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Modularization of Business Ecosystems According to Sustainable Performance Measures

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MODULARIZATION OF BUSINESS ECOSYSTEMS ACCORDING TO SUSTAINABLE PERFORMANCE MEASURES

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ABSTRACT

There is a detachment of lifetime performance analysis of container vessels from the ship planning and investment phase. This is often due to misguided performance measurement selection of the companies involved in new ship investments. This research described here aims at making it easier for companies involved in ship investments to choose their performance measures so that the lifetime performance of the ship, and therefore, the viability of the business ecosystem are valued when tracking the performance and success of the companies. A method for accomplishing this was developed and utilized in the case study later described. The selection of performance measures which support the lifetime performance and more specifically the technical utilization rate of container ships produced financial benefits for the companies and the target business ecosystem by increasing the container throughput of the shipping routes studied during the research.

KEYWORDS

performance measurement, modularization, business ecosystem.

INTRODUCTION

There is a lack of intuition regarding the measurement of the success of business ecosystems. Companies concentrate on measures that give information on quadrant profit and sales, but do not necessarily follow their impact on the business environment or business ecosystem they are a part of. As a divergence for this approach, an essential notion of business ecosystems is that of system leverage, that is, how the system as a whole can provide better outcomes based on the same input (Thomas et al. 2014).

This article aims at bringing into light the connection between performance measure selection and business ecosystem sustainability. We argue that if companies concentrate in traditional profit oriented ("modular") performance indicators the business ecosystem cannot evolve to a more sustainable level. However, if companies with different roles in the chain of resource and capital utilization cooperate with the

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goal of producing the most value of the resources available, the overall business ecosystem can produce more value from the same resources. A key aspect in achieving such focused integration is to understand the value creation architecture of the ecosystem in question (Dietl et al. 2009; Jacobides et al. 2006). We will demonstrate how, by selecting the correct performance measures among several companies, such integration can be achieved and the lifecycle value of investments can contribute to the sustainability of the system.

We offer support to the performance indicator selection with the concept of modularization within business ecosystems. By modularization we mean the conscious arrangement of dependent activities into efficient collections with a common goal for economic, social and environmental sustainability. Earlier research has shown how modular innovations are more likely to be accommodated in an industry than integral ones (Levitt and Sheffer 2011). The reason is that integral or architectural innovations require more coordination and radical changes in an industry (Henderson and Clark 1990). Modularization is a knowledge-driven activity that moves between knowledge integration and new modular (product) architectures (Brusoni and Prencipe 2006). On the business ecosystem level, the institutionalized structure of production (Cacciatori and Jacobides 2005; Jacobides and Winter 2005), however, often stand in the way of such integration and re-modularization efforts. Our aim is to contribute to this line of research by illustrating how performance measures can be used to overcome these challenges. The research question we shall address is: How to leverage business ecosystem output through new investments.

We first develop our argument theoretically by reviewing the literatures on modularity and business ecosystems. We then use an embedded case study to illustrate and further elaborate the theory.

THEORY

The term business ecosystem was coined in the popular business press to depict a number of features that extend the traditional notions of supply chains and business networks. Moore (1993) and Adner (2006) argued that one key notion is that of (increased) interdependence, that is, a company's innovation is crucially dependent on firms in its environment supporting, complementing or adopting the innovation. Both author's also note the presence of an overarching target of the ecosystems, that is, the resulting ecosystem service.

Later on Adner and Kapoor (2010) operationalized these notions as a system of component suppliers, an integrating focal firm, complementary service suppliers, and the (end) customer of the outcome this system. A likely result of the system notion is that traditional industry classifications may no longer make sense, but industries rather ought to be classified based on the function or service this system of activities produces (i.e. the system-based as opposed to activity-based classification scheme (Dalziel 2007). From a system-based view, another central notion of ecosystems is also that of leverage, that is, how systems can organized in such a way that they produce better outcomes (services) based on the same inputs (Thomas et al. 2014).

Obviously, the notion of leverage is also key in contemplating how to increase the sustainability of an industry. A dilemma in this regard, however, becomes that of ecosystem governance and supra-organizational strategizing (Tsvetkova et al. 2017). A business ecosystem is a meta-organizational arrangement that lacks the authoritarian line of command that a vertically integrated structure has (Gulati et al. 2012).

We approach the issue of ecosystem governance from the perspective of performance measurement.

