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The Institutional Role Model: A System-Dynamic Approach to Reduce Complexity

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ABSTRACT

The paper's primary objective is to make a scientific contribution by presenting an innovative, system-dynamic method for organisational change in the context of today's market complexity which is the institutional role model (IRM). It also aims to show why classical organisational theories no longer have the necessary degree of complexity to successfully tackle current challenges. The research process contains several steps. Firstly, it provides a literature-based analysis on why dynamic processes are needed to fully grasp today's complexity as well as the ground theory related to the IRM. Secondly, governmental projects that have been conducted by the authors are analysed to provide concrete cases in which the IRM was used and proved to be the superior method to organize complex systems. The aim is to examine these case studies and make a general methodological contribution to how institutions can be structured using the institutional role model and they can effectively and successfully work together. The primary aim of the model is to ensure that tasks, responsibilities and roles are systematically assigned to the most appropriate institution over time through democratic and anonymous qualitative and quantitative processes. The dynamic approach of the IRM fully considers the technicalities of today's technologies and is making sure that a high level of interoperability is guaranteed. This is one of the main assets of the IRM and making it more holistic and therefore better than previous working models. Through the anonymous and democratic questioning process the allocation of resources is optimized, since a great number of Institutions are filling out the IRM matrix and providing an assessment which institution is best suited to take over a specific role. This ensures that the organisation's resources are used effectively and efficiently.

1. INTRODUCTION

One of the major theoretical contributions of liberal economic theory after Adam Smith is the division of labour, which has ensured substantial increases in productivity throughout the centuries. The most important aspect of the division of labour process is that the different actors must be efficiently and effectively interlinked, which is achieved through cooperative structures. Only then can the division of labour improve the efficiency of business processes. However, not only is efficiency essential: the effectiveness of the measures is also of central relevance, which leads to the question of whether the right person is doing the right thing at the right time. Especially in a highly competitive environment, the efficiency and effectivity of actions is getting more and more important. Innovation within organisations, for example, is of utmost importance for the survival of organisations. This requires enormous organisational adaptability to the current environment. The use of dynamic capabilities also includes aspects such as adaptability and change to ensure corporate competitive advantage. Thus, the main question most researchers try to answer is how this high level of complexity within organisations can be managed efficiently and effectively. However, until now, researchers have been unable to understand the microfoundation of organisational performance in a dynamic environment. Microfoundation is understood as the individual-level and group-level actions in an organisation that shape strategy and lead to superior organisational performance. In every organization the primary tension is the balance between efficiency and flexibility. As organizations get older, they tend towards more rigid structure with a strong focus on efficiency. This results in a lack of flexibility and adaptability to its current environment. One of the primary duties of a leader is to actively encourage its organization towards flexibility to ensure that there is a balance between flexibility and efficiency. When considering these two dimensions we automatically deal with the environment in which the organization is operating in. It is important to mention that the environment is a much more complicated object of analysis and why it is difficult to use the stable versus dynamic dichotomy. The environment includes dimensions such as ambiguity or lack of predictability [1]. In this paper, the authors deliver a specific framework that can be used by every organisation to master their microfoundation, hence provide a clear structure on how organisations must be organized to achieve the organizational goal and provide a necessary tool to reinforce the organizational flexibility that is needed to navigate through the world's complexity.

One of the scientific contributions made in this regard is that self-regulating collaborative partnerships have significant advantages over traditional hierarchically structured organisations. However, this contribution also emphasises that the complexity of this cooperation is often underestimated, especially when considering the temporal dimension of the

cooperation. Network-based organisational forms use flexible and dynamic communication media to link different organisational systems effectively.

Networking, cooperation and adaptability are the key concepts in the literature on generating a competitive advantage over other ecosystems. Furthermore, the triple-helix model theory clearly states that innovation needs close cooperation between stakeholders [2]. However, the remaining question is how we manage this cooperation and how it can be structured in such a way to enhance organisational performance. The relevant literature does not offer any structured, practical and implementable approach to managing effective, non-discriminatory and time-dependent cooperation and thus ensuring the organisation's viability. This is where the institutional role models (IRM) approach fits in.

The IRM theory is a new method that enables multiple institutions to conduct non-discriminatory cooperation and reduce the overall system complexity, thus accelerating the process of implementing innovations and new business models, while maintaining oversight of the relevant processes. It guarantees that all relevant roles are performed by the most appropriate institutions. Therefore, the leading principle in the conceptual framework of an IRM theory is not the self-interest of institutions but the perceptions of roles and the optimal allocation of roles [3]. The IRM theory establishes a monitoring system to reduce income uncertainties among the institutions and thereby stands in significant contrast to the hierarchical and determined legal structure of operating models that focus on profit maximization [4]. Overall and in contrast to operator models, IRMs enable higher flexibility, which in turn further increases the organisation’s adaptability to changing market conditions [3].

Organisations considered as being social systems are subsumed under the category of evolutionary systems. Organizations are becoming more and more complex and therefore should not be considered as a technologically isolated system but they should rather be considered as a system that is linked with its society as well as its psychic and natural networked system [5]. Bionic as a young scientific discipline and sub-division is the science of using evolutionary solutions observed in the nature and applying them to organisations. The basic principle is the usage of cybernetic principles of the natural evolution [6, 7]. Based on this modern theory it is appropriate to use an analogy to illustrate the importance of cooperation. To illustrate the necessity of cooperation the paper is using analogy coming from the biological space. Genomes, cells, multicellular organisms, but above all society, base their structures on cooperation. Cooperation entails that one entity must incur a certain cost *c* to provide an advantage *b* to another entity. Studies show that a population consisting only of co-operators has a much higher average performance or above-average growth rate than a population consisting only of defectors. This fundamental idea underpins the IRM. How can an organisation increase synergy and growth potentials through cooperative collaboration? This is especially an important question because evolution and evolutionary processes occur on the basis of cooperation. In particular, new organisational heights can be reached when different units that are in competition with each other start to cooperate. Cooperation between units ensures a high degree of diversity and enables the cooperating units to specialise in certain subject areas, consequently achieving above-average performance. Consequently, biological and natural processes are also characterised by cooperation, the logic of which can be applied to both social and organisational processes [8].

