Port Connectivity Model in The Perspective of Multimodal Transport: A Conceptual Framework

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Abstract. As an archipelagic country, the use of several modes or multimodal freight transport in Indonesia is indispensable. As a place of "interchanging," Port is an essential element in a transportation system that supports a region's economy and becomes more in the region island where incoming and outgoing goods rely on it. Port connectivity is not just about how "good" the Port is connected to the maritime transportation network and reached by regular lines services but also contributes to the entire transport network. Generally, the higher port connectivity is, the more attractive it is to facilitate cargo transportation and reduce transportation costs and time. Port connectivity is very complex, and it will be more useful if analysed from more perspective by using comprehensive analysis. This paper proposes the conceptual framework port connectivity in the multimodal perspective that sees from three aspects: maritime connectivity, connectivity of port with the hinterland, and connectivity at the Port and using the same measurement such as generalized transport cost. Analysis on various aspects will give a better understanding of port connectivity. Conceptual framework consists of three stages, the first stage is defining the definition of connectivity, seconds stage is connectivity analysis, and the last stage is synthetic of results. The importance of conceptualizing port connectivity is because there is still a lack of research on port connectivity. It is mostly analysed only on one aspect, as we know that port connectivity is very complicated. It will be more useful if analysed from a more different point of view with a comprehensive analysis.

Keywords: Maritime, network, port, connectivity, multimodal

1. Introduction
The large volume of cargo transported indicates by sea transport to entire world make the world economy development closely related to maritime transport quality such as efficiency, quality of shipping, and port's activities [1]. A port as an “interchange” is an essential element from transportation system, has a role as an interface for various modes of transportation that supports a region’s economy and becomes more crucial to support an island region where incoming and outgoing cargo rely on it [1, 2].

One of the attributes that indicate the quality of maritime transport system is the port connectivity. Port connectivity can be described as how “good” the port connects to the maritime transportation network. Generally, the higher port connectivity is the more attractive it is in terms of facilitating cargo transportation and reducing transportation costs and time [3].

The high-level connectivity of ports has many transportation options through the port. Carriers can make choices for mode transportation, not just related to the shipping services but also inland transport that involves at least two-mode (multimodal transport) to reduce time and increase the capacity of the transportation network. The port with high-level connectivity will contribute to the transport network;
on the other hand, ports with low connectivity and less available options will give a low contribution to the transport network [3].

Understanding port connectivity can help port operators and shipping companies develop strategies that can give benefits to them. For instance, port operators who want their port's position as a transshipment hub port can be used as a benchmarking to improve services. In contrast, ocean liners can use it to select hub ports or redesign the service network to follow the hub and spoke system [4].

Recently, research related to port connectivity has increased due to the desire to understand better the importance of port connectivity and its role in supply chains. Its strategy also changes related to logistics. Port connectivity is an essential factor that is related to port competitiveness.

Mostly port connectivity define connectivity from shipping or maritime side such as developed container порt connectivity index, based on economic, network topology, and the position of port within global shipping network system [5].

Measuring port connectivity also consider the transportation time and capacity maritime network [3]. The other method is trying to combine connectivity index, attribute of port key operating dimensions. The connectivity index is measure based on number of ports that can be directly reached from port and the number of ports that can be jointly through both while attribute of port key operating dimensions consist from number of port calls, draught. Ship turn round time, port cargo traffic, annual operating hours, port charges, availability of intermodal transports [6].

Connectivity of port is also useful to define competitiveness of port, by measuring the average ship capacity of liner shipping services that deployed between port and annual frequencies liner shipping between port [7]. Connectivity also can be measured using liner shipping connectivity index, that is derived from five components: Number of container ships on the liner services; capacity of container ships (TEUs Unit); number of services; maximum vessel size; and number companies that deploying ships. All components are related to services to and from country’s port. Mostly analysis of port connectivity and especially that trying to derive the index are measure at the maritime segment. Therefore, the role of ports is vital in moving goods from the origin and destination of goods. Port functions are not only related to the maritime network, but they are also function in the transportation and logistics chain, so the connection between maritime and port with its hinterland becomes essential [8]. Some researchers consider that the port hinterland connectivity and distance seem like one of the variables that impact the cargo flow from the port to its hinterland [9]. The dry port also becomes the issues that arise when discussing port hinterland connectivity, dry port as an inland node that establishes between seaport and hinterland, supposed to have a purpose as cargo unitization and has a strong link to seaport using reliable, high capacity, and frequent inland mode such as inland waterway, rail or road [10]. Another issue is enhancing the resilience network between port and hinterland containers [11]. Furthermore, research that discusses network integration not just between port and hinterland but between maritime or sea and the landside network is still lack.

