# Evaluating a Collaborative Network of an Inter-organizational Data Exchange Project

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**Abstract**

The new data-oriented shape of organizations inevitably imposes the need to seal partnerships through data exchange projects. In fact, growing data exchange initiatives are offering increased monetary and non-monetary benefits for organizations. By and large, such partnerships are ensured by building collaborative networks. However, due to the multidisciplinary nature of collaborative networks, there is no single accepted approach that covers all the perspectives of various interest groups. This paper presents an approach that clearly identifies the opportunities for increased monetary and non-monetary benefits from data exchange projects, using Ant Network Theory.

Our approach applies cost-benefit analysis and multi-criteria evaluation to the Actor Network Theory translation process, while focusing on the problematization and interessement phases. The findings will allow to provide suggestions of alliances that are cost-effective and have a highly positive impact for the main protagonists. To facilitate the understanding of this approach, a Java EE Web application is developed and presented here.

**Keywords:** *Business Collaborative Network, Data Exchange Project, Actor Network Theory, Cost-Benefit Analysis, Interoperability.*

## 1. Introduction

Growing data exchange projects are offering increased monetary and non-monetary benefits for various stakeholders. These benefits include enhanced Information Quality (IQ) by reducing errors, easy access to information, reduced operating costs and increased revenues. On another hand, collaborative networks (CN) have become a key enabler for value creation and economic growth. In the context of IT governance, collaboration may take different forms. It ranges from business processes interoperability to data exchange, among autonomous organizations [1] [2].

Business collaboration refers to the process where several organizations work together to achieve mutual benefits, around clearly defined and agreed business or financial objectives.

Due to the multidisciplinary nature of collaborative networks, there is no single accepted approach that covers all the perspectives of various interest groups, and in particular how business and financial objectives are met and at what cost.

It this paper, we present an approach based on cost-benefit and multi-criteria analysis that can be used by different organizations that are planning to join a collaborative network, in order to gain a greater understanding of opportunities for increased benefits. The overall goal is not to build alliances by any means, but to carefully select potential collaborations that are cost-effective and have the most positive impact.

The organization of this paper is addressed as follows: section 2 presents a definition of the concepts of Ant Network Theory (ANT), business collaborative mode as well as multi-criteria and cost-benefit analysis. It also addresses the related work. Sections 3 describes the main steps of our approach. Section 4 presents the results from our case study. In section 5, the conclusions and future work are summarized.

## 2. Concepts and Related Work

### 2.1 Actor Network Theory

Actor Network Theory (ANT) conceptualizes social interactions in networks. In this context, networks integrate both the material and semiotic environments [3]. This theory suggests that there is no difference between the human and non-human parts of a technological system.

ANT declares that the world is full of hybrid entities [4]. The purpose of ANT analysis is to examine the process of translation, where one group's concerns are aligned with another's. The actors translate their interests by constructing a network and breaking the resistance of its members [3]. These actors could be an authority that either influences and uses others or has no interests and thus will follow the other actors' interests.

In order to construct a network, Callon and Latour defined an approach, inspired by ethnomethodology [5], which is based on a sequence of steps called the translation sequence. The act of translating consists of negotiating and performing a series of movements and decisions. The four main steps of the process of constructing an ANT network are as follows:

1. Problematization

The problematization phase defines the most important actors and their problems so that the other members perceive them as their own. In other words, it raises the awareness of all the actors to a specific problem, so that everyone moves towards a solution that translators are able to offer [6]. Problematization is the effort made by a number of actors to convince the others of their solution [7]. It describes a system of alliances or associations, between entities, thereby defining the identity and what each one wants [8].

2. Interessement

For Callon, the interessement phase needs the incentive devices in order to seal alliance. The incentive may be defined as "all actions through which an entity is trying to impose and stabilize the identity of the other players who are defined in problematization" [7]. The incentive devices consist of "deployment speeches, objects and devices intended to attract and attach different players to the Network" [9].

In other words, the interessement phase is building an interface and strengthening the relationships between the interests of different actors. On a strategic level, interessement can form a system of alliances that ensure the involvement of different members of an organization in the strategic process.
The main goal is to translate the interests of some actors so that other actors find them attractive and take part in the network. This is accomplished by convincing them that there are common benefits and that the proposed solution serves both their purposes as well as those of others.

