Managing Maritime Container Ports' Sustainability: A Reference Model

Cezary Mańkowski ^{1,*} and Jędrzej Chałampowicz ²

¹ Department of Logistics, Faculty of Economics, University of Gdańsk, A. Krajowej 119/121, 81-824 Sopot, Poland

² Department of Logistics and Transport Systems, Faculty of Management and Quality Science, Gdynia Maritime University, Morska 81/87, 81-222 Gdynia, Poland; j.charlampowicz@wznj.umg.edu.pl

* Correspondence: ekocm@ug.edu.pl

Abstract: The concept of sustainable development is one of the few ideas that require the integration of all areas of human life on earth in order to maintain further development without major disruptions. One such area is maritime transport, including maritime container ports. Their unique feature is the ability to combine equivalent types of transport within the framework of a cargo-handling system with related information. In order to ensure a sustainable shipping flow through ports, it is necessary to integrate management knowledge with IT knowledge, so as to build a reference model of sustainable management of transshipment in maritime container ports. The literature has neglected this problem, thus motivating our contribution to this matter. As a result of the research work undertaken, a sustainable transshipment management system is first defined as a whole unit which develops its subsystems in a harmonious way without compromising them in the process. Then, the form of the reference model is given in detail. Therefore, we suggest that the system and its constituent elements constitute a method for sustainably managing the transshipment process.

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1. Introduction

The issue of sustainable development is multi-faceted and multi-level, and concerns a variety of research topics; one of these is maritime container ports. Their importance for a sustainable economy is shown by the following data: around 80% of the volume of international trade in goods is carried by maritime transport, and this percentage is even higher for most developing countries. According to the latest records [1], in 2019 some 811.2 million TEUs (twenty-foot equivalent units) were handled in container ports worldwide, reflecting 16.0 million TEUs (or 2%) more than in 2018 and representing 2% of the total maritime trade measured by tonnes loaded. In the ranking of the world's top 20 maritime container ports in 2019, the first nine container ports are Asian ports, including seven in China; the major European ports of Rotterdam, Antwerp and Hamburg hold tenth, thirteenth and seventeenth place, respectively. Whether listed in the ranking or not, ports play an important, if not critical, role in global supply chains, a fact tangibly confirmed during the COVID-19 pandemic. This criticality of their role results from their basic function in the transshipment of goods, integrating sea transport with other modes of transport or with the next stage of sea transport (e.g., short sea shipping). Operating such systems, however, cannot be arbitrary, but must be consistent with an array of intentions and plans, and, more precisely, with the objectives of the entity managing it.

Due to the multitude of elements forming a transshipment system—made more complex by the changes taking place within it, between it and the environment, and caused mainly by uncontrollable factors—managing this system, like any other economic system, is extremely difficult as it is constantly interrupted and disrupted, resulting in what can be described as the management of a system on the edge of chaos. In order to reduce this

chaos, and in order to assert orderly, managed functioning within a managed system, it is necessary to constantly monitor the congruence of its current state with what was planned.

As the above findings are appropriate for every economic system, including a sustainable one, the management of a sustainable transshipment system requires sustainability not only its design or planning, but also in its control. Otherwise, management as a concept loses meaning: Why lay plans towards an objective if they will fail to be realised? Or vice versa: It is illogical to intend control without a plan (or a differently named pattern to which the current state can be related), because it leaves no point of reference from which to draw conclusions and formulate corrective decisions. If we assume that the essence of management—including the management of sustainable transshipment in maritime container ports—is making decisions, it is logical that there is no decision to be made without information. Therefore, there is a need for a specific component of management, the “management information subsystem”, responsible for sourcing and delivering appropriate management information to decision-makers [2], for the right information to be rightly formed, with the right content, in the right amount and obtained from the right sources, and, finally, delivered on time to the right recipients. There is probably no more appropriate entity to define the above-mentioned six Rs than the manager, whose role is to execute management decisions, in both planning and control. Since the manager is the recipient of this information, and therefore also the main user of the management information subsystem, it would be appropriate to consider their expectations from the information in such sub-systems. Additionally, from an IT point of view, it is not possible to provide an information service if one does not know what information the recipient wishes to obtain. Therefore, the first stage, common to both the design and implementation of the management information system, is defining the user’s information needs (i.e., defining requirements). Typically, managers do not have specific knowledge of the complete IT design process, but they are taught how to describe their information needs using relatively simple methods and tools.