While performance measurement literature has reached rather high maturity (Bassioni et al. 2005; Behn 2003; Folan and Browne 2005; Gunasekaran et al. 2004; Parker 2000; Powell 2004), we argue that the connections between sustainability, business ecosystems and performance measurement can be opened on a deeper level. Moreover, traditional performance measures are mostly concerned with internal matters of companies or more limited supply chain aspects, but more seldom covers the network level (Vesalainen and Autio 2017), not to mention the ecosystem level. Our approach combines the higher level business ecosystem analysis with the grass root level company management level, thereby connecting the actions of companies to the overall viability of the ecosystem.

To develop appropriate, system-level performance measurement schemes we need to understand how value is created and appropriated in the ecosystem. The concepts of an industry (Jacobides et al. 2006) or value creation architecture (Dietl et al. 2009) capture this need. The notion of architecture suggests that modularity theory could be a useful perspective. Modularity theory asserts that an integral structure is favored when the global (i.e. system-level) performance of a system needs to be maximized (such as a weight limitation in transportation vehicles). A modular structure, in turn, may be warranted when local performance for one reason or another is favored (Ulrich 1995). Typically, systems cycle between integral and modular structures along with the evolutionary dynamics of the underlying technologies (Hobday et al. 2005).

Organizational or industrial modularity literature builds from that structure and adds the notions of modularized process, knowledge, and functions (Brusoni et al. 2001; Chesbrough 2003; Fixson and Park 2008). We follow the ideas of (Jacobides et al. 2006) by illustrating the actor connections, and labor and profit division as the basis for the structures of the ecosystem in the cases. These structures are then analyzed and some of them are rearranged based on the suggested performance measures. These renewed performance measures are the result of analyzing the impact of innovations to the target business ecosystem. This way the business ecosystem can produce a more sustainable outcome than products and services alone (Dalziel 2007).

The focus and behavior of the companies is thus altered by introducing sustainable performance measures based on the viability of the ecosystem and its modules and other structures.

To further illustrate the situation, the traditionally modular construction industry can be viewed as an example (Cacciatori and Jacobides 2005). The basic idea with the introduction of design-build contracts was to incentivize contractors and suppliers to develop designs that can be efficiently built. The increased use of integrated solution deliveries or alliance arrangements, in turn, strive to incentivize the formers to contribute to the system-level performance, for example by truly reducing operating expenditure (Cacciatori and Jacobides 2005; Ivory et al. 2003; Walker and Lloyd-

Walker 2015), which is exactly where traditional or design-build contracts tend to fall short (Laan et al. 2011).

METHODOLOGY AND CASE STUDY DESCRIPTION

METHOD

We offer a case study from the container shipping ecosystem as illustrative evidence of our argument. The data on the case was collected through an action research (Helskog 2014; Lewin 1946) study together with a company that was taking a new innovation to the market. All essential actors in the ecosystem were interviewed and analyzed.

Based on our analysis of the case an ideal set of performance measures were developed in line with design science principles (Romme 2003). The theoretical basis lies in building on theory in modular approaches for ecosystem design. Adding numerical analysis to the modularity increases the systematic approach in determining the modules, and in re-modularizing existing structures of business ecosystems. A formula for calculating value can be viewed as a set of modules that are either connected directly or integrated. In comparing modular structures with numeric formulae, it is possible to understand the required re-modularization measures. Performance measures are the variables of the formulae.

CASE DESCIRPTION

MAXIMIZING THE CARGO CARRYING CAPACITY OF CONTAINER SHIPS

Company A is a system supplier in the shipbuilding industry that provides (among other things) container securing systems for containerships. In its strategy, Company A aims to be a solution provider to the container shipping industry, with the ability to maximize the cargo carrying capacity as one of its core solutions. Company A can provide an optimal container securing system for new containerships, and can also upgrade the container securing systems on existing containerships. In feasibility studies of containership investments, it has been found that Company A has the most competitive solution in the industry. Their solutions provide the highest financial value potential throughout the lifecycle of a containership, and the lowest amount of emissions in relation to the transported containers. This is possible through providing the highest cargo carrying capacity for containerships, even if Company A container securing systems are of highest price in the industry.

Still, company A found challenges in selling its products to shipyards, as they could not compete on the pricing. It was noticed that in most cases, the shipyards were focusing on minimizing the new build project costs for the containerships, and had no preference on higher cargo carrying capacity.