3. Enrollment

The enrollment phase tries to answer the question of how to define and coordinate the roles within the network. According to Callon, enrollment is "the set of multilateral negotiations, beatings forces or tricks that come with sharing and allow it to succeed" [7]. At the end of this phase, each actor in the network is assigned a specific role. This role is tightly linked to the translation of the actors' interests.

For Callon, "the enrollment is to describe the set of multilateral negotiations, coups or intelligence accompanying sharing and allow it to succeed" [7]. The enrollment can thus be described as stabilizing the system of alliances during the incentivizing phase. This configuration is the result of multilateral negotiations, trials of strength, and stratagems [7]. It is during this phase that all the network's interests are confronted to each other. This confrontation strengthens, thus, the links between all the members.

4. Mobilization

The last phase of translation is the mobilization of allies. These allies are the actors that are most affected by the various interests and should remain relatively stable in their positions [10]. They are the stakeholders and represent their groups [4]. However, everyone can act very differently to the proposed solution: abandon the coalition, accept it as it is or change the modalities

These four moments represent the phases of a general process of translation that allow building an actor network.

Figure 1 below illustrates the actor network lifecycle:

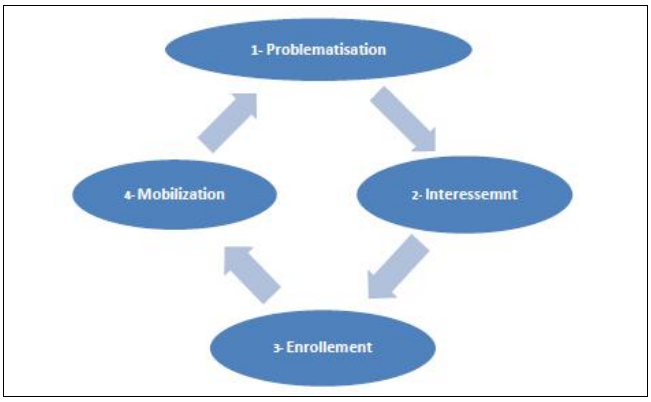


Fig. 1. Actor Network Lifecycle

## 2.2 Business Collaborative Mode

Collaboration represents one of the main relations among organizations. This means that organizations perform common jobs in order to achieve mutual benefits [11]. The same concept is used for both individuals and organizations, working together towards common objectives. The collaboration requires general, complete and lasting commitment in favor of a joint mission. Partners coordinate the collaboration and commitment to achieve the desired outcomes.

A collaboration network may represent a group of autonomous, heterogeneous and multidisciplinary entities working together in order to achieve common or complementary goals [10]. The environments in which these entities are collaborating as a network can also be heterogeneous. These differences are due to organizations' specific aspects and culture. Correlations are possible via a range of vehicles involving stockholders' Information Systems (IS).

It is suitable to note that our approach to evaluating a collaborative network of an inter-organizational data exchange project covers the problematization and interessement phases, and thus tries the answer the question of what are the essential actors and how the interests of each actor in the network are met.

For the actors who are involved in the network, our objective is not to construct alliances by any means, but to carefully select potential collaborations that are cost-effective and have the most positive impact.

In order to achieve this goal, we have implemented a cost-benefit and multi-criteria framework, for the mobilization and interessement phases.

## 2.3 Multi-Criteria and Cost-Benefit Analysis

### 1. Multi-criteria Analysis

Although the problems associated with decision-making are intrinsically idiosyncratic, they all share some common characteristics:

- A decision must address at least two alternatives to solve the problem;
- The alternatives are evaluated according to the values of the decision criteria;
- The criteria represent the factors that are important in the eyes of the decision-maker and that are influenced by alternatives.

Actually, the analysis becomes multi-criteria when it involves several criteria that are mutually exclusive in some instances.

We retain the following definition for multi-criteria evaluation: multi-criteria evaluation is "a decision support tool that allows to classify several alternatives in order of preference based on several criteria whose units may be different*"* [12].

To evaluate two job offers from two companies A and B, the decision criteria would be the: starting salary, evolution prospects, geographical proximity, size of the organization, etc. The importance given to each criterion is different depending on the person (the candidate in the case of the previous example) who must make the decision.

