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Impact assessment of trimodal hinterland transportation on regional development around inland terminals.

by

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Acknowledgments

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Abstract

The logistics industry is one of the core foundations for the economic growth of a country. Proper utilization of the transportation modes within the logistic chain can make a significant difference for a region. The hinterland nodes within the European region are still in the process of improvement. The continuous expansion in global trade ensues an increase in transporting goods around the world. The Dutch hinterland connections has an amicable infrastructure which facilitates the seaports to reach within and beyond their border. Hinterland transportations connects the major seaports to the inland terminals in different region. Not all the inland terminals in the Netherlands are facilitated with all three modes of hinterland transport namely road, rail and inland waterways. However, the significance of the hinterland connectivity cannot be ignored in the process of regional development. Therefore, the Shipping companies, terminal owners and the logistic service providers are working together to improve the hinterland connection system by utilizing all three modes of inland transportation. Based on our qulitative and quantitative data analysis, we have come to a better understanding of the development phase of certain regions with inland terminal activities. After conducting three successful regression analysis in this paper, we have proven that the utilization of the three hinterland transportation modes can accelarate the regional development around inland terminals. Our answer contributes to the perception of the regional development process around inland terminals and shows the importance of the infrastructural improvement of hinterland transportation. However, further research should be conducted in this matter to find out all related subsytems that influences the development process of a region and how it involves trimodality.

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List of Abbreviations

EU: European Union

POR: Port of Rotterdam

GVA: Gross Value Added

FEM: Fixed Effect Model

REM: Random Effect Model

CEM: Common Effect Model

GDP: Gross Domestic Product

IWT: Inland Waterways Transport

Whouse: Warehouse

LSCI: Liner Shipping Connectivity Index.

UNCTAD: United Nations Conference on Trade and Development

UNECE: United Nations Economic Commission for Europe

OECD: Organization for Economic Co-operation and Development

1. Introduction

1.1 General Context

Advances in hinterland transportation system among ports and communication technology have taken the mobility of goods and services to an unprecedented developing stage. Therefore, the major seaports are transhipping their goods and services among the inland ports and terminals to balance the operational capacity.

In present days, all the regional economies of a country are integrating and considering as one national economy. However, the progress of the development per region is not equal in most cases. Sea ports are the gateway of a country's trade and has a major contribution to the economy. The trade flow can only be maintained or increased when a port adheres its service integrity.

There are barriers to maintain certain services which can either be occur as a delay or over capacity. To resolve all relevant dilemmas, a major seaport tranships or distributes its goods to different inland terminals. And strong hinterland connections play the most pivotal role in this process. To achieve a sustainable growth momentum, a seaport should use all the available modes as its hinterland transportation to the inland terminals. Once the maximum capacity of an inland terminal is utilized, it can be an important gateway for domestic and international trade and will be able to exert positive influences on economic growth from both regional and national aspect.

This inland distribution has become a major feature of maritime freight distribution paradigm. If we consider the cost of transporting goods especially the containerized goods, the efficiency improvements are mostly obtained from inland distribution (Jensen & Bergqvist, 2013). Thus, the key distributors and terminal operators are inclining to the inland distribution process.

A port or terminal is considered as the fuel to the development of that particular region where it is located (Jung, 2011). The Inland port cluster also adds value to the domestic production effects and creates direct and indirect employment opportunity for the people in that region. Nijkamp, Stimson and Stough (2011) developed a basic structure containing five elements which triggers regional development.

a. *'The availability of productive capital*': the output of production always determined by the two factors which are labour and capital (Nijkamp, et al., 2011).
b. *'The presence of human capital*': it indicates the quality of labour input that enhances the productivity (Nijkamp, et al., 2011). It can be achieved by offering education and training or introducing new skills such as ICT to the labour unit.

c. *‘The access to social capital*’: this includes the socioeconomic interaction and communication between people of a region which helps them develop certain relations and networks among them based on trust (Nijkamp, et al., 2011).
d. *‘The usage of creative capital*’: Innovation, entrepreneurship, new challenges and opportunities considered as creative capital (Nijkamp, et al., 2011).
e. *‘The existence of ecological capital*’: The ecological balance in a region can be determined by its sustainable approach towards the production and utilization of assets (Nijkamp, et al., 2011). Sustainable potential of a region ensures the favourable quality of life for the people of that region.

   These five elements to determine a sustainable regional development are called pentagon factors (Nijkamp, et al., 2011).

Figure 1.Basic elements that triggers regional development

Source: Author, modified from (Nijkamp, et al., 2011).

In this paper, the focus is only given on the development and expansion related to the freight transportation and its impact on the region. Therefore, the analysis has been carried out by taking the number of hinterland transportation modes used in each region per year, increase of warehousing space in each region per year, the Gross Domestic

Product in each region per year and Volume developments of the Gross Value Added per region every year into consideration. The data availability on the regional basis for aforementioned elements are also another reason to choose this particular sets of factors to conduct the research. The region-specific data for employment and the Throughput data for the inland terminals are not widely available which lead to a qualitative explanation for these factors in this research.

The advancement on usage of different modes for transporting goods to and from the inland terminals are a dominant factor towards the regional development. In this paper, the relation between the hinterland transportation system and the regional development will be determined by assessing the impact of utilizing three modes of transportation to carry the cargo towards inland terminals from major seaports for the convenience of the distribution and mitigating the congestion. Whether interdependency among hinterland transportation system, inland terminal performance and regional development are reinforced or not will be determined by the end of this research.

1.2 Objectives

The logistics industry is one of the core foundations for the economic growth of a country. Logistics requires the knowledge and expertise to make an efficient planning and execute. This also involves the information streams to give an idea about the flow of goods. The global trade is expanding day by day, which results an increase in transportation of goods around the world. The Dutch hinterland connections play a vital role in development of other sectors as well by transporting raw materials as well as by transporting finished products. The strategically suitable location gives the Netherlands access to the European market. The Dutch economy strongly influenced by the logistics sector as it inputs 55 billion euros/year to the Dutch economy and employs total 813,000 employees (Netherlands Enterprise Agency, 2016) (Netherlands Enterprise Agency, 2016). The quality of the Dutch infrastructure of hinterland connections are best among the world. The facilities for waterways ranked 1^{st}, rail ranked 7^{th} and road ranked as 2^{nd} in the whole world as per World Economic Forum in 2015 (Netherlands Enterprise Agency, 2016). The total container throughput for port of rotterdam in 2015 was 12.2 million TEU which confirms a substantial amount of input to the Dutch economy (Port Of Rotterdam Authority, 2016). Increasing volumes of container transports sets higher demand for capacity requirements and the performance of hinterland transport (Behdani, et al., 2016). Therefore, the Shipping companies, terminal owners and the logistic service providers are working together to improve the hinterland connection system by utilizing all three modes of inland transportation namely rail, road and inland waterways. The trimodal transportation system is an advanced transportation concept which increases the efficiency of transport and minimize the transport cost. It is a new promising possibility to improve the performance of freight system. A trimodal hinterland connection system can also be counted as synchromodal transportation system when it is organised in a scheduled and digitized manner with the involvement of Information and Communication Technology and which strengthen the hinterland connection system and causes a positive effect to the inland terminals and their region as well as the seaports (van der Burgh, 2012).

In most of the research, the scientific attention was drawn towards the hinterland connections of deep-sea container terminals to and from inland terminals with a combination of logistics operation (Monios & Wilmsmeier, 2012). This hinterland transportation system is connecting the inland terminal to the sea ports and using it as a distribution terminal for containers. These inland terminals even offer the maintenance and repairing service or storage for the empty containers which is also smoothening the load from the major seaport hinterlands. And thus, the delivery of the cargo to the destination is getting easier and cheaper.

The objective of this research is to find out if proper utilization of hinterland transportation system is the key factor for the inland terminal performance which also triggers the regional development around that area. This thesis will analyse the impact of the trimodal hinterland transportation on the improvement of inland port performance. It will also analyse the contribution of the hinterland connection to the regional development by assessing the volumes traded to and from the inland terminals by using all available modes, the number of new business opportunity has been created around the areas, the increase in sales of land within the areas or development of warehousing and the number of employment opportunity it has created.

1.3 Problem Identification

It becomes clear from section 1.1 and 1.2 that the hinterland transportation system influences the cargo flow towards inland terminals. Utilizing all modes of transportation to deliver or tranship the cargo to inland terminal plays a pivotal role to maintain economies of scale for the operators. Major companies are focusing on port regionalisation due to the cost reduction, maintain their delivery time and balance the overcapacity on seaport terminals. Opening of Maasvlakte II even increases the congestion in Port of Rotterdam. The number of stops of carriers to the terminals increases when the number of container terminal increases which creates more congestion (Staalduinen, 2014). The improvement of Port of Rotterdam hinterland connections also taking place to save the operation time (Staalduinen, 2014). The deep-sea terminal operators and the carriers started to consider full utilization of hinterland transportation system. Therefore, the key players are gaining more control over the hinterland transportation system through vertical integration (de Langen, et al., 2013).

Some deep-sea terminal operators have been started expanding their activities towards hinterland such as ECT who developed its own European Gateway Services network (i.e. TCT Venlo). Here the question appears that if the expansion of the deep-sea terminal activity towards hinterland also influences inland terminal performance or logistics performance.

Most of the researchers shows different views about the link between the hinterland transportation activities enhancing port performance and the local economic growth or regional development but the common idea is that the ports are the generator of economic development of that region (Jung, 2011). An efficient port allows more cargo throughputs while inefficiency of a port can set its region away from the valuable sources such as markets and cheaper inputs (Haddad, et al., 2006). There are cases in many countries such as China where the regional development phase started based on the it's port centred activity especially places like Pearl River Delta region where the development was closely linked with the container port development in that region (Zhang, et al., 2005). So, the question comes if regional development can positively be linked with the inland terminal activities in countries like the Netherlands.

1.3.1 Research question

This thesis investigates to what extent the hinterland connection to and from Port of Rotterdam influences the regional development of Venlo, Hengelo and Tilburg. Thus, the main research question that this study aims to answer is the following:

"What is the impact of hinterland transportation on regional development around inland terminals in the Netherlands?"

1.3.2 Sub-research questions

The below mentioned sub-research questions will help to obtain the answer for the main research question:

1. What is Hinterland Transportation system?
2. What is the current trend of Hinterland connectivity throughout the Netherlands?
3. What are the aspects of regional development from the Netherlands perspective?
4. Who are the major players and what is their role on the development of hinterland connectivity and how does it affect the trade?

5. How does the hinterland transportation system connect Port of Rotterdam to the inland terminals?
6. How does proper utilization of hinterland transportation system influences the regional development in the Netherlands?

1.4 Structure of the paper

In this paper, the research question is answered by using both quantitative and qualitative methods.

The quantitative part is covered by regression analysis. This regression analysis has been used to hypothesize if the proper utilization of hinterland transportation results into the improvement and expansion of the warehousing in that region. In this research, we have also tried to draw a linear relationship between the trimodal hinterland transport and the development of all three-selected region namely Venlo, Tilburg and Hengelo. The development of a region has been measured by the logistic related activity such as expansion in warehousing per square meters, improvement in regional GDP, the Gross Value Added to each region due to all the economic activities related to logistics. The qualitative analysis has been conducted for the cargo throughput and the employment opportunities to highlight their importance on regional development. A formulation of throughput calculation has been discussed and the throughput of Port of Rotterdam over the years has been collected for the analysis. The below mentioned steps in this section are necessary to answer the research and sub research questions to complete the research

Step1: In chapter 2, a qualitative Literature Analysis on the Hinterland Transportation system and the current trend of hinterland connectivity throughout the Netherlands has been discussed. The aspects of regional development from the Netherlands perspective, the major players and their role in the development in the hinterland connectivity and its effect on trade also has been clarified in this chapter. All the relevant published articles about the port and inland terminals and reports has been used in this step to excerpt necessary information. Furthermore, the measurement and the determinants of port performance and its impact on regional development has been vastly discussed in this chapter.

