Business Process Modeling and Efficiency Improvement through an Agent-Based Approach

Dario RUSSO*
Banca d'Italia, Via Nazionale 91
Roma 00184, Italy

and

Franco PASSACANTANDO*
Banca d'Italia, Via Nazionale 91
Roma 00184, Italy

and

Luigi GEPPERT
Faculty of Economics, Catholic University of Milan
Milano 20123, Italy

and

Luigi MANCA
Fair Dynamics Consulting, Via Farini 5
Milano 20154, Italy

ABSTRACT

A comprehensive knowledge of a company's organizational mechanisms is a fundamental prerequisite for good management practices and effective governance, especially in the banking industry where efficiency and effectiveness have recently been becoming more and more important. This paper describes the results of a practical experience of business process improvement and change. The business modeling approach, carried out through an agent-based model, has been applied to an operational process with the aim to reduce the overlapping of the operational phases and to improve the time-efficiency. Simulation outcomes and results are discussed.

(*) The views expressed here are the sole responsibility of the authors and do not necessarily reflect those of the Bank of Italy.

keywords: Business Process Modeling, Complexity, Agent-Based Modeling, Simulation.

1. THE BUSINESS REQUIREMENTS

A comprehensive knowledge of a company's organizational mechanisms is a fundamental prerequisite for good management practices and effective governance.

The current economic crisis is forcing companies to enhance their business performances while economizing on human and material resources. Hence, the need to combine business processes and practices properly.

Public institutions are also required to improve their business performances. They must streamline their internal processes in order to guarantee high-quality services and products and respond to the need to economize on the use of resources.

Innovation and ever-growing operational effectiveness should be a company's driving force. Modeling can be a key instrument for innovation.

Process modeling is used to provide an accurate representation of complex business processes, whose analysis usually includes mapping all the functional processes and sub-processes involved.

By pointing out all the components of a business (data, organization, processes), a model allows stakeholders to define and evaluate their company better.

The literature and consultancy firms' expertise provide a huge variety of methodologies, techniques and tools that can be used to model every step of a business process (the input, the actions that transform the input, the event that triggers the process and the output or result).

Business models can result in an "as is" snapshot model, in which the current state of the business process is described, or in a "to be" model, which defines the process as it should become. By comparing these two business models, analysts can determine the soundness of existing processes and information systems and decide whether minor or substantial modifications are needed. Thus, process modeling and the resulting analyses

are helpful tools in reshaping the operational conduct of a company.

Process modeling tools should identify organizational errors and discrepancies through diagrammatic presentations that effectively summarize and streamline textual information. Through the implementation and execution of process modeling, business users can model and refine their business processes and choices. Modeling and simulation functionalities should also permit the execution of “what-if” scenarios.

Moreover, process modeling tools should perform several other valuable functions. They can allow analysts to tie activities together, keep track of inputs and outputs, and recognize overlaps and missing steps of the business process.

They must free the analysis from the arbitrariness of experts’ views, which could blur the organizational landscape by mixing objective facts and subjective opinions.

They must be easy to use, especially from a business user’s perspective. This is of the utmost importance, both in the validation phase of the model and in the simulation of “to-be” scenarios.

They must highlight the potential risks (operational, reputational, financial) of the reshaped processes.

Finally, they must clearly show how much the reengineered processes have been improved in terms of cost, quality, customer satisfaction or shareholder value.

2. THE INNOVATIVENESS

Business process modeling and simulation are a valuable tool for use with any methodology based on an appropriate comparison between "as-is" and "to-be" models, in order to analyze the situation better, reduce or draw attention to the risks of potential changes, and show the quantitative results to be achieved.[1]

In other words, modeling and simulation are the methodological tool to be used by managers in order to evaluate the performances of the processes under some assumptions and depict the effects of structural and organizational changes. They can be used to analyze "as-is" situations as well as "to-be" scenarios, through an appropriate *what-if* approach.

