

# Theory of Games and Contracts to define the Client role in Building Information Modeling

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*This research focus on the application of Theory of Games and asymmetry information to the AEC sector underling the impact of these theories to the supply chain and in particular on the evolution of the client role in a Building Information Modeling process. The mentioned theories used to be applied to macroeconomic fields, but allowed the researchers to understand the evolution of the sector and the internal behavior of the team. This analysis of team behaviors permits to grasp how the contractual frame could hold up the natural trend of the market to collaborate, which leads the sector to improve itself. The Theory of Games could be adopted as a hermeneutic tool for understanding actions and agreements to which the various parties achieve. The research provided a global analysis on the evolution of the client role in a cyclical process. Further development of the research will be the application of the theory to a real case study to catch the real team behavior in a collaborative environment.*

**Keywords:** *Building Information Modeling, game theory, contracts theory, hermeneutical approach*

## INTRODUCTION

In spite of the strong technology innovation process in AEC sector and the increasing influence of automation (and automatization) and of-site production of building systems and components (e.g. façade components, MEP, drilling construction) no productivity increment in the last half century is detected and moreover a growing cost and time overrun is regis-

tered. According to Eastman research (Eastman and Sacks), the AEC fragmentation is leading the sector to stagnated period, comparing it with the manufactures, we understand that sector has to change direction. From the 1964 the gap created between the two sector is increasing a lot. Analyzing the index of production in the early sixty, it remains stuck at the same level, at present we have a gap over a hundred

percentage points. The reason could be appointed to difference in the in the corporate structure, which changed a lot in mechanical industry. In particular, the partnering, happened in the sector, imposed an optimization of their products both in term of quality, cost and time.

Recent analyzes of the major economic think tank (i.e. McKinsey, Ellen MacArthur Foundation) or national data (CRESME) describe the construction sector as inefficient and with a low inclination to innovative processes and especially to the relational systems between the players. This last point leads to a continuing loss of value of investments defining the sector as the one with the lowest benefit index per output unit. ISTAT (Istituto Nazionale di Statistica) data confirm the statement, in particular they underline the number of self-employed workers is increasing in the last period. The fragmentation, instead of the internal cooperation, is leading the sector to paralysis.

Building Information Modeling (BIM) development implies new and fluid relations between the different actors compared to conventional processes and it is possible to identify how these relationships should be modified. UK government in its strategy (UK Cabinet Office) for the next five years requested a mandatory BIM level 2 maturity, in which the collaboration is one of the core points. Also at European level in the IDDS report (International Council for research and Innovation in Building and Construction) the structural change wished to the AEC sector re-

quest a joint response to obtain a new integrated process to deliver projects.

## THE EMPLOYER’S ROLE EVOLUTION

The definition of the employer, set for the first time by the European Union in EU directive 92/57/CEE and then in the D.Lgs. 81/2008 Titolo I art 89, is “the subject for whom the whole work is carried out, regardless of any fragmentation of its realization” he has the task of architectural, technical and organizational choices, in order to plan the various works. The employer’s role evolution is associated to the alteration of the process itself. In particular, a traditional process is linear. It starts with the expression of needs up to the validation of each step. Due to the workflow itself, the connection between the employer and the project is just the request of an asset with some requirements and specifications. On the contrary, in an integrated process, such as the BIM methodology, the project team continually engages the connection and inputs.

BIM methodology introduces collaborative forms of contract that allow a hermeneutical interpretation through the Game Theory and Contracts of the different actors in the building processes especially for the Client. According to PAS 1192:2 (British Standard Institution (BSI)), which describe the BIM workflow, we can understand that the employer has a key position in the process. The document, which represents their requirement, is the Employer’s Infor-