By and large, a decision-maker uses more than one criterion to evaluate different scenarios for a decision problem. Often, these criteria are mutually exclusive. In the case of an investment for instance, a decision-maker would like high profitability with a reduced level of risk. However, generally a high return on investment (ROI) would correspond to a high level of risk and vice versa. The decision-maker then has to figure out the most satisfactory balance between the ROI and the inherent risk.

There are several variants of multi-criteria decision aiding. One of them is the multi-criteria analysis using the Weighting Product Model (WPM).

In this method, each alternative has a corresponding score. The score is calculated based on the ratings assigned to the criteria, and the weighting coefficients that characterize the relative importance of each criterion, from decision- maker standpoint.

We denote by:

- $S_{ij}$, the score assigned to criterion i in alternative j;
- $w_i$ the weight assigned to criterion i. The weight is invariable for all alternatives.

The weighted score for alternative j will be calculated according to the following formula:

$$\sum_{i} \text{Sij} * wi \qquad (1)$$

The decision maker will select the alternative with the highest weighted sum.

The figure below depicts the global approach to formalizing a multi-criteria problem for decision aiding, using the WPM method.

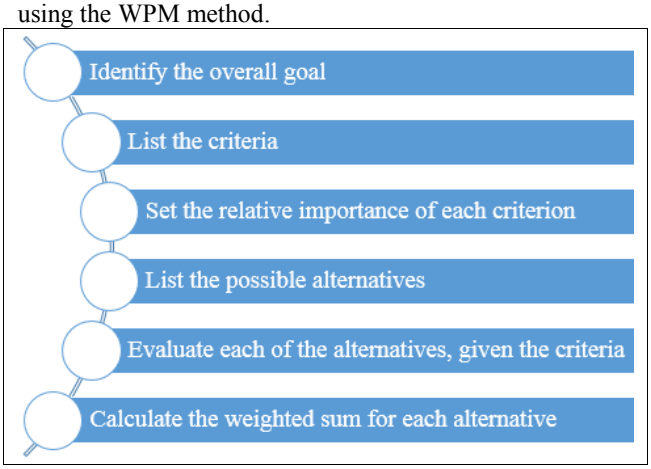


Fig. 2 Global Approach of a Multi-criteria Problem Using the WPM Method

Given the broad spectrum of decision-making problems, it should be noted that the criteria are not always quantifiable in monetary terms, making the task of evaluation even more complex. In the field of healthcare, for instance, the decision alternatives could be a medical treatment or an intervention. On the other hand, the decision criteria could be: the cost of the treatment and its effectiveness or the number of healthy years gained [13]. Under this scenario, the costs are monetary, but the profits correspond to non-monetary measures or valuations.

2. Cost-Benefit Analysis

In the same vein, cost-benefit analysis is a decision-aiding tool that can facilitate communication among stakeholders. It provides a structured framework presenting all the elements of the decision and their respective weighting, thus promoting the transparency of the process [14].
In the area of program or project management, the purpose of cost-benefit analysis is to [15]:

- Identify the best alternative or select a limited set of the best alternatives;
- Rank the alternatives from the best to the worst;
- Classify/sort the alternatives into predefined homogenous groups;
- Identify the major distinguishing features of the alternatives and describe them based on these features.

## 2.4 Related Work

The problem of implementing CN, particularly in the context of IT governance, has been given significant attention in the literature. Particularly in recent years, many types of CN [16] have been developed in response to the growing intricacies emerging from both academia and industry. Indeed, research studies trend to recognize the particular impact of the network structure on the success or failure of the CN.

As mentioned above, CN are complex systems that can be described or modeled from multiple perspectives. They were analyzed and studied by IT researchers as a virtual network. Camarinha-Matos is one of the widely recognized researchers whose contributions are focused on IT perspectives and requirements of CN.

Ahuja [17] assessed the effects of a firm's network of relations on innovation. He then elaborated a theoretical framework that links the innovation of a company to its direct ties, indirect ties and structural holes (disconnections between a firm's partners). Chinowsky [18] applied social network analysis in company level and project level to construction companies' networks. Park [19] studied collaboration effects on the resulting profit for Korean international contractors' projects.

Based on the examples mentioned above, there is no single modeling formalism or universal language that can cover all perspectives of various interest groups. Since CN have an obvious multidisciplinary nature, it is natural that we search for applicable modeling tools and approaches originating from other disciplines. In fact, computer science, engineering, and management, among other fields, have developed plenty of modeling tools that might have some applicability in CN [3].

