CO³ POSITION PAPER:

WEB ACCESSIBLE SET OF METHODS AND TOOLS SUPPORTING COLLABORATION AND CO-MODALITY

By Simone Genta & Frans Cruijssen

The presented foreground was generated with the assistance of financial support from the European Union: The research leading to these results (Deliverable D3.1) has received funding from the European Union’s Seventh Framework Program ([FP7/2007-2013- SST-2011-RTD-1-7.6]) under grant agreement n°284926

Deliverable D2.6
August 2013

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STRENGTHEN THE OPERATIONAL AND LEGAL FRAMEWORK
### Document Revision Record

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<th>Date</th>
<th>Details of Revisions</th>
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<td>1</td>
<td>09/2013</td>
<td>Original issue</td>
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Executive Summary:

Web accessible set of methods and tools supporting collaboration and co-modality

CO3

Currently industry partners face a number of severe challenges in their logistics operations. Fierce competition, demanding customer requirements, and increasing environmental concern have driven companies to intensify collaboration with their supply chain partners in order to be more efficient in their logistics operations and become more competitive. As the pressure continues, companies seek to collaborate even further with partners at the same stage of the supply chain.

Companies no longer solely focus on vertical collaboration along the supply chain but extend to network collaboration by adding horizontal connections. Some case studies on horizontal collaboration in logistics operations have shown a 10-15% reduction in transport costs and significant benefits to the environment, while preserving the same service level. It is therefore promising to add horizontal components to logistics collaboration. However, to date, the real implementation of such intensive logistics collaboration is limited.

The Calculator

One key issue to practitioners is how to implement and sustain horizontal collaboration in logistics operations. To tackle this issue, it is imperative to have a proper design of mechanisms to share the synergies fairly among contributors. There are many methods that have been proposed to share the costs or benefits of collaboration. Most of the existing literature focuses on the compensation mechanism in a buyer-seller relationship which fits well with collaboration in a vertical direction. However, these may not be directly applicable to logistics collaboration settings that constitute horizontal components.

The CO3 calculator is a software tool that can be used for education and training on the subject of collaborative concepts. In the interface real-life scenarios are represented. The user can practice the role of trustee and test the effects of collaboration.

The user has the mission:

"To create sustainable efficiency through collaboration among a number of selected shippers."

The tool that is available via a website has three main sections with different objectives:

- **Collaboration and Co-modality Example**: the site provide the user a way to see differences in transport solutions of collaboration and co-modality, allowing the user to choose between a predefined set of options on how to perform a collaboration and how transports, routes and loads change from an option to another.

- **Sharing Calculators**: the website provides two forms of Shapley value (see Shapley (1953)) calculators, in order to let users to learn the effects of the Shapley rule. The calculators are the on-line “Shapley Gain Sharing Calculator” page and the downloadable standalone “Gain Sharing Calculator” spreadsheet.
• **Collaboration Trustee Game**: the purpose of this tool is to provide an attractive way to learn collaboration concepts, aimed at a heterogeneous audience. The user is challenged to work with many numbers and eventually identify the best collaborative strategy.

**Collaboration and Co-modality Example**

The main objective of the “Collaboration and Co-modality Example” page is to provide a way to explain to a general audience the complexity of collaboration and co-modality transport solutions. It is not a real calculation tool, (calculations were done off-line before inserting results in the database) but it is a presentation of results and a navigation tool with didactic purposes.

**Gain Sharing Calculators**

The “Gain Sharing Calculator” page, provides a tool aimed at learning how to make a collaboration sustainable, using the “Shapley Value” sharing rule, starting from scratch. In addition a “Gain Sharing Calculator” spreadsheet is downloadable from the “Gain Sharing Calculator” page.

Both the tools (the page and the spreadsheet) ask first the number of shippers that the user has in the grand coalition and the costs for all possible sub-coalitions for that number of shippers. These values are supposed to come from an external optimization session where the best collaboration solution is found for each sub-coalition.

The output of the “Gain Sharing Calculator” page is a way to design the implementation plan of the coalition, following data on results table and graph for the “Shapley Value” sharing rule only.
The downloadable spreadsheet allows to calculate of-line gain sharing between shippers for all the three rules (equals sharing, proportional sharing, Shapley value sharing), giving costs and savings for each shippers and some key percentages ratios respect individual costs and totals. Also coalition stability with each rule is calculated.