Ole Peters and Alexander Adamou make an important contribution to why cooperation has a positive effect on the growth rates of a system and why cooperative systems always outperform non-cooperative ones in their growth rates [9]. They argue that this is because cooperation significantly reduces the net effects of fluctuations. The theory surrounding ergodicity should also be cited here as it has mathematically proven that ergodic systems have above-average growth rates. An ergodic system is subject to the assumption that it is highly likely that the time average and the ensemble average produce the same result. Consequently, a strictly ergodic system has a low degree of fluctuation, which is needed for the optimal evolution of a system. Thus, organisations should always choose strategies that reduce volatility and pool their resources in favour of evolution should always be chosen [9]. If we project these thoughts on economic questions, various statistical analyses show that a large number of companies fail or exit the market because the dominant management thinking and language are based on classical economic paradigms. Arie de Geus describes it this way: companies fail precisely because managers focus too much on the company’s economic activities and often forget that the true nature of their organisation is a community of people [10]. These observations thus show that classical organisational theories and mindsets are not suitable for mastering future challenges. Arie de Geus conducted a large-scale study which identified four factors needed to ensure the longevity of an organisation. The study found that long-lived organisations are sensitive to their environment; have a high level of cohesion; have a strong sense of their identity; are tolerant and follow a conservative financial structure [10]. Due to its structure, the IRM approach can fulfil the first two conditions, in particular, to a high degree. Thus, the IRM ensures a very high level of intra-organisational stability and promotes the longevity of organisations since with the IRM organisations develop a high level of sensitivity to their environment and create a high-level of cohesion. In a market environment characterized by these fluid dynamics, it is necessary to rethink the classical methods of structuring dynamic organisations and scientifically discuss new approaches. This paper aims to provide a general theoretical contribution by using governmental projects as a case study that have been conducted by the authors themselves to provide a holistic theoretical framework on how to master today’s complexity.

The following paper is structured as followed. First of all, the chapter “Material and Methods” deals with the ground theory on which the IRM is based and underlines the importance of cooperation by using an analogy from the biological area, followed by a detailed description of the IRM and how the IRM is used on an operational basis. In the chapter “results and discussions” several governmental case studies are presented that have been conducted by the authors are described showing that the IRM has a proven track record as being one of the leading organizational tool to reduce overall complexity. GAIA-X is one of the most recent governmental projects that is using the IRM to establish a viable system architecture making sure that the project goals are reached. GAIA-X is funded by the German Federal Ministry of Economics in order to come up with a solution to build the next generation data infrastructure with a strong focus on openness, transparency and security of the data infrastructure. The chapter “conclusion” summarizes the main findings, followed by the recommendation part that is coming up with

concrete practical recommendations and implications. Like every theory the IRM has also its limitations resulting in a concrete research question. These aspects are addressed in the last chapter called “limitations and future research”.

This paper’s primary objective is to make a scientific contribution by presenting an innovative, system-dynamic method for enacting organisational change in the context of today's market complexity. It also aims to show why classical organisational theories no longer have the necessary degree of complexity to successfully master today's challenges. The classical methods are to one-dimensional which is not sufficient anymore to master today’s complexity. The effectiveness of the proposed method is confirmed using government projects that have been managed by the authors. The paper aims to present a scientific and practical reappraisal of the main findings, placing them in a scientific context and making them accessible to the general public via open source. It also aims to ensure that the methodological approach is accessible so that it can be applied in organisations and hence have a practical value. Sharing this approach with the scientific community is the next step in introducing a theory of organisational change that delivers a new, needed and different approach to overcoming complexity.

2. MATERIAL AND METHODS

When a new project consisting of different partners begins, the partners’ strategic behaviour is often a substantial problem. The partners are aligned in their business objectives (e.g., concentration strategy, market growth strategy, revenue-maximizing strategy or rationalization strategy), which are easily changed, especially in publicly traded companies with flexible shareholder structures [3]. However, company members that agree on their goals can easily disagree on any operational, tactical and strategic management decisions. Therefore, the danger of moral hazard constantly threatens operator companies; for instance, this can occur when the management of an operating company intends to introduce a new service at the same time as another member of the company. One of the main reasons that moral hazard is a challenge for companies is that organisations are characterised by high information asymmetry. This information asymmetry and moral hazard challenge is solved by using the IRM since this model provides a transparent and anonymous tool that promotes a trust-based cooperation between different institutions and prevents any kind of strategical behaviour to the detriment of the organisation. Moreover, the IRM makes sure that the organizational goal is reached in an efficient and effective manner. Furthermore, situations often arise in which individual companies are not deployed using their capability and consequently cannot develop their full potential. This is often because the companies inside and outside the partnership are not organised adequately and in line with their characteristics. As a result, significant friction losses occur, which can have considerable consequences for the business structure and success of the company.

Consequently, one operating company may implement a defence strategy to hinder another company from entering the market in order to protect the company’s market share. There are strategic market mechanisms that can be used by organisations leading to a market deterrence. This places the operating company in a rationality trap because its interests diverge from those of individual company partners. Thus, moral hazards and rationality traps decrease a company’s adaptability to changed market conditions and prevent product or service innovations. Furthermore, today's systems, which include both societies and organisations, are characterised by an extremely high degree of complexity, and the various elements of a system are highly interrelated. In this context, complexity can be understood as diversity. There is a high degree of interdependence in current organisations, whether at the intra- or extra-institutional level, which has led to an exponential increase in complexity. Complex structures can only be managed by applying concrete and appropriate models and rules to the social system [6, 11]. Institutions are only perceived as such when a set of rules exists; this is because an adequate system-environment differentiation is only possible through a concrete identification and implementation of rules [12]. Rule systems are able to enable orderly action. Among other things, through these systems, companies can establish rules to enable action that is appropriate to the company complexity. The classical operator models have the considerable disadvantage of only being able to describe one-dimensional cause-and-effect relationships and for most they do not include the temporal dimension that is highly important for the survival of organisations.