There are also many developments in other disciplines that can contribute to the start of a foundation for CN : complexity theories, game theory, multi-agent systems, graph theory, decision aiding algorithms, formal engineering methods, federated systems, self-organizing systems, swarm intelligence, and social networks, to cite but a few.

Cost-benefit and multi-criteria analysis can provide a valuable tool in business cases involving many decision-makers who interact with each other. In the case of CN, these models could offer tools to: track ROI, manage cost and profit sharing among the network players, and highlight the most cost-effective alliances among the network.

In the next section, we will present our approach to implementing the problematization and interessement phases using a cost-benefit and multi-criteria framework.

## 3. Evaluating a Collaborative Network of an Inter-organizational Data Exchange Project

### 3.1 Positive Impact Assessment

The first part of our approach to tracking ROI of a network that collaborates to share data, consists of understanding how an organization's business/financial objectives and results are linked to the joining and taking part to a CN.

The following steps summarize the process of measuring the positive impact on the strategy execution of an organization:

1. Identify leading factors that contribute to achieving short-term business/financial objectives of an organization;
2. Configure the importance of these factors according to the specifications of each organization;
3. Measure the positive impact of each candidate according to the factors above;
4. Order potential candidates by positive impact.

1. Leading factors that contribute to achieving short-term business/financial objectives of an organization

Due to organizations' specific aspects and sets of success factors, and in order to provide a generic approach that can be implemented without any adjustment, the second step of our approach introduces the context-aware and configurable weighting coefficients (WC), illustrated in Table 1.

Table 1: Configuration Canvas for Positive Impact Calculation

| Factor | Values | Rating | WC |
|---|---|---|---|
| Impact on daily operations | • true<br>• false | • 1<br>• 0 | |
| Impact on short-term business/financial objectives | • increasing revenues<br>• increasing productivity<br>• reducing costs<br>• increasing end-user satisfaction<br>• meeting regulatory driven compliance<br>• other | • 0.15<br>• 0.15<br>• 0.15<br>• 0.15<br>• 0.15<br>• 0.15 | |
| Impact on downstream analysis | • true<br>• false | • 1<br>• 0 | |
| Impact on decision making | • true<br>• false | • 1<br>• 0 | |
| The above results are provided quickly | • true<br>• false | • 1<br>• 0 | |
| Nature of data to exchange | • master data<br>• transactional data<br>• historical data | • 1<br>• 0.75<br>• 0.25 | |

The purpose behind using a weighing coefficient is to allow each organization to express the importance of a success factor, depending of its context and strategy.

To cite few examples where using different weighting coefficients is relevant:

- Public organizations may have more concerns about increasing end-users satisfaction (citizens in this particular case), than increasing revenues;
- Healthcare actors may give more attention to meeting regulatory driven compliance than to the other factors, while still important, owing to the fact that norms and standards are mandatory in the field of healthcare;
- Industrial companies may give the same importance to all the factors above.

2. Measurement of the impact of candidates on overall project

Business and IT leaders in charge if data exchange and sharing initiatives should:

1. List all the candidates of the problematization phase;
2. Configure the importance of each factor by acting on the associated weighting coefficient. The sum of all weighing coefficient must be equal to 100;
3. Answer the questions in the first column of Table 1.

The positive impact of each candidate will be calculated using the weighed sum strategy:

$$\sum_{i=1}^{m} (Ri * Ii)/100 \quad (2)$$

Where $R_i$ is the rating for the factor "i" and $I_i$ is the weighing coefficient that is associated with the factor "i", that was previously defined by both business and IT leaders. The obtained score ranges between 0 and 5, where "0" refers to "unnoticed impact" and "5" refers to "high positive impact".

Table 2. Positive Impact Levels

| **Impact score** | **Impact level** |
|---|---|
| 0 – 1.5 | 0 – unnoticed to low impact |
| 1.5 – 3 | 1 – medium impact |
| 3 – 4.25 | 2 – high impact |
| > 4.25 | 3 – very high impact |

3. Order partners by positive impact

After iterating over all potential candidates and calculating the associated positive impact score, candidates are automatically classified by priority, in order to spot the point of departure to identify opportunities for increased benefits from data sharing.

## 3.2 Implementation Complexity Assessment

While the first part of our approach deals with understanding and assessing how possible candidates among a CN positively impact an organization's objectives and results, the second part of our approach focuses on the assessment of the implementation complexity associated with the realization of a CN.

