module. For E&C companies for managing big projects that also include procurement of materials and equipment, post-ordering services we would also suggest adding Procurement works sub-model and Cash Flow sub-model in order to improve business planning and timing of the project.

Project Control module aims to take control actions when the project experiences schedule delays. These actions are needed to maintain and adjust project to keep the real progress with project plan. It becomes possible while changing human resources and work time in the module. In the module we need to find the compromise between willingness to adjust human resource and willingness to overtime work, because huge overtimes may result in decrease of labour productivity and additional human resources require additional project costs.

Goal management module shows how managers adjust project goal to the changes that project may experience due to weather conditions, supply shortages, delays in orders and taken control actions. This module gives us the information to which extent the manager is willing to adjust the goal.

The process management module is a core component of SD model which captures the dynamics of work execution within a project.

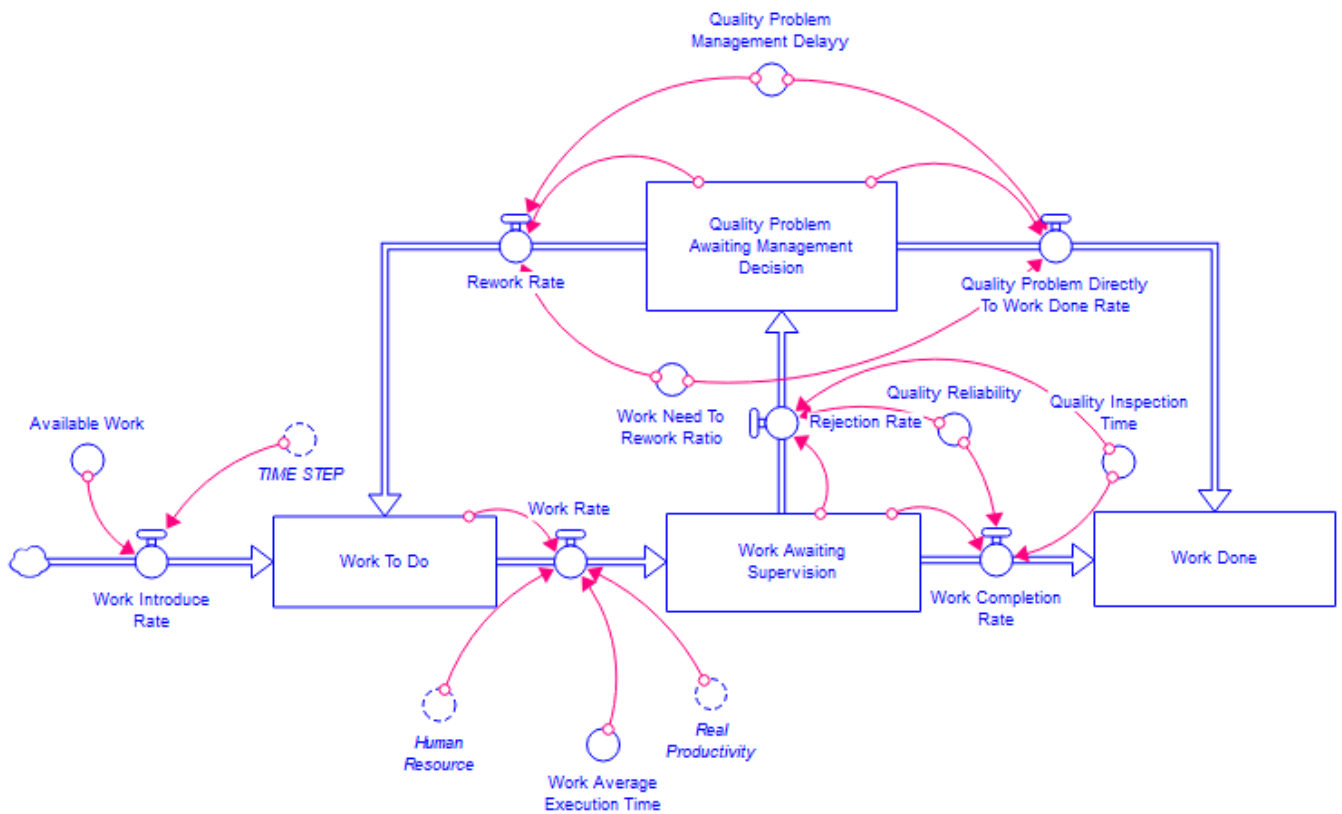


Figure 1. Process management module proposed by Yujing Wang, Yongkui Lib and Peidong Guoc [4]

There are four main stocks in Process management module. These are Work To Do (WTO), Work Awaiting Supervision (WAS), Quality Problem Awaiting Management Decision (QPAMD) and Work Done (WD). Module has exogenous and endogenous variables. Example of exogenous converters are Available Work, Human Resources, Real Productivity and Time Step. As well as there are possible other exogenous variables.

Main hypotheses represented by Process management sub-model:

- 1) The scope of work is distributed not immediately but gradually, that is represented by Work Introduction Rate. It means that activities are time-managed and scheduled by the managers.
- 2) Work being done depends on human resources available and real productivity. Work execution rate is also defined by work average execution time, that may express either the average market rate for such works or own experience from the other projects of the company..

- 3) Every activity needs to be supervised. Depending on the results of supervision the work is either marked as completed or transformed into work that has a problem that is awaiting management decision.
- 4) Management decides whether the work should be redone or it can be approved and marked as completed. Both decision making and rework cause delays in execution.

In our model there are no biflows. Process management module is usually structured as transition from input to output through possible delays. The sub-model contains a reinforcing loop: WTD – Work Rate - WAS – Rejection Rate - QPAMD - Rework Rate - WTD. An increasing of WTD leads to increase in WAS stock then QPAMD also rises. Finally, based on the Rework Rate additional work is added to WTD.

Nowadays, Project Management of Construction projects is becoming more and more popular and improved. The construction process is highly dynamic and uncertain, especially due to different types of shocks in pandemic time. Project Management includes numerous processes such as procurement of materials and equipment, quality estimation, solutions provision, work supervision, financial and cash flow planning and others. Given the above features of Project Management of Construction projects there is one of the most effective tools for solving problems and meeting challenges in this sphere and it is System dynamics approach. For further research we can add new exogenous variables to our Process Management Module. For example, shocks in Supply of materials, equipment or subcontractor works, influence of weather conditions, cash flow gaps may negatively affect works execution.

References:

1. Michelle Meisels, 2022 engineering and construction industry outlook, Deloitte, 2022.
2. Sterman, John. "System Dynamics: systems thinking and modeling for a complex world." (2002).
3. Sterman, John D. "System dynamics modeling for project management." Unpublished manuscript, Cambridge, MA 246 (1992).
4. Yujing, Wanga, Lib Yongkui, and Guoc Peidong. "Modelling Construction Project Management Based on System Dynamics." Metallurgical and Mining Industry 9 (2015): 1056-1060.