**Collaboration Trustee Game**

The “Collaboration Trustee Game” is based on a scenario where a trustee (the player) wants to create a coalition between shippers taken from a selected set on shippers that operate in France. The set of shippers is supposed to arise from a market analysis and it is assumed that for these shippers the relevant detailed shipping data are available. This case is based on the project conducted for Mars and its partners: a joint inventory centralization with collaborative deliveries to customers in France, which are the distribution centers of a number of retailers. However, in the tool we work with anonymous dummy data always.

In this game, the player is called to impersonate a trustee. The set of proposed shippers (all shippers are invented) is a heterogenic set coming from different types of industry, with very different shipping volumes and different willingness to cooperate, from hesitate to willing. To create the illusion of a real scenario, the tool offers a short description of each shipper, with logo and principal KPIs.

The collaboration type in this scenario is a co-modality collaboration from a common DC (where all participating shippers in the coalition are supposed to have their products on stock) to each final destination. Transportation will be performed only by trucks with a load capacity of 33 pallets each. The transportation costs to each destination are based on transport volume (in terms of number of pallets) and the distance from the DC.

The game is turn based. At each turn (a year) all costs, savings and budgets are updated and recorded. A chart reports graphically the evolution costs sustained during the turn, incomes from savings and the final budget at the end of each year. There is also a “Scoreboard” table where best players are reported together their final budgets.

The player can:

- **Change the coalition**: the player can change the coalition by adding or removing shippers. Each change has a cost that depends on the number of shippers that enter or leave the coalition, due to management and legal work needed to change the coalition;

- **Ask for an advice**: the player can pay € 100,000 to ask an external advice to identify the best change he can make (or the best two shippers coalition to start with);

- **Improve the sharing rule**: while not affecting directly savings, the gain sharing rule used affect the stability of the coalition. To improve the stability the player can invest in changing the sharing rule to a more stable rule;

- **Do nothing**: a possible action is also to do nothing, letting the coalition unchanged. In this case costs and savings are applied and the budget changes consequently.
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1. Introduction

1.1. Background

The EU-funded project CO3 (Collaboration Concepts for Co-modality) aims to develop, professionalise and disseminate information on the business strategy of logistics collaboration in Europe. The goal of the project is to deliver a concrete contribution to increasing vehicle load factors, reducing empty movements and stimulate co-modality, through collaboration between industry partners, thereby reducing cost and transport externalities such as congestion and greenhouse gas emissions without compromising the service level. The project will coordinate studies and expert group exchanges and build on existing methodologies to develop legal and operational frameworks for collaboration via freight flow bundling in Europe. Furthermore, the project consortium of knowledge institutes and specialised industry players will develop new business models for logistics collaboration. The developed tools, technologies and business models will be applied and validated in the market via pilot studies. Finally, the CO3 consortium will promote and facilitate matchmaking and knowledge-sharing through conferences and practical workshops to transfer knowledge and increase the market acceptance of collaboration.

The core of the CO3 project is what is referred to as the applied research cycle. This cycle has been set up as a continuous learning and feedback loop between:

- the models and tools needed for supporting collaborations;
- the most suitable business models for groups of companies wanting to collaborate;
- the actual test cases for collaboration.

These elements are developed under individual work packages as shown below.

![Diagram of the CO3 Applied Research Cycle]

FIGURE 1: THE CO3 APPLIED RESEARCH CYCLE

1.2. Scope of the deliverable, aim and objectives

Currently industry partners face a number of severe challenges in their logistics operations. Fierce competition, demanding customer requirements, and increasing environmental concern have driven companies to intensify collaboration with their supply chain partners in order to be more efficient in their logistics operations and
become more competitive. As the pressure continues, companies seek to collaborate even further with partners at the same stage of the supply chain.

Companies no longer solely focus on vertical collaboration along the supply chain but extend to network collaboration by adding horizontal connections. Some case studies on horizontal collaboration in logistics operations have shown a 10-15% reduction in transport costs and significant benefits to the environment, while preserving the same service level. It is therefore promising to add horizontal components to logistics collaboration. However, to date, the real implementation of such intensive logistics collaboration is limited.