The following steps detail the process of scoring the implementation complexity of a CN that aims to exchange and share data, what will allow to associate different levels of complexity (ranking from low to very high complexity) to data exchange projects:

1. Identify leading factors that contribute to the calculation of the implementation complexity of a data exchange network;
2. Configure the importance of these factors according to the specifications of each organization;
3. Measure the positive impact and the implementation complexity;
4. Prioritize data to improve according to the scores obtained in the previous step.

1. Leading factors that help in calculating the implementation complexity of data accuracy improvement.

Business experts should allow answering the questions in Table 3.

Table 3: Configuration Canvas for Implementation Complexity Calculation

| Factor | Values | Rating | **WC** |
|---|---|---|---|
| Risk factors | • severe<br>• major<br>• standard<br>• minor<br>• minimal | • 1<br>• 0.75<br>• 0.5<br>• 0.25<br>• 0 | |
| Level of changes | • severe<br>• major<br>• standard<br>• minor<br>• minimal | • 1<br>• 0.75<br>• 0.5<br>• 0.25<br>• 0 | |
| Level of data quality | • low<br>• medium<br>• high<br>• very high | • 1<br>• 0.75<br>• 0.5<br>• 0.25 | |
| Does the data object have attributes with great weight identification in relation to another data source? | • false<br>• true | • 0<br>• 1 | |
| Is the data processing: | • manual<br>• semi-automatic<br>• automatic | • 1<br>• 0.5<br>• 0.25 | |
| What is the size of the data to process? | • very large<br>• large | • 1<br>• 0.75 | |

| | | | |
|---|---|---|---|
| | • medium<br>• low | • 0.5<br>• 0.25 | |

2. Measurement of the complexity of data accuracy improvement projects

The implementation complexity will be calculated as follows:

$$\sum_{i=1}^{m} (Ri * Ci)/100 \quad (3)$$

Where $R_i$ is the rating for the factor "i" and $C_i$ is the weighing coefficient that is associated with the factor "i", that was defined previously by both business and IT leaders. The obtained score ranges between 0 and 5, here where "0" refers to "minimal complexity" and "5" refers to "severe complexity".

Table 4. Positive Impact Levels

| Complexity score | Complexity level |
|---|---|
| 0 – 1.5 | 0 – very low-to-low complexity |
| 1.5 – 3 | 1 – medium complexity |
| 3 – 4.25 | 2 – high complexity |
| > 4.25 | 3 – very high complexity |

To summarize, our approach consists of:

1. In the context of a CN, determine what business candidates contribute the most to the business's objectives and results;
2. Determine the data exchange project complexity;
3. Recommend the optimal business case for the CN.

After completing our research and in order to calculate automatically our indicators, we have implemented a Java EE Web application, which main functionalities are:

1. Create a new candidate of a CN;
2. List registered candidates;
3. Assess the positive impact;
4. Assess the implementation complexity;
5. List all previous assessments.

The figure below depict a screenshot from our Java EE Web application:

## 4. A Use-Case Study

In order to test our approach of actors identification based on ANT, we work on the inter-organizational data exchange project for the Department of Lands of Morocco (DoL).

The DoL administers the State-owned land mass. Its primary purpose is to unlock the potential of State's lands for the economic, social and environmental benefits, while optimizing the value of the State's land assets. The DoL is pursuing its objectives through a number of fully automated business processes including: administering the sale of State's property, managing the Government's land acquisition program, leasing eligible lands for investment, revenue accounting, managing government employees housing, among others. In a dynamic and changing environment and to enable the DoL to carry out its attributions, it is important that the DoL works with its partners. In particular, data exchange projects allow enhancing the DoL's information quality, reducing errors