Step2: In chapter 3, a quantitative Analysis has taken place where it includes all the data collection, throughput data for the Port of Rotterdam, and the Hypotheses. There are several data inputs necessary in this regression analysis. The number of available modes to transport the cargoes from the main ports into the inland terminals, the information regarding the space occupied in warehousing per region, the percentage change of GDP in each region per year and the percentage change of Gross Value Added to each region per year has been collected from different consultancies, terminal reports, national statistics databases and prepared for the regression analysis in this chapter. The available data has been run through STATA14 and Excel to conduct the regression and carry out the t/F test to prove the hypotheses.

Step 3: Chapter 3 section 3.4 covers the part methodology where all the scenarios has run to find out the impacts of hinterland transport activity on regional development.
The impact of the using all three transport modes on increased logistics related terminal activity such as the expansion of warehousing around the region has been taken into consideration in this step. A regression analysis has been carried out to draw a linear relationship between these two variables. Same process has been followed to carry out the regression analysis between modes and GDP per region. Another regression analysis has been carried out to find a linearity between modes and Gros Value Added to the region. The number of transportation modes are considered as the independent variable for all three hypotheses and the dependent variables are Warehousing, GDP and Gross Value Added. After running the regression analysis, a scatter diagram has been drawn to determine whether a linear model appears to be appropriate or not to identify possible outliers. Once all three regression equations are determined, the coefficient and the p value has been used to figure out whether there is a linear relationship between the hinterland transport modes used to and from inland terminals and the regional development.

Step 4: In chapter 4 and 5, the outcomes of the research, the decision and the limitations have been discussed. The information derived from Chapter 3,4 and 5 has been concluded in chapter 6 to complete the research.

2. Literature Review

Hinterland transport for ports has been a focus for many years and a lot research has been conducted to find out the best hinterland connection system. The usage of all the available modes as a combination for hinterland transportation system has been proven the best choice by many research.

Zheng and Pel (2015) identified the benefits of synchromodal freight transport system in Dutch logistic sector by finding out the reduction in delivery times and utilizing the capacity of each mode. Their research has also shown that the effects of synchromodal freight transport is also economic, environmental and societal performance indicator (Zhang & Pel, 2016).

Also, UNECE (2010) try to determine the performance of seaports and their hinterland connections to identify good practice in achieving efficient and sustainable hinterland goods movements in their research paper which was prepared by Allan Woodburn (Woodburn, 2010).

A research paper from Delft University of Technology was published focusing on developing technology to improve hinterland connectivity so that the current congestion problems in ports will be smoothen by shifting some load to the inland locations accompanied by a movement of operations such as stripping and stuffing, warehousing (Visser, et al., 2007). He also has shown the modal split in percentage in his research.

In a recent research, Wiegmans, Witte and Spit has carried out a statistical analysis to find out how the performance of an inland port explain their changes in size and growth (Wiegmans, et al., 2015). The idea of using the regression model in the thesis to find out the impact of hinterland connectivity on regional development was influenced by their research. It gives a very good overview on the inland port and regional development. However, Wiegmans, Witte and Spit (2015) also highlighted that due to the data unavailability, the research did not draw a significant relationship between the inland port activities and the number of jobs and therefore, they have suggested to conduct further research on this matter. Monios and Wilmsmeier (2012) has conducted a qualitative analysis to support the port regionalisation as well but their focus was not limited to one country and not very specific (Monios & Wilmsmeier, 2012).

Albert Veenstra and Rob Zuidwijk (2010) mentioned in their paper that the development of hinterland connections will have a positive impact on logistics platforms and will create new jobs in logistics hotspot (Veenstra & Zuidwijk, 2010).

The port of Rotterdam authority as well set a vision to improve their business operating in the port and to develop the connection with the inland terminals throughout the country to create more jobs to attract skilled people. Also, they set a vision to contribute to the regional development as because a dynamic port requires a dynamic region (Port of Rotterdam Authority, 2016).

2.1. Measuring port performance

Port efficiency and performance vastly contributes to a country's economy as the world economy is driven by the maritime sector (Meersman , et al., 2008). Ports are the gateways of world maritime trade and it is accounted that 80% of the total merchandise trade volume were seaborne trade and in terms of value, maritime trade covers two third of the total merchandise trade (UNCTAD, 2016).

A port is generally a location on shore which is used to receive and transfer goods to and from various places by using all available logistics options, for example, ships as a seaborne transportation and rail, inland waterways or road as inland transportation. Ports work as a node between the maritime and hinterland transportation to complete the logistic chain. Logistics system is the identifier of global trade. The growth of a countries economy depends on its import and export which firmly determined by its efficiency in logistic sector as because an efficient logistic system can tie the knot between international and domestic markets (The World Bank, 2016). The president of the International Federation of Freight Forwarders Association Mr. Huxiang Zhao says, "No trade can be done without logistics and inefficient logistics will result poor trade" (The World Bank, 2016). To improve the performance in the recent days, ports are relying more on inland transportation (Alamoush, 2016). An improvement in port performance can be achieved if the port starts to reduce port congestion, decrease cargo dwell time and enhance productivity and competitiveness by an efficient coordination and utilization of hinterland transportation (Alamoush, 2016).

Hinterland is defined as the inland area that is used to distribute imported cargo and collect exported cargo (Woodburn, 2010). To have a good inland transport network, most of the ports have a designated hinterland facility. For instance, the land based activity of a port depends on the access of the transportation towards the port, the type of the transportation, the size of the terminal and the way it operates. The hinterland connectivity often includes all modes of transportation such as railway, Inland waterways and trucks. For instance, Large ports like Port of Rotterdam has its clearly defined hinterland facility with a proper access for all three modes of transportation such as railway, trucks and inland waterways. A proper infrastructure of hinterland can maximize the connectivity of a port towards different geographical regions within or outside the country. The congestion problem is one of the main issue that most of the sea ports are facing now a day. It basically causes due to the irregular transport flow to and from hinterland which negatively influences the port performance. The container terminals are relatively concern about the ship sizes as the carrier companies are continuing to order bigger sizes of vessel to minimize cost. These large carriers can impose congestion and over capacity problems to the terminals which can be avoided by a rational plan for the utilization of hinterland transportation system.

Containerization of the cargo is one of the core motive to improve hinterland connectivity. In the review of maritime transport 2016 by UNCTAD, three policies were discussed to improve a regions Liner Shipping Connectivity Index (LSCI). Two among those three policies were concerning port hinterland activity. In the first policy, the suggestion was made to widen the range of port hinterland to facilitate the trade and transit. However, the expansion of hinterland is often difficult due to the higher inland transportation cost and the disorganized border-crossing process. A suggestion was made to make the markets more competitive in the second policy. A competitive market will open options for the shippers where they will be able to choose terminals, shipping and trucking companies. Because any restrictions on transportation like cargo reservation regimes in road haulage system or cabotage restriction in shipping ensues lower maritime connectivity (UNCTAD, 2016).

In this research, the port performance has been measured based on the performance of ports hinterland activity. To focus on that, several papers and models related to hinterland activity influencing port performance has been reviewed. The three modes of transportation within hinterland connectivity are

Road Transport:

Road transport such as trucks are the primary mode of transportation that has been used to carry goods from one place to other because of its ease of accessibility. Even though most of the larger ports rely on all 3 modes of transportation for their hinterland connectivity, however the road transportation remains the main priority because the flexibility of the trucking schedule and the accessibility for the trucks to carry goods to any places where there is a road, keeps it on the top of the chart (Veenstra, et al., 2012).

Trucking system also allows the logistic service provider to delivery door-to-door basis. Nevertheless, concentrating only on road transportation also occurs the traffic congestions around the region, extensive carbon emissions which creates environmental issues, extra pressure on port infrastructure due to excessive trucking movement and safety issues due the undiligent trucking activity (Alamoush, 2016).

The price determination for trucking also stays as one of the major concern. Toll system has been introduced in many European countries which is basically a payment that has to be paid by the truck drivers for a certain period of time or distance on the road. The road transport infrastructures in countries like the Netherlands, Germany and Belgium are mostly developed and operated by either commercial or semi-commercial operators who also introduced some charges for the road transportation such as the toll for passing the Westerchelde tunnel in Zeeland which connects the two Dutch port region namely Flushing and Terneuzen or Liefkenshoek tunnel in Antwerp which connects the both side of the port of Antwerp (Merk & Notteboom, 2015). Most of the Road transport specialist expects that the kilometre charges for road transport within all over Europe will be fully operational by 2030 (Merk & Notteboom, 2015). Not only these charges are taken to recover the infrastructural cost but also it is taken to balance the environmental and congestion issues. The congestion pricing is based on the principal to assuage the congestion of road transport around the port hinterland area. It is usually carried out by issuing surcharges on transport vehicles during peak traffic hours within certain congested areas. The implementation of congestion surcharge also influences the movement of traffic and direct it to off-peak hours or to a different non-congested route. Congestion surcharges perhaps appears an extra cost for the vehicles however, in the broader sense it saves the operational cost for the transport by reducing waiting time and fuel consumption.

Moreover, the terminals are very much concern about the trucking delay at the gate since it is accounted as a subsystem of terminal and its efficiency determines terminal productivity as well (Zhao & Goodchild, 2010).Many researchers have investigated in the fact to improve the performance of gate operations in relation to trucking to facilitate the elimination of congestion and environmental externalities (Acciaro & McKinnon, 2013). This gate operation can be improved by the coordination of the terminal operators and shippers or the freight forwarders and the port authorities and also by using ‘first come first serve’ system, window system or the appointment system (Chen, et al., 2013). ‘First come first serve’ system is the most commonly used system among terminals however it often creates rush during operational hours which results long queue.

Most of the major seaports are trying to involve modal shifts in their distribution process and hinterland connectivity but it is not possible for all the connecting terminals due to the unavailability of all three modes of transport such as rails, roads and inland waterways because of their geographical position (de Langen, et al., 2012). The congestion creates by road haulage can be mitigated by using various strategy such as ‘Port gate strategy, dedicated freight routes, Potential automated hinterland transport technology’ (Alamoush, 2016).

The port gate strategy was well explained by Acciaro & McKinnon in their discussion paper where they mentioned how it can reduce the traffic congestion and the idle trucks in ports by using window system, appointment system. Merk and Notteboom have also included the before mentioned system to avoid the trucking congestion however they have also included a strategy where the trucks operated within off-peak hours will be provided with an incentive or an exemption to the fee that is charged during the peak hours (Merk & Notteboom, 2015). Another interested concept which has been discussed by many researchers like Acciaro & Mckinnon (2013) and commonly used by major seaports now a day is the extended gate strategy (Acciaro & McKinnon, 2013). It is a strategy where the major ports relocate a part of it close to hinterland where they carry out all the formal procedures (Alamoush, 2016). European Container Terminal (ECT) has already introduced the extended gateway concept in the Netherlands. Trimodal Container Terminal (TCT) Venlo is one of the extended gate within ECT network (Hutchison Ports, 2017).

The dedicated freight route system has been introduced in many locations where a corridor is dedicated only to facilitate an uninterrupted road haulage. It Helps to mitigate the traffic congestion in areas close to the ports.

The automated hinterland transportation system for road is still a subject to research. Many researchers have been working on it and came up with solutions but it requires a large capital investment and infrastructural development before the terminals agree to make the system operational.

Railway transport:

The hinterland traffic is mostly dominated by trucks thus the ports have been shifting towards different modes of transportation to reduce congestion and save operational time. Rail is of the commonly used mode in European ports and specifically within the Le Havre range. Several types of goods such as containerized goods, dry or liquid bulks, general cargo can be carried by the railway transport to and from Port hinterlands. External cost also has become a major concern for the terminal operators and the freight forwarders since most of the external cost are caused by the trucks (Merk & Notteboom, 2015). Therefore, many ports are trying to change their main hinterland transportation modes from road haulage towards railway. However, it is not as easy to completely depend on railway transportation, since a good railway infrastructure is not available in all the port areas. Thus, the modal split for most of the port hinterlands stays unchanged.

