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A framework for use in modelling the modal choice decision making process in North West England's Atlantic Gateway.

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***Abstract* — The task of producing a generic model of the modal choice decision making process is a challenging one. Modal choice is strongly influenced by the infrastructure limitations and geographical constraints of the area in which the decision is being made. With this in mind, addressing modal choice on an individual basis for each region may be the optimal solution. This is the approach adopted in this paper. The creation of a modal choice model is a multistage process of which this paper addresses the first stage, the production a framework of the decision making process. Firstly, a number of criteria that are commonly used in modal choice models are identified. Then a number of gaps in the criteria utilized in previous papers are established. Subsequently, the method used to produce a framework of the decision making process within North West England's Atlantic Gateway is outlined. Through consultation with transport industry experts in North West England, an initial list of sixty eight papers was reduced to thirty six that were considered to be of specific relevance to modern day freight transportation within their region. The criteria used in each of these papers were then, along with further industry input, used to create the foundation on which a modal choice framework specific to the Atlantic Gateway could be built. A greater understanding of what influences modal choice within this region will allow informed decisions to be made by policy makers on how to more efficiently utilize the available modes of freight transport. Having established this, future work can then go on to build upon these findings. This paper recommends that future work is performed to establish the weights of each criteria and sub-criteria within the framework. This should then be followed by establishing industry's perceptions of the best and worst alternatives for moving freight within the Atlantic Gateway.**

***Key words* — Freight transport, Modal choice, Northern Powerhouse, Atlantic Gateway, North West England.**

I. INTRODUCTION

Overuse of the road network has led to greater levels of congestion, elevated levels of road surface wear and tear and an increase in transport related air pollution. When taken in combination with the failure of attempts to balance modal split the road network's continuing slide towards breaking point seems to be beyond question. However, circumstances have conspired to present one particular region of England with a tabula rasa for the development of new policies to influence the modal split of freight transportation.

England's economy is currently based around a London-centric model. The recent move towards developing what has become known as a Northern Powerhouse is aimed at rebalancing the economy of the nation for the betterment of all of its citizens. The Atlantic Gateway is an integral part of these efforts. At the same time, the devolution of powers and responsibilities from national government to regional authorities may provide an opportunity for positive change the likes of which has not be seen in the North of England since the beginning of the industrial revolution.

Different regions are influenced by their own geographical and infrastructure constraints. Devolution ensures that decisions are made locally and are therefore more able to meet local needs. A greater understanding of what influences modal choice within the Atlantic Gateway will allow local policy makers to make better informed decisions on how to accommodate the increasing levels of freight transportation on the existing local transport infrastructure.

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II. BACKGROUND

The Atlantic Gateway refers to the area of North West England that forms the corridor between Merseyside and Greater Manchester. With Manchester and Liverpool combined having a population of over four million people this represents the largest area of urban population in the United Kingdom outside of London (The Peel Group, 2012). The Atlantic Gateway has been targeted for fifty billion pounds of investment over the next fifty years. This investment is aimed at driving development and growth in urban areas by creating housing, jobs, improving connectivity and upgrading transport and logistics infrastructure. It also provides an approach for informing policy development and establishing national priorities to rebalance the economy (Cheshire and Warrington Local Enterprise Partnership, 2014)

At present the United Kingdom relies predominantly on the transportation of freight by road. Some of this enters the country in ports on the south coast and is then transported the full length of the country to its destination in Scotland. As a result, England has some of the most congested roads in Europe. Using the Port of Liverpool and the Manchester Ship Canal to move goods into the heart of Northern England would go some way to alleviating this problem in the North West of England. The Manchester Ship Canal represents a viable alternative to road. It runs alongside Europe's largest industrial estate (Trafford Park) and currently uses less than ten percent of its freight capacity. The problem lies in convincing freight businesses to utilize alternative transport modes to road. The purpose of this paper is to present a framework that is the first phase in the development of a tool that could ultimately be used by policy makers to influence the modal choice decision making process and produce a shift of freight carriage to more sustainable transport modes.