One key issue to practitioners is how to implement and sustain horizontal collaboration in logistics operations. To tackle this issue, it is imperative to have a proper design of mechanisms to share the synergies fairly among contributors. There are many methods that have been proposed to share the costs or benefits of collaboration. Most of the existing literature focuses on the compensation mechanism in a buyer-seller relationship which fits well with collaboration in a vertical direction. However, these may not be directly applicable to logistics collaboration settings that constitute horizontal components.

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- **Collaboration Trustee Game**: the purpose of this tool is to provide an attractive way to learn collaboration concepts, aimed at a heterogeneous audience. The user is challenged to work with many numbers and eventually identify the best collaborative strategy.

1.3. **General notes**

The site is designed in a way that is scalable: scenarios of “Collaboration and Co-modality Example” and “Collaboration Trustee Game” are stored into a database and it is possible to add more scenarios if needed in the future. All scenario numerical values are chosen to give an idea of the processes and methods, but don’t pretend to be real costs, times, quantities or distances.
2. The Main Page

The website is accessible at the address http://88.32.124.84/CO3. At the first access the main page with a brief description of the website is presented. If the user has never accessed the website, he can freely register as a new user by clicking on the “Register” link present on the top right of the page. If the user is already registered, he can log-in by clicking on the logon link on the top right of the page, and inserting his credentials in the page that appears. The links to the other sections of the tool will be accessible only after a successful login. All login data are kept in a database for statistical purposes only.

**FIGURE 2: THE MAIN PAGE OF THE WEBSITE**
3. Collaboration and Co-modality Example Page

The main objective of the “Collaboration and Co-modality Example” page is to provide a way to explain to a general audience the complexity of collaboration and co-modality transport solutions. It is not a real calculation tool (calculations were done offline before inserting results in the database), but it is a results presentation and navigation tool with a didactic purpose.

The “Collaboration and Co-modality Example” page is accessible from the main page of the website and allows showing by a GIS view and by means of tables, the complexity of a scenario where different shippers that work in a wide territory are present and that can collaborate. The GIS view allows (by buttons on the border) to scroll the map (directional buttons), zoom in and out (plus and minus button) and to reset the map to the main extent (the ‘R’ button), based on current user selection. Tables, in general, allow drill-down in the data, showing further details based on the context.

3.1. Shipments Profiles

The “Shipments Profiles” section of the “Collaboration and Co-modality Example” page presents a GIS view of all shipments of the scenario (see Figure 3). Each shipment is graphically represented as a red line from the pick-up location to the delivery location. A “Shippers” table allow the user to select a shipper to see details about his shipments.

![Figure 3: "SHIPMENT PROFILES" SECTION OF THE "COLLABORATION AND CO-MODALITY EXAMPLE" PAGE](image)
When a shipper is selected, all shipments of other shippers become faded in the GIS view and a table of the shipments of the selected shipper appear on the bottom. Selecting one of the shipments, all but the selected shipments on the GIS view become faded. Clicking again the selected shipment or the selected shipper will reset the GIS representation.

### 3.2. Decision Effects

On the left of the page different choices on how to perform the collaboration between two or more shippers are present. The user can choose one of the options and see how his decisions affect shipments and transports in the “Decision Effects” section.

In the “Shipments Movements” subsection a GIS view of all shipments is presented, together with a table where all shipments of the scenario are listed (see Figure 4). When a specific shipment is selected, the GIS view focuses on the path followed by the shipment and a transports details table on the bottom of the page will appear.

In the “Transports Movements” sub-section a GIS view of all transports is presented with a table containing all transports in the scenario that are activated by the user’s choices. Selecting a transport, the GIS view will focus on the path of the selected transport and a table that report transport path details appears on the bottom. Selecting a specific leg of the path, another table containing a list of shipments transported on the selected leg will appear (see Figure 5).

**FIGURE 4: DECISION EFFECTS ON SHIPMENT MOVEMENTS**
*(LEFT WITH NO SHIPMENTS SELECTED, RIGHT WITH ONE SHIPMENT SELECTED)*
3.3. KPIs

The KPI section allows seeing the main KPI of the current situation based on user decisions. There are general KPIs, transports specific KPIs and shippers specific KPIs.
4. Gain Sharing Calculators

4.1. Gain Sharing Calculator Page

The "Gain Sharing Calculator" page (accessible from the main page of the website), gives a tool to manage a (big) coalition, using the Shapley Value sharing rule.