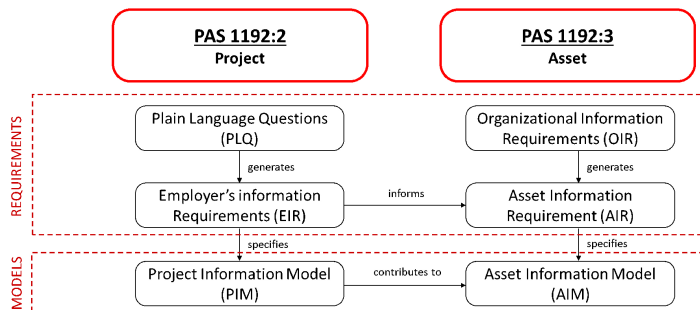


Figure 1  
Shared information  
in a BIM process  
(source: PAS 1192:  
2, modified)

mation Requirement (EIR). As explained in Fig. 1, it has the double scope of (i) specifying the ultimate aim of the asset, therefore the Project information Model (PIM) has to be developed, (ii) informing the Asset Information Requirement (AIR). The Organizational Information Requirements (OIR) - the compensation of the Plain Language Questions in the Asset Information Model (AIM) -generates it, all merged in the AIM.

Figure 2  
Shared information  
in a BIM process  
(source: AEC(UK)  
BIM Technology  
Protocol)

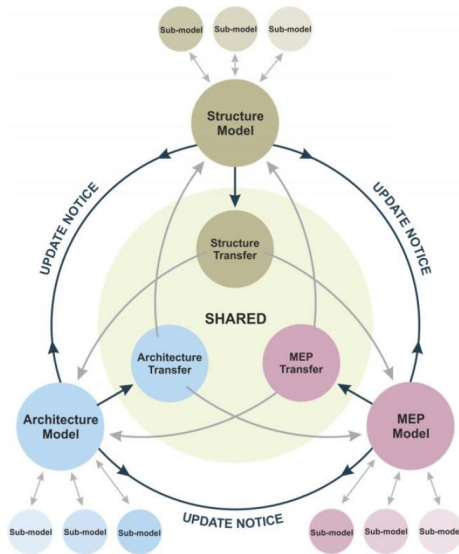
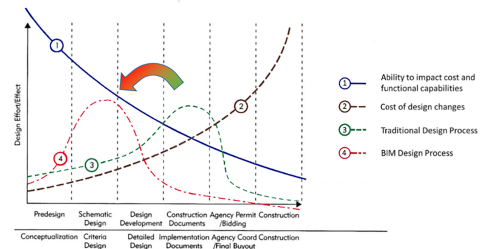


Figure 3  
Backwarding  
decisions in a BIM  
process (source:  
MacLeamy's curves,  
modified)

coming team leaders, collaborating deeply throughout the industry, and applying key elements, owners can summon meaningful and lasting change.”

Thus the relationship/negotiation between Client/Sponsor-Designer-Manufacturer-Manager might be addressed with the available methodologies/technologies in the perspective given by game theory and contracts, in order to accurately define the scope within the economic, legal and financial field defining the bargaining power of the parties. This analysis allows the reconstruction of the signifier from the meaning that each of the contract parties historically hold, considering the impact, the temporal presence and cognitive processes contextualizing the relationship.

The back-warding (Fig.3) of the choices involves a reduction in costs for obtaining the same result, this consequence is caused by an increasing level of information and decision in the early process stage, which guarantees a maximizing level of resource exploitation.



The initial contract can be located in the documents' sphere drawn up by the client, with which relies on professional management work BIM aspects. This document is used each time to validate the evolution of the project also verifying it with the Employer themselves. Quoting Barbara White Bryson, who entrusts to the Client a key role in the entire process: "But it is owners who can impact the industry most deliberately and aggressively. Owners can drive innovation on their projects and create profound change in the industry. In fact, owners are uniquely positioned to innovate and participate to it. By planning the design and delivery process, be-

Accordingly, increasing attention to the relationship of the parties will be empowered because of the significant shifts of responsibility that the new contracts and funding frameworks (as exemplified by the Public/Private partnership model). It is evident that the subjects' behavior, even in the presence of "complete contracts" will be oriented to the increased ownership of benefit shares.

The issue of relations between the parties belonging to the building process has never developed in terms of the economic, regulatory and funding situation would have needed, but almost exclusively in

terms of conflicts that constantly judicial chronicles delivered.