II. LITERATURE REVIEW

Since the publication of its 2001 transport white paper (European Commission, 2001) the European Union has been attempting to rebalance the modal split in Europe to 1998 levels. To this end the EU devised the Marco Polo (European Commission, 2003) and the Motorways of the Seas (European Commission, 2006) programmes as key elements of its policy to achieve the shift of cargo from road to sea. With the current failure of these programmes to deliver their goal the road network's continuing slide towards breaking point seems to be beyond question.

Work in the field of modal choice and the related fields of route choice and carrier selection is already extensive with a wide range of approaches having been utilized in the past. Potentially the most popular approaches have been: case studies (Torbianelli, 2000), cost benefit analysis (Paixao and Marlow, 2001), SWOTH analysis (De Oses and Castells, 2008) and logit based models (Rich *et al.*, 2009).

Studies tend to either be aimed at the development of a generic equation or carried out within a specific geographical region, such as occurred in: France (Gouvernal, Slack and Franc, 2010), Spain (Feo-Valero *et al.*, 2011) and Canada (Brooks and Trifts, 2008). However, national boundaries often contain within them a variety of different regions, each of which may have their own transport related constraints. As a result, adopting a national approach to modal choice may be considered less effective than adopting a more specific, regional approach.

A. Popular criteria in previous modal choice studies

Previous work on the subject of modal choice has identified an extensive list of potential factors that may influence the decision making process. These criteria have been utilized in many different studies.

Cost The criterion that cuts straight to the heart of the modal choice issue is cost. From as early as the 1970's many pieces of research have included this factor in their models of the decision making process. Having previously been defined as the "total user cost" (Dial, 1979), the cost criterion can be taken to mean the total amount of money expended to take the cargo from door to door. This includes transport, handling, storage, and any other financial outgoings resulting from the movement of the freight.

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Distance The distance that a given route covers is another significant factor that often occurs in modal choice literature (Cullinane and Toy, 2000; Feo *et al.*, 2011). It has been argued (Paixao and Marlow, 2002) that modal choice is a direct function of distance. In Hjelle (2010) distance was used to argue that the most energy efficient freight routes are those which are based upon cargo movements by road. This conclusion resulted from the low load factor of seaborne transport compared with that of road.

Transit Time Transit time, defined as the "door-to-door transport time, including loading and unloading", has been established in numerous previous studies as a significant indicator for freight shippers (Bardi *et al.*, 1989). Although referred to under a variety of titles; such as: timescale, shipping speed, and wait time; each of these reflects the same issue, the length of time that the receiver has to wait to take receipt of the cargo after the time of ordering.

Delays Directly connected to transit time is transit time reliability, more commonly referred to as delays or punctuality. This is another factor that is commonly included in modal choice models and is therefore believed to heavily influence modal choice decision making (Danielis *et al.*, 2005; Grosso, 2011). It refers to the degree of certainty and predictability in the travel time of a given transportation system. The modes of transport with a more reliable transit time provide the shipper with a greater level of assurance that their shipment will arrive at its destination within an acceptable range of its scheduled time. It represents the level of confidence that can be placed on the carriers anticipated transit time from door-to-door.

Service Frequency Service frequency has been identified on numerous occasions as an important indicator for freight shippers (Grosso, 2011). Beuthe and Bouffioux (2008) define service frequency as the "service per week actually supplied by the carrier or the forwarder". Service frequency is also among the criteria used to characterise the future European Motorways of the Sea (European Commission, 2012).

Controllability and Traceability In Cullinane and Toy (2000) the number of article appearances of specified modal choice criteria were assessed and it was found that Controllability/Traceability was amongst the top fifteen criteria used in modal choice studies. The high number of mentions that this criteria receives in modal choice studies appears to make it an essential element of any modal choice decision making framework. However, Controllability (the ability to influence a shipment) and Traceability (the ability to see where a shipment is) are clearly two separate factors.

Market Factors In the past, there have been a number of factors that have been considered in modal choice studies that could be grouped under the heading of market factors. These are those that influence people within an organisation from outside without them necessarily knowing. Those that have been studied, include: financial stability (Menon *et al.*, 1998), global container rates (Bird, 1988), market attributes (Gray, 1982), market considerations (Mangan *et al.*, 2001) and lack of investment (Department for Transport, 2007).