These so-called reference models contain a very general IT formulation of the systems or processes within a given industry, presenting all their essential elements in one diagram. As professional academic illustrator A. Smith states, “illustrative diagrams are useful in displaying complicated information, and if designed correctly, they can help readers understand data and concepts more easily. In addition to the clarity that they bring, illustrative diagrams are like a work of art” [3] (p. 19). There are many approaches to producing such diagrams, but if a diagram is to clearly reflect the subject of research that it models, it should use standard notation to reduce ambiguity in communication [4]. For methodological reasons (explained in Materials and Methods), the event-driven process chain (EPC) diagram was selected to design a reference model for the sustainable management of transshipment in a maritime container port. Its inventor, A. W. Scheer, says “as opposed to freely drawn sketches, tables make event-driven process chains (EPCs) more readable, but they also impede the illustration of complex procedural structures such as loops” [5] (p. 16). The results of the systematic review by A. Amjad et al. [6] confirm the broad range of applications for EPC diagrams in scientific work, including the construction of reference models [7].

As a result, the reference model fulfils the functions of an IT tool (with its own methodology) for management purposes, allowing managers to better understand their own management system and related information needs and to serve as a benchmark to check whether management information needs have been identified and refined in relation to all the elements specified in the reference model, or, more simply, that something has not been forgotten. The same role is played by the reference model from an IT point of view, serving IT specialists to check that all elements have been included by the manager in their specification of information needs.

Despite a rich scientific achievement in sustainability and port management [8,9], sustainability issues in relation to maritime container terminals are scarce. Data records obtained from a search of the MDPI journal database on 11 June 2021 at 16:30 show that

out of 35,428 publications in the journal *Sustainability*, 16 included “sustainability” and “maritime” in the title or keyword; there were four such publications in other MDPI journals. From the content analysis, it appears that only seven publications address “sustainability” and “maritime” in some of its aspects, namely:

- How to understand sustainable maritime transport and how blockchain technology can be used to make maritime transport more efficient and sustainable [10];
- A literature review on sustainability in maritime studies [11];
- The challenges of sustainability in the economic, environmental and social dimensions concerning maritime transport, including maritime ports [12];
- Digitalisation as a sustainable solution for maritime logistics [13];
- The development of a composite sustainability index of port regions for management purposes [12];
- Information systems such as Port Community Systems [14].

Extending the literature search to all Web of Science publication databases (Clarivate Analytics, Databases = WOS, BCI, CCC, DRCI, DIIDW, KJD, MEDLINE, RSCI, SCIELO, ZOOREC; Timespan = All years; Search language = Auto) using the words “sustainability AND marine” in the title or in keywords according to the formula $TI = (sustainability AND marine) OR AK = (sustainability AND marine)$, returned 131 publications on 14 June 2021 at 15:58. Restricting the search formula to the keywords “sustainability” plus “maritime” and “management” yielded 22 publications. Since the port reference model is very generic [15], it may not necessarily be searched for using the word “sustainability”. Therefore, by changing the search formula to “ $TI = (reference\ model\ AND\ port\ management) OR AK = (reference\ model\ AND\ port\ management)$ ” returned one publication entitled “Development of Online Reference Model for the Logistics Information Standard” [16]. Unfortunately, the words “management” or “port” did not appear in the title or keywords, so it is strange that the WOS database returned it as a search result. Nevertheless, a content analysis of this publication indicated that it is about logistics information standards. Although Figure 1 of this paper, according to its title, should show a business process, it instead shows an information flow, which cannot be considered correct because information is a resource and not a process. The lack of a process diagram (activities or functions) to determine the information flow and way this information flow was narrowed to a flow between entities rather than within them (e.g., in a port), makes it difficult to consider the proposed model a reference model since it does not show all relevant elements of the modelled object.

Summarising the results of the literature survey, it has to be said that while the issue of port management is widely discussed in the literature, the aspect of sustainable management is less researched, and the reference model of port management can hardly be considered correct. Unfortunately, this is not an isolated opinion, as other researchers have expressed the opinion that “particularly noticeable is the lack of research and practice that would offer the authorities in port regions adequate management instruments that could assess, monitor and measure the effects of the implementation of sustainability strategies” [12]. Therefore, the research objective is to develop a reference model for the sustainable management of transshipment in a maritime container port, and the purpose of this paper is to present the research results obtained.

The research objective formulated above is realised by means of the materials and methods, which are described in detail in the next section. The results of this objective are presented in the section on port management from the stakeholders’ perspective, which is then generalised in the following section, containing a reference model for the sustainable management of transshipment process in maritime container ports, followed by the discussion and conclusion sections.

2. Materials and Methods

The following methodological approach was proposed to achieve the research objective. Four methodological assumptions were formulated as a starting point:

- If the object of reference modelling is to be a system, general systems theory should form the methodological basis;
- If the research task is to build a reference model, it is necessary to identify and select an appropriate reference modelling architecture, standard and tool;
- If the modelled system is to address the sustainable management of transshipment in a maritime container port, the general systems theory should be detailed to the level of the theory of sustainable management of transshipment by such ports;
- If the sustainability of operational, tactical and strategic decisions related to the transshipment process in these ports depends on the possibility of achieving consensus among stakeholders (decision-makers), it is necessary to discuss the methods of achieving such a consensus.

