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Analyzing labor cost drivers in the Belgian inland navigation sector

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Abstract

The cost of inland waterway transport is subject to various factors, such as the ship type, with regard to the type of cargo carried, the dimensions of the vessel or convoy, or the tonnage capacity of the ship or convoy operating on a waterway. Different cost components need to be taken into account by inland shipping businesses in their decision-making processes, on aspects such as the self-employment of the ship owner, or the salaries paid. Similar to other transport modes, the costs of inland navigation can be divided into fixed and variable components. While the costs of fuel change depending on the distance of the shipping activity, and are thus considered variable, capital and labor costs are considered to be largely fixed, changing with time rather than distance.

The amount of labor costs depends on minimum wage regulations, or standard tariffs, established in the industry, as well as on regulations governing the minimum number and composition of the crew. Other major factors affecting labor costs include the type of operation, concerning the number of sailing hours per day, as well as the equipment standard of the ship, depending on a range of different technical parameters. The different drivers of labor costs in inland waterway transport are discussed in this research paper, based on data applicable to shipping operations in the Rhine corridor and Belgium.

After a review of literature and applications on cost modeling in inland navigation, a new cost simulation model, currently in development for the sector, is introduced. Its basic functionality is presented, before the computations of its labor cost module are explained in detail.

The model makes use of pre-defined, up-to-date values for minimum salaries and compensations, and includes a number of differently-sized ship classes and convoy formations as input parameters. As a first application, it is used to analyze how changes to a number of key parameters affect the labor cost of convoy operations on inland waterways. Each convoy formation is defined by different manning requirements, which specify the number and composition of the crew, based on different professions required aboard. The analysis particularly focuses on cost reductions through the self-employment of ship owners as members of the crew. Systems and strategic analyses are used to determine the degree to which costs can be saved through different approaches to self-employment. The analysis reveals that labor costs can be noticeably reduced through the self-employment of ship owners as boatmasters in the case of small convoy formations. With increasing dimensions of the convoy, however, the savings through self-employment compared to operations with a completely hired crew, decrease continuously. Moreover, the work required for entrepreneurial activity is likely to prevent owners of large fleets from sailing as crew members.

Keywords: Inland waterway transport; cost simulation model; labor cost

Nomenclature	
Barge	Ship without own propulsion, usually pushed by a towboat
Boatmaster	Another term for a ship's captain
Convoy	Push-tow or coupled train
Coupled train	Formation of a number of ships consisting of a self-propelled vessel and one or more barges
Push-tow	Formation of a number of ships consisting of a towboat and barges
Towboat	Also referred to as pushboat, small-sized ship pushing one or more barges
Vessel	Ship, in this paper mostly referring to inland waterway ships with an own propulsion

1. Introduction

Along with rail transportation, inland navigation is generally considered an alternative mode for transporting freight of low value over long distances of intracontinental movement. In contrast to products of higher value, for which transportation costs only account for a small fraction of their landed cost, the cost of transport is an important criterion for moving low-value freight (Blauwens, De Baere, & Van de Voorde, 2010). This type of freight is characterized by a high transportation cost relative to its value, i.e. its price at the market place. As such, it is essential for low-value products to have inexpensive distribution systems. (Rushton, Croucher, & Baker, 2010). Accordingly, the composition of goods transported by inland ships is also largely defined by liquid and dry bulk freight (see, for instance, PBV, 2015).

Thanks to their high capacity, inland ships are usually considered a low-cost alternative to other transport modes (NAIADES, 2015). The capacity of an individual inland vessel, however, can vary between 250 and around 4,000 tons (Beelen, 2011). Convoys can transport up to 27,000 tons on selected waterways in Europe. The maximum capacity allowed per ship or convoy sailing on a waterway depends on the length, beam, draft, and height of the vessel units in relation to the dimensions of the river or canal (ECMT, 1992).

More than 41,000 km of canals, rivers, and lakes were navigable in the EU-28 in 2012. Waterways in Germany (more than 7,700 km), The Netherlands (ca. 6,100 km), and France (roughly 5,000 km) together account for about 45% of the total length. Belgium also benefits from a dense network of waterways (more than 1,500 km in total), in relation to its area. (EC, 2014). Aside from larger rivers and canals, such as the Rhine or the Albert Canal, small waterways are also relevant for transport, particularly in Belgium and The Netherlands. Small rivers and canals cover a large region in the Flemish hinterland of the port of Antwerp, and in the Dutch hinterland of the ports of Rotterdam and Amsterdam (van Hassel, 2011). Most of the newly added capacity to the inland navigation sector, however, consists of larger vessels, incapable of navigating these small waterways. While the total loading capacity of all inland ships with a length of up to 55m has been on the decline since 1965, large vessels (more than 86m in length) have steadily increased in tonnage (Van Hassel, Vanelslender, & Sys, 2015; Vereniging 'De Binnenvaart', 2014). The average capacity of a dry cargo vessel now amounts to 1,551 tons, whereas a tanker vessel can carry up to 1,919 tons on average in Belgium (PBV, 2015).