Summary of selected popular criteria from previous modal choice studies The broad employment of this limited collection of criteria may demonstrate that they are indeed those that are most influential on the modal choice decision making process. Alternatively, it could be that researchers are creating an echo chamber effect within which a limited number of criteria are included in an increasingly large number of models. This may be due to a lack of imagination amongst researchers, a lack of engagement with industry, or a belief that highly educated, like-minded researchers are infallible.

B. Under represented criteria in previous modal choice studies

Some criteria, although they are stated as being of relevance when discussing modal choice with industry representatives, are not significantly covered in the existing models. The most significant criteria of this sort that were identified through this work are:

Pollution Whilst energy efficiency is of importance when considering the distance that a given route covers it is also of importance with regard to the external impacts (pollution) resulting from freight transportation. The more energy required to move a cargo from its origin to its destination the more pollution that will be produced (Hjelle, 2010). In the past, work has been done to identify the gaps in modal choice and carrier selection research (Meixell and Norbis, 2008). Environmental

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concerns were found to be a theme that was entirely missing in their body of research. None of the forty eight articles reviewed by Meixell and Norbis had any mention of these issues in them.

Security A definition of security in a containerised supply chain is "the physical and procedural security standards of the various commercial perimeters e.g. warehouse, container consolidation facilities" (Riahi, 2010). In a similar way to how pollution has been overlooked in previous studies of the modal choice decision making process, security is also under represented. Only one paper from all of those selected by Meixell and Norbis considered security. In that paper (Voss *et al.*, 2006) security was identified as a potential new criterion for inclusion in future modal choice studies.

Claims Processing The idea of claims processing as a criterion influencing modal choice is suggested in Wong *et al.* (2008). This paper is aimed at modal choice in China where the legal structure surrounding claims awards compensation to both the plaintiff and the defence in a case. Under these circumstances the efficiency with which claims can be processed is of concern to everyone involved. The legal system in the United Kingdom is different but with claims processing being omitted from many of the existing modal choice studies this represents an oversight in many models.

Safety Record The model produced by Gursoy (2010) includes "shipping safety" as a criterion that is "assumed to be effective in the shipping mode choices of shippers". However this criterion is not commonly found amongst the multitudes of other papers covering modal choice. This lack of mention of a mode or company's safety record in many models represents a gap in the study of modal choice.

Image of Mode Having had discussions, off the record, with a number of operators in the freight industry it was found that shippers have a biased image in their mind of what a given transport mode has to offer. It was hoped that this would be addressed by the work done by the University of Westminster to analyse the strengths and weaknesses of the road, rail and water modes of transportation (Department for Transport, 2007). However, the freight operators that were spoken to for this paper, have identified what they refer to as the 'image of a mode' as being highly relevant to the decision making process that they go through when selecting a transport mode. This may be the case but modal image is not a criteria that has been captured in previous models.

Finances The finances of a company can be a difficult criterion to collect data for. It is for this reason that many studies of the modal choice decision making process choose not to include it. However, The United Kingdom's Department for Transport identified financial conditions as playing a role in modal choice (Department for Transport, 2007).

Summary of the selected *under represented criteria from previous modal choice studies* The absence of this collection of criteria from the majority of previous modal choice models may have been an oversight or it may have resulted from them being perceived as not having an impact upon modal choice. However, regardless of which may be the case, their omission from previous studies represents a series of gaps in the understanding of the decision making process.

III. METHODOLOGY

To develop the framework that is presented in this paper, the following procedure was followed:

A. *Identification of the criteria that influence the modal choice decision making process (Step One)*

To understand the process involved in making a modal choice the first major step is to determine the factors that influence the decision making process (D'Este and Meyrick, 1992). The qualitative and quantitative criteria that influence freight transportation modal choice decision making have been widely examined in the past. A review of the literature that covers the field of modal choice was performed and identified sixty eight significant journal papers from the last thirty five years.