According to the founder of general systems theory, “a system can be defined as a complex of interacting elements” [17] (p. 55). For very few applications of this general systems theory is it sufficient to distinguish only two parts of the system, i.e., the whole and its elements, including relationships. For very complex socioeconomic systems, such as container ports, which involve many elements (or subsystems) that are composed of even smaller elements (or sub-subsystems), often correlated in a very complex way, it is proposed to see the system as a holon.

Holonism claims that “organisms and societies are multi-levelled hierarchies of semi-autonomous sub-wholes branching into sub-wholes of a lower order, and so on. The term <holon> has been introduced to refer to these intermediary entities which, relative to their subordinates in the hierarchy, function as self-contained wholes; relative to their superordinates as dependent parts” [18] (p. 58). This means that the system of sustainable management of transshipment in a maritime container terminal should be seen as a multi-level hierarchical holon, which is a subsystem of a higher-level system—e.g., the system of a region, country, continent or world, of which the port is a part, and at the same time the port is a system that consists of subsystems (or components, elements, etc.).

If the aforementioned system is to be a management system, its basic subsystems must be defined. The literature on management maintains a traditional view that the management system includes four components: planning, organising, leading and controlling [19]. While boundaries between planning and controlling are understandable, in relation to organising and leading they already raise doubts (e.g., if planning does not also mean organising, and if organising something does not mean planning or controlling organised activities). Perhaps that is why clearer proposals have appeared in the form of management concepts hidden under the acronyms PDCA (plan, do, check, analyse), DMAIC (design, measure, act, improve, control) A3 or 8D/PSP (problem-solving process) [20].

Therefore, this article presents a so-called closed algorithm/cycle of transshipment management in maritime container ports, which includes six subsystems. The first of these is the subsystem for planning the object of management, namely a transshipment system. In particular, it includes analysing the current state of the port and its neighbourhood; establishing key performance indicators, also verbally (e.g., mission, vision, desired opinion, etc.); planning the organisational structure (i.e., who does what, most often described in the form of a business plan, strategy, functional plans, quality book, organisational scopes (competences, duties and powers), procedures, instructions, activity diagrams and resource flows; and communicating planning decisions to the contractors of the managed object, that is, the transshipment system. The second component is the subsystem for measuring the implementation of planning decisions by the performers of transshipment activities. Specifically, this involves measuring the current status of these activities according to the indicators that were planned. The third element is a variation identification subsystem, which compares the planned state with the current state and determines whether there is a variation. This comparison concerns not only quantitative but also qualitative indicators, i.e., those described in words (textual variables, e.g., compliance with the procedure, etc.). If there are no variations, it is concluded that the managed transshipment system is working as planned and therefore it is not necessary to switch to other subsystems than

the three already mentioned. On the other hand, if a variation is recorded, the transshipment management system must be supplemented by a fourth component in the form of a subsystem for analysing the significance of the identified variation. It can have two states: the variation can turn out to be either insignificant or significant. In the first case, a return to activities carried out under the second measurement subsystem takes place, because although a variation has been detected it is insignificant. If, however, the variation is significant, there is a need to extend the transshipment management system by a fifth subsystem—explaining the reasons for variations—as well as by a sixth subsystem—taking corrective decisions on the functioning of the transshipment system. Since corrective decisions are planning decisions, as they inform about what to improve, what to change, how things should work better, etc., the next element is the measurement subsystem described above, at which the loop of the transshipment system management algorithm closes.

These six subsystems of the transshipment process system in maritime container ports can be further subdivided into successive sub-subsystems; for example, in the planning subsystem the following components can be listed: analysis, key performance indicators planning, organisational structure planning, etc. Nevertheless, each of them still has the features of a relatively independent system, although at some point of this division one must ask what the elementary parts of this smallest subsystem are that do not exist independently, but only in combination with other parts? To answer this question, modelling methods and tools are helpful, thus can also be treated as a continuation of the detailing of general systems theory from the perspective of the perception of economic reality. There are many modelling methods and even more modelling tools, especially IT tools, in the form of software applications. Thus, which should one choose, and which are the best? Both in theory and in economic practice, two approaches to the above problems can be distinguished: non-scientific and scientific.