The railway system in Europe has been developed remarkably and the railway network within the Hamburg - Le Havre range turns out as one of the most efficient, fast, reliable and sustainable railway network in the world. There have been some notable changes are taking places in European railway system which is called rail liberalization. The railway infrastructure managers will become the responsible authority for any kind of infrastructural development or organizational change under the rail liberalization process. The idea behind rail liberalization is to reinforce the collaboration between the member states and the infrastructure authority which upshots a better corridor management. However, there are still some technical issues that needs to be solved such as differences in railway signalling system, gauging system and electric network system among pan-European countries. Several steps have been taken to solve these technical issues to widen the railway network within European countries. All the technical hindrances within pan-European railway network are expected to be solved by 2030 (Merk & Notteboom, 2015).

Nonetheless, the rail transportation market in Europe is still monopolistic. To overcome this matter, reformation of nationwide and Europe-wide railway network is still an ongoing process. Owing to the fact of environmental issues caused by road haulage system, the number of container shuttle services have been increased in past few years (Acciaro & McKinnon, 2013). Several improvements in the railway track has been observed in recent years within the Netherlands to Germany rail network. For example, The Betuwe Route is a dedicated freight transport corridor which is laid between Port of Rotterdam and Germany. This 160-km rail line also covers the Maasvlakte area in Port of Rotterdam. As per Port of Rotterdam authority, the Betuwe Route is expected to be extended in coming years. The expansion is called the 'Third track' which will enable a direction towards Oberhausen to provide a better connection for the route. This development in railway infrastructure will provide separate tracks for passenger and freight trains which ensue a rise in the number of cargo train movement.

Currently the Betuwe Route has been used by 70% of all freight trains between Germany and the Netherlands (Port Of Rotterdam, 2016). The Zevenaar-Emmerich border crossing capacity at present is 110 cargo trains per day and after the completion of 'Third track' in 2023, It is expected to increase to 160 trains per day and in 2030, it will increase to 192 cargo trains per day (Port Of Rotterdam, 2016).

However, there are still some coordination problem exists in the railway transportation system in Europe such as congestion problem due to unused capacity, delays due to inadequate planning and peak-load problem (van der Horst & de Langen, 2008). De Langen and Van der Horst also suggested four key ways to improve the coordination problems:

- "Introducing incentives": It can be carried out by developing a reward system, or tariff discriminations or by auctioning the unused capacity,
- "Forming alliances": Formation of inter-firm coalitions can be made through all types of vertical cooperation within the transport chain,
- "Change in organizational scope": Using risk sharing tools or incorporation among the actors can be a way to change the organizational scope,
- "Collective action": This can be carried out through intervening either by government or private organization (van der Horst & de Langen, 2008).

Acciaro and McKinnon (2013) discussed about how can a ports container rail transportation adds value for the investors and the users. They discussed about differentiating three completely diverse issues that are also interrelated such as how a user of container rail transport can be benefitted, how can quality of service and the price determination influences the efficiency and the reliability of the railway system, and how the development of rail network and funding for it positively influences the operation (Acciaro & McKinnon, 2013). For the users, it will only be valuable when they can get some benefit from using this mode. The environmental issue has become one of the major concern for the shippers now a day and thus, the use of rail transportation can help them to operate sustainably. The quality of the rail service and the pricing policy generally determines the attractiveness of the mode. An effective rail transport service should be able to offer an access to all the terminals and shifting yards at the port, communication among all parts of network and the efficiency of it. Infrastructural improvement also attracts the users to rely more on rail transportation. However, in most cases the infrastructural cost is not fully recovered by the freight pricing policy. The cost associated with the infrastructural development likely to have an influence on the railway operation. Unlike the road transportation system, the cooperation between public and private sector is not very successful in railway infrastructural development issues. The freight railway infrastructure development in Europe generally requires a certain amount of public funding due to its longer infrastructure recovery time which does not attracts the private investors and in case if it is financed by the private sector, the development likely to be under-provision due to maintain the economies of scale associated with the process (Monios & Lambert, 2013).

Inland waterway transport:

Inland waterway transport generally indicates the barge transportation to carry goods between ports and harbours. This transportation system is one of the least used mode within the logistic chain even though it is the best option to maintain economies of scale and to resolve the environmental issues created by trucks and to mitigate the congestion in the terminals. In the European countries, the usage of inland waterways has been increased. More than hundreds of regions and the industrial areas within Europe are connected by inland waterways which covers approximately over 37,000 kilometres and 21 EU member countries have inland waterways and 13 among them have a waterway network which is interconnected (European Commission, 2017). Compare to road transportation, the inland barges consume only 17% energy per km/ton and 50% energy compare to the rail transportation, while it also ensures safer transportation for any kind of dangerous goods (European Commission, 2017).

The European policy makers are more concern on the implications of inland waterways within the European intermodal transport chain due to its sustainability and the less congestive operational approach (European Commission, 2011). Therefore, most of the major Western-European seaports are now prioritizing the role of the inland waterways in their hinterland transportation chain however, the freight transport statistics doesn't reflect much improvements (Caris, et al., 2014).

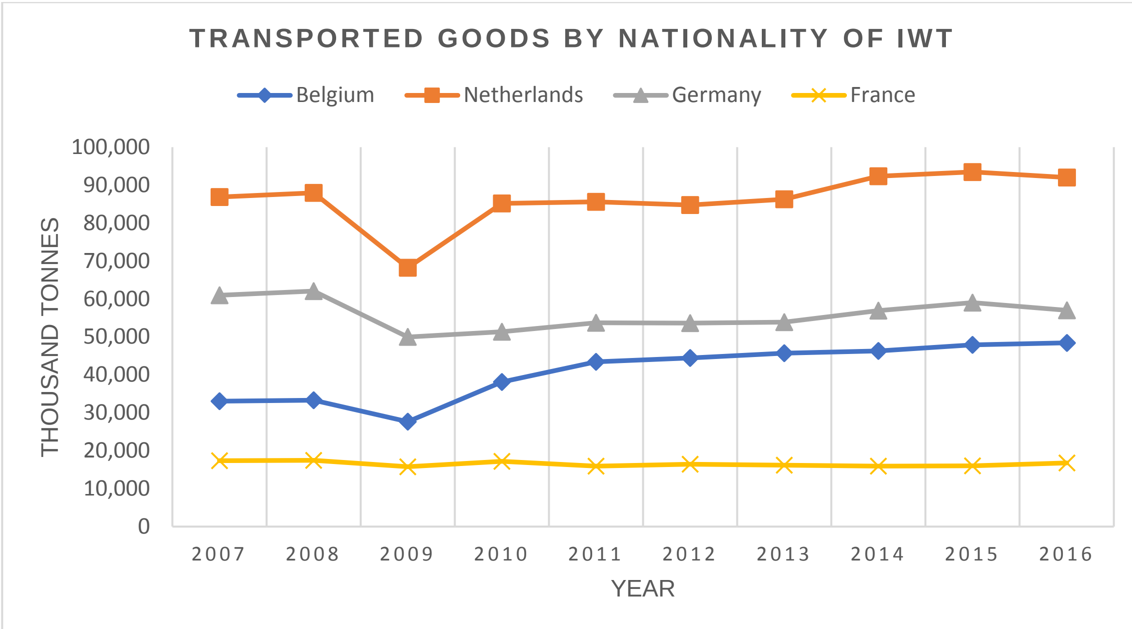

Figure 2: Transported goods by inland waterways

Source: Author, data collected from (Eurostat, 2017)

Caris, Limbourg, Macharis, Van Lier and Cools (2014) has come up with some research proposal to integrate the inland waterways in the hinterland transport chain such as developing affiliation between the logistics activity and the transport topography, operational efficiency of the inland waterways to overcome the time and congestion. Their research helped to establish the strategical formation of inland waterways to assist on the process of spatial developments (Caris, et al., 2014).

The inland waterway transports in Europe are mostly designed under certain standards which helps them achieve sustainability as well as economies of scale however, some of the new innovative approaches to make the inland vessels more sustainable are not very convincing and attractive to the inland vessel owners due to its higher costs (Hekkenberg & Liu, 2017). Still there are many technological advancement such as bio inspired propulsion, new hull design, reduction in fuel consumption are taking place to reduce the operational cost of inland vessels (Hekkenberg & Liu, 2017).

The European inland waterway transportation development programme 'NAIADES II' are actively working to promote and set up a guideline for the inland waterway transportation by explaining the importance of all party's involvement and the tactics to governance the policy actions towards this sector (European Comission, 2013). The major intervention extents discussed in this programme are "quality infrastructure", "quality through innovation", "smooth functioning of the market", "environmental quality through low emission”, “skilled workforce and quality jobs”, “the integration of inland waterways into the multimodal logistic chains” (Maraš, 2017).

An acceptable margin of inland waterway utilizations cannot be achieved by only maintaining a high quality of infrastructure, it also requires a higher demand for inland waterway transports and a modal shift within the hinterland transportation chain (Maraš, 2017). Inland waterways transport can be a cost reductive optimal solution for the existing issues within the supply chain network which may attract the shippers towards this mode of transportation (Caris, et al., 2014).

Due to the lower freight rate and reliability, many container shippers have continued to use inland barges as the mode of their transportation (van der Horst & de Langen, 2008). The rail freight transport has become a competitor for the inland waterways however, the inland barges are still able to keep their market shares stable in the transportation market (Wiegmans, et al., 2015). The inland waterway plays a key role in the hinterland transportation system within Europe and continues to grow.

Impact of hinterland transportation on port performance

Many researchers have been indicated the problem that most of the ports are facing nowadays related to their hinterland connectivity. The proper access to the port hinterland and the utilization of all the modes of transportation can trigger the performance of a port by removing extra congestion on the road, over capacity issues in the stacking yards or the delay times for ships due to the capacity handling problem. Therefore, the actors in the logistics and supply chain are actively trying to resolve the issues related to the port hinterland facilities and trying to focus on the whole chain instead of just focusing on one specific leg. If the hinterland transportation system of a port is not efficient enough or sustain a higher cost, there is a possibility that the port will suffer a significant traffic loss (Woodburn, 2010).

On the other hand, a poor and inefficient hinterland connectivity can cost a port its demand towards the carrier companies and the shippers. The carriers and the shippers usually choose their port of call based on the terminals cargo handling capacity, their ability to maintain flexibility, reliable modes of hinterland transportation, the turnaround time of a ship in that terminal and unable to provide any of these facilities according to the shippers or carriers requirement might negatively influence a terminals competitiveness in the market (Alamoush, 2016). Inefficiency in the hinterland connectivity also causes a higher inventory cost and an adverse effect on the entire chain. Only an efficiently organized hinterland transportation system of a port can allow and manage higher volumes of container flow in that port (van der Horst & de Langen, 2008). And a raise in the throughput indicates an improvement in port performance. Similarly, the competitiveness of a seaport or terminal rest on its ability to handle the cargo and in which extent it reaches to its hinterland destination (Acciaro & McKinnon, 2013). The trade can be expanded by amplifying the hinterland transport modes and providing a better-quality transportation service (Merk & Notteboom, 2015).

It has been objectified from all the relevant researches that the port competitiveness, higher trade volume of a port and port traffic congestion are clearly related to its hinterland connectivity and has an impact on port performance however, the bottlenecks in the hinterland connectivity yet to be solved. The deficiency of hinterland connectivity also ensues higher transportation cost due to longer ship turnover time which effects the performance of the port (World Bank, 2008). Therefore, to improve the performance of the port, it is very important to concentrate on regulating and forming a strong hinterland transportation network. From the research conducted by Alamoush (2016), it is also made clear that an improvement in port hinterland intensify the port performance in general. Nevertheless, the determination of port performance tied down many subsystems within the process which even makes it more complex to figure out. The key point that has been highlighted in most of the research is that a good and organized hinterland system always brings some positive influence on a ports performance.