The typical nature of organizational mechanisms means that both the issues to be faced and the environment where those issues arose involve dealing with a complex system.

That internal *complexity* is increased by the presence of human activities and their impact on the whole system. While the working rules and the constraints of a process can be appropriately defined, tested and deployed, the application of accompanying human activities is often biased by human behavior that, for many reasons, is not always in line with the specifications and directives given.

A system is typically defined to be complex if it shows the following two properties:[2] the system is composed of interacting units; the system shows emergent properties that arise from the interactions of the units and that are not properties of the individual units themselves.

In other words, a complex system shows "new", emerging properties that do not belong to the units that are part of the system. And while the properties, interacting rules and environmental constraints of each single unit are usually known before (ex-ante), the emergent properties of a complex system are unknown before and manifest themselves only later in time (ex-post).

When complexity is one of the dominant aspects, the most appropriate way to analyze a system is by using modeling and simulation in order to understand its behavior and predict its evolution.

If, for example, the system is a process, modeling and simulation can give a numerical indication about the need for resources, the lead times, the duration of an activity, and so on.

This gives a detailed quantitative value to the analysis and an assessment of all the possible performance indicators applied. Consequently, it can provide evidence to underpin the ideas, doubts, and intentions of the managers involved in possible operational and organizational changes.

It is a formidable tool for verifying "through the numbers" the current reality and exploring quantitatively "beyond yonder" solutions and ideas.

Commonly used business process modeling and simulation techniques are usually based on either Discrete-event (process based) Modeling or System Dynamics Modeling [3], two classic techniques developed in the 1950s and currently used in several domains.

Recently, an innovative technique has been made available for process modeling and simulation. This technique is called Agent-Based Modeling and Simulation (ABMS) [4].

ABMS is based on the concept of "agents", i.e. units of a system that interact, behave and "move" in a defined environment by following appropriate rules and showing appropriate properties.

The technique is a valid and innovative option for coping with complex systems inasmuch as it takes into account the properties of the units instead of considering the general properties of the system. Under this perspective, and consistently with the definition of complexity, the properties of the system are not necessarily known beforehand but are shown after the system has evolved.

Thus, in many respects, ABMS is a technique that is of great help in simplifying the efforts needed to catch the intrinsic complexity of systems in many domains.

The case described below is a practical application of ABMS. Even though here we cannot go through the most technical aspects, it is interesting to see that the model has been created by making both administrative objects (payments) and human resources belong to appropriate classes of "agents".

Observing the properties, interacting rules, behavior and environmental constraints of each single class is easier and clearer than first analyzing the global properties of the whole process, which are sometimes unknown.

Under this approach, the properties of the whole process become the result of the system's evolution in time, clearly shown by the simulation.

The properties of the classes of agents that have been considered in an "administrative space-time" window of 1 working day.

3. THE CASE STUDY

The domestic payments back-office process
Banca d'Italia (BdI) operates yearly a certain amount of manual credit transfers. These transfers refer to payments originated by Departments and Branches of the Bank, by public administrations and institutions (for treasury operations) and by non-automated account holders' operations. The case-study refers to the back-office phases of the payments.

Back Office includes all the checking and settlement activities related to the trading operations performed by the corresponding Front Office function. These operations are carried out for institutional purposes, non-institutional portfolio asset management and treasury payments.

The activities performed can be summarized as follows:

1. *registration of the operation* in the internal IT systems and release of the confirmation to the counterparts;
2. *checking of the confirmations* received from the *counterparts*;
3. *request for settlement* (by means of handling operations on accounts and/or securities settlement) to external systems of securities settlement and cash;
4. *handling of abnormal situations* and write offs;
5. *checking of the adequacy of the collateral margins*;
6. *reconciliation of all accounts with movements*;
7. *registration* of the operations in the internal IT systems (accounting system and other internal databases) and closure of the operating day.