A non-scientific approach, also listed in the literature, consists of adopting a two-stage (or two-step) procedure, that is, adopting first a method and then modelling tool. Most often, to construct economic process models a descriptive method with a verbal description or a graphical method with a tool in the form of a flow chart are adopted, but without explaining the methodology of its construction, which most likely results from the assumption that they are so simple that the reader can be trusted to understand them. The problem with properly understanding the descriptive model is that the description is sequential, whereas the processes also run in parallel. Due to the fact that the reader is not (yet) able to read the author's thoughts, but only their text, there may be and usually is a break in the flow of thought and a loss of understanding of the mutual relations between the described elements of the model, and then further problems identifying levels and perspectives (points of view or aspects) of the description, as well as questions regarding why these particular and no other elements were specified in a given model. In addition, there are problems interpreting a verbal description, which could be ambiguous, since a word (text variable) is not a number, and a sentence is not a mathematical equation, so it can be understood differently, not necessarily in accordance with the intention of its author. Therefore, when using a model in a descriptive form, it is crucial to follow strict rules of this description. Even if some words are to be repeated, in the case of modelling, for which it is very important to accurately represent reality, the unambiguity of a verbal description is more important than stylistic correctness. The problem with parallelism of the process flow is eliminated by supplementing a verbal description with a flow chart, but unfortunately in this case it is also necessary to explain the graphic symbols being used (e.g., which symbol reflects resources and which represents activities or how arrows, solid lines, dashed lines, etc. should be interpreted). This opinion is shared by others. For example, K. Hinsén states that “researchers should know and understand in detail the models they apply. These models are shared by a research community and formalised using a suitable standard notation to reduce ambiguity in communication” [21] (p. 5).

The above-mentioned problems should (at least theoretically) be eliminated by adopting a scientific approach that differs from the previous one in that the applied methodology

for modelling economic processes is not two-level, but four-level (or four-stage) and is not the decision or result of the work of one person, but of many researchers [4]; therefore, it bears the hallmarks of greater objectivity and unambiguity of understanding the model, and thus greater applicability in the form of successful implementation projects. At the highest level of scientific abstraction (at the first stage), the modelling methodology requires the creation (arrangement) of a philosophical approach in the field of ontology [22], i.e., a way of perceiving reality (the world), of which sustainable management of transshipment process in maritime container ports is a part. Even a brief description of this issue requires a separate paper; however, for the purposes of the methodology of building a reference model of the above system, it is assumed that these dependent elements of economic reality are processes, events, resources and the relations connecting them. Together they form a relatively independent system in the holonic sense. Parameters are not mentioned as a separate ontology in order not to isolate them from their carriers (processes, events, resources and relations), so they appear together with them as an immanent feature of them. Concretisation of ontological assumptions can take the form of one of several modelling architectures [23] (level two), which at an even lower level of abstraction use multiple standards (notations or languages) [24] (level three), which are supported by even more tools [25] (level four).

It may seem excessive to extend the methodology for modelling economic systems from two-stage to four-stage modelling, but it is ontological assumptions, by virtue of being the most general, that are also the most enduring. Thus, by comparing the degree of compatibility of a given modelling standard to the relatively unchanging ontological foundations over time, we can determine which one should be chosen. Although architectures, standards and tools are not described in this paper—as each of them would require a separate publication—in our opinion the architecture called Architecture of Integrated Information Systems (ARIS) [26], according to the EPC standard [27] using ARIS Architect & Designer software [28], is the most compatible with the ontological assumptions outlined above, and is thus appropriate for modelling the sustainable management of transshipment processes in maritime container ports.

If the above-described transshipment management system in maritime container ports is to bear the characteristics of a sustainable system, it is necessary to define sustainability in relation to the system in question. As the aforementioned literature review on the understanding of sustainability in maritime sciences has already been done [11], there is no need to repeat the research, only to immediately state that sustainability is usually equated with the terms “resources for the future” or “environmentally desirable” [29]. Of course, caring for natural resources is very important, if not vital. Nevertheless, living in a sustainable way seems to mean more than living in harmony with nature, as it also includes such spheres of life as cultural, social, political, economic, technical, etc. Although the literature mentions three aspects (dimensions) of marine sustainability—environmental, economic and social [11]—considering the relatively full range of environmental elements, at least three more dimensions should be listed—i.e., technological, legal and political—which together make up the concept of the economic environment, abbreviated as PESTEL (political, economic, social, technological, environmental and legal) [30]. This allows at least six stakeholder groups to be identified that significantly determine the sustainable development of maritime ports. Due to the interrelationship of these six spheres, or more precisely because of their multi-aspect and multi-level interdependence, they must be sustainable, or in other words integrated, managed, coordinated, applied, synergised, economised, socialised, etc. It is not very important whether the results of these activities are called sustainability, integrity, coherence, holism, systemism, optimisation, cooperation, emergentism, interdependence, synergy or economy of scale, but rather how one can think and act in accordance with at least one of these concepts, since sustainability is the only aspect of an economic system that combines other partial aspects of that system into a whole, thus avoiding suboptimal development by that system.