There is the interaction between inland and maritime transportation, for example, the choice of load and discharge port and origin-destination transit time considerations, which is the evidence that holistic optimization of intermodal transportation has implications for a liner shipping [12]. The quality of inland and maritime transport connection also significantly changes the hinterland [13]. Landside and sea integration become vital in logistics. These also develop along with the transportation network and need to incorporate to measure port connectivity [14].

Since there are the function or port as an “integrator” for sea mode and land mode, multimodal transport is an important consideration when building the port connectivity model. The origin and destination cargo locate at inland locations, so it is essential to consider the inland transport network when arranging the shipping network [12].

The port itself as an infrastructure transport has to meet the performance required to support trade connectivity, such as capacity and availability related to container and transshipment volume and port productivity [15].

Therefore, it is essential to develop port connectivity from the multimodal perspective that consists of maritime connectivity network, connectivity at port, and hinterland port connectivity.
Connectivity is an attribute of the network that indicates the quality and cost to move freight from origin to destination [16, 17]. The cost to move freight in the transport model is transport costs. Besides the cost, several attributes indicate the network's quality, such as time, capacity, and external attributes such as environmental variables e.g., pollution, accident, noise, congestion. These attributes or non-monetary costs then translate into the monetary using the value of time. The cost that consists of monetary elements and non-monetary elements is generalized costs [18]. Since the port connectivity analysis from three different aspects (maritime connectivity network, connectivity at port, and hinterland port connectivity) has different measurements, the cost is one of the variable measurements that can integrate those aspects. The transport cost or the generalized cost will be one of the useful variables that have fair representation as a measurement of port connectivity.

Moreover, there is a lack of a robust conceptual framework related to port connectivity that consider maritime segment, port, and hinterland side, and using the same measurement such as generalized transport cost and this paper is trying to fill that gap. This paper formulates the conceptual framework to measure port connectivity especially based on the generalized transport cost. Port connectivity has been compared to how the port can reduce the overall generalized transport cost. This paper aims two-fold: first, construct a theoretical framework for port connectivity, and second, propose conceptual framework

This paper will be structured as follows: the second section proposed a literature review concerning the former studies related to multimodal transport, port connectivity, maritime/shipping connectivity and connectivity to hinterland, and connectivity at port., section three will propose the conceptual framework port connectivity. Finally, the last section will be concluded and give some directions for further research.

2. Literature Review

2.1. Multimodal Transport
The freight transportation chain consists of three-segment: pre haul (first mile), long haul (door to door transit of containers), and end-haul (last mile). Mostly pre haul, and end haul carried out with land modes, and for the long haul, transportation can use the road, rail, air, and water modes [19].

Multimodal freight transportation is freight transport using of at least two different modes sequentially can be a road or rail vehicle or vessel and the unit of transportation can be a box, a container, a swap body [19].

Multimodal freight transport has a complex structure and involves many stakeholders, using at least two modes of transport such as railways, Maritime routes and the roads to deliver cargo door-to-door [20].

Planning in multimodal transport consist of multiple objects and involves a multi-criteria decision making process, the objectives might such of the minimization of cost, time, and carbon emissions as well as improvement of service levels and utilization [21]. The purpose of multimodal network design is to identify network structures (number and location and terminals) to minimize network costs and transport demand. [22].

Some studies related to multimodal transport network have been done and related with the sea transport and other modes using several approaches. One stream of the studies is related to network design for multimodal strategic planning to determine suitable action planning to improving transport infrastructure[23] that incorporated multiple stakeholder, multi type container [24] or optimal intermodal freight routing for export and import container cargo [25]. The other one is network design for shipping service of large scale intermodal or intermodal liner shipping service [12] incorporated inland and maritime transportation [26], inventory, emission [27].

Beside the network design there also some studies related to routing problem Routing problem for container multimodal transport that incorporating inland/feeder transport [28, 29], inventory, emission [27].
The objective of the studies is related to minimizing cost such as total cost [12, 27], total operating cost Meng et al., 2012), transportation cost of carriers and operational cost of hub operators [24], minimization of travel time and of travel cost [25], minimizing the expected total cost [29], and minimum generalized transport costs [28].