Domestic credit transfers
Domestic credit transfers are executed by the BI-COMP system while foreign ones are settled according to the system of the receiving bank and the tariff clause requested (*TARGET2* or *STEP2* of *EBA-Clearing)*.

BdI Departments and Branches request credit transfers by means of a written message containing the information (beneficiary name, payment date, beneficiary bank, payment reason, etc.) needed for payment execution.

Two Units are involved in the process. The Payment Unit enters the operation in the IT procedure and the Accounting Unit, after verifying the availability of funds, confirms the operation.

This activity is performed by both Units and provides a check on the requests, also by means of *office-automation products*, a payment phase and an accounting phase that, more specifically, in the case of operations requested by private parties, provides for the intervention of BdI Branches to recover expenses.

At the end of the day, the Payment Unit prepares a table containing all the operations put in place to be signed by the Head of the Department and the Accounting Unit operates the check on all the operations put in place, also with reference to the complex activity of the *TARGET2-BI* **and** *BI-COMP* systems BdI balance.

Human resources in the two Units work on shifts in order to carry out operation from 7.30 a.m. till 7.00 p.m. There are three kinds of employees: Assistants, Coadjutors and Officers and each category performs different tasks.

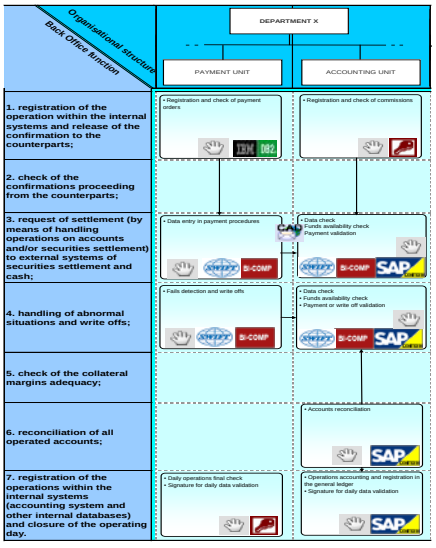
Officers of the first Unit authorize, by signature, the transmission to the second Unit of the payments registered within the IT system, in order to allow this Unit to start working on them.

The tasks of the two operating Units are therefore different and sequential. An Assistant of Unit A cannot perform the tasks of an Assistant of Unit B. Unit B starts its operations only when Unit A has completed its tasks for each single process.

The domestic payments process is not the only task performed by these Units, but it is the most important one as every payment has to be carried out within a time limit (5.30 p.m.). Should this time be exceeded, counterparts apply to the Bank for the payment of penalties. This is why this process is a top priority for both Units, even if to perform it the workforce engaged is less than 20 per cent of the available force in ordinary conditions.

The variance of the daily processed payments is very high. Generally, around 50 per cent of these payments have to be carried out on a manual basis, while a certain degree of automation is applied for the remaining 50 per cent.

Some payments, generally the institutional ones, have to be processed with the highest priority.



Goal of the modeling exercise:

- to verify the effect of employees' absence on the process completion time (due to holidays, training, sickness, etc.), acting in the different roles;

- to verify the effect of stress situations on the process completion time and on the employee utilization ratio (high

number of payments to be processed, high percentage of completely manual payments, high presence of priority institutional payments to be processed);

- to investigate the possible advantages arising from an organizational variation (a merger of the two Units) or a change in the authorization and control process.

4. THE SIMULATION OUTCOMES

Among the different simulations carried out, the following have been selected:

A. AS-IS Normal Activity: time performances in a day with a standard volume of payments (2 organizational units).
B. AS-IS Absence of employees: time performances in a day with a standard volume of payments and with the absence of 1 critical resource per shift (2 organizational units).
C. AS-IS Abnormal activity: time performances in a day with a 300% increase in the volume of payments (2 organizational units).
D. TO-BE: time performances with a possible merger of the 2 Organizational Units into just one.