A list of the criteria identified in these papers was passed to management staff within North West England's freight transport industry. Those consulted evaluated the relevance of the various criteria to today's transport industry in North West England. Their work allowed the initial list of papers to subsequently be reduced from sixty eight to thirty six that were considered to have the most relevance to modern day freight transportation in North West England. These papers are listed, in

chronological order, in Table 1.

Table 1: A chronological list of the thirty six papers utilized in the development of the framework.

Year	Title	Author
2011	Mode Choice: Road transport versus intermodal transport: An analysis applied to the Port of Genoa and the Port of Antwerp.	Grosso
2011	A stated preference analysis of Spanish freight forwarders modal choice on the south-west Europe Motorways of the Sea.	Feo, Espino and Garcia
2011	The importance of the inland leg of containerised maritime shipments: An analysis of modal choice determinants in Spain.	Feo-Valero, Garcia-Menendez *et al.*
2010	Hinterland transportation in Europe: Combined transport versus road transport.	Fremont and Franc
2010	A method for transportation mode choice.	Gursoy
2009	European Common Transport Policy and Short-Sea Shipping: Empirical Evidence Based on Modal Choice Models.	Garcia-Menendez and Feo-Valero
2008	Analysing qualitative attributes of freight transport from stated orders of preference experiment.	Beuthe and Bouffioux
2008	Evaluation of factors for carrier selection in the China Pearl River delta.	Wong, Yan and Bamford
2007	Freight Modal Choice Study: Behavioural barriers and factors influencing modal choice - Final Report.	Department for Transport
2007	Motor Carriers' and Shippers' Perceptions of the Carrier Choice Decision.	Premaux
2006	Selection criteria of transportation mode: a case study in four Finnish industry sectors.	Punakivi and Hinkka
2005	The core shipper concept: a proactive strategy for motor freight carriers.	Dobie
2005	Logistics managers' stated preferences for freight service attributes.	Danielis, Marcucci and Rotaris
2003	A Simultaneous SP/RP Analysis of Modal Choice in Freight Transport in the Region Nord – Pas-de-Calais.	Vellay and de Jong
2002	Motor carrier selection criteria: perceptual differences between shippers and motor carriers.	Premaux
2002	Modelling port/ferry choice in RoRo freight transportation.	Mangan, Lalwani and Gardner
2002	Freight mode choice and adaptive stated preferences.	Shinghal and Fowkes
2001	Identifying Relevant Variables and Modelling the Choice Process in Freight Transportation.	Mangan, Lalwani and Gardner
2000	Time Valuation in Freight Transport: Methods and Results.	de Jong, Gommers and Klooster
2000	The competitiveness of the river-sea transport system: market perspectives on the United Kingdom-Germany corridor.	Konings and Ludema
2000	Identifying influential attributes in freight route/mode choice decisions: a content analysis.	Cullinane and Toy
2000	Performance Perceptions, Satisfaction, and Intention: The Intermodal Shipper's Perspective.	Evers and Johnson
1999	International containership carrier selection criteria.	Kent and Parker
1999	Modelling Freight Transport Costs: A Case Study of the UK-Greece Corridor.	Beresford
1997	Carrier selection: do shippers and carriers agree, or not?	Murphy, Daley and Hall
1997	A longitudinal assessment of motor carrier-shipper relationship trends, 1990 vs. 1996.	Crum and Allen
1993	Time-based strategy and carrier selection.	Murphy and Farris
1993	Factors Influencing Freight Service Choice for Shippers and Freight Suppliers.	Matear and Gray
1992	Carrier Selection in a RO/RO ferry trade. Part 2: Conceptual framework for the decision process.	D'Este
1992	Carrier Selection in a RO/RO ferry trade. Part 1: Decision factors and attitudes.	D'Este and Meyrick
1991	Motor carrier selection criteria: Perceptual differences between shippers and carriers.	Abshire and Premeaux
1989	Motor carrier selection in a deregulated environment.	Bardi, Bagchi and Raghunathan
1989	A comparative evaluation of freight transportation choice models.	McGinnis
1988	Freight forwarders speak: the perception of route competition via seaports in the European Communities Research Project – Part 2.	Bird
1986	Elements of Port Operation and Management.	Branch
1979	Shipper Attitudes Towards Freight Transportation Choice: A Factor Analytical Study.	McGinnis

Source: Own.