2.2. Port Connectivity

Connectivity is an attribute of the network that indicates the possibility to reach all nodes from all nodes and refers to the quality and costs to move freight or persons from an origin to a destination at a specific time and using various modes [16, 17]. Connectivity’s itself can act as the degree to which nodes in a network connection to each other [30]. According to various authors [31-33], there are two primary perspectives on connectivity: (1) the accessibility or (in)direct connectivity perspective; and (2) the centrality or hub connectivity perspective.

There at least three main perspectives on connectivity, namely a narrow perspective focused on the availability and characteristics of infrastructure and transport services, a broader perspective that includes trade facilitation procedures, and a supply chain management perspective [34].

Port as a node in a supply chain that is serving logistic services and information transfers, it functions as an interface that links sea and land transport, so there is a new perspective to understand port connectivity related to dynamics liner shipping network inter-port relationships in the supply chains. [35].

The various objectives of analyzing port connectivity are also important for consideration. There are several objectives in analyzing port connectivity, including understanding more about networks, connectivity related to port and hinterland connectivity, and port competitiveness.

Some studies derived the connectivity index to measures the liner shipping connectivity [36], port container accessibility [3, 5-7] or integrated port connectivity that derived from hinterland connectivity, inner bay connectivity and international connectivity [14].

Several methods use for measure index connectivity that derived from five component such as number of container ships on the liner services; capacity of container ships (TEUs Unit); number of services; maximum vessel size; number companies that deploying ships. All components are related to services to and from country’s port [36].

Model that develop connectivity is network-based hub port assessment (NHPA) model consider the connectivity and cooperatives, that can be used as a platform analysis of port which can be develop into a global or regional hub port and the sustainability of hub status for existing hub ports [37].

Models for port connectivity also derive from a global container liner shipping network perspective by determine transportation time and capacity. [3].

A comprehensive model was developed with an index that integrated port connectivity using Multi criteria decision (TOPSIS method) with variable that related to hinterland connectivity, inner bay connectivity and international connectivity [14]).

2.3. Maritime/ Shipping connectivity

The maritime container liner networks have some different characteristics compared with other transportation, such as: (1) Mostly, the routes of container liners are circular or usually it’s called pendulum route. The ships call is not running bi-directionally but visit a series of port and return to origin port, while bus and railway mostly running bi-directionally on routes. (2) The circular route makes the network is directed and asymmetric (3) Lines consisting into main lines and branch lines, mostly for main line involves a serial port calls a cross the ocean, are long haul lines [38].

The maritime network is also influenced by the commodity. Commodity diversity plays a vital role in maritime traffic distribution among ports, [39] applied global maritime flow in which ports and links are differentiated into the simple basis of five major commodity groups, coupling from single to multiple commodities with several measurements.

Mostly studies about liner/ shipping/ maritime connectivity using network analysis such as using graph theory [2, 4, 40-42] or gravity methods [43, 44]. Some studies also analyses using statistical
analysis to identify important node (port) based on different centrality measures [38] or to identify the impacts of liner shipping connectivity and port infrastructure on freight rates using the case study Caribbean freight rates [45].

Several attributes and variables to analyses shipping/ maritime connectivity used in the connectivity studies, namely frequency and vessel size [42, 43], maximum and minimum vessel capacity [40, 43], number of link between port [40], flow of containers [2, 5, 7], Flow commodities [39], Distance between port [2, 41].

The one best approach to analyze ports positions in the network including all carriers, services, and ports connected is using classical methods of network analysis. [4]. The main attribute from connectivity refers to quality and cost, so considering the cost to move cargo from origin port to destination port is one of the critical factors, but in recent studies cost variable relatively does not applied much to measure shipping/ maritime connectivity The shipping/ maritime connectivity is related to maritime transport cost and economic [46-48].

How good the maritime/ shipping connectivity also can be translated to how “good” the quality and the cost to move cargo from origin and destination, so to improve the connectivity can also be by reducing the cost. It is related to design and optimize the shipping network. Many studies have been done related to design shipping network and they have the objective to minimize cost and are involved with many variables such operating cost, sailing cost, transit cost, inventory, penalty, handling cost [49-53], speed [52, 54, 55], bunker cost [55, 56], time [56-58], transit time restriction [52], emission [51, 59], uncertain demand [26].

2.4. Port connectivity to hinterland

Hinterland is an inland area of a port where most of its business activities originate from that area. It is the catchment area of the port as the points of origin/destination of the cargo that movement through a particular port. The traditional concept of the hinterland is an area that has a continuous line boundary which covers the economic influence of the port in a land area [60].