2.2. Determinants of port performance

Performance of a port can be influenced by many factors like the geographical location of the port, hinterland connectivity, the port dues and charges, the crane handling capacity, the quay length, port access and many other port related features (Alamoush, 2016). But in broader sense, the port performance can be measured from various aspects such as market tends and structures, socio-economic impact, environmental aspects, logistical and operational performance and governance indicators. If logistical performance and the operational performance of a port need to be considered than the determinants can be the intermodal connectivity, quality of port community systems, mean time customs clearance, on-time performance, maritime connectivity, ship turnaround time and so on. The focus of this research is on hinterland transportation, inland terminal activities and the regional development. Therefore, only few of the related determinants has been immensely discussed which are the location of the port, the hinterland access and the terminal efficiency.

Location of the port

The location of port is one of the first fact that determines the carriers and the shippers port choice. Researchers like Jung (2011) has proven the fact how the location of a port influences its overall financial and operational performance. A research shows that the financial performance of a port is positively related to the distance from the port to the centre of that region however, it does not significantly influence the operational performance of a port (Caldeirinha, et al., 2009).

The ports that has better access towards different regions are more active and receives more trade flows compare to the ports that is not well located or isolated from other regions. For example, Port of Rotterdam is located at the estuary of Rhine and it takes only 2 hrs for a vessel to reach to the port from the deep-sea (Port of Rotterdam, 2016) where Port of Antwerp is located on upstream of Scheldt river and it takes approximately 8-9 hours to reach to the port from the deep-sea by a vessel (Port of Antwerp, 2017). The allowable draft of port of Rotterdam is higher than port of Antwerp as well. Even though the container terminal of Antwerp situated in a very close proximity to the city compare to Rotterdam however the draft restriction and the shorter distance for nautical accessibility makes Port of Rotterdam more optimal than Port of Antwerp (Notteboom, 2003). The total throughput for Port of Rotterdam in 2016 was 461.2 million tonnes (Port of Rotterdam, 2017) and the total throughput for Port of Antwerp in 2016 was 208.4 million tonnes (Port of Antwerp, 2016) and a large part of this difference between the throughput of these two ports occurs due to their geographic location. A study based on Spanish ports also proved that the location of the port and its hinterland accessibility has a considerable influence on the port total throughput (Garcia-Alonso & Sanchez-Soriano, 2009).

The hinterland accesses

In recent days, the access to the port hinterland is one of the key factor while determining port performance. Studies by Alamoush (2016) and Wildenboer (2015) has established the relation between the port hinterland accessibility and port performance. The port competitiveness and the total throughput of a port immensely depend on the accessibility of its hinterland (de Langen & Chouly, 2004). Therefore, to improve the overall performance of a port, the access and connectivity of port hinterland need to be developed.

The Port of Rotterdam, Amsterdam and Antwerp has strong hinterland infrastructure and network which connects these ports to most of the Pan-European region and this reflects on their performance and they have a competitive advantage over most of the ports in nearby countries such as Germany and France as they are connected by the same river (de Langen, et al., 2012).

Port of Rotterdam is continuously working on the infrastructural development of their hinterland network. There are few firms who have invested on their hinterland and it positively affected the performance of the port. ECT has invested on inland terminal and hinterland activities towards the Netherlands, Germany and Belgium which introduced an integrated transportation system to all these inland terminals and also positively affects the other firms and organizations within the port cluster (de Langen & Chouly, 2004). There are other big companies who has considered port hinterland accessibility as a very important determinant of port performance and started investing or collaborating with other companies to improve the hinterland connectivity in Europe. For example, Maersk line has collaborated with P&O Nedlloyd and started the rail shuttle service named ERS from Port of Rotterdam to carry the containerized goods. Vopak has introduced innovative chemical barges which has also influenced the other barge operator to come up with more innovative ideas for inland waterways which helps to improve the hinterland connectivity. Port of Rotterdam has also developed partnership with most of the accessible region from POR hinterland and the firms around it to draw customers attention towards them (de Langen & Chouly, 2004).

Terminal efficiency

Another important determinant that influences the performance of a port is the terminal efficiency. The performance of a port is basically measured by its cargo throughput and that depends on the terminal efficiency. “Terminal efficiency can be defined as the total number of the containers loaded and unloaded to the terminal per hour which reflects the labour and capital productivity levels in ports” (L.Tongzon, 1995). However, the concept of measuring port performance by its throughput depends on the how the operation of that port is being evaluated.

Many researchers like Cullinane, Wang, Song, Ji (2006) have been collected data and developed several models to find out the most effective determinants of port performance. One of the approach is called Frontier approach which was introduced by M. J. Farrell in 1957 (Farrell, 1957). In recent days, the frontier approach is being studied either as Data Envelopment Analysis or Stochastic Frontier Analysis (Cullinane, et al., 2006). However, in all the cases, the researchers have used several inputs such as labour, infrastructure, capital and so on but the output measurement was limited to cargo throughput which indicates that the efficiency is determined by the cargo throughput.

The terminal efficiency depends on some key factors such as crane handling capacity, quay size to accommodate large vessels, the labour productivity, use of advance technologies, stacking capacity, slot scheduling and so on. Delays during operation can be a major obstacle towards achieving terminal efficiency. By reducing the delays, a terminal can increase their productivity. An efficient terminal can handle more cargo and have better throughput (Wildenboer, 2015). The efficiency level of a terminal indicates how fast that terminal can handle containers and how fast the vessel turnaround time in that terminal. The port users often tend to choose their port of call by its level of efficiency and an increase in the number of customers means an increase in the market shares which also indicates a rise in the total throughput (Tongzon & Heng, 2005).

2.3. The relationship between the inland terminal activities and the regional development

As mentioned earlier, the opinion from all the researchers who has discussed about the relationship between the inland terminal activities and the regional development has pointed out two different views. Researchers like Fugita & Mori (1996) who represented the optimistic view says that an increase in the port activities trigger the regional development (Fugita & Mori, 1996) where the pessimistic researchers like Vallega (Vallega, 1996) and Goss (Goss, 1990) says that the continuously growing demand from the region is the reason behind the rise in the freight flow in the ports (Jung, 2011). However, the most accepted view is that the regional development and the growth of the local and national economy largely depend on how the ports play a part in it (Deng, et al., 2013). The production of a region can maintain economies of scale by improving the port logistics system of that region and the infrastructural development of logistics system can only take place when there are proper investments involved which also has a positive effect on the economic growth of that region (Li-zhuo, 2012). Li-zhou (2012) also discussed that how the investment in port logistics infrastructure will multiply the national income.

There are many logistics activities that takes place near the port which also adds value to the regional development. The value-added logistics activity includes "labelling, customizing, adding of parts or manuals, configuration, blending and mixing, final assembly, managing of goods and information flows, inventory control" (Jung, 2011). All these activities are taken place in near or around the ports which continuously helps the region to grow economically and infrastructure wise. Activities like the storage of goods, the production of goods and the transportation of goods depend on the service quality of a port, how develop its infrastructure is and how well located it is. A port cluster basically indicates a group of firms or companies that involves themselves in all the aforementioned activities around the port area which also contributes to the regional economy and development (de Langen, 2004).

Jung (2011) in his research, focused on how the port related activities for instance storage and distribution of cargo, stevedoring and other activities that adds value increase the demand in that region and sets an ascending employment ratio and production rate. In another study about China shows that, how the port supply, demand, value added activities are positively linked to each other and directly or indirectly influences the regional economy and its development (Deng, et al., 2013).

A study shows that a port region has an approximately 40% higher GDP than a landlocked region (Chowdhury & Erdenebileg, 2006). The empirical result of another research reveals that a 10% increment in a ports throughput can rise the GDP of that region by 0.01-0.03% and all other region near to the port by 0.06-0.2% which indicates a 0.05%-0.18% spillover effect (Bottasso, et al., 2013). Moreover, the demand for the port related services in a port region also increases by the economic growth of a non-port region (Bottasso, et al., 2013). More port activities and services require more man power and creates local employment opportunities. As Eveline Wildenboer (2015) mentioned in her research how Bottasso, Ferrari, Conti, Merk and Tei (2013) has proven that an increase in terminal throughput creates more jobs for the local people, and the higher employment rate makes the regional economy stronger (Wildenboer, 2015). However, the development in the port infrastructure and increase in port activities only has a positive effect on the regional development in developed countries while it has a slightly negative effect in the developing countries (Hilling, 1996).

2.4. Major players and their role on hinterland connectivity

The major actors in port sectors and the supply chain and logistics sectors are getting integrated day by day to improve the service to their customers. In recent days, the major sea ports and the inland terminals are playing pivotal role in the supply chain system by challenging all the active market players in the system with all the operational issues for instance, the charges for dwell time, windows for berthing, trucking slots and so on to optimize terminal capacity and elevate the operational performance of the entire chain. This will more likely encourage the terminals to be capacity constrained which will make the role of terminal operators even stronger within supply chain.

As per Rodrigue & Notteboom (2009), the extended gate concept is used in a form of satellite terminal when the distribution takes place within a short distance or it can be used as an inland terminal when it needs to consider a long-distance corridor. When the extended gate concept is used, the players such as the transport and terminal operators play very dominant while the distribution centres takes a very limited participation in it. On the other hand, when the dimension changes and the extended distribution centre concept is used, the role of the actors change where the distribution centres play as a dominant actor and the transportation and terminal operators act as a facilitator (Jensen & Bergqvist, 2013).

The deep-sea and inland terminal operators are trying to reduce the free time for container to stay in the terminal by applying higher charges to the containers that stays longer in the terminal and by optimizing terminal buffer function and therefore the logistics players are acting fast to make the best use of the free time. Active players within the European region for example, the ECT Rotterdam who are using the extended gate strategy and JVC Belgium who acts as the extended distribution centre has been successfully alleviated their warehousing and dwell time costs by making the best use of the free time in the terminal and by improving a combination between inland and deep-sea terminals (Jensen & Bergqvist, 2013).

In the Netherlands, the major players who introduced the extended gate for Rhine-Scheldt Delta hinterland were the ECT Delta terminal of Rotterdam, APL shipping line and the logistics provider and the DHL freight forwarder. This strategy also initiated the further improvement of hinterland transportation. The concept was to move the containers from Port of Rotterdam immediately after arrival to TCT Venlo by rail. The inland railway connection towards TCT Venlo is also operated by ECT. APL is the information provider who notify ECT about the Venlo bound containers. Furthermore, the inland terminal at Venlo has its own licensed warehouse therefore no extra custom clearance required by APL logistics. The active role in this hinterland transportation and cargo distribution mainly stays between ECT and APL who are the two major players in the Netherlands. There are few more major actors like Maersk Line, Shipit intermodal transport organizer, Eurogate, DP world, CMA CGM who are actively involved in synchronizing the distribution process by improving port hinterland transport network and playing a key role in the entire supply chain. Maersk Line is trying to collaborate between their terminal operator APM and rail operator ERS (European Rail Shuttle) to move their containers toward hinterland. The coordination between DP world and CMA CGM is opening new windows for the terminal gateways like Antwerp and London. DP world has also collaborated with Shipit to set up hintermodal transportation system in Antwerp area which helped to establish a strong affiliation between inland operators and the shipping lines (Jensen & Bergqvist, 2013). MSC, and CMA CGM have developed their own rail services within Le Havre range to accelerate the pace of delivery.

Barge market used to be dominated by the independent barge operators which has been changed in past decades (Rodrigue & Notteboom, 2009). Few of the major deep-sea carrier companies have directly involved themselves into the inland barge operating business to reduce operational cost and the delay (Rodrigue & Notteboom, 2009). Few active players in this sector are Maersk, MSC, CMA CGM who offers their own river shuttle or barge services to their customers. These key actors are focusing more towards hinterland connectivity by either developing their own modes of hinterland transportation such as trucks, rail and inland barges or collaborating with the third-party operators to ensure the quality service for their customers (Rodrigue & Notteboom, 2009).