The deployment of newly purchased, mostly large, ships, which concentrates on major waterways, has resulted in a surplus of capacity compared to actual demand levels, in both the dry cargo and bulk liquid markets. As such, it has caused intense price competition, with decreasing freight rates, mostly on major routes, and an underutilization of smaller waterways (Van Hassel, Vanelslender, & Sys, 2015). Dutch, Belgian, and French inland navigation businesses have been experiencing low freight rates since the financial crisis of 2008 and the economic recession it caused (Lendjel & Fischman, 2010).

Different measures have been proposed, according to which the sector could achieve sustainable profitability. Strategies for both free and regulated markets have been considered.

By maintaining the current strategy of a free market without government intervention, a possible solution could imply the foundation of large co-operatives, which would manage operational aspects as well as capacity adjustments. Although such co-operatives already exist, they mostly include owners of small vessels only. Co-operatives between owners of large inland ships are yet to be established (Van Hassel, Vanelslander, & Sys, 2015). Online freight exchanges are another option considered. These would need to be open to all parties engaged in inland waterway transport. This approach would likely reduce transaction costs associated with the acquisition of freight to be shipped. It would, moreover, enhance the integration of inland navigation in the logistics chain, and could also serve as a platform for open dialogue between shippers and carriers (Lendjel & Fischman, 2010).

In a regulated market, Europe-wide legislation would be required. A proposed option could then be a system under which available cargo would be distributed equally among the different ship owners. Such a regulation, however, would likely oppose liberalization strategies adopted by the E.U. in the past decade (Van Hassel, Vanelslander, & Sys, 2015). With the exception of transportation along the Rhine river, the inland navigation sector used to be regulated in The Netherlands, Belgium, and France until the early 2000s, under systems of chartering by rotation, known as ‘toerbeurtsysteem’ or ‘tour de rôle’ (Official Journal of the European Communities, 1996; Beelen, 2011). Another option in a regulated market could be the implementation of an old-for-new capacity mechanism. Under such a rule, the newly added capacity would need to approximate the level of capacity scrapped, taking into account the business cycle of the sector. The implementation of such a regulation would likely imply significant challenges, however, due to the required harmonization among the national legislations in European countries (Van Hassel, Vanelslander, & Sys, 2015).

A different measure has recently been put forth in Belgium, as per Royal Decree of November 7, 2013. According to this regulation, it will be no longer allowed to offer inland shipping services at prices below the cost of the service in Belgium (Belgisch Staatsblad, 2013). Since this rule will initially apply to Belgian waterways only, however, its effects on Belgium’s inland waterway fleet, and on other fleets operating in the Rhine corridor, are yet to be observed. Similarly, the implementation of this regulation requires accurate knowledge of the costs of inland navigation services, creating the need for a cost-calculation tool to be utilized by the sector. Such a tool, also proposed by Lendjel & Fischman (2010) for the French inland waterway transport sector, would need to provide insights into the costs associated per trip. As such, carriers would be better informed and less inclined to set freight rates too low to recover the cost of their service.

This research paper describes the labor cost component of such a tool. The component is part of a wider research project into developing an over-arching instrument to calculate the internal fixed and variable costs of inland waterway transport, as well as the external cost components.

The paper is structured as follows: Section 2 presents a review of literature relevant to inland waterway transport cost models. Subsequently, Section 3 develops the labor cost calculation framework. Finally, Section 4 applies the labor cost module to solve the following question:

To which extent does the self-employment of ship owners affect the labor cost of convoy operations in the inland waterway transport sector?

More than half of the inland vessels registered in Belgium are used by self-employed owner-operators. However, the level of the owners’ self-employment as crew members is generally known to be lower in the case of convoys, compared to single vessels. This is partly for the reason that a push-tow often has a number of co-owners, who consider the ownership to be primarily an investment, often spread over numerous ships (Beelen, 2011). In addition, large-scale operators of push-tows, such as De Grave-Antverpia, operating 6 towboats and 72 barges, are not likely to apply self-employment strategies, due to the entrepreneurial activity associated with managing the fleet and operations (De Grave-Antverpia, 2015).