Port hinterland is a geographical area where most of the area is served by ports where the ports have a substantial part of their business (most of the traffic flow is generated). Port's Hinterland is an area that can be reached at a lower cost and faster time compared to other ports [61-63].

The boundary of the hinterland area is difficult to determine because it depends on various things such as commodities (for i.e. bulk or containers), time (examples relating to season, technological change, port policy, economy, etc.) and modes of transportation, as well as the dynamic market. Port hinterland is not static but dynamic [64, 65].

The ability port to attract traffic is strongly influencing port hinterland because the origin and destination of the movement of goods is at landside [61].

Two main factors that affect to the shape of the hinterland are: 1) the effectiveness of infrastructure networks (such as toll roads and railways), it can determine the direction of hinterland development and (2) the location of the inland terminal (intermodal platform). The inland terminal plays an important role in expanding the port market area, the strategic location of the terminal is an attractive factor attractive gravitational factor), and reduces the "frictions" caused by distance [60].

The problem of seaports’ accessibility to the hinterland can be approached from infrastructural and market perspectives. From an infrastructural perspective to resulting in the seamless operating multimodal, the critical consideration is a good network of roads, railways, and rivers/canals, together with efficient interconnecting systems. From the market perspective, efficient and effective companies that provide hinterland transport services to deliver to customers. [66].

Reduce transit and transport time, and lower transport costs is essential for better port connectivity with inland container transport networks therefore ensuring product quality and decreasing risk product damage also important.

the gap of accessibility among regions can reduce by providing better connection by implementation of intermodal networks reduces the gap of accessibility among regions by providing better connections to container ports. The benefit of intermodals in terms of freight cost savings can be greater in remote
places to sea ports, given low enough shipping cost decay effects and proximity to intermodal infrastructures.[67].

The function of the port as a distribution strongly involves the storage of goods at hinterland transport. Therefore, hinterland transportation capacity should be necessary to correspond with the volume of loading and unloading cargo at its port. Therefore, it does not always consider because loading and unloading a vessel not always correspond to the moment of loading of the hinterland mode. It is essential to consider the capacity of hinterland transport because one of the competitive factors in the cost of the logistic chain is transport cost, so essential to ascertain the sufficient capacity of the hinterland of transport.

In terms of the relation of container network, mainly the research about containership routing and scheduling in liner shipping focuses on the ocean side, and there are a few studies on the inland transportation containers directed at the optimization of both maritime and inland transportation. The choice of load and discharge port and transit time considerations are some of example interaction between inland and maritime transportation [12].

It is evident to have a better result of integrated multimodal/intermodal transport optimization, which incorporated maritime and inland transportation with several variables such as network shipping and inland network. Transport cost such as shipping cost, inventory cost, transshipment cost [12, 27, 29], inland cost [27], uncertainty travel times [29], emission [27], repositioning container [26].

2.5. Connectivity at Port
Connectivity at port basically related to the port capacity and availability also multimodal facility, for example a container port terminal provides facilities to transfer container between sea vessels and land transportation modes, such as truck and rail. Port terminal has three areas. The sea-side area includes the quays, crane and other loading and unloading equipment to facilitate the loading and unloading of containers into and from ships. The land-side area is an interface between the land and sea transportation systems where are locate the truck and train receiving gates. This area is the place for rail cars to load and unload cargos. The yard area is the place for loading and unloading cargos to the truck and stacking loaded and empty containers.

Capacity port as a transhipment port becomes essential to determine, in line with increasing the function seaport as the hubs. Imported goods to supply to hinterland and cargo from hinterland are grouped and loaded into the ships that take place at the seaport [3].

The facilities of port also the important to analyses as variable such as number of cranes, storage area, berth and water depth, and inter-modal connections, number of port calls; distance between ports [35, 37, 46], port throughput [43]. However, the capacity and availability can translate it into the cost and time; the port with sufficient capacity and availability service has good performance. The impact is at a low cost and reasonable time because of the port services' effectiveness.

2.6. Generalized transport cost
One indicator to be developed as an indicator to measure connectivity is a transport cost. Transport cost consists at least three part i.e., shipping transport cost, port cost, and inland transport cost.