The terminal operators in Europe has introduced another concept to the customers which is called "Integrated Terminal Operator Haulage" (Notteboom, 2008). This system keeps the terminal operator responsible until the cargo is delivered to the inland terminal from deep-sea port. By using this system, terminal operators are engaging themselves more into the inland transportation. However, some issues arise due to the lack of information exchange but a good coordination among the shipping lines, shippers and the freight forwarders can solve this problem and enhance the progress of integration among the key players of the hinterland connections.

3. Methodology & Analysis

The theoretical outline behind the hinterland connectivity and its impact on port performance, regional development and its relationship with the port activities has been explained in chapter 2 of this paper. In this chapter, the data analysis will be carried out to draw a relationship among trimodal hinterland transportation system, port performance and regional development. The aim of this paper is to prove that the utilization of all three modes of hinterland transportation system plays a positive role in the port productivity which directly or indirectly accelerate the development of that region as well.

The analysis will only focus on the container transportation and it will be limited within three inland terminals and their region in the Netherlands namely Tilburg (Barge terminal Tilburg B.V.), Venlo (TCT Venlo) and Combi Terminal Twente (CTT Hengelo) due to their trimodal transportation handling facilities. Port of Rotterdam has been contemplated as the major sea port in this paper, thus the hinterland transportation to and from POR towards all the three inland terminals has been considered for the research.

Most of the indicators mentioned in this paper has been quantified however, due to some limitations, few of the indicator has been explained qualitatively. Due to the unavailability of some data, it is explained qualitatively in some parts. Therefore, the paper has been developed based on both quantitative and qualitative analysis.

This chapter gives a clear idea about how the analysis has taken place, how the data has been collected and a complete picture of the methodology. The regression model for the research has been taken from Gerald Keller (Keller, 2014) and the article behind it is Inland port performance: a statistical analysis of Dutch inland ports (Wiegmans, et al., 2015).

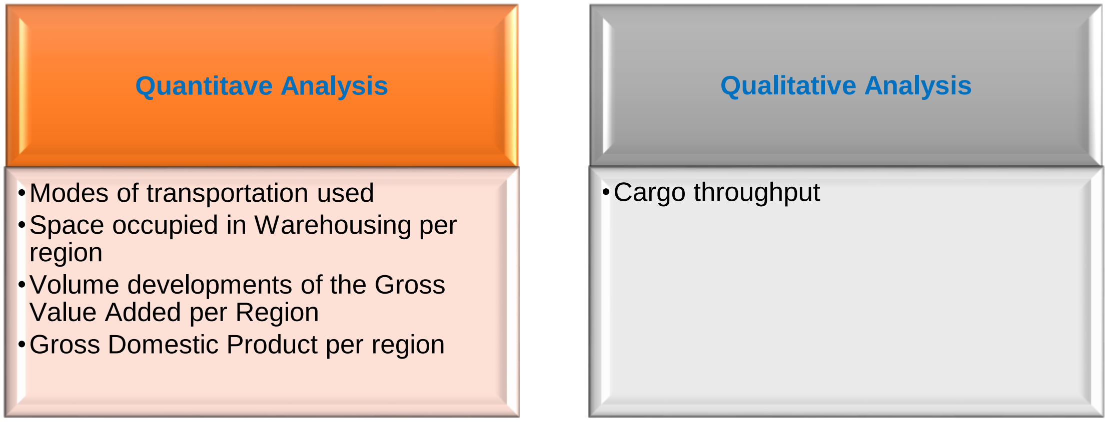

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Figure 3. Analysis structure

Source: Author

The quantitative part in this chapter highlighted all the important factors involving number of transportation modes for freight cargo, space occupied in warehousing in each region, Gross Value Added to each region from all the economic activity directly or indirectly related to ports and logistics, Gross Domestic Products per region. The available number of transportation modes to and from all three selected regions namely Venlo, Tilburg and Hengelo has been used as the key identifier to find the impact of trimodal hinterland transport. The space occupied by warehousing activity is accounted as the logistic related regional development activity. In this paper, we have assumed that the development in warehousing sector is a reflection of the improvement in the inland terminal and logistical activity. The Gross Value Added per region and the changes in Gross Domestic Product per year in each region from all the economic activity related to the port and logistics sector have been considered as well. A brief explanation of all the related activities are mentioned in chapter 3.3.1, Table 1.

This chapter will contain 4 sub chapters where the throughput, Hypothesis structure, Data and the complete Methodology will be discussed.

3.1. Throughput

Throughput is the maximum number of production unit or product that has been processed within a certain period. Throughput also identifies the productivity of a port or terminal. Throughput is basically calculated by the handling capacity of a terminal per vessel per hour for 24 hours a day and then 365 days per year. Throughput is always published on port yearly report to compare within the regional level or internationally. The handling capacity that has to be considered for the throughput calculation includes the actual handling time, waiting time for the vessel, the equipment used and the available working days (PARK , et al., 2014).

UNCTAD has provided a basic calculation method for Berth throughput in one of their publication which is as below

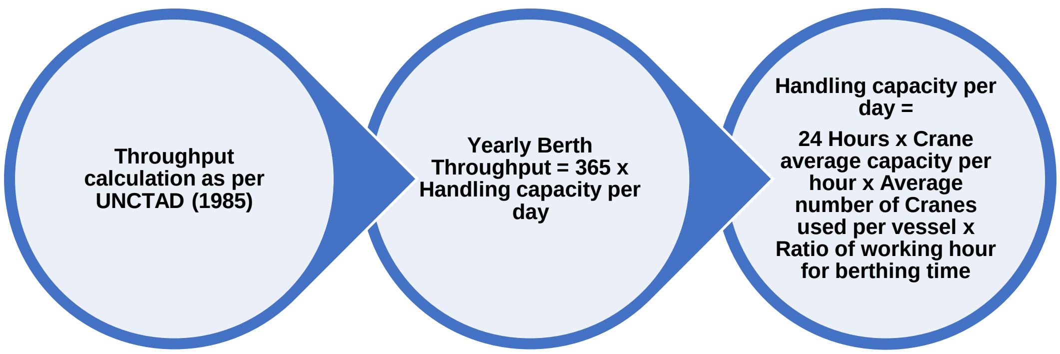

Figure 4. Throughput calculation

Source: Author, adopted from (UNCTAD, 1985).

However, the actual throughput of a terminal is considered as one of the three components of operational port performance. Generally, the port performance can be determined by the ports productivity, utilization and output (Soberón, 2012). The output in this scenario is considered as the Throughput. The amount of cargo a terminal can handle over a certain period which is typically a year, without stipulating the resources employed, is defined as Throughput. Throughput can be expressed with a unit of tons/year or TEUs/year depending on the types of cargo handled by the terminal.

In this research, the throughput has been collected from the Port of Rotterdam yearly reports where they have given the exact throughput figure for past years. Therefore, the calculation method has been ignored. The yearly throughput that has been collected from the Port of Rotterdam year-end report has been shown below in a scatter diagram

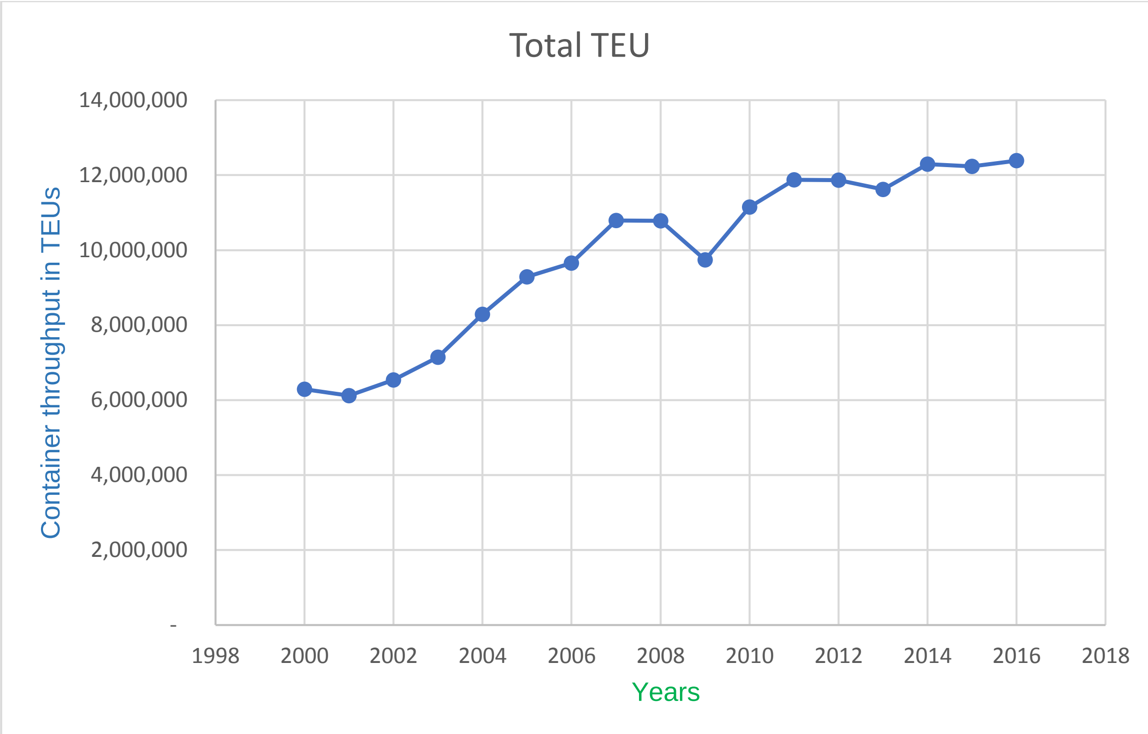

Figure 5. Port of Rotterdam yearly container throughput

Source: Author, compiled data from the yearly reports of Port of Rotterdam (Port Of Rotterdam, 2017).

The chart shows that how the container trade has been gradually increased since POR started to develop their hinterland connectivity. The table with throughput figures has been included in the Appendices.

3.2. Hypothesis

To investigate the correlation between the trimodal hinterland connectivity and the regional development, few hypotheses will be carried out as mentioned earlier in this paper. In chapter 2 of this paper, we have discussed the theoretical perspective of the trimodal hinterland transportation and its influences in regional development from various aspects. It also leads us to make a decision on selecting different identifiers for regional development. To run the regression analysis, we need to develop few hypotheses which will give us enough information to answer the main research question. In this case, we have taken four very important factors which can be used as the variables to build the hypothesis structure. Each hypothesis will establish a relationship between the hinterland transportation modes and each of the identifier for regional development which is also related to the port and logistics performance. The Hypothesis will structure as follows