4.1.1. Input Data

The tool first asks the number of shippers that the user wants in the final coalition. After that, the tool presents the list of all possible sub-coalitions for that number of shippers. The synergy values of these subcoalitions are supposed to come from an external optimization session where the best collaboration solution is found for each sub-coalition.

There are some soft monotonicity constraints on the inputs.

These constraints are soft in the sense that if they are not fulfilled only a warning message is raised, but the calculations are always performed. A hard constraint is that all data inserted are positive numbers.

In Figure 7, an example is reported that clarifies the two soft constraints:

- an implementation plan is prepared for three shippers and sub-coalitions cost are inserted in the table;
- the sub coalition S1+S2 has a bigger than the sum of single cost of S1 and S2. The optimal collaboration in this case is that S1 and S2 work alone (non-collaborating coalition) with a collaboration cost equals to the cost for S1 plus the cost for S2. Calculated savings are negative for this sub-coalition;
- the sub coalition S1+S2+S3 has a cost lower than the cost of his sub-coalition S2+S3 alone. This is a non sense, because S2 and S3 could collaborate together making the same transportation solution of S1+S2+S3 and achieve a lower costs for S2+S3.

![Figure 7: Example of soft constraints messages on input data](image)

4.1.2. Output: Implementation Plan Table and Graph

If all constraints are satisfied, the output of the "Gain Sharing Calculator" page is formed by the implementation plan of the coalition, which is the way to start from scratch and create the final coalition adding one shipper at time. This is done by applying the sharing rule to each sub-coalition, as showed the next page in Table 1.
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**TABLE 1: SHAPELEY VALUE IMPLEMENTATION RESULTS TABLE EXAMPLE**

Each row of the table is relative to a sub-coalition, while columns report cost and saving for each shipper in the sub-coalition. Cells shaded in dark gray relate to shippers that are not available in the coalition row. Cells shaded in green are relate to the preferred sub-coalition of each shipper. In this example it is possible to note that the whole coalition is not stable because shipper $S3$ has a preference for the sub-coalition $S1+S2+S3$, while the shipper $S4$ has a preference for the sub-coalition $S1+S2+S4$.