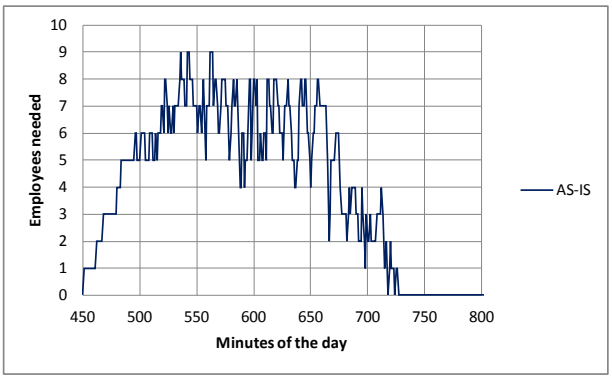
The runs presented here are summarized by the need for human resources (employees) appropriately plotted (black curve) on a time graph of 1 working day.

The Y-axis of the graph represents the number of employees needed and the X-axis represents minutes in the range [450, 1170], corresponding to the daily working time [07:30, 19:30].

As an important constraint of the process, the completion time must be within 17:30, i.e. the 1050th minute.

A. AS-IS Normal Activity

The "normal activity" run reproduces what happens in reality over a normal working days, with a standard volume of payments.
The graph shows the following behavior:



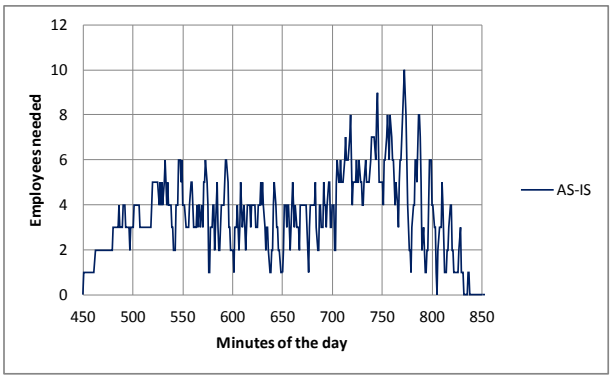
The completion time occurs at the 744th minute (12:24), the number of "Full Time Equivalent" resources is 3.17 and the maximum number of resources to be used is 9. The time required for 1 payment (the payment lead time) is 134 minutes.

In the standard volume (of payments) case, the performance of the process is in line with expectations, since the completion time is well before the time limit (17:30).

This means that, by finishing payments before the time limit, employees can work on other processes.

B. AS-IS Absence of employees

The "absence of employees" run reproduces what happens over a normal working day, with a standard volume of payments and with the absence of 1 employee per shift.



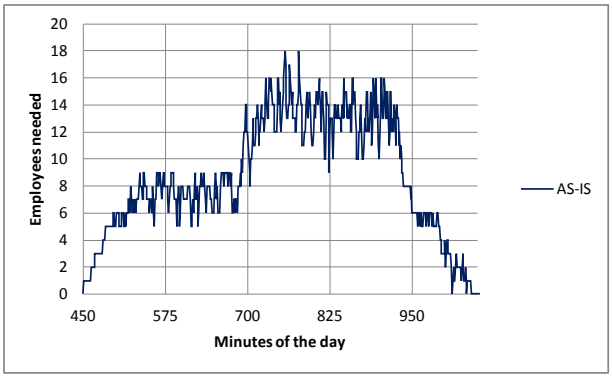
The completion time occurs at the 860th minute (14:20), the number of "Full Time Equivalent" resources is still 3.17 and the maximum number of resources to be used is 10. The global time required for 1 payment is 210 minutes.

The unavailability of an employee is caused by many different reasons; sometimes it happens that the employee is present but allocated to another activity related to another administrative process.

C. AS-IS Abnormal activity

The "abnormal activity" run reproduces what happens over a normal working day, with a volume more than triple the standard one. This is a very "extraordinary" case.