Therefore, we agree with opinions [31] which claim that sustainability is the ability of a system to develop all its subsystems harmoniously. In other words, if a system allows one of its parts to deteriorate or develop inadequately, in any aspect, in relation to other subsystems, it cannot be called a sustainable system. This may be a radical understanding of sustainability, but it contains clearly defined boundaries. Applying this proposal to the definition of sustainable development of the cargo transshipment management system in maritime container ports, it should be stated that the most difficult tasks of identifying, analysing and adopting those, and no other, parameters that give this system the characteristic of sustainable development occurs in the planning component, because subsequent subsystems operate on those parameters that have already been planned. The literature on this subject provides a set of sustainable development indicators for the maritime industry, including ports [32], so there is no need to quote them, and critiques or proposals for a new set would require a separate study. However, due to the nature of maritime ports, it is necessary to indicate a special group of indicators that do not exist in other industries, namely the degree of pollution of port basins, the optimal speed of vessels within the port in terms of pollution emissions, the container loading index, the utilization of port quays' storage space, the functionality of container reservation system, etc.

Integrating the understanding of a transshipment management system with sustainable development as presented above, the sustainable management of transshipment in maritime container ports is defined as a holistic system that develops all six subsystems—planning, measuring, identifying deviations, analysing the significance of deviations, explaining the causes of deviations and taking corrective decisions—with respect to the transshipment process, in a harmonious way without deteriorating any of these subsystems. Among the many factors that determine the sustainable management of port systems, many researchers point to stakeholders [33–35]. Therefore, the discussion on this topic and, in particular, on how to achieve a consensus between conflicting interests that may interfere with sustainable port development, will be continued in the next section.

3. Sustainable Management of Maritime Ports: A Stakeholder Perspective

Stakeholder theory offers a rich forum for interdisciplinary debates that bring business and society together [36]. According to Freeman's classic definition, a "stakeholder is any group or individual who can affect, or is affected by, the achievement of a corporation's purpose. Stakeholders include employees, customers, suppliers, stockholders, banks, environmentalists, government and other groups who can help or hurt the corporation" [37] (p. vi). In relation to maritime ports, it should be noted that three main stakeholder groups are usually distinguished in the literature—terminal operators, port users and port administrators [33]—but they can be regrouped into six categories according to the previously mentioned concept of the market environment, PESTEL [30]. Within each category, different entities can be distinguished (e.g., maritime carriers, freight forwarders, road carriers, etc. are usually in the group of port users, while state-owned or private port management companies are examples of port administrators) [38]. Similarly, terminal operators can be business entities of different ownership structures.

Stakeholders may influence the management of the port driven by their interests. Consequently, there may be conflicts of interest between stakeholders. For example, port infrastructure is usually developed and managed by the port administrator. Improving access (e.g., dredging port channels) can conflict with terminal operators, and therefore must be agreed at different levels of management [39]. It may also interfere with the schedule of shipping lines or other entities that perform cargo transshipment operations, for example. An interesting example of stakeholder conflict is presented by Wilmsmeier et al. [40], who present the case of the Guayaquil port area in Ecuador, the second largest container transshipment site on the west coast of South America, handling more than 2 million TEUs in 2019. As the sedimentation problem caused by the Guayas River flowing through the port of Guayaquil continued to worsen, it was decided to build a

completely new port in Posorja, 85 km from Guayaquil, and to transfer all transshipment operations there. However, it turned out that not all operations were transferred to Posorja, as some concessions were granted to private owners in Guayaquil, triggering a conflict of a competitive nature between the administrators of these two ports, followed by a management conflict between the national and local authorities and between the authorities of neighbouring municipalities, which finally led to these two ports competing with each other instead of complementing their different specialisations, deep-sea transport (Posorja) and feeder transport (Guayaquil).

This case and other examples [41] of conflicts of interest show the importance of methods used to build consensus between stakeholders. The literature [33,42] mainly applies multi-criteria analysis as a general methodological approach for creating consensus between individuals or groups of conflicted stakeholders. The following three methods of this approach are most commonly used:

- Analytic Hierarchy Process (AHP);
- Multi-Actor Multi-Criteria Analysis (MAMCA);
- Decision-Making Trial and Evaluation Laboratory (DEMATEL).