From the table is possible to identify potential concerns form shippers to grow a sub-coalition adding a specific shipper. These concerns are about a shared saving quote reduction and consequent transport costs rising, if a shipper is added to the current coalition. To help the user to identify these concerns, an implementation graph is provided, as show in Figure 8.

```figure8```
Each node of the graph is a sub-coalition, and reports costs and saving for each involved shipper and their totals. Connections between nodes show how a specific sub coalition on the left can grow to a bigger coalition on the right. If the connection is green then no shipper has concerns to the growth else if the connection is red one or more shipper will see a reduction in their savings. The names of these shippers are written in blue near the red connection.

FIGURE 8: IMPLEMENTATION PLAN GRAPH EXAMPLE

Every implementation plan must follow only green connections. Depending on the specific synergy values, it is possible that for some sub-coalitions the grand coalition is not accessible. In these case the implementation plan must lead to the better (i.e. with bigger savings) reachable coalition. In the example a possible implementation plan that terminates with the biggest coalition starts with S3 and S4, then add S1 (or S2) and finally add the remaining shipper. In particular, the graph shows that having S1 or S2 (or both) in the starting coalition will not lead to the grand coalition.

Next to the analysis of companies entering the coalition, the same graph can used to consider controlled exits of one or more companies.

4.1.3. Optimal Implementation Plan Consideration

In general, the objective is to maximize the savings letting the coalition to grows, ensuring in the same time the satisfaction of all shippers involved at each step. Departing from a set of shippers, the better sub-coalition to aim to is a sub-coalition with the maximum total savings (it is possible to take into account also coordination costs) among all sub-coalitions that are stable and reachable from scratch.
Finding the best path to reach the best final sub-coalition require instead other criteria. One proposed criterion could be to choose the plan that maximizes the minimum savings growth for each involved shipper in all steps of the plan (smoother plans). Another criterion could be to choose the plan that maximizes the cash flow (better savings earlier). For more details on this approach, that is based on the concept of Shapley Montonic Development paths, please refer to Cruijssen et al. (2008).

The current version of the tool doesn’t implement any optimization of the implementation plan, but described graph and table outputs could help in finding an optimal plan.

In the example showed in Table 1, best reachable sub-coalition is the whole coalition, with a total saving equals to 8.01 (but note that this coalition is not stable). As described in the Paragraph 4.1.2, the two possible growth plans for the whole coalition are:

- **First solution**: start with S3+S4;
  - S3+S4 -> S1+S3+S4: S3 see savings grow from 3.6% up to 10.7%, while S4 don’t see grows in his savings, stopped at the initial 6.3% (no change). Total savings with this sub-coalition are equals to 2.00;
  - S1+S3+S4 -> S1+S2+S3+S4: S2 see his savings grow from 20.0% to 22.5%, S3 savings grow from 10.7% up to 33.9%, and S4 savings grow from 6.3% up to 30.2%;

- **Second solution**: start again with S3+S4;
  - S3+S4 -> S2+S3+S4: S3 see savings grow from 3.6% up to 27.4%, while S4 see grows in his savings from 6.3% to 22.9%. Total savings with this sub-coalition are equals to 6.01;
  - S2+S3+S4 -> S1+S2+S3+S4: S2 see his savings grow from 31.7% to 32.9%, S3 savings grow from 27.4% up to 33.9%, and S4 savings grow from 22.9% up to 30.2%;

Looking the evolution of the two best plans above, the second solution appear to be better, because of the bigger total savings at the intermediate steps and a smoother saving growth for all the shippers. In particular, in the first solution, S4 has no motivation to add S1 to the initial coalition, due to a 0% growth of his savings in the first step. In the second solution the minimum growth (the growth of S2 savings in the last step) is instead 1.2%: in this case every shipper has an economical motivation to let the coalition grows at each step.

### 4.2. Gain Sharing Calculator Spreadsheet

The "Gain Sharing Calculator" spreadsheet is downloadable from the "Gain Sharing Calculator" page of the website, both in the Microsoft Excel 2007 format (with ".xlsx" extension) or the ODF format (ISO/IEC 26300:2006 - OASIS Open Document Format for Office Applications, with the ".ods" extension) to be opened in a wide set of spreadsheets (i.e. OpenOffice).

This tool performs a calculation of gain sharing of a coalition up to eight shippers, with three sharing rules: Equals, Proportional and with Shapley Value. In *Figure 9* is present a screenshot from the ".xlsx" version.

#### 4.2.1. Input Data

The first data to insert is the number of shippers on the very top of the sheet. The number of sub coalition is equals to a power of two with the number of the shippers
as exponent, so for eight shippers (the maximum number allowed) the number of sub coalitions is $2^8 = 256$.

Inputs cells are the only cells not protected in the sheet, and are highlighted by yellow balloons (also some indicators are highlighted in the same way). Sheet protection is not covered with password, so the user can unprotect the sheet to make major changes if needed. Protection is here only to avoid unanticipated formula changes.

### 4.2.2. Output

The spreadsheet calculates gain sharing between shippers for all the three rules, giving (on top of the sheet) costs and savings for each shippers and some key ratios.

### 4.2.3. Coalition Stability

For each sharing rule, a column calculate the stability condition for sub-coalitions and a STABLE/UNSTABLE label assert if the coalition would be stable under each of the sharing rules. Conditional formats show in red unstable condition of each rule and what sub-coalitions cause it. The calculator intuitively illustrates how stability of a collaboration can depend on the specific gain sharing rule that is selected.