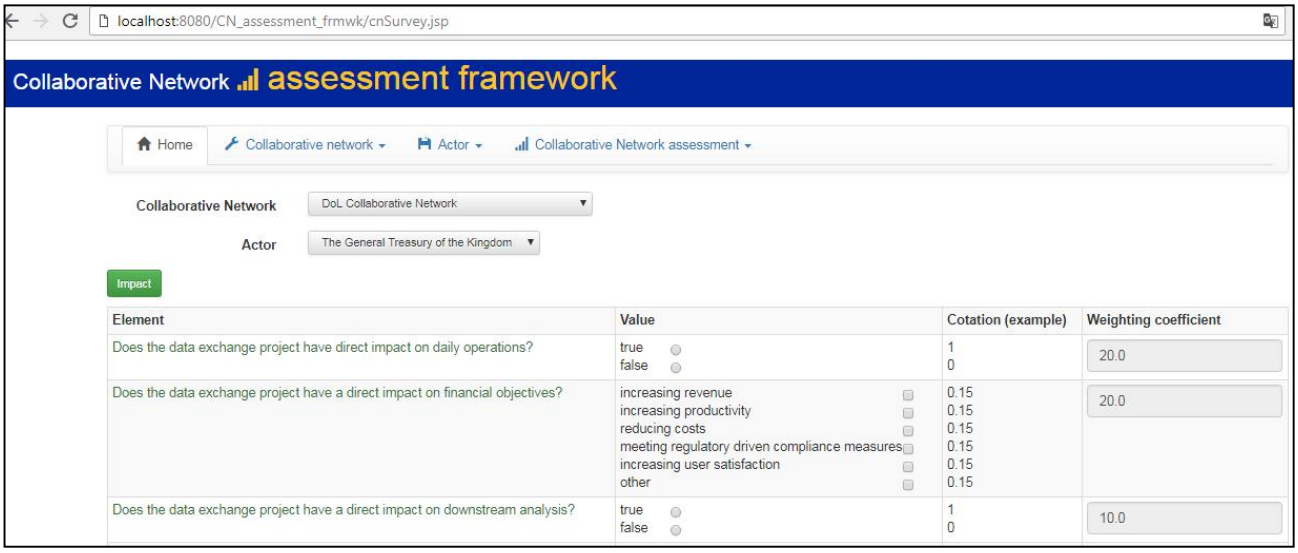


Fig. 3 Collaborative Network Assessment Framework

and thus processing time, enabling access to information and more importantly extracting true value through data. Given the current economic challenges and budgetary pressures facing most organizations, there is a substantial desire to achieve those targets successfully, with reasonable budget and changes.

In addition to the DoL, the data exchange project involves other departments of the Ministry of Economy and Finance:

- The Staff Administration Department (DDP[1])
- The Tax Directorate (DGI[2])
- The General Treasury of the Kingdom (TGR[3])
- The Budget Directorate (DB[4])

In the current case study, each actor has its own IS:

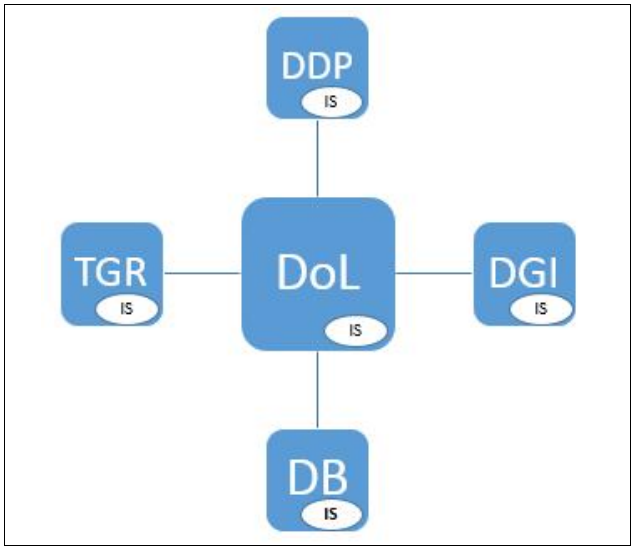


Fig. 4 Collaboration Network of the DoL

Our Web application was used to automatically calculate the positive impact and complexity indicators. The results of the experiment are provided below:

[1] *Direction des Dépenses du Personnel*
[2] *Direction Général des Impôts*
[3] *Trésorerie Générale du Royaume*
[4] *Direction du Budget*

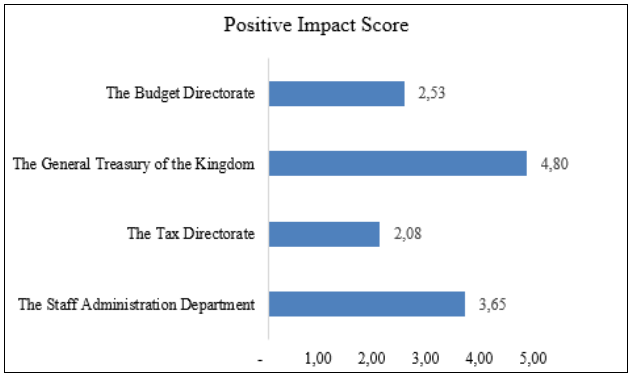


Fig. 5 Positive assessment score for the analyzed business partners

Figure 5 illustrate the results of the positive impact score calculation. As it can be observed, the highest impact score was related to "The General Treasury of the Kingdom", followed by "The Staff Administration Department". "The Budget Directorate" and "The Tax Directorate" had the least impact on the business/financial objectives of the DoL.