The second concept underlying an institution is the action system [11]. Action systems comprise concrete courses of action that occur within the framework of the regulatory system and are intended to serve a specific organisational and/or personal goal. These two levels, namely action and rule system, are essential to adequately grasping the structure of an institution. On this basis, the IRM theory was developed to solve this complexity problem. Finally, institutions exist in a certain time-space structure. The IRM bases its system dynamics on the concept of the institution, which comprises both a system of rules and a system of action and considers the temporal development of interdependent relationships between individual and institutions. These three elements constitute the main features that differentiate the IRM from classical operator models, the latter of which can only capture under-complex cause-and-effect relationships that do not consider the relevant temporal dimension [6]. System-dynamics is the science explaining non-linear cause-effect relationships in complex systems by using incremental feedback loops and adapting tools to a changing political, social or managerial environment [13, 14]. The IRM theory is a structure that has a minimum level of complexity and can thus better describe, structure and organise system relationships. These types of theories are needed for current organisations to act in a way that is appropriate to their complexity and enables viability.

The IRM theory is based on institutional economics [11], systems theory [12], and the theory of system-dynamics [15, 16]. The IRM theory is based on theoretical developments of the authors paper [17]. To further these theoretical explanations and tract the origin of the IRM, it is crucial to describe the various stages of development in the field of role models. In theory, operator models are divided into three types: an operator that is fully publicly owned; an operator with public and private interests; an operator that is fully privately owned.

The operator model is usually selected using a multi-criteria evaluation that defines specific objectives and requirements. The evaluation can be based on qualitative and quantitative factors that provide an empirical basis to bolster the decisions. The distribution of company roles must fit to the entire supply

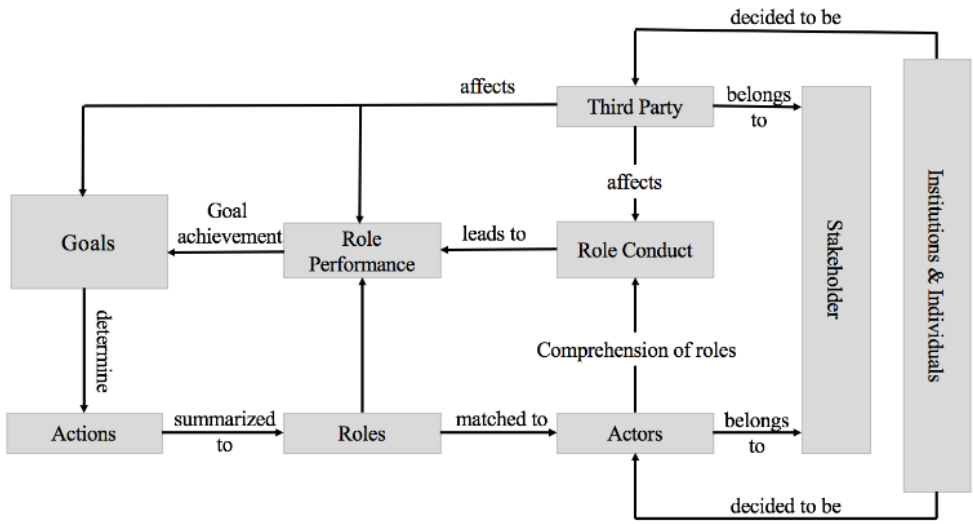
chain of an organisation. The elements of the supply chain include the organisational functions of procurements, production and distribution and several other functions, depending on the organisation under observation. In service provision, the elements of the supply chain (analogous to the organisational functions) include data collection, data processing and provision of services. Every operator model must be structured in advance to be functional. The primary level that must be regulated is the operational-organisational structuring of the operator concept. The operational-organizational level includes the legal form of the organization, the definition of the capital structure and the determination of the shareholder structure. Furthermore, companies must determine investor financing and the marketing of services or products in advance. These are routine actions and decisions that must be made in the context of organising an operator model [18].

These operator models have significant deficits. Major decisions have to be taken in advance and are not resilient to market structure change or any other changes affecting the institution (such as knowledgeable employees leaving the company). Thus, the first rule from Arie de Geus is violated since the classical operator-model is not sensitive to its environment and therefore its adaptability is limited. In addition, there are considerable transaction costs because institutions cannot be certain of whether the system's structuring will adequately fulfil the operational tasks, and it is not possible to undergo a quick and uncomplicated restructuring because the system is not fluid. Due to the insufficient dynamisation of the structure, knowledge and competences cannot circulate freely in the organisation. Consequently, it can be assumed that the organisational potential cannot be fully exploited. Due to the complexity of these institutions, linear models such as the operator model do not sufficiently capture all the market dynamics. There is thus a need to organise the relations between individuals to ensure the optimal functioning of the system [19]. This approach was pursued and further developed in the Federal Highway Research Institute's (BASt) research project on operating systems and introduction scenarios for cooperative systems [18]. Part of the BASt's conceptual development is providing a matrix solution for intelligent transport systems (ITS) in road traffic [20]. This article written by Schulz assesses the application of the IRM to the project called "Marktdesign Kooperativer Systeme" [21]. Geis and Schulz more broadly applied the IRM concept to questions concerning critical infrastructures [22].

As mentioned, the IRM makes use of three disciplines: institutional economics, systems theory and systems dynamics. These three disciplines contain essential components that are useful to understanding how organisations function in general. Organisations have been increasingly viewed as social systems again. This conception considers, in particular, the organisation's communication network and the individuality of employees [5]. Especially in view of the growing internal and external complexity of the environments in which organisations operate, it is no longer possible to pursue planning-determined approaches to structuring organisations: increasingly, behaviour-based structuring is more appropriate. In particular, managers must make the difference between the organisational system and its environment [5]. These two aspects – namely, complexity and system-environment differentiation – make it clear that a one-dimensional organisational view is no longer appropriate to capture, describe and organise organisations according to individual objectives. Complex and diverse challenges require approaches that make complexity manageable. These three disciplines enable a better understanding of the organisation due to their axioms and regularities. Systems theory describes the relationship between the organisation and its environment. System dynamics is a discipline that can capture and describe the dynamics that exist inside and outside an organisation, and institutional economics ensures that the semantics are sufficiently precise to properly capture the object of analysis. There are a large number of publications for each of these disciplines; thus, these are well-researched domains.