According to the AHP method, stakeholders compare the validity of criteria by making a pair-wise comparison, then turning the qualitative scale into a quantitative one, and finally selecting the decision with the highest score [43]. An interesting example of the AHP method in use was presented by Duleba and Blahota [44]. Based on a number of simulations, especially on urban public transport in the city of Mersin, Turkey, in 2017, they showed how consensus can be achieved among three groups of stakeholders with different priorities and motivations. The novelty of the AHP method presented by Duleba and Blahota [44] is the development of an algorithm that minimises the distance vector between the preferences of different stakeholders, though it is unfortunately limited to only three stakeholder groups. The study by Macharis et al. [34] concluded that when each stakeholder has their own criteria, the MAMCA method is recommended for decision-making support instead of AHP. MAMCA also uses a set of criteria, but it differs from AHP in that instead of adopting a single set of criteria for all stakeholders, a single decision-maker or group of stakeholders uses their own set of criteria. In another study by Macharis and Bernardini [45], the effectiveness of different multi-criteria decision-making methods in solving stakeholder problems was proven, though they suggested using MAMCA in situations when stakeholders are involved from the beginning of the decision-making process. Regardless of whether the criteria are common to all stakeholders or separate, it is necessary to have a way of identifying and prioritising them and exploring interdependencies. Such functionalities are available in a step-by-step procedure known as DEMATEL [46]. One example is the study by Venkatesh et al. [47], in which barriers to supply chain integration between port stakeholders were explored and prioritised using DEMATEL to overcome conflicting stakeholder interests, leading to the conclusion that a “lack of awareness of supply chain integration by stakeholders and a lack of government support in driving such large-scale projects is negatively influencing their success, even though the government is keen to strengthen port services through integration projects” [47] (p. 242). Another example is a case study where DEMATEL was used to quantify the relationship between barriers that were limiting coastal shipping development in India, including ports and port areas, in order to make stakeholders aware of the importance of these barriers and then to design appropriate coherent actions for them [46].

The problem of port management outlined above from a stakeholder perspective, especially the existence of diverse interests and the need to deal with them to ensure sustainable port development, indicates the need to include stakeholder management methods into the port’s management system. As these methods currently exist in the form of IT applications, in the proposed reference model they are part of an IT system called the “stakeholder management module”, which supports the implementation of all functions of sustainable management of the container transshipment process.

4. Reference Model

Carrying out the research objective by means of the adopted methodology resulted in a reference model for sustainable management of transshipment in a maritime container port shown in Figure 1. According to EPC notation, its description was extended by additional explanations as follows:

The system called “sustainable management of transshipment in a maritime container port” is in relation with two other systems, called “sustainable transshipment in a maritime container port” and “stakeholders of a maritime container port”. The first one is a management system, so its structure is detailed, while other two, with which it is related, are treated as “black boxes”, without revealing their structures (although this can be done). The reason for adopting such a relationship is that the system called “sustainable transshipment in a maritime container port” is an object or execution (managed) system for the former managing system, while the “stakeholders of a maritime container port” system is a collection of external systems of customers, suppliers, investors, shipping lines, shipowners, customs officials, phytosanitary inspectors, local governments, environmental organisations, the media, etc., which are rather uncontrollable systems, and thus it is difficult, and perhaps not even necessary, to look into their structure. Coming back to the system called “sustainable management of transshipment in a maritime container port”, its main components (subsystems and elements) are the six functions (activities and processes) marked in green. Their special place in the system results from the fact that they are the only dynamic (active) element of this system, having the property of transforming input resources into output resources. Although functions are so important, they are unfortunately not visible, and the closest representation of them is a movement, flow or service. Their dynamism is also the reason why these activities are named using verbs in the present continuous tense, as opposed to events (marked in red), which should be understood as a situation or state of affairs that took place not in a period of time, but at a certain moment (point) that has already occurred. Therefore, verbs in the past tense are used to describe them. Resources are best understood intuitively, usually broken down into human, material, information and financial resources. The resources that appear in the reference model, such as reports, applications (marked in grey), IT (marked in blue) or Port Authority (in the sense of human resources) (marked in yellow), are described using nouns and adjectives to indicate that we are talking about resources and not about what happens to them or what has happened to them.

Other inherent elements of the presented system are relations in the form of arrows or lines, including rules (logic gates). They relate events to actions, which relate to resources. Without relations there would be no system, only chaos; that is why the type of relations also defined by verbs is so important, for example, relations that activate, create, lead to, support, execute, mark entry or exit, are responsible for, etc. Despite the use of verbs to denote relations, they should not be confused with activities, because relations do not process anything, do not produce or transform anything, and therefore do not consume resources. It can be said that these are special properties of elements, since it is not possible to define a relation without talking about the elements that particular relation connects. Relationships also include rules, which can also be named compound relationships. There are three basic rules in the EPC standard: AND, OR and XOR (exclusive or). In the presented model, only the “XOR” rules are used, which means that the elements connected by this rule are mutually exclusive. If the “AND” rule were used, it would mean that the elements connected by it occur together, and the “OR” rule would indicate different combinations. These rules are used to indicate the appropriate relation between events, while for relations between functions (including the so-called interface process) only the “AND” rule may be used.