**FIGURE 9: THE DOWNLOADABLE GAIN SHARING CALCULATOR SPREADSHEET**
5. Collaboration Trustee Game

The “Collaboration Trustee Game” is based on a scenario where a trustee (the player) wants to create a coalition between shippers taken from a selected set on shippers that operate in France. The set of shippers that will collaborate is supposed to be created from a market analysis and after detailed shipping data are acquired. In the following paragraphs a description of various elements of the game is provided.

5.1. Situational Background

This case is based on the CO3 project conducted for Mars and its partners: a joint inventory centralization with collaborative deliveries to a fixed set of customers in France, which are the distribution centers of a number of retailers (however, in the tool we work with anonymous and invented data always!) See the picture below:

5.2. Trustee: the Player

In this game, the player is called to impersonate a trustee, and he will start to operate with an initial budget of € 250’000. The trustee will start with no coalition and will want to create a coalition between shippers, but each action performed will be subjected to different costs (see Paragraph 5.6.2 for further details). The objective of the trustee is to create the best coalition, stated that the trustee earns money depending on the collaboration savings reached.

5.3. Shippers

In this scenario the set of proposed shippers (all shippers are invented) is a heterogenic set coming from different types of industry, with very different shipping volumes and different willingness to cooperate, from hesitating to willing. To create the illusion of a real scenario, the tool offers a short description of each shipper, with logo and some KPIs. All shippers’ data are show in the “Shippers Profile” section of the “The Collaboration Trustee Game” page.

A GIS view shows how shipments of the different shippers are distributed over the territory by a Pie Chart representation. The player can see the shipments distribution among shippers hovering on each destination with the mouse pointer. A screenshot is shown in Figure 10.
5.4. Collaboration Type and Transportation Costs

The collaboration type in this scenario is a transport bundling collaboration from a common DC in the north of France around Paris (where all participating shippers in the coalition are supposed to delivery shipments) to each final destination.

Transportation will be performed by standard trucks with a load capacity of 33 pallets each. The transportation costs to each destination are defined based on transport volume (in terms of number of pallets) and the distance from the DC. The Figure 11 shows the graph of transportation cost from the DC to each destination varying on number of pallets to be delivered (up to 200 pallets).

FIGURE 10: SHIPMENTS DESTINATIONS PIE CHART WITH DETAILS ABOUT BEAUVAIS DESTINATION

FIGURE 11: TRANSPORTATION COSTS FOR THE DIFFERENT DESTINATIONS IN FUNCTION OF SHIPMENT VOLUME (PALLETS)
5.5. Situation
Each turn the tool shows situation to the user in order to allow him to take decisions on how to proceed.

5.5.1. Budget Evolution
Each turn costs, savings and budget are updated and recorded. At the top of the page a box is presented reporting the last action performed by the user, followed by current turn number and budget. A chart reporting graphically the evolution of the budget is also present, detailing costs sustained during the turn (fixed in red, coalition changes in yellow, investment in magenta and coordination in orange), incomes from savings (in light green) and the final budget at the end of each turn (the wide blue bars). Hovering with the mouse pointer on costs and savings give exact values, while hovering on the budget bars give all details of the specific turn (as showed in Figure 12).

All turns data are also provided in the "Turns Summary" table on the "Take a Decision" section of the "Collaboration Trustee Game" page (see Figure 14 at page 25).

At the bottom of the same section also the “Scoreboard” table is provided where best players are reported together their final budgets. In the scoreboard only the best achievement for each player is stored.

![Figure 12: Game Evolution Chart and Details of a Turn](image)

5.5.2. Coalition Status
The status of the current coalition can be viewed in the “Coalition Status” section of the “The Collaboration Trustee Game” page (see Figure 13). A GIS view shows the shipment distribution of the coalition shippers by a pie chart. Below the GIS view three tables with numbers describing the current status of the coalition are reported, as showed in Figure 13.

The “Coalition Daily Cost” table shows aggregate data, reporting for each destination:

- the sum of individual cost that current coalition shippers will spend if working alone and not in the coalition;
- the total number of pallets to be shipped, the corresponding number of trucks and their average filling percentage;
• the cost incurred by the whole coalition when they collaborate, and the corresponding savings.

The “Gain Sharing” table shows details on how collaboration savings are shared among all shippers in the coalition. For each shipper the total individual cost over all destinations is reported and, for each rule available (see Paragraph 5.6.2 for sharing rule improvements details), the resulting costs after gain sharing is also reported.

Finally, the “Coalition Stability” table shows for each sub coalition the cost and the corresponding cost after sharing rule application for each rule that is available to the player. If for some coalition the cost is better than the cost after the gain sharing with the rule applied currently, the coalition is unstable and breaks, requiring creating another coalition the next turn. See Paragraph 5.7 for further details about stability.

FIGURE 13: COALITION STATUS TABLES

5.6. Rules and Costs