However, Company A found success in collaborating with the operational departments of liners, more specifically the cargo planning departments. The cargo planning departments promoted Company A solutions to the senior management of the liner company, and through this the senior management provided the procurement department with a larger budget to purchase new containerships, with the mandate that Company A solution is to be set as a demand in the procurement criteria to the shipyard.

CASE DISCUSSION FROM A PERFORMANCE MEASUREMENT PERSPECTIVE

Through their strategy as a solution provider, Company A has found that they need to be an active part of the container shipping business ecosystem. In their internal development aiming to become a solution provider, Company A conducted several practices to understand the lifecycle value creation of containerships. They also positioned themselves according to a variable that is part of the formula in modelling the lifecycle value of containerships. The variable is technical utilization rate, which is defined as the actual maximum capacity of the containership in relation to the nominal (i.e. registered) capacity. Containerships are registered to a certain capacity, measured as twenty-equivalent foot containers (TEU), based on the hull characteristics of the ship. Company A has found that containerships cannot carry the full registered capacity with non-optimal container securing systems. Through modelling different scenarios of a certain set of containers to be loaded on a ship, Company A can accurately estimate the actual maximum capacity, and through this calculate the technical utilization rate.

Company A has chosen technical utilization rate as a performance indicator for their business and internal operations. It is also the part of the containership that they can impact and hence could be responsible for. Company A's R&D department strives to create innovations that maximize the technical utilization rate of containerships, and the sales department uses the technical utilization rate as one of the main sales arguments.

Company A sales can be viewed as an attempt to facilitate industrial business ecosystems that provide containerships with the highest technical utilization rate. The shipyards that the sales department approached were, however, unwilling to purchase container securing systems from Company A. The lacking will of shipyards can be explained through conflicting performance indicators in the current industry structure.

Shipyards focus on minimizing the actual project costs from containership new build projects. This is due to the industry standard process in procuring containerships, where ship owners start a tender or bidding competition with shipyards for the total investment, and select the shipyard according to the lowest price that fulfills the required specifications. The negotiated investment cost, *i.e.* the investment cost for the ship owner, which at the same time is the revenue for the ship yard, is set from the tender or bidding. The shipyard's profit is based on the difference between the negotiated investment cost and the shipbuilding project costs. The shipyard's financial benefit is only based on the new build project, and therefore the shipyards lack interest in other parts of the containership lifecycle value creation. From the shipyards perspective, Company A offered a higher price on the container securing systems than other suppliers, which resulted in higher shipbuilding projects costs, and as a result Company A's offering had a negative effect on one of the main performance indicators for the shipyard.

The success for Company A in selling solutions to liner cargo planning departments can be explained through enhancing the performance measures of the customer companies. Liners' cargo planning departments strive to maximize the amount of containers on containerships, and therefore the higher technical utilization rate provided by Company A directly enhances the performance indicator of the liner cargo planning department. The senior management of liners is in turn responsible for company profit, which is tied to the lifecycle financial value of containerships, which the higher technical utilization rate supports. Company A also had challenges in selling to the liner procurement departments, and this is due to their performance indicator of minimizing the investment costs.

Company A sales to liners can be viewed as an attempt to reshape industrial business ecosystems that strive to operate sustainable containerships.

SYNTHESIS TO METHOD FROM CASE STUDY

OVERVIEW OF METHOD

Based on the case study, a method is proposed that supports actors in positioning themselves in an industrial business ecosystem, and supports them in finding the relevant partners. The method includes four steps.

The first step is to gain an in depth understanding of the lifecycle value creation of the investments in the ecosystem. This includes understanding the formulae in modeling the economic, environmental, and social lifecycle value creation.

The second step is to position the actors according to variables in the formula that they create the value to. The variables are set as performance indicators for the actor.

The third step is to compose existing industry practices into modules, according to the variables in the formulae for modelling the investment value creation. Each module is based on variables that are formed by actors within a certain industry function.

The fourth step is in determining which variables contribute to the lifecycle value of the investment the most. This step is the re-modularization of existing industry practices based on the contribution of the actors to the lifecycle value of investments.