More often, the abnormal volumes are about double the standard values.



The completion time occurs at the 1061st minute (17:41), the number of "Full Time Equivalent" resources is 11.67 and the

maximum number of resources to be used is 16. The time required for 1 payment is 182 minutes.

In this case the working activity is "border line" and becomes risky, because the completion time is 11 minutes after the maximum permitted time.

This means that on days where the volume is huge, employees must proactively shorten the usual work time assigned to each activity in order to ensure compliance with the time limit.

Even though this situation is not usual, when it happens over the year, it generates not only the risk of "non-compliance" with time limit (ineffectiveness of the process), but also employee stress and the risk of people "burning-out".

D. TO-BE activity

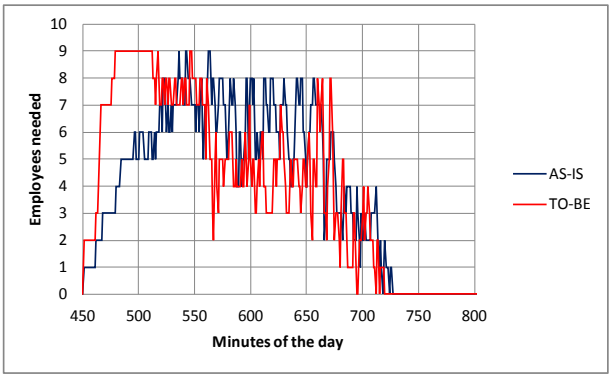
The "abnormal activity" run reproduces what happens over a normal working day with a possible merger of the 2 Organizational Units.

In the "1 division only" model employees' working time, if available, can be used in all the phases of the process while in the "2 division" model, the working time of an employees can be allocated only if the related activity is performed within the division to which the employee belongs.

Let's consider the comparison of the new simulation runs with the 3 previous AS-IS' ones.

The graph now contains 2 curves: the AS-IS curve (in black) together with the TO-BE one:

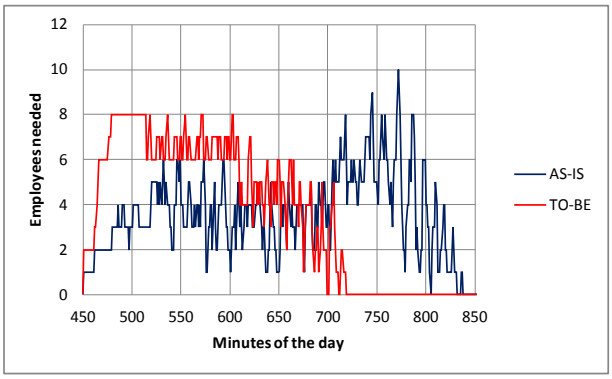
Normal Activity



Looking at the new curve compared to the previous black one, the completion time occurs at the 739th minute (12:19), the number of "Full Time Equivalent" resources is 3.17 and the maximum number of resources to be used is 9. The time required for 1 payment (the payment lead time) is 159 minutes.

There are no meaningful differences with respect to the equivalent AS-IS case; the completion time is a bit shorter while the time required to carry out a single payment is longer. This is due to a different allocation of employees that tends to concentrate on the early phases of the process ("moving" capacity).