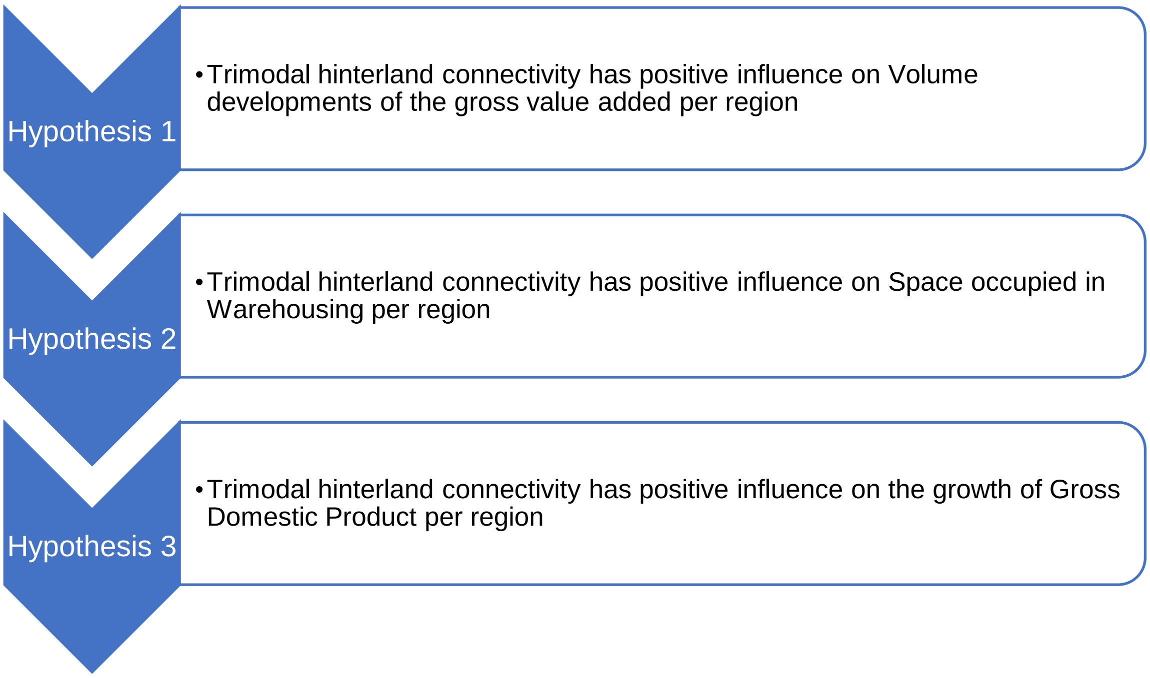

Figure 6. Hypothesis

Source: Author

Hypothesis framework

An independent variable and a dependent variable needs to be present to conduct a hypothesis. In this research, the framework of the hypotheses has been set with the available data. Due to the data unavailability, the regression has been kept limited to the concept of single linear regression analysis. The Simple linear regression allows draw relationship between two distinct quantitative variables within a statistical approach. One of the variable is independent which denoted as x and the other variable is dependent and denoted as y. The Simple Linear regression can be formulated as

$$y_i = E(Y_i) + \epsilon_i = \beta_0 + \beta_1 x_i + \epsilon_i$$

Here,

$$y_i = The\ observed\ response\ for\ experimental\ unit\ i\ or\ dependent\ variable$$

$$x_i = The\ predictor\ value\ for\ experimental\ unit\ i\ or\ independent\ variable$$

$$\epsilon_i = Error, \qquad \beta_0 = Intercept, \qquad \beta_1 = Slope$$

Based on this Simple linear regression formula and the data collected for the research, the framework of the hypothesis has been made. The aim of this research is to investigate the relation between the modes of hinterland transportation system used every year within Venlo, Hengelo and Tilburg and the regional development of those three areas. The data for the regional develop is limited to Volume developments of the gross value added per region, Space occupied in warehousing per region and the yearly rate of population moved towards the specific region due to the unavailability. Therefore, only these three indicators are considered as the dependent variables in this research.

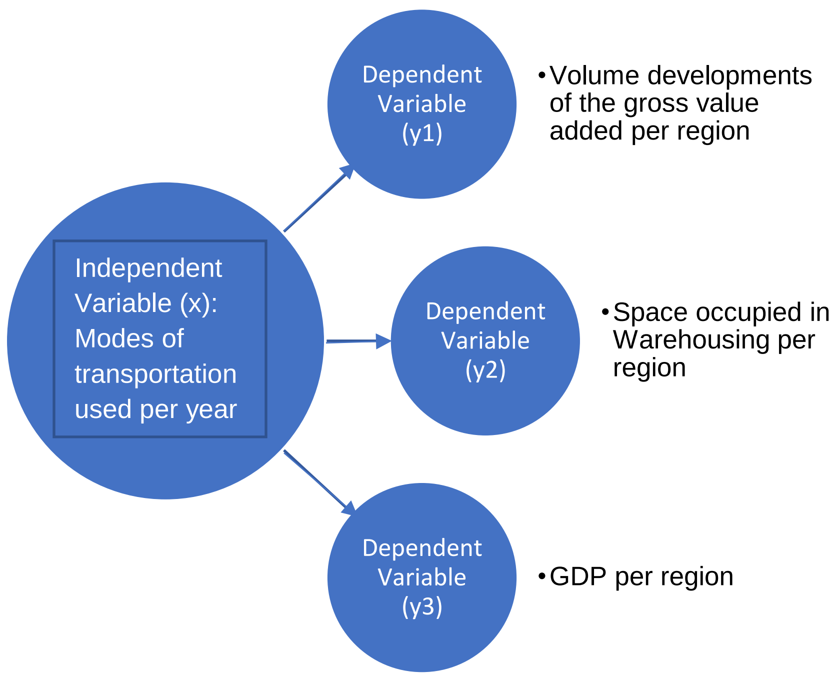

Figure 7. Hypotheses framework

Source: Author

Based on the hypotheses, a conclusion has been drawn to answer whether the number of hinterland transportation modes has an influence on the regional development around the inland terminals in the Netherlands and if that relationship does make sense from the theoretic standpoint.

3.3. Data Strategy

The region-specific data for the research are collected from different sources related to the port, terminal, municipality, logistics and consultancy organizations. This research paper only includes the data for the regions within the Netherlands. The regions that have been highlighted are Rotterdam, Venlo, Tilburg and Hengelo. Due to some limitations, few of the indicators has been discussed qualitatively however the complete dataset for the measurement of warehousing in each region and how it grows over the year has been collected successfully. The yearly cargo throughput data for the inland ports were unavailable and due to that, the qualitative analysis has only been conducted base on POR cargo throughput data. The exact figure for the yearly growth of warehousing occupancy is not available in any database but we have managed to extract the correct data from Dutch association of real estate agent NVM and converted it in excel format and prepared for STATA. The growth of warehousing over the year is considered the most important port activity related indicator towards regional development.

The selection of the three inland regions are based on their hinterland connectivity. All the inland terminals in these three regions Venlo, Tilburg and Hengelo are connected trimodally with Port of Rotterdam. Data availability for those regions are also another reason behind choosing Venlo, Tilburg and Hengelo. However, this research is focusing on trimodal hinterland transportations and all three of these inland terminals are operating road transport, rail transport and inland waterways to carry their freight cargo which lead us to select them for the research. To get the connectivity information, we have considered the number of modes which has been used over the years to connect all three regions with Port of Rotterdam and other ports in Germany and China. Inland terminals in Venlo for example is a part of European Gateway and one of the most important inland terminals in the Netherlands. Tilburg has the largest warehousing area and one of the most active freight rail connection within national and international range.

3.3.1. Data collection and compilation

The data used for the analysis includes the number of modes available per year, Volume developments of the gross value added per region, Space occupied in Warehousing per region and the change in GDP per region which indicates the socio-economic development of the region. The yearly container throughput for Port of Rotterdam has been drawn in a scatter diagram on Figure 4.

Data for volume developments of the Gross Value Added per region, GDP per region and yearly rate of population moved towards the specific region are not municipality specific data however all those data are COROP region specific data. COROP stands for Coordinatiecomissie Regionaal Onderzoeks Programma which means the Coordination Commission Regional Research Program. COROP regions are used within the Netherlands by the Statistics Netherlands for the analytical purpose. Each COROP region includes few municipalities close to each other. In this research, The COROP regions has been used are Twente which covers Hengelo, Midden-Noord-Brabant which includes Tilburg and Noord-Limburg which counts for Venlo.

The data collected for the research can be explained as follows. The unit of measurements are different for each type of data however that did not require a conversion to run the model. The container throughput mentioned for the POR is in TEU (Twenty Equivalent Unit). The GDP and the Gross Value Added per region is in percentages. The modes of hinterland transportation used and the rate of population moving towards the region is measured in numbers. And the warehouse space is measured in square meters.

All the data for the research has been collected from various sources. The information about the number of transportation modes used has been gathered from the inland terminal websites, Rail Cargo information Netherlands and Nieuwsblad transport and Bureau Voorlichting Binnenvaart (BVB). The data for the POR yearly container throughput has been collected from several annual reports of POR and Clarkson Research Services Limited. All the data relates to GDP per region, Gross value added per region are collected from CBS Statistics Netherlands. The warehousing data has been collected from the Dutch association of real estate agent NVM.

To input the data in STATA statistical analysis software, we have compiled it in one Excel spreadsheet in a form of panel data. Each variable has been defined clearly and prepared to run for the analysis.

Table 1. Description of the variables used for analysis

Type of variable	Variables (proxies)	Components	Units	Symbol for STATA
Independent	Modes of transportation	Barge, Rail, Truck	Number	Modes
Dependent	Warehouse	Logistic spaces	m2	Whouse
Dependent	Volume developments of the Gross Value Added per region	All economic activities including: Agriculture, forestry and fishing; Mining and quarrying; Manufacturing; Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities; Construction; Wholesale and retail trade; repair	%	GVA

		of motor vehicles and motorcycles; Transportation and storage; Accommodation and food service activities; Information and communication; Financial institutions; Renting, buying and selling of real estate; Consultancy, research and other specialized business services; Renting and leasing of tangible goods and other business support services; Public administration, public services and compulsory social security; Education; Human health and social work activities; Culture, sports and recreation; Other service activities; Activities of households as employers; undifferentiated goods- and service- producing activities of households for own use; Extraterritorial organizations and bodies.		
Dependent	Gross Domestic Product per region	All economic activities including: Agriculture, forestry and fishing; Mining and quarrying; Manufacturing; Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities; Construction; Wholesale and retail trade; repair of motor vehicles and motorcycles; Transportation and storage; Accommodation and food service activities; Information and communication; Financial institutions; Renting, buying and selling of real estate; Consultancy, research and other specialized business services; Renting and leasing of tangible goods and other business support services; Public administration, public services and compulsory social security; Education; Human health and social work activities; Culture, sports and recreation; Other service activities; Activities of households as employers; undifferentiated goods- and service- producing activities of households for own use; Extraterritorial organizations and bodies.	%	GDP

Source: CBS Statistics, NVM and the inland terminal websites; modified by author

In the next step, the data has been filtered and prepared to input into the STATA software for regression analysis.

3.3.2. Model

This research contains information of 3 different regions for 10 years period which gives us enough details to choose Panel Data Analysis to carry out the regression analysis. The time frame is chosen as 10 years because of the availability of the data. All the selected inland terminals started to use the trmiodal hinterland transportation and developed the hinterland infrastructure only within past 10 years which also gives us enough motive to choose this time frame. This Panel Data Analysis can also be named as the cross-sectional time series analysis. The data contains 30 observations as because the time dimension chosen for the data is 10 years and the space dimension considered 3 regions. Therefore, the panel data is strongly balanced.

There are some advantages of using panel data analysis (Cullinane, et al., 2006). Panel data analysis allows large amount of data with more variability, efficiency and degrees of freedom, and less co-linearity within the variables. Allowing heterogeneity (individuality or uniqueness) among the individual variables makes the panel data analysis preferable than other structures. In this research, we use the STATA 14 software to analyze the data where it provides a panel data platform to carry out a time series analysis. "STATA is a complete and an integrated statistical software package that provides everything for data analysis, data management and graphics" (STATA, 2017).

Panel data analysis has three different regression models. Each of the three models can be used for the suitable data based on the hypothesis test. The name of these three models are Common Effect Model (CEM), Fixed Effect Model (FEM) and Random Effect Model (REM).

Common Effect Model (CEM) is also called Pooled OLS Regression. In this model, the cross-sectional data and the time series data are used as a combination. However, this model does not provide very accurate output due to its heterogeneity nature which ensues a biased or unreliable outcome of coefficient correlations (Gujarati & Porter, 2009).

Fixed Effect Model (FEM) is also known as Least Squares Dummy Variables. This model also has a heterogeneity nature. This model allows its every entity to have an intercept value which can vary on the subjects but it does not depend on overtime which is why it is time-invariant (Gujarati & Porter, 2009).

The last and the final model is called Random Effect Model (REM) which is also known as Error Components Model (ECM). The model has two error components which are namely cross section and time series error (Gujarati & Porter, 2009). This model signifies the mean value of all the cross-sectional interceptions and the random deviation of individual interceptions while all the subjects in the FEM model only has fixed intercept value (Gujarati & Porter, 2009).