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From these papers an extensive list of potential criteria were identified. All of the terms found in these papers, along with contributions made by representatives of industry, were compiled in to a list.

B. Group similar criteria together under individual headings (Step Two)

In step one of this process, consultation with industry, in conjunction with a review of thirty six selected papers, was used to construct a list of terms typically identified as influencing the modal choice decision making process. A wide variety of terms to identify individual criterion have been used in previous modal choice decision making studies. The terms used in this work are a combination of those which are most commonly encountered in the research literature and those which are currently in use in the freight industry.

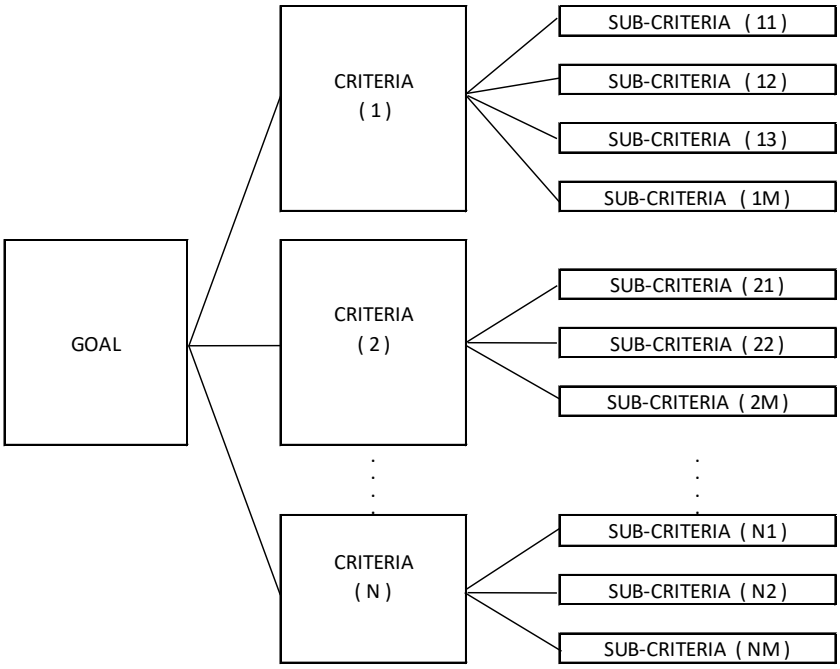

Figure. 1 Example of a general hierarchical framework. Source: Riahi (2010).

To produce a more easily manageable framework it was necessary to group these terms together. Previous research (D'Este and Meyrick, 1992) has demonstrated that the grouping of factors which influence modal choice into broad categories is feasible. Each term was gathered together with other similar terms and then these collections were issued with a heading that reflected the nature of the group. Each of the individual headings (criteria) under which the similar factors (sub-criteria) were grouped was also given a relevant title.

C. Construct a modal choice decision making framework (Step Three)

The hierarchical structure constructed to represent the modal choice decision making process is divided into three levels. These are: Goal, Criteria, and Sub-Criteria (Fig.1). The Goal in this paper is to study the modal choice decision making process between road, rail and water in the Atlantic Gateway of North West England. The criteria are the titles that were allocated in step two to describe the similar sub-criteria grouped beneath them. The sub-criteria are the factors that were identified, through discussions with industry and review of relevant literature, as having a role to play in the decision making process.

Utilising the established criteria headings a concise framework was generated with the purpose of modelling the modal choice decision making process occurring in the Atlantic Gateway of North West England.

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II. RESULTS

The purpose of this paper is not to produce a data set but instead to generate a framework for modelling the modal choice decision making process in North West England's Atlantic Gateway. With this being the case there are no practical results to be displayed. The framework itself (Fig.2) constitutes the results.

In this paper the main criteria of the framework serve as umbrella categories whose purpose it is to allow various sub-criteria to be united under a single heading. The criteria selected to meet this objective are:

A. Service – Under which the sub-criteria that affect the perceived quality of the available transport are grouped.
B. Route – Under which the sub-criteria that identify the characteristics of a chosen route are grouped.
C. Carrier – Under which the sub-criteria that determine the procedural effectiveness of the company providing the transport service are grouped.
D. Shipper – Under which the sub-criteria that influence the person making the freight transport decision as they operate within their own organisation.