However, a consideration of these singular disciplines often significantly limits the solutions, and the full potential of these disciplines is only unlocked once they are linked. This enables a more holistic view of the research object. The IRM has taken up this system-immanent weakness, and Schulz has developed a solution model that can grasp and structure organisations more holistically. Figure 1 presents a schematic overview of the IRM's approach. The term "institution" is the critical starting point in this figure and individuals are the smallest units of institutions.

This figure shows the stakeholder structures and the process for the development of a role model.



Source: [18]

Figure 1. Development of a role model

Institutions include companies, authorities, associations and courts. Economically speaking, an institution is a social subsystem with decision-making rights and duties. Institutions regulate the behaviour, communication and actions of individuals. They are created to reduce various forms of uncertainty through improved planning and predictability where information asymmetry exists. Therefore, an institution imposes rules that individuals must adapt to, using them to coordinate among themselves. These rules enable people to move within a predefined framework and, therefore, to act at any time [4]. Such assembling is appropriate in this project's context because individual actors like the Federal Minister of Transport and Digital Infrastructure are influential in introducing Cooperative Intelligent Transport Systems. In general, institutions are control systems (regulations) and systems of action [11].

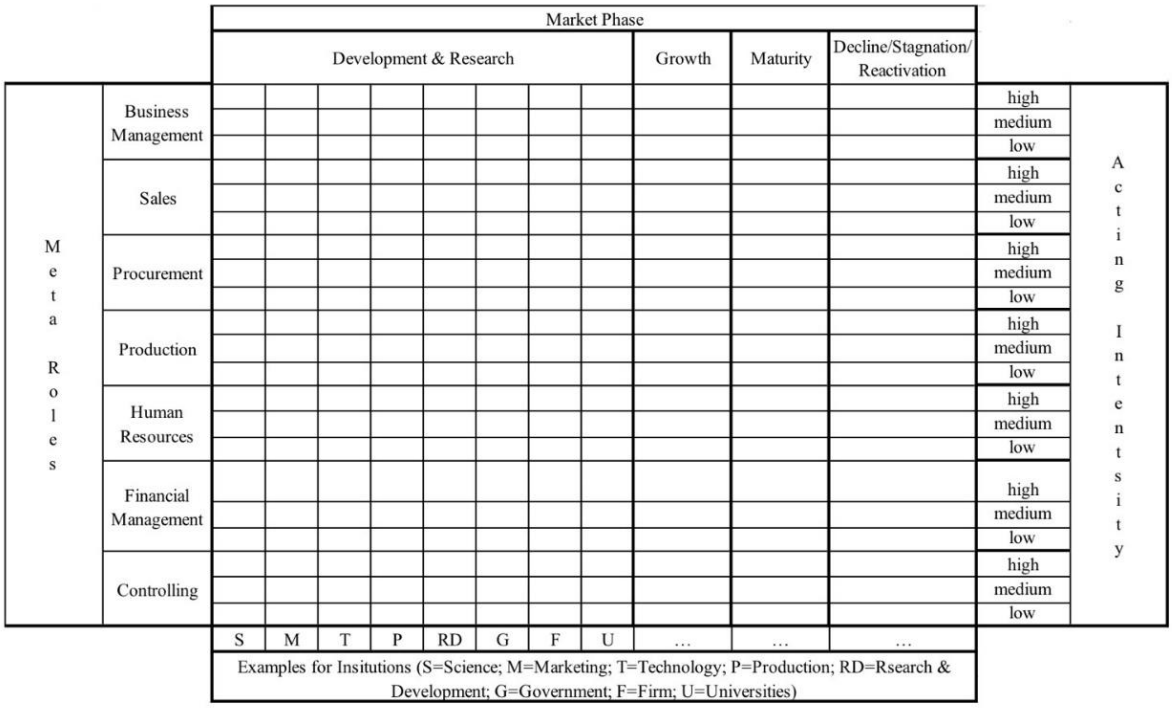
Legislation, for example, is a control system. Beyond the legal framework, control systems include behavioural standards and the habits of markets and the organizations, which are components of markets and corporate structures. Systems of action require acting individuals. This feature separates systems of action from the control system [11]. Therefore, a control system is an abstract structure of sentences, norms and conditions. A system of action is an individual, as the smallest unit, or a corporation, as the bigger unit. In the IRM framework, relevant systems of action are represented by public or private institutions, observed at the legalistic level.

Market relations do not exist between third parties and the relevant actors of the IRM. Consequently, there is no opportunity for negotiation, beneficial use, or exclusion from the consumption of a good or application of a service between these two groups. However, in the context of IRMs, the third party or parties are positively or negatively affected by the democratic process of role distribution within the ecosystem. Thus, third parties attempt to promote or impede the role model by influencing the role perceptions of actors, the result, and the target achievement. This group of third parties is not determined as it is specific for every role model. While it is suitable for actors to have no third parties, this is not the best-case scenario. The best-case scenario for actors is to have a group of third parties that all support the role model. The worst-case scenario is to have a group of third parties that all them oppose the role model. The schema illustrated in Figure 2 presents an extract of the development of an IRM. The dimensions of the characteristics value the "acting intensity" (high, medium, low) and the "market phase" (development and research, growth, maturity, decline – stagnation – reactivation) for operational purposes, since these two dimensions have a great impact on the distribution of the role to the best suited institution. On this basis, the development phase can be further classified into research and development, introduction and operation.

Figure 2 shows the template used for the execution of the IRM.