The debate on BIM needs the combination with new relational forms between the subjects involved in the construction process, which constitute the basis of a new conceptual paradigm. The last decades registered an evident reduction of investment in public infrastructures and buildings and the attempt to reshape, reduce in number and increase the qualification of Contracting Stations. This stresses a new strategic management of relations between AEC subjects becoming an essential condition to achieve advantages in the medium and long term with a new relational approach rather than transactional one, which should analyze the contractual practices in terms of efficiency and reconstruction of internal cognitive processes defined into the request-offer relationships. In this direction, the games and contracts theory is the appropriate analytical tool to analyze the relationships between AEC subjects, inasmuch it addresses the decisional issue and contractual relationships of many players, whose actions derive from their expectations regarding the opponents' moves. As originally formulated, the theory of games traditionally is used as a forecasting and monitoring instrument to examine the equilibrium condition and find out the best solution of a stated problem. In fact, a certain problem might present a multiplicity of equilibria that are not always optimal, but satisfactory.

## THEORY OF GAMES

Through the Theory of Games are studied all the situations of strategic interaction, where the usefulness of an individual depends not only on his actions but also on other agents. One of the most exemplificative example is the Prisoner's Dilemma, an imperfect information game, in which two players have to make decisions without knowing what will be taken on the other hand.

The Theory of Games is a vast discipline the aim of which is to analyze the strategic behaviors of the decision makers (the players), i.e. studying the situ-

ations in which several players interact by pursuing common, different or conflicted objectives. Aforementioned theory deletes the individualism principle, placing the benefits of group above the individual ones, in fact according to this theory the highest behavior is not derived from what is best for the individual but from what is best for the community.

Given a game, the player is entitled to choose the strategy that he prefers in the whole of possible strategies: the player will choose the strategy that maximizes his benefit and therefore, the same strategy will be chosen from several players, only if this one will maximize the avail of each player when all implement the same solution.

The well-known solution of the Theory of Games is the Nash Equilibrium, according to which each gamer has at its disposal at least one strategy from which he has no interest in moving away from if all the other players have done their choice.

In the Prisoner's Dilemma (Fig. 4) game there are two possible strategies: (i) to confess: it represents the dominant strategy as it is the best regardless of what the other will do; (ii) to not confess: it represents the more convenient strategy if and only if also the other will not confess. The Nash Equilibrium for the Dilemma is (to confess, to confess) but this is not absolutely the best result: if the players had canted to communicate they would choose to not confess. When the equilibrium is reached, no player can improve is own result only changing his own strategy and therefore he is bound by others' choices.

		Player 1 confess?	
		No	Yes
Player 2 confess?	No	10    10	0    15
	Yes	15    0	5    5

Figure 4  
Prisoner's Dilemma

Having said this, it follows that in the process of choosing a strategy to be adopted the operators are confronted with a conflict between: (i) individual rationality: to pursue the maximization of personal interest; (ii) efficiency: to pursue the best possible result, both individual and collective. Against this backdrop, it will refer and describe tests made under the economic market and under the Research and Development sector, in which the forms of interaction between people and the conditions (that allow some strategies instead of others) were analyzed (specifically under what circumstances the operators are willing to cooperate or not). The first experiment it will be described applies the Prisoner's Dilemma to the study of endogenous transfers that can lead to cooperation and coordination mechanisms between market operators. Therefore, it will be studied the compensation mechanisms that arise to promote the cooperation, the test carried out consider couples of players and they are composed of two steps [4]. Step 1: the players establish an offer of a payment for the counterpart in order to cooperate. Step 2: know the amount, the gamers play choosing to cooperate or not. The identified couples of payment participating in the game guarantee the mutual collaboration and convert the game into a coordination game; for this reason, in the second step the players are able to choose the mutual cooperation or the mutual waiver, as described in Nash Equilibrium. Choosing to mutual cooperate it's more likely when payment couple are identical as they lead to the grant of similar results for both sides.

However, this choice is rather rare in Prisoner's Dilemma in which, even though it's possible to get high profits through collaboration, non-cooperation remains the dominant strategy for each of the players.

The solution to this test is discernible into Qin's theory (Correia-da-Silva) according to which the necessary and sufficient condition to induce players to cooperate is to provide the other with the minimum amount necessary to convince him to cooperate.