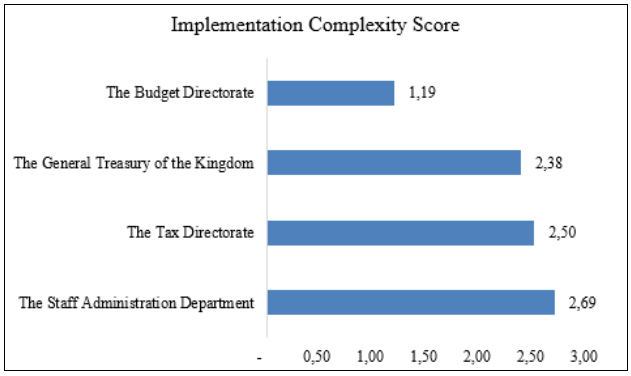


Fig. 6 Implementation Complexity Score for the Analyzed Business Partners

Figure 6 illustrates the results of the implementation complexity score calculation. As it can be observed, the highest score was related to "The Staff Administration Department".

A closer look at the results of the questionnaires administered via our Web application and the breakdown of these results in relation to the evaluation criteria provide information regarding the elements that contributed to high or low levels of positive impact and implementation complexity.

Collaboration with "The General Treasury of the Kingdom" has a significant impact as it contributes to almost all factors in table 2. However, this collaboration is

complex owing to the fact the processing is semi-manual and the size of data to process is high.

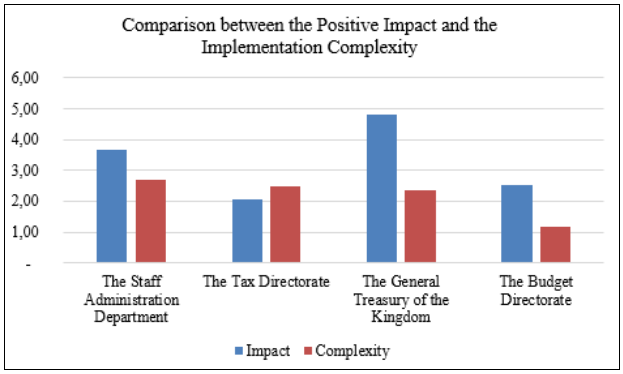


Fig. 7 Comparison between the positive impact and the implementation complexity

What we have accomplished so far allows us to associate quantitative measures to the positive impact and the implementation complexity of different alliances among a CN.

In order to build the optimal business case for their data exchange project, stakeholders at the DoL will use figures 5, 6 and 7 that represent respectively the benefits and the costs inherent to data exchange projects.

## 5. Conclusions

Organizations are discovering that embracing collaborative networks has a significant impact on their strategic goals, helping them achieving the growth, productivity and financial objectives they desire.

In data exchange project, partners collaborate to share information to reduce error rate, enhance information quality, enable access to information, increase efficiency and leverage true value through data.

The demand for collaborative networks assessment and cost-benefit analysis is maturing, especially when it comes to organizations having no or very little experience in the field of collaboration networks.

This work presents an approach to identify actors in a data exchange project, using ANT. Our approach investigates ANT translation process, while focusing on the problematization and interessement phases.

Our approach highlights the most cost-effective coalitions among a CN. In practical terms, we have established two global indicators of positive impact and implementation complexity, to measure the business value of data exchange projects.

To summarize, the result of the work accomplished so far shows how to measure in a quantitative manner the business value of data exchange projects, in the context of collaborative networks, by establishing two global indicators of positive impact and implementation complexity.

For our case study to be complete, we have to perform the same assessment from the DoL partners' side. The diversity of organizations' aspects makes it also challenging to see how our model will perform in other contexts other than public administration environment.

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