It is possible to distinguish between two types of IRMs: technical role models and economic role models. Technical role models are regularly applied in the development of a system's architecture. For an extended period, there had been no economic equivalent to these models, and it was not possible to automatically transfer technical role models into economic business models. The institutional-economic role model fills this gap and provides a solution to fully integrating the technical and economic dimensions into one organisational tool, thus ensuring that a holistic perspective is used.

The IRM approach is new and being systematically developed. The IRM matrix requires two input vectors. First, economic and technical roles have to be identified using interviews, which is the qualitative method. For economic roles, classical business roles should be adapted to the roles needed for value creation. The conceptual character of the present development requires a relatively high degree of abstraction from these roles.



Source: Schulz:[3]

Figure 2. Schema for the development of an institutional role model

Roles derived for the examination are called meta-roles. Examples of economic meta-roles are business management, services, human resources, financial management, or controlling.

The aim is to identify best-case scenarios or at least operative role models. The first necessary step in creating an operative role model is the successful identification of suitable actors. Furthermore, the institutions most suitable to represent these actors should be identified. Because institutions are not involved in the identification process, the willingness of identified institutions to assume roles is unclear. Various approaches can be used to identify suitable actors: the regulatory approach, the cooperative approach, a mix of regulatory and cooperative approaches or the expert evaluation.

In the regulatory approach, the regulator identifies the most suitable actors for different roles. To assign roles to the identified institutions, the regulator must possess property and negotiation rights. In contrast, the cooperative approach is narrower. Here, the most suitable actors are exclusively selected from a pool of actors who agreed to assume a role. Thus, there is a risk that some roles are not assigned because certain institutions are not considered in the pool of actors. However, the advantage is that both the negotiation period and costs are lower because the considered institutions have already indicated their willingness to assume the role. More precisely, the identification of actors occurs though a selection process, which consists of three steps:

Every actor reveals their preferences regarding the identified roles. The values range between one (lowest willingness to assume a role) and five (highest willingness to assume a role). Then, using a 360° evaluation including the perception of other institutions and expert opinions, the IRM can provide a relative assessment taking all the different evaluation into account in regard to the optimal distribution of roles to the respective and best suited institutions. Lastly, based on the questioning and the specific algorithm, the roles are neutrally assigned to the best suited institution.

By mixing the regulatory and cooperative approaches, the weaknesses of both approaches (e.g., missing right of disposition, the low willingness of institutions, the small pool of institutions or long negotiation periods) are mitigated. The mix of regulatory and cooperative approaches is applied in various steps. First, the regulator identifies institutions most suitable for assuming the roles. The "own view" value is the willingness of a partner to assume the role. Institutions are assessed to determine their willingness to take over a specific role, and only institutions willing to assume roles will be assigned as actors. Then, the cooperative process is applied through a 360° feedback evaluation. Here, the average value of the partner view is 3. This reflects the arithmetic average, namely an aggregated value.

Furthermore, the exact composition of the average value is relevant. In an extreme example, each partner may vote 3. In this case, the variance between partner views is zero, and the partners agree on their impression of the partner in question. However, the average value of 3 could also be a result of mixed voting: for example, eight partners could have voted 5, one partner 2, and the remaining five partners 0. The average vote of this mixed voting would therefore be 3, but the breakdown of results indicates disharmony between partners concerning the capability of the partner in question to assume the particular role. Thus, it is critical to understand the composition of this value. This evaluation process is conducted using an algorithm that evaluates all the answers provided by the institutions that voted anonymously. Based on the calculated results, the model can ensure that all the relevant technical and economic roles are assigned to the best-suited institutions. This democratic process ensures that there is a high enough acceptance of the assigned roles within the organisation, thus avoiding any kind of conflicts related to assigning roles. The empirical process includes statistical metrics such as standard deviations and means calculations, thus providing a neutral approach to evaluating the survey results.

Lastly, the regulator can compare these cooperatively derived results with the respective regulatory framework. Thereby, they have the opportunity to realize a mix of role models, which is the most practical outcome for their regulatory goals. The idea behind having a neutral view is thus two-fold: First, the partner view should be adjusted according to the variance between partners. Second, as partners are not equally important (e.g., multi-national companies and small research laboratories have differing importance, in contrast to a one man, one vote system), each partner's voting should be weighted according to the respective firm size.

In some situations, different environmental effects can lead to the failure of operator models. Furthermore, an operator model can implode and fail from within due to the unwillingness to introduce an operator model. If market failures are observed, and consequently operator models are neither designed nor operationally implemented, the responsibility for implementation is transferred to the state or any other institutions willing and able to take over this specific role and/or responsibility. The state has more room for manoeuvring than traditional organisations. This is particularly due to its area of competence. Through legal acts, the state can extend its area of competence as it wishes and consequently assume responsibility over certain tasks and functions. For example, the state can assume responsibility over the following areas: regulatory, competition, research, industrial, small and medium-sized enterprise (SME) and environmental policy [18]. To fulfil this paper's aim, it is suitable to analyse case studies to visualise the IRM using practical examples. The case study method is suitable for the analysis of facts because a large number of case studies have been carried out for research projects of different ministries; thus, the effectiveness of this model has already been successfully proven several times. From a scientific standpoint, the successful implementation of the IRM is suitable to document best practices and work out the essential characteristics to ensure a successful implementation. Thus, the present case is both a case study and a field experiment that has been used in several research projects. These observations provide the analytical framework to demonstrate effectiveness and efficiency of the model.