Model selection

It is required to run 3 tests to find the best regression model that fits the data namely Likelyhood ratio test or Chow test, Hausman test and Breusch-Pagan Multiplier test. The sequense and the framework for all three tests are as follows

Chow test:

This test will indentify whether CEM or FEM fits the data and best suit for the analysis. The structure of the hypothesis as per STATA software is given below

H_0 = CEM is more appropriate to analyze the data

H_1 = FEM is more appropriate to analyze the data

Condition: If prob. F = 0.00 < α = 0.05, reject hypothesis H_0 and consider FEM is more appropriate to analyze the data.

Hausman test:

Hausman test is carried out to find whether REM or FEM is best fit for the regression analysis. The structure of the hypothesis for Hausman test is given below

H_0 = REM is more appropriate to analyze the data

H_1 = FEM is more appropriate to analyze the data

Condition: If prob. chi2 = 0.00 < α = 0.05, reject hypothesis H_0 and consider FEM is more appropriate to analyze the data.

Breusch-Pagan Multiplier test:

This test is carried out to find the most appropriate model among CEM and REM which can be used for the regression analysis. The structure of the hypothesis to carry out Breusch-Pagan Multiplier test as per STATA software is given below

H_0 = CEM is more appropriate to analyze the data

H_1 = REM is more appropriate to analyze the data

Condition: If prob. chi2 = 0.00 < α = 0.05, reject hypothesis H_0 and consider REM is more appropriate to analyze the data.

The regression analysis has been carried out in the next step of this research. The simple linear regression formula for the analysis will be as follows

$$Whouse \ = f\ (modes)$$

$$GDP = f\ (modes)$$

$$GVA = f\ (modes)$$

4. Results and Discussion

This chapter contains two sub chapters. In the first sub chapter, the regression model, it's use and the result from the analysis has been discussed vastly. And the second sub chapter explains the research question with valid discussion.

4.1 Model and Outcome

Step 1: Model selection

To run the panel data regression analysis, we have carried out three tests to choose the best model that fits the data. Firstly, we have carried out Chow test to find out whether CEM or FEM model is the best fit for the data. In the next step, we have carried out Breusch-Pagan Lagrange Multiplier test to the best fit between REM and FEM model. Lastly, we have carried out the Hausman test to find out if FEM is more appropriate than REM to analyse the data. The condition to select the model for each test are same as mentioned in chapter 3.3.2.

After conducting all three tests, we have found that the REM data is the best fit for the population and warehouse data and the CEM model is best fit for the GDP and GVA data.

In this research, we have used only one independent variable and 3 dependent variables. Therefore, we must formulate the model 3 times under the structure of simple linear regression to carry out the panel data analysis. The formulation structure for the Panel regression model will as follows

$$Whouse_{it} = \beta_0 + \beta_1 Modes_{it} + \mathcal{E}_{it}$$

$$GVA_{it} = \beta_0 + \beta_1 Modes_{it} + \mathcal{E}_{it}$$

$$GDP_{it} = \beta_0 + \beta_1 Modes_{it} + \mathcal{E}_{it}$$

Where,

GVA = Volume developments of the Gross Value Added per region

GDP = Gross Domestic Product per region

Whouse = Warehouse

Modes = Modes of transportation

$\beta_{0\,=}$ intercept value

β_i = linear coefficient of each parameter

The letter i represents specific regions, and t denotes the time; i =1,2,3; t = 1, … 10.

$\mathcal{E}_{it}$ = error value for each specific region within 10 years' time.

As next step, we have run the correlation test to see whether each dependent variable is correlated with the independent variable or not. In this research, we have used only one independent variable thus the model has been run 4 times individually for each dependent variable. In this case, we have also carried out 4 correlation tests however the result does not bring any significant changes in the process.

Step 2: Descriptive approach

As we have mentioned earlier, STATA has shown that the panel data is strongly balanced. The outcome from the STATA after conducting the descriptive statistics run are given in Table 2. The unit of measurement for all the variables are as mentioned in Table 1. The number of observation for all the dependent and independent variables are found 18 which considered 10 years period timeline for all the 4 variables within 3 separate regions. As per the theory, the more numbers of observation give more accurate results thus the outcome of this test is significant enough due to its number of observations.

Table 2. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Modes	18	2.5	5144958	2	3
Whouse	18	725444.4	549115.1	20000	1516000
GDP	18	1.6	2.836734	-3.5	5.9
GVA	18	1.772222	2.683897	-3.1	6

Source: STATA, modified by author

From the output, we can observe a significant difference between minimum and maximum value of all the dependent variables. The most important dependent variable to measure the terminal related regional development is Whouse and it is appeared that the difference between the minimum and maximum value for Whouse is very high. Which proves the trend of significant increase of warehousing due to the increase in transportation modes within that region.

The difference in the minimum and maximum space occupied by Warehousing appear to be very high with a relatively strong standard deviation of 549115.1. Which is an indication of widely distributed dataset. A substantial change in the value of GDP and GVA has been observed as well.

Step 3: Pearson's Correlation Test

Pearson correlation coefficien symbolizes as (r) which typically draws the strength of the relationship between the dependent and the independent variable. The range of the value is within -1 to 1. The value 1 or close to 1 indicates a very strong correlation and vice versa. The lower the value the weaker the corelation is. Likewise the value zero indicates no relationship between the variables and a negative value of (r) specifies an inverse relationship between the variables.

Table 3. Pearson's correlation level

Coefficient Value	Strength of Association
0.1 < |r| 0.3	Small correlation
0.3 < |r| > 0.5	Moderate correlation
|r| > 0.5	Strong correlation

Source: (Cohen, 1988)

The output received from STATA after conducting the Pearson test draws a clear picture of the relationship between independent and dependant variables. The output from the test are as follows

Table 4. Pearson's correlation value from the test

	Modes
Modes	**1**
GDP	**0.0081**
GVA	**0.0106**
Whouse	**0.6641**

Source: STATA, modified by author

As we have mentioned earlier, the higher the correlation value, the stronger the relationship between the variables. From Table 4, it is observed that the correlation value between Modes and GDP is non negative but lower than 0.1. The correlation level mentioned in Table 3 only indicates the correlation strengh within the range of 0.1. It is not clear if the correlation should be counted as zero if it is less than 1 or it should be counted as a small correlation. Therefore, in this paper the correlation value for GDP with

Modes and GVA with Modes counted as a positive value and shows small correlation. The most important variable Whouse has a very strong correlation with the Modes which is 66%.

As we have only one independent variable and 3 dependent variables, we run the model 3 times seperately. Therefore, no overlapping or collinearity problem has been found in this analysis. Due to no multicollinearity issues, we can safely avoid the VIF test.

Step 4: Homoscedasticity test

Homoscedasticity is a critical assumption to control the panel data analysis and it is only present when the independent variables has the same variance (Wooldridge, 2012). The violation of homoscedasticity is called heteroscedasticity and it occurs when an independent variable has different error term values or when the investigated data has outlier (Gujarati & Porter, 2009).

In STATA 14, we use the robust option to avoid the unbiased result. It also enables the robust-heteroscedasticity standard errors and permits STATA to adjust the standard error in the panel data which helps it to control the heteroscedasticity (Torres-Reyna, 2014).

Once all the steps are successfully completed as per the requirements, it is necessary to interpret the results.

4.2 Interpretation and discussion

F-Test

F test is used globally to find out the validity of the model. It gives a clear view on the coefficient value within the model. If the F-test < ($\alpha = 0.05$) then the model is valid.

The *F* Statistic is used to see whether all the coefficient in the model differs from zero. It is used as an analysis tool globally to test the validity if the model. The model is valid if the F-Stat < ($\alpha = 0.05$). In this research, we found all the Probability F- test < 0.05 which means all the model are valid and fits the data.

R-squared

Coefficient of determination or R-square specifies the percentage of the dependent variable which can be explained by the independent variables. Panel regression model has three types of R-squared namely within, between and overall however for the REM model we have chosen R-squared within to conduct the analysis (STATA, 2017). The range of R-squared stays within 0 to 1 which also can be explained in a percentage level and the higher R-squared value indicates the dependent variable can be explained by the independent variable more.

Application of the outcome to the equation

As soon as we get the outcome of the analysis, we need to apply that to the equation to make the interpretation easier. Usually magnitude and significant are the two ways to interpret the coefficient of regressors. The extent of the effect for instance, how much one unit of independent variable can change the dependent variable, can be explain by magnitude. On the other hand, the significance level is to measure how precise the coefficient is. T-statistic test is carried out to find the p value which measures the significance. Prob. T < α means that the independent variable has a significant effect on dependent variable.

The 3 equations with the β_0, β_1 and $\mathcal{E}_{it}$ value taken from the outcome of the model is shown below

$$Whouse_{it} = -6616.981 + 292824.6\ Modes_{it} + 146795.94$$

$$GDP_{it} = 1.488889 + 0.0444444\ Modes_{it} + 3.1002789$$

$$GVA_{it} = 1.633333 + 0.0555556\ Modes_{it} + 2.9320564$$

Table 5: Output of first regression analysis between Modes and Whouse

MODEL 1 Whouse						
Nb of obs	18					
Nb of groups	3					
R-sq (within)	0.4162					
e it	146795.94					
Prob > chi2	0.0019					
Variables	**Coef.**	**Robust Std, Err.**	**t**	**p-value**	**95% Conf Interval**	
Modes	292824.6	94293.16	3.11	0.002	108013.4	477635.8
β0	-6616.981	110431.2	-0.06	0.952	-223058.2	209824.2

Source: STATA, modified by author

Now from the outcome of the model, we can see that the first analysis between Whouse and Modes has a p-value less than 0.05 which explains that the independent variable has a strong significance level and R-sq value of 0.4162 which means that the 41% of the variance of the dependent variable can be explained by the independent variables.

Table 6: Output of second regression analysis between Modes and GDP

MODEL 2 GDP						
Nb of obs	18					
Nb of groups	3					
R-sq (within)	0.0023					
e it	3.1002789					
Prob > chi2	0.9227					
Variables	**Coef.**	**Robust Std, Err.**	t	p-value	95% Conf Interval	
Modes	0.0444444	0.4581228	0.10	0.923	-0.8534598	0.9423487
β_0	1.488889	1.357495	1.10	0.273	-1.171753	4.149531

Source: STATA, modified by author

The second analysis between GDP and Modes has a p-value of 0.923 which is >0.05 and R-sq = 0.0023 which means the independent variable does not have a strong significance over dependent variable and only 0.23% of it can be explained by the independent variable.

Table 7: Output of third regression analysis between Modes and GVA

MODEL 3 GVA						
Nb of obs	18					
Nb of groups	3					
R-sq (within)	0.0015					
e it	*2.9320564*					
Prob > chi2	0.9005					
Variables	**Coef.**	**Robust Std, Err.**	**t**	**p-value**	**95% Conf Interval**	
Modes	0.0555556	0.4444673	0.12	0.901	-0.8155843	-0.9266954
β_0	1.633333	1.352934	1.21	0.227	-1.018368	4.285035

Source: STATA, modified by author

The Last analysis between GVA and Modes also has a p-value>0.05 and R-sq = 0.0015 which means the independent variable does not have a strong significance over dependent variable and less than 1% of it can be explained by the independent variable.

The overall results from the analysis is satisfactory as it has somehow drawn a relationship between independent and dependent variables.

Proving Hypothesis

In this part of the research, the hypothesis structured in chapter 3.2 is going to be answered

H1: Trimodal hinterland connectivity has positive influence on Volume developments of the gross value added per region

The output of the model gives a higher p-value than 0.05 for both GVA and GDP. Therefore, the significance of the independent variable Modes on dependent variable GVA and GDP is very less. Which means that the modes of transportation used in inland terminal activity does not significantly influences the Gross Value Added and Gross Domestic Products per region.

$$GVA_{it} = 1.633333 + 0.0555556\, Modes_{it} + 2.9320564$$

However, the value of coefficient is positive which was mentioned earlier in the equations and that shows a slightly positive influence on GVA and GDP. So, the hypothesis cannot be rejected. Which means that trimodal hinterland connectivity has positive influence on Volume developments of the gross value added and GDP per region however, it might depend on many other factors other than Modes of hinterland transportation.