In this paper the sub-criteria selected to populate each of the main criteria groups of the framework are:

A1. Administration – The timeliness, efficiency, and accuracy of the administrative processes involved with moving a shipment from its origin to its destination.
A2. Cost – The total cost of moving a shipment from its origin to its destination.
A3. Delays – The punctual arrival of shipments at their destination.
A4. Traceability – The real time tracking of cargo after it has been dispatched.
A5. Controllability – The ability to control a shipment after it has been dispatched.
A6. Value Added Services – The ancillary service options offered to compliment the core service. These are something extra that is typically provided at no additional charge.
B1. Transit Time – The time taken to move a shipment from its origin to its destination.
B2. Frequency – The number of journeys carried out by a transport mode between a shipment's origin and destination over a given period of time.
B3. Distance – The distance travelled by a shipment from its origin to its destination.
B4. Capability – The physical facilities and processes available to meet the needs of the shipper.
B5. External Impacts – The pollution and other externalities resulting from the movement of a shipment from its origin to its destination.
B6. Security – The security of the supply chain between the shipments origin and destination.
C1. Finances – The size of the carrier company and its financial stability as perceived by its users.
C2. Damage/Loss – The carrier's history of shipment loss and damage.
C3. Claims Processing – The ease by which the carrier finalises settlements to cover loss, damage, over charge, or other complaints.
C4. Flexibility – The ability of the carrier to accommodate the varying requirements imposed upon them by customers.
C5. Certification – The management systems that are in place within the carrier organisation and which are recognised by ISO (or equivalent) awards.
C6. Safety Record – The carrier's history of injuries, fires, fatalities, collisions, groundings, and any other accidents resulting from the transportation of shipments between their origin and destination.
C7. Image of Mode – The public image of the transport mode most commonly associated with the carrier.
D1. Market Considerations – What is going on in the shippers chosen market? The market factors that influence the decision maker from outside the shipper's organisation.
D2. Location – The position of the shipper with regards to freight transport infrastructure and the level of access that this offers to each mode.