3. RESULTS AND DISCUSSION

In many large-scale government projects, there are various institutions and many roles and tasks that need to be fulfilled; however, it is often difficult to known which role or tasks need to be fulfilled and institutions are best-suited to take over these roles. Most institutions are not aware of which role or task need to be fulfilled to successfully complete projects. One of the key findings resulting out of the case study is that the IRM approach allows for the faster identification of the relevant roles or tasks and institutions needed for the successful

realization of specific objectives. The identification process, in which the relevant roles are identified, is conducted through a structural empirical process that uses qualitative research methods. Every project requires key actors to be responsible for different activities. Through IRM, not only are the roles and relevant institutions identified quicker, but the interaction between actors, such as interactions in the field of government activities, can also be quickened. The North Rhine-Westphalian transport ministry aims to implement ITS within the state. Thus, relevant roles should be identified, such as a contact person for the road development administration. The key is to identify goals, not in the form of administrative tasks but of political objectives that a ministry wants to realize. Until now, only the existing administrative structure were used to act as the relevant institution taking over a specific role. The IRM approach provides governments and other institutions a new perspective by asking which roles are necessary and then matching a role with the relevant institution. At times, this also means creating new jobs instead of increasing the workload for existing employees or companies, which results in more flexibility. Further, this allows for a more flexible structure, quick coordination of specialists, and faster implementation of measures. In turn, this allows for goals to be realized in a simpler manner.

Furthermore, one of the major challenges that organisations face is achieving harmony within the organisation. The IRM uses a transparent and democratic process to assign roles and tasks to the best-suited institutions. This leads to a high degree of acceptance within the organisation, which ultimately results in a high level of harmony. Overall, this transparent organisational structure also increases productivity by optimising interoperability and diminishing transaction costs.

Moreover, the IRM is an extremely resilient organisational tool since it enables organisation to very quickly adapt to a changing environment; this is because the IRM can immediately identify an alternative institution that can take over the relevant roles without having to sacrifice the functionality of the system.

Last, the IRM is an extremely versatile tool that can be used in many different areas of analysis. The IRM has been used to accelerate innovation processes in organization by having clear and flexible structure allowing the organization to increase its speed of innovation considering the product life cycle. But not only can the IRM be used for innovation processes, but it can also be used to promote the sustainable development of organization by significantly reducing the transaction costs related to an organization. This clearly shows that the IRM can be applied in various areas and has a high level of flexibility, making it a highly competitive organizational tool.

3.1 Market design C-ITS

To demonstrate how to apply IRM, this article discusses the study “Market Design for C-ITS” [21]. C-ITSs are a crucial element of future mobility in Europe and worldwide. They are a subset of the overall ITS, communicating and sharing information between vehicles, roadside units and backend systems. The objective of MDS, which was commissioned by Germany’s BASt, is to inform the industry about potential initial C-ITS services and the involved transport ministers of Germany, the Netherlands and Austria. However, the infrastructure involvement in the context of the C-ITS spans beyond the scope of the Memorandum of Understanding (MoU). The initial services that this MoU discusses are roadwork warnings and improved traffic management using vehicle data [23]. For this project, the public-sector perspective on suitable initial C-ITS services was underpinned by an expert assessment. Furthermore, IRM was used for this project to identify the roles and institutions needed in the different market phases (its introductory and operating phases) and then match the institutions with the roles using empirical approaches such as a questionnaire. Using the IRM allowed the relevant government body to reduce any negotiations and transaction costs.

This figure illustrates a filled out IRM matrix for the MDS project.

Figure 3 shows an extract of the IRM matrix, including a temporal dimension (market phase: development and research), the relevant technical and economic roles, and the actor dimension (15 anonymized partners, numbered from 1 to 15). Contrary to the IRM matrix used by Geis and Schulz [22], *Acting Intensity* was replaced by a *360°-Assessment* (own view, partner view, neutral view). A part of the study was dedicated to identifying both the technical and economic roles related to the broader set of initial services. The broader set of initial C-ITS services consists of In-Vehicle Signage, Floating Car Data, Hazard Location Notification, Road Works Warning, Speed Optimization, Stationary Vehicle Warning, Red Light Violation Warning, Cooperative Vehicle-highway Automation System (Platooning), Traffic Information and Recommended Itinerary, Traffic Jam Warning, and Wrong Way Driver Warning. The set of C-ITS services is largely congruent with the list of Day-One services elaborated on the C-ITS platform [24].

Using the IRM approach, five economic meta roles were identified (business management, service management, human resource management, financial management and controlling). On the technical side, three meta roles were considered (content collection, content provision and service provision). Furthermore, two market phases (market implementation and operation) were considered. Overall, fifteen relevant institutions were identified; which institutions 1 to 7 and 15 are shown in Figure 3. A variety of public and private institutions were part of the study. The five public institutions include a public legislator, construction authorities, a public road operator, road traffic authorities, and a public service provider. Further, there are two institutions which could be private or public: a broker and standardization bodies. Lastly, the eight private institutions are a private content owner, a private content provider, a private service provider, the automotive industry, the automotive supplier industry, the information and communication industry, a communication network provider and the traffic engineering industry. Overall, a complex and broad variety of institutions were involved.

Figure 3 focuses on the In-Vehicle Signage C-ITS application using the IRM matrix. In contrast to the initial IRM concept, the acting intensity was replaced by a 360° (expert) assessment covering different expert judgments (technical university view, [TUV], business consulting view [BCV] and theoretical economic view [TEV]). Using expert judgments, it is possible to determine which institution is most suited to each role. Overall, it was easy to change the acting intensity in the IRM matrix to the 360° assessment of the MDS project.

Implementing a transparent IRM can ensure that a fair distribution mechanism exists among the various actors, thus creating sustainable cooperation projects and service products. Furthermore, technological innovations create room for

financial manoeuvring. Cooperation enabled by IRM allows institutions greater space for action and greater systemic stability.

Further, whether it is a public or private company or even an industry, IRM allows for time advantages for the necessary adjustments of their current business models and adapt to new developments and industry trends. Overall, IRM simplifies inter-industrial cooperation. Misaligned interests, mistrust and uncertainty are frequent barriers to collaborations. Thus, there is a need for change in the institutional organization of multi-actor business models. In particular, public-private partnerships often tend to be unstable due to the misaligned goals or mistrust. However, partnerships between private firms can be hindered by competition law. This is especially the case for corporations that dominate the market because the legal system has very strict limitations on the extent to which they can collaborate. The IRM approach enables market-dominant corporations to collaborate without violating the competition law.