APPLICATION OF METHOD TO THE CASE STUDY

Step 1

The task of modeling sustainable lifecycle value for containerships is a complex one, as it includes several different formulas (for ex. separate ones for the economic, environmental, and social value), and modelling the lifecycle value from different actors' perspectives. The relevant variables for the case study relate to the containership revenue generation for liners, and the investment costs of the containership. The formula, which these variables are a part of, is therefore the focus of this section. The basis for the lifecycle financial value is structured accordingly:

$$R_t\ (N) = \sum_{t=0}^{N} Rev_t - OpEx_t - CapEx_t$$

Where N defines the number of yearly periods in time, t, of the yearly generated revenue, Rev_t, yearly operational expenditure, $OpEx_t$, and yearly capital expenditure, $CapEx_t$. The operating, voyage, cargo handling, and minor maintenance costs (spare parts and lubricates among others) are included in the $OpEx_t$ and $CapEx_t$ is the ship investment and dry-dock maintenance costs.

Rev_t from the liner perspective is based on the amount of transported payload containers per year $C_{TEU,t}$ (measured as TEU), and the freight rate, α. The freight rate varies on different routes and can fluctuate even on a weekly level, and therefore the actual revenue generation of a containership requires detailed data on the ship route and historic or projected freight rates on route. A simplified method of modeling the revenue generation, is through setting an average freight rate on the containers, $\alpha_{avg,t}$, which forms the formula:

$$Rev_t = \alpha_{avg,t} * C_{TEU,t}$$

Estimating $C_{TEU,t}$ is based on the nominal capacity of the container ship, q_{nom}, the amount of roundtrips per year, RT_t, and the technical- (U_{tech}), commercial- (U_{com}), and operational utilization rate (U_{op}). Due to seasonal fluctuation in container flow demand, each roundtrip of the containership should be modelled separately, and each roundtrip should be further divided according to each route included in the roundtrip. In an ideal situation, the containership would carry containers according to q_{nom} on each route, but due to several limitations, this capacity is seldom reached. These limitations are represented by the utilization rates. U_{tech} represents limitations from the cargo securing systems. Optimal container securing systems can result in that $U_{tech} = 100\%$, while non-optimal container securing systems can result in that $U_{tech} = 75\%$. U_{com} represents seasonal and other market based limitations on filling the ship, and should therefore be determined per shipping route and time of year, and U_{op} represents limitations in gaining full capacity due to operational reasons, and should therefore also be estimated per route and according to events in planning the container ship cargo capacity and events during port operations. In a more simplified estimation of $C_{TEU,t}$, it can be set that the ship is operated on the same loop each year, *i.e.* the ship sails between the same set of different ports, and an average can be set on U_{com} and U_{op}. A simplified formula for modelling $C_{TEU,t}$ is therefore:

$$C_{TEU,t} = RT_t * q_{nom} * U_{tech} * U_{com,avg,t} * U_{op,avg,t}$$

From a liner perspective, and in the case that the liner owns the ship, the yearly capital expenditure, $CapEx_t$, can be divided into the investment cost for the containership, $CapEx_{inv}$, and the required dry dock maintenance every three to five years, $CapEx_{DD,t}$. $CapEx_{inv}$ is the relevant variable for the case study, and is interesting in the sense that the entire $CapEx_{inv}$ is paid to the shipyard that constructs the ship. $CapEx_{inv}$ from the liner perspective is therefore the same variable as the revenue generated from a project for a shipyard. The shipyards profit from the project is based on the difference between $CapEx_{inv}$ and the actual project costs of the shipbuilding project, $CapEx_{proj}$. The investment costs of the container securing systems, $CapEx_{CSS}$ are part of $CapEx_{proj}$.

Step 2

As a provider of the container securing systems, Company A can be responsible the technical utilization rate (U_{tech}) and hence the lifecycle value creation of containerships. The technical utilization rate is therefore the position of Company A in container shipping ecosystems, and an assigned performance indicator for Company A. Another relevant variable for Company A is the investment costs for the cargo securing systems ($CapEx_{CSS}$).