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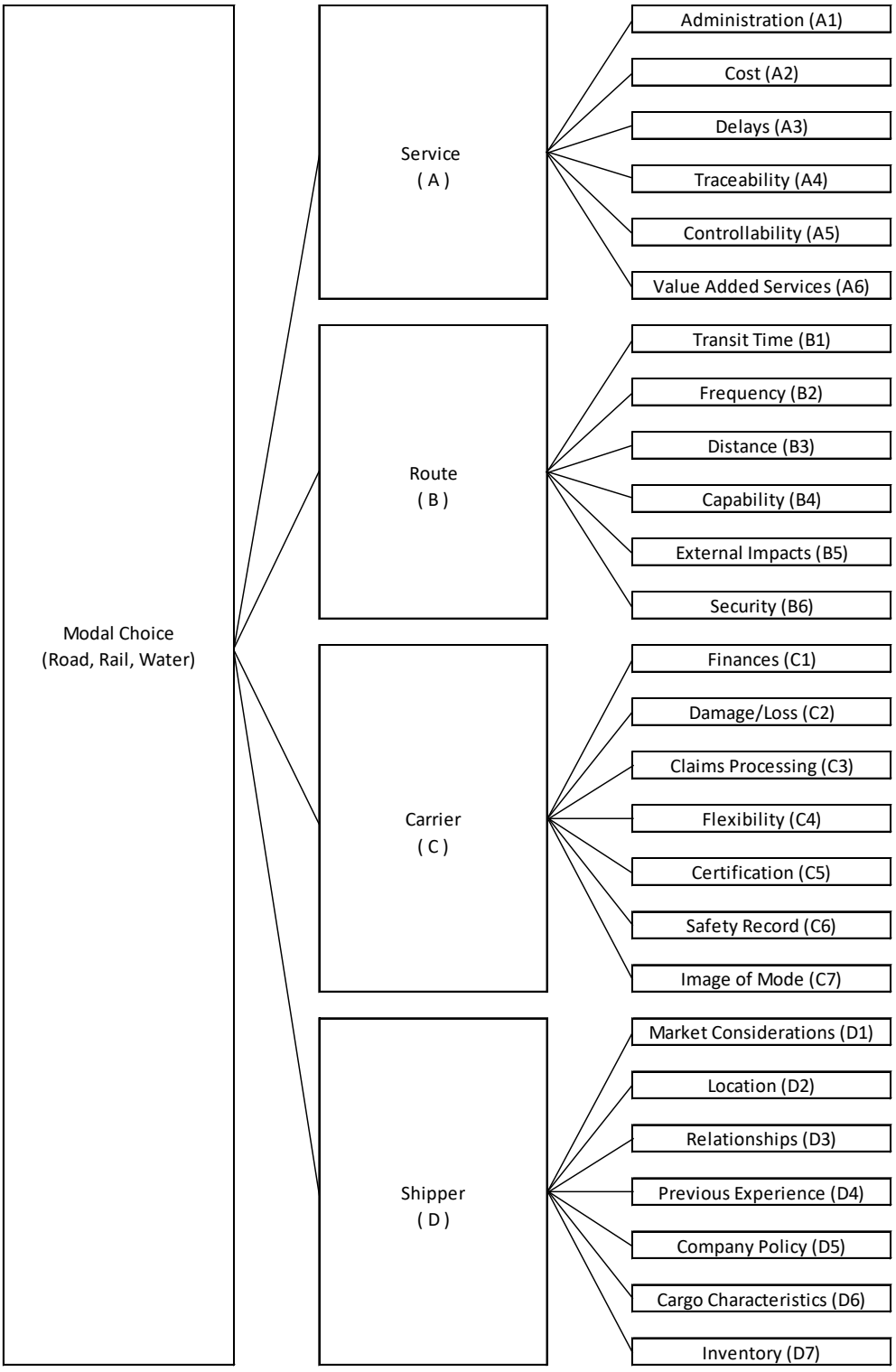

Figure 2. Framework for modelling the modal choice decision making process.

D3. Relationships – The condition of existing relationships that the shipper has with its existing (but also potential) suppliers, carrier companies, and customers.
D4. Previous Experience – The shipper's level of satisfaction with the outcome of previous cargo shipments.
D5. Company Policy – The company policies that influence the decision maker internally within the shipper's organisation.

D6. Cargo Characteristics – The nature of the cargo being transported. Is it hazardous, perishable, out of gauge, or likely to contaminate other cargoes?
D7. Inventory – The inventory levels held by the shipper. Is the shippers supply chain push or pull focused?

IV. CONCLUSION AND RECOMMENDATION

A significant body of research aimed at identifying the factors that influence modal choice already exists. How these factors combine to reflect the modal choice decision making process that occurs in the mind of the decision maker has been covered to a lesser extent. The review of relevant literature that was undertaken for the purpose of generating the framework produced in this paper demonstrates that it is possible to construct a hierarchical framework of the modal choice decision making process occurring within the geographical area of the Atlantic Gateway. The prospect of producing a generic model of the modal choice decision making process is a much more challenging one. Modal choice is strongly influenced by the infrastructure limitations and geographical constraints of the location in which the decision is being made.

The next phase of research in to modal choice in the Atlantic Gateway will be to collect data for each of the criteria and sub-criteria that make up the framework in this paper. When expert opinion can be utilized to apply weights to each of them it will be possible to identify those that make up the majority of the weight in the decision making process. The next phase of work on this topic will identify the weight of each of the criteria and sub-criteria by using the Analytic Hierarchy Process (AHP).

With the relevant weights, best and worst solutions identified it would then be prudent for any future modal share policies devised to influence the decision makers of the Atlantic Gateway to use this information as there centre piece. For instance, policies could be developed where a combination of the most heavily weighted factors (identified through AHP) could be utilized in an attempt to make the less popular modes of freight transportation (identified through TOPSIS) more acceptable alternatives to North West England's logistics industry.

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