The developed institutional economic role model is designed to assist in overcoming these risks by providing an individual – independent but action-based – system. The approach assumes that those actors who participate in the system and support the introduction of new measures follow the same overall goals as individuals. After defining the relevant sets of actions, singular actors can take over certain roles. Thus, IRM enables a systematic identification of essential roles and promotes the commitment of the involved actors. Furthermore, a system cannot suddenly collapse because an action set is no longer covered since the IRM is a dynamic and agile method that ensures that the system is viable at any time. This is one of the crucial advantages of the IRM since most classical static operator models or organizational structures collapse as soon as one of the institutions is not performing their tasks anymore. Classical organizational structures do not have the necessary resilience to risks related to dynamic changes in the organizational structure. Only organizations that are best able to adapt to their environment will survive significant transformations. This is one of the main reasons that corporations fail. Their organizational structure is too rigid and they cannot quickly adapt to a changing environment; thus, there is a lack of adaptability. As organisations mature and grow, they tend to focus on efficiency, which is why leaders actively ensure that their processes and structures are flexible and adaptable. Eisenhardt et al. state that leaders can manage the apparent contradiction between efficiency and flexibility using high-order thinking [1]. The IRM addresses this issue by providing a framework and mechanism that is democratic, transparent, ensures efficiency and is often dynamic. Therefore, it provides a balance between efficiency and flexibility, which is required to successfully operate on the market. Superior performance in dynamic environments is achieved by ensuring a healthy balance between efficiency and flexibility [1]. The structural process allows the organization to quickly adapt to the changing environment by including new institutions, new roles or shifting responsibilities. Most economic theories fail to include dynamic dimensions in their models, basing their analysis on time-independent dimensions and *ceteris paribus* assumptions. However, this ignores actual economic dynamics. This is why, as the inventor of IRM, we opted for a dynamic approach that includes a time dimension (the market phase in our case study). The IRM addresses a significant challenge, namely that research on network outcomes does not significantly address the time aspect, which is crucial to evaluating the network outcome [25].

The matrix considers several variables: a temporal dimension (market phase), the acting intensity, economic roles (based on technical architecture) and the various actors that have agreed to participate.

Market implementation, In-Vehicle Signage

Meta-Rollen												
	Business Management	2	2	3	1	3	1	1	3	Expert 1	360° Assessment
		2	2	2	1	3	1	1	3	Expert 2	
		2	3	2	0	0	0	0	0	Expert 3	
	Service Management	0	0	0	1	3	1	3	3	Expert 1	
		0	0	1	1	3	1	3	3	Expert 2	
		0	0	2	0	0	0	0	0	Expert 3	
	Human resources	2	0	3	2	3	1	3	3	Expert 1	
		2	1	3	2	3	1	3	3	Expert 2	
		0	2	3	0	0	0	0	0	Expert 3	
	Financial Management	2	2	3	1	3	1	3	3	Expert 1	
		2	2	2	1	3	1	3	3	Expert 2	
		0	3	2	0	0	0	0	0	Expert 3	
	Controlling	3	3	3	2	3	1	3	3	Expert 1	
		3	3	2	2	3	1	3	3	Expert 2	
		0	3	2	0	0	0	0	0	Expert 3	
	Content Collection	**0**	**0**	**3**	**2**	**3**	**1**	**0**	0	Expert 1	
		0	**1**	**3**	**2**	**3**	**1**	**0**	0	Expert 2	
		0	**2**	**3**	**0**	**0**	**0**	**0**	0	Expert 3	
	Content Provision	**0**	**0**	**3**	**1**	**3**	**1**	**3**	2	Expert 1	
		0	**1**	**3**	**1**	**3**	**1**	**2**	2	Expert 2	
		0	**2**	**3**	**0**	**0**	**0**	**2**	2	Expert 3	
	Service Provision	**0**	**0**	**1**	**1**	**3**	**1**	**3**	3	Expert 1	
		0	**0**	**1**	**1**	**3**	**1**	**2**	3	Expert 2	
		0	**0**	**2**	**0**	**0**	**0**	**2**	0	Expert 3	
		1	2	3	4	5	6	7	…	15	
		Legislation	Construction authorities	Public road operator	Road traffic authority	Public service provider	Broker	Standardisation bodies		Traffic engineering industry	
		Public Institutions					Public/Private				
		Institutions									

Source: Schulz: [22]

Figure 3. Market implementation for in-vehicle Signage

The practical implications of the IRM become clear when applying it to different projects that provide empirical evidence. The IRM was applied to a major project conducted by the Federal Ministry of Education and Research which aims to develop the artificial intelligence platform of the German automotive industry (AI project). This project made it clear that the IRM is an important component for GAIA-X because it enables collaboration between multiple institutions. Therefore, the IRM will be an integral part of the mobility of GAIA-X's system architecture. The IRM will be used in three working groups. This ensures that, to successfully implement the defined use cases, the structuring, coordination and cooperation of all partners is carried out according to the system-dynamic and ergodic principles. The IRM plays a central role in building the overall system architecture on the economic and technical levels.

One of the key questions underlying this empirical evidence (AI-Project, GAIA-X) is the model's academic value. In the academic literature, agent-based models in particular are discussed as possible solutions to complex challenges. Furthermore, a large number of cooperative games are discussed theoretically, especially in the field of game theory. However, these theories often have considerable practical deficits, which then need to be corrected on a theoretical level. Most of these theories use *ceteris paribus* assumptions; however, these can rarely apply to this complex world as they do not adequately capture multidimensionality. Because of this, it is imperative to use a dynamic model. On a theoretical-academic level, there have, so far, been no contributions that can describe and organise the aspects of non-discriminatory, cooperative, efficient and effective collaboration between different institutions (set of rule and action systems). The present IRM is intended to provide a theoretical and practical toolset to reduce complexity and increase the adaptability of organizations. The case studies cited above serve as an exemplary illustration of the commercial and economic usefulness of this tool. Due to the considerable synergy effects and cooperation rents, both material and human resources can be used much more efficiently and with the greatest possible organisational acceptance. These findings were confirmed, for example, by the Baden-Württemberg Ministry of Transport; the IRM was used in the course of this government research project to organise a mobility database infrastructure and automated driving system. Finally, the IRM methodology will be used in the European data cloud project GAIA-X to link all stakeholders effectively and efficiently and design, structure, organise and implement a multi-actor process. Last but not least, the IRM is used in the Hydron project, which is conducted in cooperation with Airbus Defence and Space and the Ministry of Economic Affairs of the State of Baden-Württemberg.