Figure 1. Reference model of the sustainable management of transshipment in a maritime container port according to ARIS architecture and EPC notation, supported by ARIS Architect & Designer, ver. 10.

As explained above, this model can be described as follows. The system called “sustainable management of transshipment in a maritime container port” is activated by the event “a request for sustainable management of a transshipment in a maritime container port was received”. This event initiates the first function (action) named “planning a sustainable transshipment in a maritime container port”. To perform this function the following resources are required:

- Human—in the form of the Maritime Port Authority, which carries out the function;
- Information—in the form of “a request for sustainable management of transshipment in a maritime container port”, which is an output of the “stakeholders of a maritime container port” system, or “reports or additional data required for sustainable management of a transshipment in a maritime container port”, which is an output of the “stakeholders of a maritime container port” system, and “IT system”, which supports the function (of course, especially with IT planning methods and tools for sustainability management purposes, including the stakeholder management module);
- No materials are needed (not to mention buildings, office equipment, etc.);
- No money is needed to perform the function.

To better understand the relationship between the system, events, activities and resources, the following explanation has been added. The execution of any function (activity) occurs in response to an event, occurrence, situation or something else that may be perceived consciously or unconsciously. The same relationship between activity and event occurs at a higher level (i.e., at the level of activities that make up the process of sustainable management of transshipment in a maritime container port). In other words, something has to happen to initiate these actions. Whether this is the founding decision of the port owner(s) or demands addressed to the contractors that result from such decisions, this situation must be somehow described—not as an elaboration, but in an abbreviated form—for the purpose of the reference model. Therefore, in the reference model there is an event symbol named “a request for sustainable management of a transshipment in a maritime container port was received”. Unfortunately, the need to use a mental abbreviation may cause ambiguity and doubt, not only about this symbol but also about all the others, which would mean that in order to clarify the abbreviations additional publication would be required. Just as sending an order is not the same as receiving one, because we can send something to someone without them receiving it, the mentioned event “a request . . . was received” (which is not a purchase order) is not a description of how to strive for success in the form of acquiring and then realising an order, but only a brief description of an event which initiates a whole system of actions, resources and events and the relations connecting them, in order to achieve this success. Thus, it is the whole system of “sustainable management of transshipment in a maritime container port”, with all its symbols saying what to do (functions), in response to what events, with what resources, linked by what relations, written in the form of a reference model (and therefore very generally) that provides a way to succeed in managing transshipment activities in a maritime container port. For example, if this or another part of the model is not working properly, there is a function (highlighted in green) called “Identifying variance. . .” which identifies the difference between planned and reported indicators. If the reported indicators are not the planned ones, another action called “Analysing variance significance. . .” is performed in order to determine whether the difference is significant (preferably statistically) or not, in order to avoid over-reactivity of the whole system. If so, the next function “Explaining causes of the variance. . .” is executed to find the correct reasons why something is malfunctioning. Based on the knowledge of these causes, the final activity “Taking corrective decisions. . .” is performed with the aim of restoring the malfunctioning element to the planned state, possibly correcting plans, including restructuring the whole system or even exiting the market. As this is a closed loop system, the next activity is “Measuring . . .” the reality and again “Identifying variance. . .”, this time of whether the corrective decisions were executed as described or not, because if not, the loop repeats itself. Thanks to the above dependencies, supported by the “IT

system (including the stakeholder management module)", the whole system takes on the characteristics of an ultra-sustainable system.

Continuing the description of the model, it should be stated that the execution of the activity called "planning sustainable transshipment in a maritime container port" using the aforementioned resources causes this function to produce the following resources:

- No humans created (in the sense of persons with newly created features—in particular, passengers can be considered "a special product" of the passenger transport function);
- Information—in the form of "a request for reports or additional data from stakeholders of a maritime container port", which is an input of the "stakeholders of a maritime container port" system, "planned indicators for sustainable transshipment in a maritime container port", which is an input of the "sustainable transshipment in a maritime container port", the "measuring a sustainable transshipment in a maritime container port" function and the "identifying variance in a sustainable transshipment in a maritime container port" function;
- No materials produced;
- No money produced.

The execution of the function "planning a sustainable transshipment in a maritime container port" not only produces resources, but also creates a new situation briefly described by the event "a sustainable transshipment in a maritime container port was planned". This description of a fragment of the model is similar for the other parts of the model, where no rules are involved. Therefore, one more description of the model's elements connected by the "XOR" rule is given below. The event named "variance in a sustainable transshipment in a maritime container port was identified" initiates a function named "analysing the variance significance on a sustainable transshipment in a maritime container port". To perform this function the following resources are required:

- Human—in the form of the Maritime Port Authority, which carries out the function;
- Information—in the form of the "report on the identified variance in a sustainable transshipment in a maritime container port", which is an output of the "identifying variance in a sustainable transshipment in a maritime container port" function, and the "IT system", which supports the function (especially with IT variance analysis methods and tools for sustainability management purposes, including the stakeholder management module);
- No materials are needed (not to mention buildings, office equipment, etc.);
- No money is needed to perform the function.