Total costs are ships costs, port costs, inland/feeder transport cost, inventory costs, and external costs is CO2 cost [27]. Component of ship cost are capital cost at sea, operating cost at sea, bunker cost at sea, capital cost in port, operating cost in port, bunker cost in port. Port cost has component port due and terminal handling charge. Inventory cost has component inventory cost at sea and inventory cost in port (during ship operation and dwell time), inventory cost during inland transport. Cost of inland transport in this paper consider using road capital cost, operating cost, overhead cost, infrastructural cost (e.g. toll fee).

Generalized transport costs are costs to move one unit for each commodity, calculated based on the cost structure for each mode of transportation and transshipment, including external costs such as the cost of CO2 emissions if they are incorporating in the transportation model.
As seen on figure 1, the components of generalized cost can vary depending on the costs incorporated into the transport modeling. Generalized cost consists of maritime transport components with ship size and maritime access (time and cost), port performance and costs at the port, and generalized hinterland costs.

![Figure 1. Illustration Generalized Transport Cost Component.](image)

3. Proposed Conceptual Framework

The conceptual framework is formulating the port connectivity that integrated the maritime, port and hinterland segment and the assessment of connectivity is using relative accessibility with generalized transport cost as a measurement variable. As seen on figure 2, There are three stages of the process. The first is definition of connectivity, in this part, it is proceeded to define the variables of measurement; the second process is an analysis that consists of the essential elements, which are an assessment of the connectivity and policy scenario to improve the port connectivity. The last part is the synthesis of the results.

![Figure 2. Proposed Conceptual Framework.](image)

3.1. Definition of Connectivity

The conceptual framework begins with definition of connectivity. Connectivity indicates the quality and costs of the network and the possibility to reach all nodes from all nodes.

As seen on figure 3, connectivity can be seen from a narrow perspective, which consists of an infrastructure network and service network. The broader perspective is more related to supply chain...
management and trade facilitation. This paper will see from the narrow perspective that the infrastructure network focuses on the port as a node that links sea and land transport. The service network consists of the shipping network and hinterland network, involving at least two modes or as a multimodal network. Port connectivity seen from a multimodal perspective means that the ocean side or seaside and the landside are involved in the multimodal network.

The narrow perspective can be seen from three aspects of connectivity: maritime/shipping connectivity representing the connectivity at the seaside. It gives a view of how good port connect with other port. Hinterland connectivity describes how "good" port connects with the hinterland, and connectivity at port represents port availability and capacity. It can also be one of the indicators of port performance.

Figure 3. Connectivity Framework.

*Source: author elaboration*

Network’s effectiveness or feasibility of the network could obtain from overall cost or unit cost when travel within it [30]. This paper trying to develop port connectivity model based on the generalized transport cost.
As seen on figure 1 and 4, every segment from the cargo movement, it translates into the generalized transport cost. Each connectivity aspect, like maritime connectivity, connectivity at the port, and hinterland connectivity measure in generalized transport costs, indicates that better connectivity has lesser generalized transport costs.

The use of generalized cost because the model is also trying to capture the non-monetized attribute and translate it into a monetized attribute. This model incorporates the time that spends to move from origin to destination and translate it into monetized through the value of time.

3.2. Connectivity analysis

The second step is the connectivity analysis. This step is building the model port connectivity. As the measurement already decided, which is generalized transport cost, the analysis that suitable is adapted from the accessibility analysis based on the generalized transport cost. Generalized transport costs derive from each segment of the transport chain movement that consists of the maritime, port, and hinterland segment. Each part has activities and translates it into the generalized cost. After defining the generalized cost, its use to assess the port connectivity by accessibility analysis.

Using equation (6), the port connectivity can assess from the value of relative accessibility. The port that has minimum value of relative accessibility is the most accessible port.

Government or port operator may have several scenarios of policy regarding the transport network including port, such as development of port, development of rail or road, increasing the ships frequency, increasing the number of ships. All the scenario has an impact to generalized transport. The change on the generalized transport will affect to the value of the accessibility which mean also have an impact to the port connectivity.

The mostly connectivity model using graph theory, and the model doesn’t integrate maritime and inland sides. A model that incorporated both maritime, port and inland side developed using Multi-criteria decision, with several variables and then assets using an index [14]. Using the same measurement, such as time and capacity, the model has conducted, but the analysis only at the maritime side or port to port connectivity [3]. A model that will build in this paper using generalized transport cost as a measurement of the node is port to port and port to the hinterland, and using the same measure is generalized transport cost. the used of exact size make it more comfortable to identify which part from
maritime or land part which has low connectivity then the scenario of policy will be more focus on the domain that needs more improvement.