Step 3

Figure 1 presents a modular decomposition of the lifecycle financial value creation of the containership according to existing industry practices. The yearly revenue (Rev_t) and yearly operational expenditure ($OpEx_t$) are an outcome from the ship operations, which fall under the responsibility of the liner. The investment costs ($CapEx_{inv}$) and dry dock maintenance costs ($CapEx_{DD,t}$), are an outcome from decisions in the process of ship ownership, which in this case is the liner. Ship operations set a demand for shipping capacity from the ship owners, who procure the ship. This is represented by the arrow between the modules. The liners procure the ship from shipyards, who are responsible for the shipbuilding and design. The outcome from these processes are the project costs ($CapEx_{proj}$). As part of the shipbuilding project, the shipyard procures the technical parts for the ship from the system suppliers. The container securing systems is part of the system supply. The container securing suppliers form the technical utilization rate (U_{tech}), and costs for the container securing systems ($CapEx_{CSS}$).

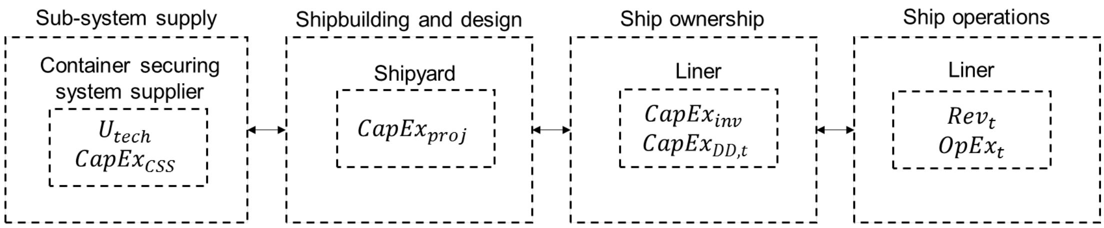

Figure 1: Modular breakdown of the container securing system procurement for containerships

The challenge for Company A in selling container securing systems according to U_{tech} to shipyards can be seen in Figure 1, in that the $CapEx_{CSS}$ is directly connected to the $CapEx_{proj}$. There is in turn a clear distance between U_{tech} and Rev_t, which provides the indication that the industry structure needs to be restructured in a manner that these two variables are connected.

Step 4

One option for Company A in connecting U_{tech} and Rev_t, was to strive to create a more efficient industrial business ecosystem (Figure 2) where all actors connected to the container securing system procuring process aim to collectively create sustainable value for the containership. This would involve re-modularization the industry structure to combine the functions under the goal of container ship lifecycle value creation (R_t). This has so far been proven unsuccessful, and can be explained by the fact that the performance indicators for the shipyard are not related to the lifecycle value of the containership, but to its capital expenditure (and to the shipyard as an isolated business).

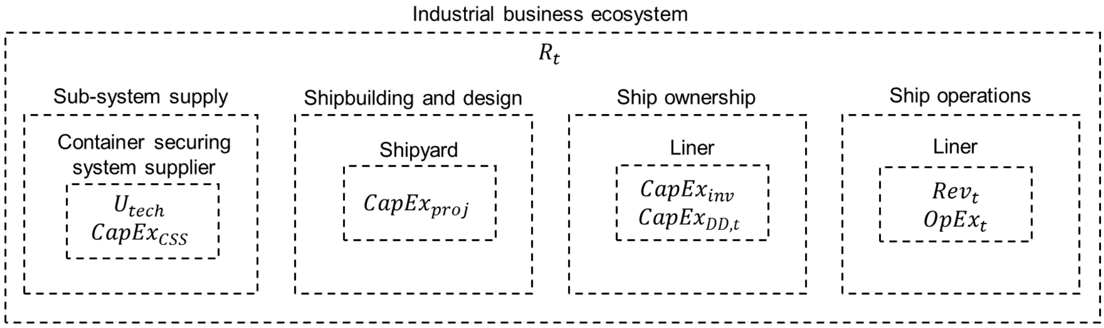

Figure 2: Optional re-modularization to form a container shipping ecosystem

The successful reconfiguring of the ecosystem for Company A is illustrated in Figure 3. This involved a re-modularization of the existing industry structure towards combining the performance indicators that form the lifecycle value, while the shipyard remains an independent, complementary module of the ecosystem. The shipyard is connected to the more integrated modules through the ship ownership function.