During the investigation, it was found that coop-

eration levels are different if: (i) transfers of payment are permitted, otherwise (ii) if transfers of payment are not possible. The first condition is due to Nash Equilibrium's one and where the transfer of reward can deliver results due to the cooperation for both similar or different parties.

The results of the test show that cooperation levels are higher when payment couples moved among the players are identical and when the transfer gives similar results for both sides.

Is possible to adapt the previously explained experiment to a real situation, namely real estate and AEC sector. In these, both the parties request a fair compensation for the service they are going to offer to the other, this reward is just a guarantee deposit or a re-entry in case of greater commitment. In this way, new collaborative contractual theories lead to a review of the structure of the process. As will be explained later, the insertion of a contractual part within it leads to a different view. However, in many cases, individuals tend to get the best out of their own, not considering others, however, this approach does not produce either a global gain or the team or even the project that will be damaged due to selfish behavior.

## **INFORMATION ASYMMETRY**

In a market the possibility of developing perfect competition mechanism and resource allocation is conditional upon the occurrence of a symmetric information condition; for this to be achieved the information have to respect the characteristics of completeness and accessibility without any cost. Unlike the mentioned hypothesis, in real life information is considered to be like an economic asset and for this reason it is not accessible without any cost, and moreover it is likely that not all the requisite information is available while making economic transactions.

So it is possible to define the existence of an asymmetric information when, within economic process, an information is not entirely shared between people belonging to the same one; this configuration enables one part of the involved agents to possess a higher number of information than the rest of the

competitors, out of which they would have a competitive advantage.

In fact, as part of a perfect competition, information symmetry is taken for granted and within the market, the operators argue about endogenous factors caused by each companies' management abilities such as prizes, quantities, strategies and expertise. On the other hand, information asymmetry is an exogenous variable which corrupts those aspects in a way that the financial and economic markets' results are influenced by them (Billett, Garfinkel, and Yu).

Among the different types of problem caused by information asymmetry, this document is focused on analyzing the adverse selection which consists in an operator that has much more information than the one is going to pledge an agreement with. In this situation it is reasonable to assume that during the trades the operators are not aware of the quality of the other's products as well as theirs own because they are given lacking and confusing information (Correia-da-Silva).

Due to this informational confusion and heterogeneity, the business-men are keen on using clever behaviors, which consist in competitive actions that lead to achieve their own interests.

Based on the work environment, the kind of profit achieved by the results and the possible stimulating influence, both parts can choose to act or not to act in a cooperative way. However, the strategic interaction is represented by the Theory of Games and situations attributable to the Prisoner's Dilemma are well described in this document.

As an example of adverse selection, at the beginning the document shows the Akerlof's Lemon Market Theory (Akerlof), then it present other examples of the same subject but in other situations such as the translation industry and the financial one. Next, the article analyses the problem which Akerlof had to cope with and it reconsider them as a modern problem, and then move on to behaviors strategies that take place in the economic market and in the Research and Development industry when information asymmetry is present.

## **THEORY OF GAMES AND ASYMMETRY INFORMATION APPLIED TO RELATIONAL CONTRACTS**

As described before, over the recent decades, some traditional project delivery systems have emerged claiming to fill the gap between the design and construction projects, but they have shown to be not efficient enough. In this context, some collaborative contracts were developed in a lot of countries (e.g. US, UK and Italy), but they have mainly the same characteristics. Due to their structure and composition, traditional contracts create unavoidably a conflict of interest, which cannot be solved and they impose a rigid division of stakeholders' works. These new working organizations allow achieving the final scope, which is the optimized project. These complementary approaches meld in report (Smith, Mossman, and Emmitt), which concluded that the optimal project delivery method, would be an integrated approach executed under Lean principles.

Following the tripartite division of the knowledge provided by Habermas, game theory could be adopted as a hermeneutic tool for understanding actions and agreements to which the various parties achieve.