The study area divides into the zone. Each zone is associated with a centroid and represents origin or destination. The origin or destination can be a zone or terminal transport (port) and connectivity modeled using a transport network. The suitable model adapts from [68] modeled the generalized cost that consists of generalized cost at maritime, port, and inland.

As connectivity measure using generalized cost, the simple measure is using accessibility that represented through impedance matrix. Impedance represent through generalized transport cost. Generalized transport cost that incorporated to the model adapted [68] from as follows:

\[ GC_{od,i} = GC_{oi}^m + GC_i + GC_{ij}^m + GC_i + GC_{id}^h \]  
(1)

\[ MS_{s} = MS_{d} = \sum MS_{s} \left( C_{si} + t_{si} \ast vot_{s} \right) \]  
(2)

where:
- \( MS \): market share for ship category \( s \) for each loading/unloading port \( i \)
- \( C_{si} \): cost shipping
- \( t_{si} \): shipping time for each shipping category
- \( vot_{s} \): value of time at shipping.

Generalized cost Port component adapted from [68]:

\[ PC_i = v_i + r_i + d_i \ast vot_{di} + z_i \ast vot_{Zi} \]  
(3)

\[ PG_i : \text{Generalized port and terminal cost} \]

\[ GC_i^m : \text{Penalty for congestion port} \]

\[ v : \text{port cost} \]

\[ r : \text{terminal cost} \]

\[ d : \text{handling time (days)} \]

\[ vot(d) : \text{value of time for handling (days)} \]

\[ vot(z) : \text{value of time for storage (days)} \]

Generalized cost hinterland component consist from origin/destination with road or rail from loading/unloading to hinterland.

\[ GC_{id}^h = \sum MS_{dmi} \left( C_{dmi} + \left( t_{dmi} \ast vot_t \right) \right) \]  
(5)

MS mode share for each mode (rail, road) to hinterland \( d \), \( C \) is cost for each mode \( m \), \( t \) is inland travel time and \( vot_t \) is value of time at inland.

the model use accessibility matrix, the relative accessibility for transport terminal/ port \( a_{od,i} \) consists from origin \( o \) and destination \( d \) via port \( i \), transportation cost from \( o \) to \( i \), \( C_{oi}^m \), \( m \) is maritime link, using mode \( m \) and transport terminal cost \( p_i \), and transport cost from \( i \) to hinterland \( d \), \( h \) is maritime link, using mode \( h \) the function as follow adapted from [69]:

\[ a_{od,i} = \beta_1 C_{oi}^h + \beta_2 P_i + \beta_3 C_{ij}^m \]  
(6)

From the equation, the accessibility of the transport terminal/port \( i \), from origin \( o \) to port \( i \), and also same for the reverse, from port \( i \) to zone \( o \) has resulted. In standard application of accessibility measurement, the smallest distance, cost, time will imply the higher accessibility and it means also has a good connectivity.

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3.3. Synthesis of the Results
The last stage is to synthetise of the results, this part is trying to formulate the scenario of policy that has most impact to the port connectivity. The assessment on connectivity will find the scenario of policy that has the highest impact to the port connectivity. Further the connectivity model will result in the robust scenarios of policy related to the improvement of port connectivity.

4. CONCLUSION AND FUTURE WORK
Connectivity is one indicator that the network has a good connection; in terms of transport, it means that the network can facilitate freight or passenger movement effectively and efficiently. In terms of port connectivity, the Port should be having a good connection between other ports and the hinterland. The port is also functioned as an interchange between mode, maritime mode, and rail or road mode, and it is essential to capture the connectivity from the multimodal perspective.

This paper offered the conceptual framework to formulate port connectivity using generalized transport cost as a variable and measures using relative accessibility. The generalized cost is built with considering the whole cargo movement segment, starting from the hinterland, maritime segment, and port itself. This paper will give contribution significantly to the connectivity model using the accessibility measurement.

Future work will discuss and elaborate further on the measurement of generalized cost. The question that may arise is about the detailing of the generalized transport cost variable because there are so many variables that might be involved in it; besides, the conceptual framework's applicability to the real case should be challenging.

Further, the conceptual framework will be applied to assess the connectivity of port in Indonesia. As an archipelagic country, using more than two-mode is inevitable, the port will be an interchange between maritime transport and land transport. Port connectivity be an essential variable to consider in the scenario of policy.

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