H2: Trimodal hinterland connectivity has positive influence on Space occupied in Warehousing per region

To prove the second hypothesis, we need to look up to the following equation

$$Whouse_{it} = -6616.981 + 292824.6\, Modes_{it} + 146795.94$$

Here, we can see that the coefficient value is positive and higher which proves that we cannot reject the hypothesis. So, the independent variable Modes has a positive influence on dependent variable warehouse.

The p-value for this model is less than 0.05 which also indicates the presence of its strong significance on the dependent variable. Therefore, we can conclude that the trimodal hinterland connectivity has a significantly positive influence on space occupied in warehousing per region.

H3: Trimodal hinterland connectivity has positive influence on the growth of GDP added per region

The last hypothesis is based on the independent variable Modes and the dependent variable GDP. In this case GDP defines as the yearly Gross Domestic Product in all three specific regions around inland terminals. To prove this hypothesis, we must look up to the following equation

$$GDP_{it} = 1.488889 + 0.0444444\, Modes_{it} + 3.1002789$$

It is appeared in the equation that the coefficient value is positive thus, it is impossible to reject the hypothesis. However, the value is very small and it does not represent a significantly strong relationship between transportation modes and the GDP growth.

Also, the p-value for this model is higher than 0.05 which indicates that the independent variable does not have a strong significance on the dependent variable. Nevertheless, the relationship depends on both the magnitude and the significance of the outcome and the magnitude of the coefficient shows a positive value. Therefore, the decision can be made that the trimodal hinterland connectivity has a positive influence on the yearly growth or change of GDP per region but does not significantly make a difference.

5. Limitations and recommendations for further research

There are some difficulties related to data collection and resources while conducting this research. Some of the regional data for instance, throughput for inland terminals over the years, employment rate of each specific region was unobtainable. The national employment data was available however, it was not region specific and the manual segregation of the data can be incorrect and give a very erratic out of the analysis. Therefore, we have not included the employment rate in this research although it is one of the key indicator of the regional development. Also, the data of GDP and GVA were taken based on the COROP region which does not clearly specify the growth in Venlo, Tilburg and Hengelo. The throughput for the inland terminals were not available for last 10 years and due to the port performance calculation were not carried out.

In this paper, the trimodal connectivity and its impact on regional development have been discussed where the focus is only on one field related to the terminal activity such as the warehousing space. A suggestion for the further research can be investigating vastly on regional development level not only related to the port activities but also the socio-economic welfare.

6. Conclusion

This paper intends to investigate the impact of trimodal hinterland transport on regional development. The research has established an analytical framework to measure the extent of the trimodal hinterland transportation. In this paper, the research has been conducted only considering the inland terminals located in the Netherlands and we have tried to draw a positive linear relationship between the port activities and the regional development through the analysis.

The main research question of this paper is "What is the impact of hinterland transportation on regional development around inland terminals in the Netherlands?" which has been answered by all three hypotheses in this paper where we have successfully established a positive linear relationship between the hinterland transportation modes which we have considered as independent variable and the three dependent variables namely the increase in warehousing around the region, the Gross Value Added to each region and the GDP growth per region.

From the outcome of the regression analysis, it is made clear that the utilization of trimodal hinterland transport has a positive influence on the regional development. The significance level of the influence is not vast however it is proven as positive which satisfies the aim of the research.

Wildenboer (2015) has successfully drawn a positive relationship between the port performance and the regional development in his research (Wildenboer, 2015). Also, Alamoush (2016) found a positive relationship between the hinterland connectivity and the port performance which is not very significant (Alamoush, 2016). In this paper, we have taken only a few factors such as warehousing, GVA, and GDP into consideration which does not represent all the subsystems within the regional development process. The outcome of this paper ties the trimodal hinterland connectivity with regional development, however, the suggestion can be made to conduct further research on this topic by taking all the factors such as employment rate, and infrastructural development into consideration. The outcome of this paper leads the way for more thorough analysis concerning the hinterland transportation and regional development in future studies.

The research gives a clear view on how the hinterland connectivity should be improved to accelerate the regional development. The Warehousing space is considered the most important indicator for the regional development in this paper due to its relationship with the port and logistics activity. The regression analysis provides sufficient evidence to prove the hypothesis in every step by acquiring all the possible outcomes. The Inland terminal in Venlo has planned to open its third freight rail connection, Tilburg is now connected to China by their rail network. These developments are taking place due to the improvement in port efficiency and the socioeconomic growth around the region. The vision towards port strategy starts from the extension of the administrative borders of the POR through collaboration with other connection within its port network. This collaboration among all the nodes can elevate the trade flows throughout the ports and terminals in the Netherlands. One of the core focus, therefore, should be the hinterland connectivity. A proper utilization of all the hinterland transportation modes can reduce over capacity and the congestion in the major seaports (Klink, 1995). As we have proven in this research that the utilization of all three hinterland transportation modes can significantly influence the growth of warehousing which brings opportunities to the region and adds values to the economy. Therefore, the utilization of hinterland transport modes has to be taken into consideration while focusing on the regional development around inland terminals. The proper implementation of the plan requires guidance and assistance from the major investors and the policy makers who can think beyond the limitations and motivate others to involve in this strategic and infrastructural development of hinterland transport modes.

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Appendices

Appendix 1: Transported goods by nationality of IWT

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Belgium	33,067	33,299	27,648	38,098	43,454	44,423	45,730	46,318	47,878	48,434
Netherlands	86,870	87,965	68,234	85,145	85,584	84,794	86,295	92,354	93,476	91,979
Germany	60,981	62,076	49,965	51,375	53,697	53,625	53,921	56,949	58,990	57,020
France	17,347	17,466	15,789	17,228	15,914	16,421	16,190	15,939	15,985	16,767

Port of Rotterdam has a perfect geographical location to connect it to all the inland terminals within the Netherlands and the countries like Germany, Belgium, France, Switzerland and Austria by its inland waterway network. Due the geographical advantage, Port of Rotterdam is now concentrating more into inland waterway for their freight delivery towards the destination. A large number of sustainable, flexible and modern inland vessels have been used to carry all types of cargoes such as containers, dry bulk, liquid bulk, project cargoes to and from Port of Rotterdam. A statistic says, 50% of the total inbound and outbound cargo between Port of Rotterdam and Europe are carried by inland shipping (Port Of Rotterdam Authority, 2016).

An advantage for the inland waterway connection from Port of Rotterdam to Germany is not to pass through any locks which saves cost and time. As per the Port of Rotterdam report, the reliance on barge for container transportation is expected to increase in the coming years because of the launching of Maasvlakte II. Some organizations like Nextlogic have been developed to bring the terminals and the barge operators under the same platforms to achieve the optimization in container handling by inland shipping (Port Of Rotterdam Authority, 2016).

Appendix 2: Port of Rotterdam yearly container throughput

Country	Port	Year	Total TEU
Netherlands	Rotterdam	2016	12,385,168
Netherlands	Rotterdam	2015	12,234,535
Netherlands	Rotterdam	2014	12,297,570
Netherlands	Rotterdam	2013	11,621,045
Netherlands	Rotterdam	2012	11,865,916
Netherlands	Rotterdam	2011	11,876,900
Netherlands	Rotterdam	2010	11,147,572
Netherlands	Rotterdam	2009	9,743,290
Netherlands	Rotterdam	2008	10,783,825
Netherlands	Rotterdam	2007	10,790,829
Netherlands	Rotterdam	2006	9,653,232
Netherlands	Rotterdam	2005	9,288,399
Netherlands	Rotterdam	2004	8,291,995
Netherlands	Rotterdam	2003	7,143,918
Netherlands	Rotterdam	2002	6,533,805
Netherlands	Rotterdam	2001	6,119,512
Netherlands	Rotterdam	2000	6,289,508

Source: Author, Compiled from (Port Of Rotterdam Authority, 2016)

Appendix 3: Data used for regression analysis on STATA

Region	Year	Whouse	GVA	GDP	Modes
Hengelo	2005	20000	2.5	2.5	2
Hengelo	2007	25000	5.6	5.5	2
Hengelo	2009	25000	0.4	0.1	2
Hengelo	2011	28500	3.6	3.3	2
Hengelo	2013	31000	-1.3	-1.6	2
Hengelo	2015	31000	1.9	2.2	3
Venlo	2005	619000	-0.2	-0.2	2
Venlo	2007	798000	6	5.9	2
Venlo	2009	951500	-3.1	-3.5	2
Venlo	2011	994500	3.6	3.3	3
Venlo	2013	994500	0.1	-0.2	3
Venlo	2015	1287000	1.6	1.9	3
Tilburg	2005	841500	2.2	2.2	2
Tilburg	2007	1081500	6	5.9	3
Tilburg	2009	1202000	-2.5	-3.5	3
Tilburg	2011	1270000	3.2	3.3	3
Tilburg	2013	1342000	0.2	-0.2	3
Tilburg	2015	1516000	2.1	1.9	3

Source: Author, Compiled from (CBS, 2017) , (Bak, 2016), (GVT Group of Logistics, 2017), (CTT Intermodal Transport, 2017), (Wanders, 2014).

<u>Notes:</u>

1. All the warehousing data are in square meters.
2. All the data for Gross Value added and Gross Domestic Product are on percentage.
3. The information about the number of modes available for each terminal was collected from each terminal website.

Appendix 4: STATA outcomes

Analysis between modes and Warehouse

```
Random-effects GLS regression                   Number of obs      =        18
Group variable: REGION                          Number of groups   =         3

R-sq:                                           Obs per group:
     within  = 0.4162                                         min =          6
     between = 0.9095                                         avg =        6.0
     overall = 0.4410                                         max =          6

                                                Wald chi2(1)       =      9.64
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0019

                               (Std. Err. adjusted for 3 clusters in REGION)
------------------------------------------------------------------------------
             |               Robust
      Whouse |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       Modes |   292824.6   94293.16     3.11   0.002     108013.4    477635.8
       _cons |  -6616.981   110431.2    -0.06   0.952    -223058.2    209824.2
-------------+----------------------------------------------------------------
     sigma_u |  256794.11
     sigma_e |  146795.94
```

```
. summarize Whouse Modes

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
      Whouse |        18    725444.4    549115.1      20000    1516000
       Modes |        18         2.5    .5144958          2          3
```

Analysis between modes and GDP

```
Random-effects GLS regression                   Number of obs      =        18
Group variable: REGION                          Number of groups   =         3

R-sq:                                           Obs per group:
     within  = 0.0023                                         min =          6
     between = 0.2500                                         avg =        6.0
     overall = 0.0001                                         max =          6

                                                Wald chi2(1)       =      0.01
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.9227

                                 (Std. Err. adjusted for 3 clusters in REGION)
```

GDP	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
Modes	.0444444	.4581228	0.10	0.923	-.8534598	.9423487
_cons	1.488889	1.357495	1.10	0.273	-1.171753	4.149531
sigma_u	0					
sigma_e	3.1002789					
rho	0	(fraction of variance due to u_i)				

. summarize GDP Modes

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	18	1.6	2.836734	-3.5	5.9
Modes	18	2.5	.5144958	2	3

Analysis between modes and GVA

```
Random-effects GLS regression                   Number of obs      =        18
Group variable: REGION                          Number of groups   =         3

R-sq:                                           Obs per group:
     within  = 0.0015                                         min =          6
     between = 0.0976                                         avg =        6.0
     overall = 0.0001                                         max =          6

                                                Wald chi2(1)       =      0.02
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.9005

                                 (Std. Err. adjusted for 3 clusters in REGION)
------------------------------------------------------------------------------
             |               Robust
         GVA |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       Modes |   .0555556   .4444673     0.12   0.901    -.8155843    .9266954
       _cons |   1.633333   1.352934     1.21   0.227    -1.018368    4.285035
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  2.9320564
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
. summarize GVA Modes

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
         GVA |        18    1.772222    2.683897       -3.1          6
       Modes |        18         2.5    .5144958          2          3
```