It was observed during the project that the productivity of the participating institutions increased significantly through the application of the Institutional Role Model, which is why the success of the Institutional Role Model was able to be measured and proven with concrete KPIs. This proved that the Institutional Role Model has a high practical relevance.

4. CONCLUSION

In conclusion, the IRM provides a system-dynamic and holistic approach to organising complex organizations. In a fast-changing environment, adaptability and the ability to respond to change are crucial. Hierarchically structured organisations are too rigid and do not provide the necessary flexibility to quickly respond to change. Therefore, a new approach was designed that address the disadvantages of traditional models and offers a system-dynamic organisational tool that uses qualitative and quantitative research methods based on empirical standards to provide organisations with a transparent and democratic process. After using empirical methods to identify all the relevant roles and institutions, the IRM sheet is set up and filled out by the relevant institutions. After an empirical evaluation process, the roles can be assigned to the most suitable institutions to improve interoperability and adaptability and reduce transaction costs without being discriminatory, which is one of the predominant rules in European competition law. The IRM delivers an innovative approach to reducing complexity in organisations and ensuring organisations are more able to master large and difficult transformations. The IRM's effectiveness has been proven in its application to different projects that the authors have conducted on behalf of the Federal Ministry of Transport and Digital Infrastructure. Moreover, one of the greatest assets of the institutional role model is the fact that it can be applied to many different fields and research question. Furthermore, it also provides the option to easily change the observation level, resulting in a great level of adaptability, since macro analysis as well as micro analysis in organizations can be conducted. This flexible approach to reduce organizational complexity will be used in the governmental project called GAIA-X, where the IRM is used to build a system architecture enabling all the partner to work with each other in an efficient and effective manner to establish a European cloud solution in order to counterbalance the market power of the hyper scaler. The paper clearly shows that the institutional role model has experienced a growing acceptance among scientific research as well as practical governmental research.

One of the limitations of the article is that no quantitative impact was measured throughout the government projects and therefore no quantitative results were shared. This is because most of the governmental projects are limited in time, making it difficult to empirically assess the impact of the introduction of the IRM. For the future development of this technology, it would be useful to use the IRM in an organization over a longer period of time in order to be able to quantitatively assess the positive impact of the introduction of the IRM.

5. RECOMMENDATIONS

This paper has established that classical and static organizational tools that have been used in the past decades are not sufficient and suitable to apply to the dynamic and complex world we live in. Current society needs system-dynamic tools that consider temporal dimensions and focus more on co-operation rather than pure competition. To generate superior economic growth, mathematicians have proved that co-operation is the preferable strategy. The IRM considers the temporal dimension and the co-operation dimension by providing a democratic and transparent process to determine which role has to be taken over by which institution to achieve the overarching institutional goal. The IRM provides a structured, theory-based and methodologically sound approach to restructuring and organizing organisations. Therefore, we recommend that institutions focus more on system-dynamic models and

promote these approaches to reduce the complexity in organizations.

6. LIMITATIONS AND FURTHER RESEARCH

The usefulness of the IRM theory was demonstrated by implementing the IRM process for the MDS project. The theory allows us to identify whether partners in a project have the willingness to assume all-important technical and economic meta-roles and, in the end, reveals the partners' cooperation intentions (willingness to cooperate). Thus, the results of the IRM process are of great value for the organisation funding the project and the project members. During the project, the funding organisations receive information on the partners' willingness to introduce project results to the market. They are also informed of which project members do not cover meta-roles. Therefore, the IRM process enables a more efficient and transparent monitoring of and agency over research projects.

The IRM process is advantageous for project partners as it improves transparency between partners. The internal organization of the project is improved through the identification of relevant technical and economic role models. Furthermore, by matching institutions with particular roles, the IRM clarifies whether the partner selection is optimal for the economic and technical role models. The results of the IRM process set the foundation for negotiation between partners, ensuring the results of the research project at introduced to the market.

A limitation of IRM is that the application of technological innovations has an economic significance and therefore government institutions and private institutions in the projects must be coordinated. So far, there are no case studies and more empirical evidence is needed to increase innovation in private companies. This model does have a high degree of dynamism. We have found that the acceptance of IRM processes is particularly high among the people responsible for development (engineers and technicians), but there is a lack of understanding of the complexity in the economic community. Consequently, IRM has to be simplified so that it is easier to use and it can be applied to different organisational levels within institutions. Furthermore, certain key performance indicators were defined for the individual results of the IRM model, such as the evaluation of transaction cost, the evaluation of synergy effects, overall fixed costs which offer the organisation the possibility to record the effectiveness of the individual measures and restructuring. In addition, the model was intensively developed in other projects. It was used, for example, in the context of establishing a mobility database infrastructure and introducing automated driving for the German transport ministry to ensure effective coordination. Consequently, it can be stated that this model's degree of flexibility allows many thematic areas to be covered. This is one of the decisive advantages of IRM compared to the classic operator models or agent-based models.

The assignment of actors to roles based on the IRM approach is a useful and flexible aspect of the model that provides relevant information and insight in the deployment preparation phase. Further, the IRM approach can be adapted to various informational needs related to the scope of the studies and projects. It has also been proven that several versions can be derived from one generic concept. The merits of the concept enhance transparency, improving the understanding of mutual dependencies in the context of collaborative action. Overall, the concept can offer design options and support for significant decisions.

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