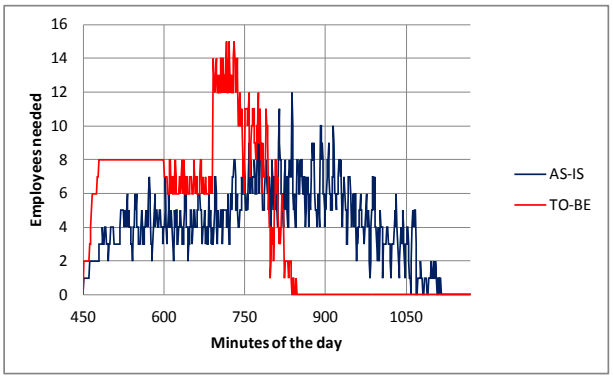
Absence of employees



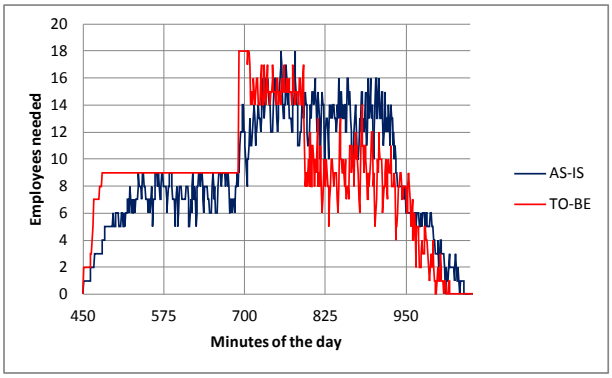
The completion time occurs at the 742nd minute (12:22), the number of "Full Time Equivalent" resources is still 3.17 and the maximum number of resources to be used is 8. The time required for 1 payment is 167 minutes. This is a case that clearly shows the advantages of merging the 2 divisions.

As it was figured out by managers, even though the efficiency of each single employee is the same as in the corresponding AS-IS case, the simulation clearly shows that overall the system is made much more productive by improving the "volumes-completion time" trade-off.

The case of absence of employees is even more evident on a day where the volume of payments doubles. In this situation, the AS-IS case is critical, since the completion time is clearly after the permitted time limit (19:05) while in the TO-BE case it is kept well before (14:21). See the next graph.



Abnormal activity



The completion time occurs at the 1041st minute (17:21), the number of "Full Time Equivalent" resources is 11.67 and the maximum number of resources to be used is 18. The time required for 1 payment is 301 minutes.

The simulation shows that the risk of overshooting the completion time limit is lower than in the corresponding AS-IS case.

5. THE RESULTS AND THE CONCLUSIONS

As far as the results are concerned, the organizational lesson learned shows that the merger of the 2 current operating divisions into just 1 division is very beneficial.

The merger produces the following main advantages:

- an evident increase in the productivity of the whole process; which means both increasing the effectiveness of the process and freeing part of the employees' working time, possibly for use in other processes;
- a sensible reduction of operational risks, by improving the volume/completion time trade-off; which means carrying out more payments within the completion time limit with the same number of employees;
- a reasonable reduction of the people "burn-out" threshold, especially on "abnormal activity" days.

All these advantages have been quantified through simulation runs, after the AS-IS model had been appropriately calibrated using the data related to the current situation.

In conclusion, the case showed that business process improvement initiatives at a bank can be better analyzed and explored through the use of modeling and simulation techniques. These help managers to open broader perspectives on the scope of the problem and make it possible to:

- assess the existing situation quantitatively;
- solicit new ideas for modifications and changes;
- verify and quantify different hypotheses figured out "on paper";
- explore new possibilities by looking at "what happens beyond yonder";
- show and understand counter-intuitive situations not always evident in the context of operational routiones;
- demonstrate the validity of assumptions quantitatively.

Furthermore, technically speaking, the use of the innovative ABMS technique simplifies the modeling and simulation approach and gives both aspects a very realistic picture of the current situation and a reliable tool with which to explore the future.

6. REFERENCES

[1] L. Geppert and R. Fiocca, "Reverse marketing and business paradigms", **SIM Italian Marketing Society Congress**, Florence (IT), 2009.

[2] G.W. Flake, **The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation,** The MIT Press, Cambridge, MA 1998.

[3] J.D. Sterman, **Business Dynamics: Systems Thinking and Modeling for a Complex World**, Irwin-McGraw Hill, Boston, 2000.

[4] M.J. North and C.M. Macal, **Managing Business Complexity**, Oxford University Press, 2007.