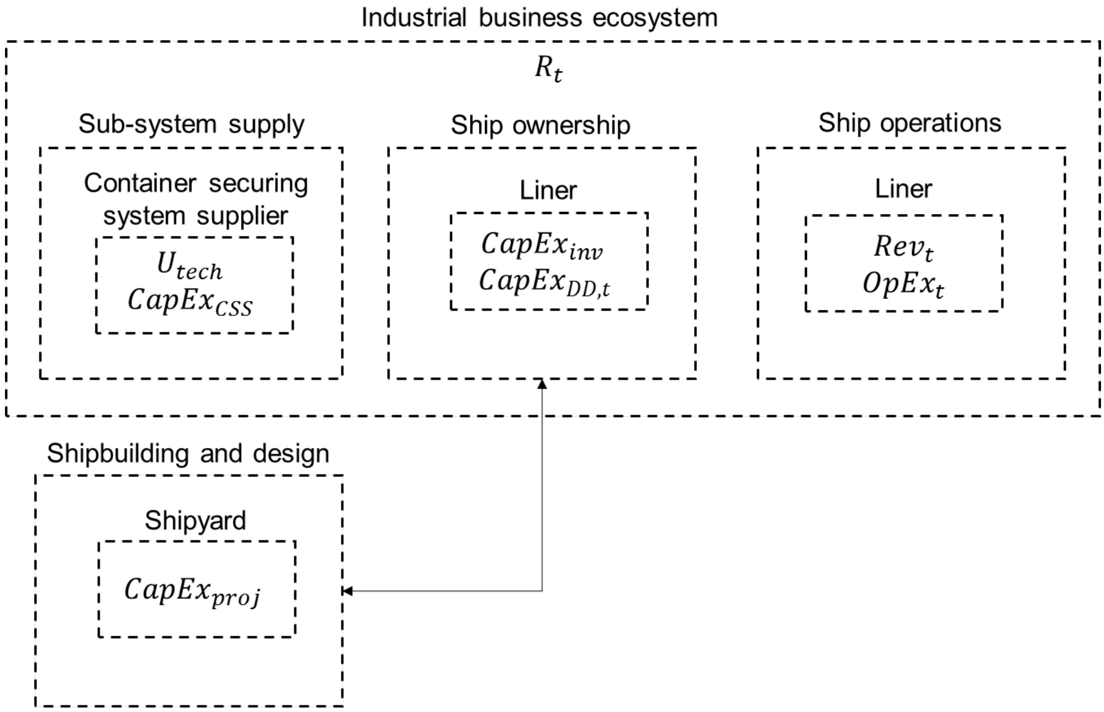

Figure 3: Actual re-modularization of the container shipping ecosystem

DISCUSSION AND CONCLUSIONS

Verification with performance measurement theory

A central argument in research on industrial business ecosystems is that the aim of the industrial business ecosystem is to maximize industry sustainability. This provides a clear direction for the ecosystem performance measurement. Performance measures for each actor in the ecosystem should be determined according to their contribution to the sustainable value creation in the ecosystem.

Understanding the lifecycle contribution of the investments to the ecosystem can be viewed as a process towards operationalizing the strategy of sustainable value creation. In performance measurement research, it is recognized that translating the vision into metrics provides practical clarity to the verbally formulized strategy (Kaplan and Norton 1996). The desired outcome of the strategy and required operational focus to gain this is clearer through direct performance. In the method presented in this paper, the desired outcome is set, and the lifecycle value model provides the parameters that directly impact sustainable value creation and the required operational focus. Another verifying insight from performance measurement theory is that performance measures influence behavior (Neely and Bourne 2000). When actors are aware of how their success is measured, then they tend to work towards improving this measure, especially if there are incentives tied to it. This supports the argument from industrial business ecosystems research that all actors in the ecosystem should acquire performance indicators that contribute to sustainable value creation in the industry.

Limitations and applicability of method

The authors find that the method presented in this paper serves as a basis for industrial ecosystem design through determining the required role of each actor in it. This provides a necessary basis for the ecosystem structure, but does not provide insight to the required collaboration mechanisms and operational procedures in the ecosystem. Understanding the numbers and formulae also requires closer insight, which may not be available readily.

The method presented in this paper can be viewed as a basic principle in drawing first rough pictures and identifying the focus of the needed re-design and the scale of implementation. These are two highly complex areas and span towards a broader set of more focused theories.

We find the design of performance measures a suitable approach to view this method from. A notable factor is that researchers have identified that there is no unified way to determine performance measures (Franco-Santos et al. 2007). The authors argue that understanding the lifecycle value and placing it in a modular approach provides a direction of unified theory for determining relevant performance measures for different actors involved in the ecosystem. This is based on the vision of constantly improving sustainability in the industry ecosystem.

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