Performing this function with the above resources produces the following resources:

- No humans;
- Information—in the form of the "report on a significant variance in a sustainable transshipment in a maritime container port", which is an input to the "explaining the causes of the variance in a sustainable transshipment in a maritime container port" function, or the "report on a non-significant variance in a sustainable transshipment in a maritime container port", which is an input of the "measuring sustainable transshipment in a maritime container port" function;
- No materials are needed (not to mention buildings, office equipment, etc.);
- No money is needed to perform the function.

The execution of the above function also leads to two mutually exclusive events, the first "a significant variance in a sustainable transshipment in a maritime container port was identified" or the second event, "no significant variance in a sustainable transshipment in a maritime container port was identified".

In addition to the previously mentioned possibility of using this reference model to better understand the management process and related information needs, it can also have the following uses:

- A tool to support the creation of business models and strategic management documents, such as a business plan, economic strategies, functional plans, etc.;
- The first stage—and at the same time a reference for subsequent stages—of the process of designing an information system dedicated to the sustainable management of transshipment in maritime container ports;
- A model that can be used for engineering, reengineering, certification, standardisation, integration, increasing system resilience against disruptions, accelerating system responsiveness, improving agility, removing unnecessary functions and resources, etc.;
- A model that can be used as a conceptual framework to build a detailed “as is” or “as it should be” routine model, supplemented by procedures and instructions for the daily performance of duties; or
- A model that can be used as a mind map for critical thinking purposes.

5. Discussion

It seems that a fundamental critique of reference models is their usefulness in the management of economic systems, including sustainable management. In-depth managerial knowledge supported by experience and backed by integrated IT systems with extensive modules and a decision support system, business analytics and a control tower should not leave even a faint suspicion that trivial distortions of information remain or that there are problems (e.g., with the integration of a port’s materials index database and a logistics operator’s database in order to deliver the required materials to the port, resulting in each parcel having a separate invoice for the same full value instead of receiving three parcels with one invoice, meaning that it has to be paid three times to the courier. Why, if changes are made to the port’s IT system, obviously full of platitudes such as being “for the good of the workers”, has no one discussed these changes with the workers, the users of this system, beforehand, instead of giving the workers new procedures to learn and follow and blaming the users if something does not work, although they do not know how to operate the system? The examples cited from the expert experience of the authors of this paper are not meant to point blame, but to clearly formulate the question, “If it is so good, why is it so bad?” Who serves whom, does the port manager support IT people, or is it the IT people who are supposed to support the manager? If we agree with the latter suggestion, then we also know the source of the information needs. The problem, however, is that a verbal description of these needs is inadequate, because information technology requires information with logic gates (rules) to define IT functionality precisely, and this is often beyond the IT capabilities of managers. Perhaps this is why IT specialists with business experience build reference models, instead of managers who know the basics of architectures and IT notations for describing the business systems they manage. Unfortunately, it turns out that the reasons for unsuccessful IT projects in business are at the stage of defining users’ information requirements, because if something is not understood or overlooked at this stage, it becomes more and more difficult, and sometimes impossible, to correct mistakes in the subsequent stages of the project. While agreeing with the opinion that no-one better understands the information needs of a manager who has to manage the container transshipment process in a sustainable way than the manager, it seems that the reference model presented herein has at least partially demonstrated its usefulness in understanding the complexity of decision-making matters and IT support for them.

6. Conclusions

The issue of sustainable port management is multifaceted and therefore very complex. To reduce such complexity, this publication presents a reference model for the sustainable management of transshipment in maritime container ports. This model includes all the necessary elements in interaction with each other, which is intended to help achieve success in container transshipment management and to keep the whole system sustainable if one part of the model does not work correctly. What is on the one hand an advantage of the reference model, i.e., its generality, which allows the operation of a complex system to be

understood, is on the other hand its disadvantage, as it requires a high degree of abstraction, leading to doubts and ambiguities, which also contributes to the need for appropriate IT modelling notation, e.g., EPC. Therefore, the recommended direction for further research is a more detailed specification of the individual elements of this model. Such articles may need to be case studies in order to be applicable, to a specific port authority, for example. Nevertheless, even in this situation, the reference model presented herein will still serve to ensure sustainability, especially by indicating the relationships with other internal or external elements of the system.

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