As every game, also the “Collaboration Trustee Game” has some rules, such as turns, costs, earnings, possible actions, etc. They are explained below.
5.6.1. Turns
Each action of the player is done in one turn. A turn is equivalent to a year of operation. Each turn the trustee must sustain operational costs:

- Fixed costs: these are costs to maintain the offices and the other resources and is worth about € 5,000.00;
- Coordination costs: these are costs to coordinate the collaboration of the shippers that form the current coalition and to coordinate shipments. Roughly these costs are worth about € 10,000.00 for each shipper in the current coalition plus € 100.00 for each shipped pallet.

Each turns the trustee also earns from current collaboration savings, based on a percentage about 10% of overall savings.

The game can run at most for 20 turns. After that, the game stops and the player must terminate the game to register his score in the scoreboard.

5.6.2. Actions
The player can perform one action each turn. The player actions, which are available in the “Take a Decision” section of the page (see Figure 14), are:

- **Change the coalition**: the player can change the coalition by adding or removing shippers, more than once a time. Each change has a cost that depend on the number of shippers that enter or leave the coalition, due to management and legal work needed to change the coalition:
  - € 10,000 to change only one shipper at time;
  - € 25,000 to change two shippers at time;
  - € 45,000 to change three shippers at time;
  - € 100,000 to change four shippers at time;
  - € 150,000 to change five shippers at time;
  - € 250,000 to change six shippers at time;
  - € 400,000 to change seven shippers at time;
  - € 700,000 to change eight shippers at time.

- **Ask for an advice**: the player can pay € 100,000 to ask an external advice to identify the best change he can make (or the best two shippers to start with). The tool acts as an advisor and performs a search to identify the best change in terms of savings to perform. If a solution is found (a better coalition by adding or removing a shipper) the change is applied automatically, together with coalition change costs as per the previous point. The advisor cost is applied also if a solution is not found (i.e. the current coalition is the best) and no coalition changes are suitable, or if the resulting coalition is unstable and breaks (see Paragraph 5.7);

- **Improve the sharing rule**: while not affecting directly savings, the gain sharing rule used affect the stability of the coalition. To improve the stability the player must invest in changing the sharing rule to a more stable rule. At the start the rule applied is the “Equals Rule”, where all shippers in the coalition will receive the same amount of money equal to savings divided by number of shippers. The first improvement that a player can acquire (at the cost of € 30,000) is to change to the “Proportional Rule”, where gains are shared between shippers in a proportional way, based on their individual costs.
The final improvement that the player can acquire (at the cost of € 50,000) is to pass to the “Shapley Rule” where gain sharing is calculated with the Shapley formula. Improving the sharing rule doesn’t allow to change the coalition, so it is the only action taken in a turn;

- **Do nothing**: a possible action is also to do nothing, letting the coalition unchanged. Also in this case costs and savings are applied and the budget changes consequently;

- **Terminate the game**: Sometime it is not possible to proceed to the next turn because final budget will be less or equal to zero. The player can terminate the game and records his score in the scoreboard. The tool will show a message if the current score is the personal best score or is the overall best score among all players. Only the best score of each player is recorded in the scoreboard;

- **Restart the game**: if the user doesn’t want to proceed in the game nor to register the game in the scoreboard, the game can be simply restarted.

![Image of the “Take a Decision” section]

**FIGURE 14: THE “TAKE A DECISION” SECTION**
5.7. Coalition Stability

A key aspect of the collaboration between three or more shippers is the concept of coalition stability. A coalition is said to be stable if no sub-coalitions has economical motivation to break the bigger coalition. In unstable cases the coalition can’t survive because the identified sub-coalitions have an incentive to leave and start a smaller collaboration. An example with four shippers can be found earlier in this report (there are many unstable coalitions of less and more shippers that can be formed in the game with the different sharing rules). An example coalition is composed by [Dunder Mifflin + Hunch + Natures Path + Petsgo]. In Figure 15, is possible to see that using the "Equals" sharing rules there are three sub coalitions that are unstable ([Hunch + Natures Path] ; [Dunder Mifflin + Hunch + Natures Path] ; [Hunch + Natures Path + Petsgo]), while with the "Proportional" and the "Shapley Value" rules, the instability is due only to the [Hunch + Natures Path + Petsgo] sub-coalition.

<table>
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<tr>
<th>Shipper</th>
<th>Individual Cost</th>
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<th>Shapley</th>
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**Gain Sharing**

**Coalition Stability**

<table>
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<tr>
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**FIGURE 15:** AN EXAMPLE OF UNSTABLE COALITION IN THE GAME

It is possible to see that partners individually are satisfied by each sharing rule, the instability happens only at sub-coalition level. As shown, using the Shapley value rule reduces but doesn’t eliminate the risk of unstable coalition. An unbeneﬁcial consortium also cannot and will not survive by means of a good rule.

When a coalition becomes unstable in the game, it breaks at the end of the turns and the player will have to create another coalition, maybe investing in a better sharing rule to avoid a new instability.
References