Despite their structural diversity, the parties involved in AEC sector reveal the typical conditions for the application of game theory, such as: (i) conflict, (ii) strategic interaction, (iii) strategic options and (iv) set of rules. The former point is conflict, envisioned as a requirement of each of the parties to maximize the potential economic resources to the most convenient conditions for himself. This aspect is caused by a selfish behavior that in a team can cause a sequence of inconsistency due to the desire of the single to provide as less information as possible to provide a work without incur in the liability risk. A problem, each party has, is to decide how much he can trust on the others, they have the possibility to believe in the others, but they could incur in sharing too much information which can advantages others.

The second one is strategic interaction and interdependence of the choices, based on a net of con-

flicting or collaborative actions in which each of the parties shall take account of others before making their own moves. Strategic options, which are sets of decisions in a given context defining the contractual history and its development paths. these mechanisms could cause a series of consequences of skepticism in the team.

Also set of rules, sanctions, conventions and behavioral habits which motivate operators, for economic exchanges to take place. Relational contract applies this theory to align the interest of the operator, in fact a sharing pain and gain act is used to let people improve the scope and its final result.

## CONCLUSION

The study the relationships of AEC Subjects by game models within the hermeneutical approach means to emphasize the strategic interaction character and conflict in the choices based on the significance that individuals ascribe to action in a specific operative context. The game is "a human paradigm" resulting from the subjects' characteristics, their bargaining power and operative context in which they operate; participation in the game does not put all parties on an equal situation (non-neutrality of the game), and even there is not a general consensus on all the rules (contestability of the game). In production activities management, the actors establish agreements with content, possibly minimum and with standard rules, if, through them, are able to "control" the relational instability level and, at the same time, maintain a degree of freedom to realize their goals protecting their competitive advantages. The hermeneutical approach of the games allows to interpret the competitive dynamics of a contractual relationship between the AEC parties according to a perspective that accepts the existence of a multiplicity of meanings, shares and solutions that all equally possible for the relative advantage position, giving up the idea of arriving at definitive solutions.

In this context, the proposed future scenario is carried out using an approach that aims to deepen the strategic interaction processes existing between

the participants in the construction process. According to this approach, the theory of games and contracts can be used as a tool for understanding the parties' agreements, the reasons and their cognitive processes, and despite the needed simplifications, this representation would assume a normative value in a meta-decisional vision. This means providing a systemic vision of the relationships complexity that permits an implemented understanding of decision-making processes.

The paper also outlines the situations defining the interaction processes, underlining the following requirements: essentiality, irreplaceability, interdependence of subjects and the bargaining power modulated by opportunistic or collaborative interaction processes which may be treated, respectively, as not cooperative (incomplete opportunistic contracts) or cooperative (collaborative complete contracts) games.

Based on the abovementioned articles, the drawing of experiments and related issues, it is possible to understand how the issue of adverse selection is important and how its presence in different sectors of our society influences the performance and results of the same. Against this background, in order to reduce the information asymmetry and improve the efficiency levels in which markets operate, many institutions have decided to invest in activities such as (Siegenthaler): (i) reporting and (ii) screening. The first activity involves aspect of market management. The agent, who owns the information, uses means such as guarantees, quality certifications and advertising to demonstrate and ensure both the company's characteristics and the state and characteristics of the good or service it offers in the market. The second activity involves aspect of the administration. The agents carry out market regulation, information evaluation and quality control over the good or service on the market, in order to prevent the reduction of the average quality of the products. In addition, in order to restore market functioning, institutions require to agents engaging in social activities requiring additional costs, this means that the reduc-

tion in informational asymmetry requires the parties concerned to define new cost margins. The uncertainty aspect has also been studied also for the Theory of Games, where a player must choose a strategy of action to maximize the global profit, knowing that the results of the same do not only depend on it, but also from the strategy chosen and pursued by the counterpart that is unknown to Initial player.

The player's tendency is to choose a strategy that leads to the maximization of their profit, at the expense of the community. The player is willing to change his strategy when he is aware of the strategy of the other, through free communication mechanisms, and the expected result continues to increase. Thus players' cooperation mechanisms are encouraged when they can communicate and share information about the strategies they intend to implement, aware that the end results will have similar entities for both parties. In conclusion, collaborative contract - and more in general co-operation mechanisms - are the way to mitigate the adverse selection phenomenon, such as the persecution of an informative and efficient communication between the various operators.

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