Nevertheless, self-employment can result in potential cost savings. Additionally, it provides a greater flexibility of managing the cost of labor (Beelen, 2011).

2. Review of existing literature and cost models for inland waterway transport

Generally, the costs of the provision of a transportation service can be divided into time and distance costs. While time costs, often referred to as fixed or standby costs, do not change with the activity of the transport vehicle, distance costs are superimposed on time costs, and only occur in case of actual vehicle activity (Blauwens, De Baere, & Van de Voorde, 2010; PINE, 2004). Labor costs are generally considered to be time costs, and fixed. They are affected by a range of different factors that will be addressed and analyzed in this research paper.

The costs of labor are subject to minimum crew and salary regulations that attribute a minimum number of crew members or salaries, for the personnel aboard, to ship length or tonnage. As such, the dimensions of vessels or convoys operating on inland waterways have an important effect on the cost of the crew. Other important factors for the cost of labor include the type of cargo the vessel can transport, usually distinguishing between dry cargo and liquids, the type of operation, according to the number of operating hours per day, and the equipment standard of the ship or convoy. The opportunity cost of the ship owner's self-employment is another important component of the labor cost (Beelen, 2011).

The costs of inland waterway transport for the providers of the service have been studied and modelled in a limited number of publications. Generally, these can be divided into general cost models, based on collected values, such as averages, relevant for the cost calculation, and specific models, relying only on the user's input.

One example of a general cost model is a calculation tool developed for the Dutch Ministry of Infrastructure and the Environment (Rijkswaterstaat, 2014). This model was developed as a Microsoft Excel application, and is largely based on average values for a range of ship types and classes, collected by Panteia (2014), and frequently updated. A detailed description of the model's calculation is presented in a study by NEA (2009), which preceded the model's development. The model distinguishes among a range of cost components, and provides values for the costs per ton-km and TEU-km. The cost categories considered include depreciation, interest, labor, insurance, repair and maintenance, port tariffs, and other expenses. For the calculation of the costs of labor, the model uses publicly available data, concerning binding regulations in The Netherlands. These govern minimum salaries for different crew members aboard an inland vessel as well as the employers' contributions to their social insurance. Most rules on the minimum size and composition of the crew operating a vessel or convoy, however, are common across the EU.

Although the model by Rijkswaterstaat (2014) considers a wide range of ship types as input parameters, it does not allow for the adjustment of details. For instance, it does not distinguish between ships completely operated by hired crews, and those with self-employed ship owners aboard. Similarly, it does not allow for detailed input relevant for other cost components, such as capital costs. As such, a ship's purchase value or year of acquisition cannot be specified, and the value determined is based on averages from the sector.

Table 1. Classification of self-propelled vessels operating on European inland waterways (own composition, based on Beelen, 2011)

Name of ship class	Spits	Campine	New type campine	Canal du Nord	Dortmunder	Rhine-Herne	Large Rhine vessel	Large container vessel
Length (m)	38.5	50	55	60	80	85	110	135
Beam (m)	5.05	6.6	7.2	5.75	8.2	9.5	11.4	15
Draft (m)	2.2	2.5	2.5	3.2	2.5	2.7	3.5	4
Tonnage (t)	350	600	700	800	1,100	1,500	2,800	4,500

Another recent general cost calculation model for inland navigation, developed by Beelen (2011), considers a similar variety of factors for modelling the internal costs of inland waterway transport, divided into fixed and variable components. Not taking push-tows or coupled trains into account, it simulates costs for eight typical classes of single, self-propelled, inland vessels, as shown in Table 1. Moreover, it distinguishes between dry cargo and tanker ships.

The model considers the costs of capital, labor, insurance, communication, administration, and licenses, as well as overhead costs as fixed. Fuel costs are a major variable cost component, depending on the activity of the ship. Half of the cost of repair and maintenance is estimated to be fixed, whereas the other half depends on the activity of the vessel. To a great degree, the model depends on averages collected from various sources. For the cost of labor, however, it relies on binding regulations for inland navigation businesses in Belgium. This scientific model is used for several case studies, simulating a range of different transportation scenarios.

Other important contributions to calculating the cost of inland navigation have been made by PINE (2004) and PLANCO (2007). Both studies are general cost models, and are based on estimations and average values collected.

PINE (2004) computes the cost for three types of similar-sized, single, self-propelled, vessels (ca. 80 x 9.5 x 2.5 m, and 1,250 tons maximum deadweight capacity), each operated in a different inland waterway corridor, a large Rhine vessel (110 x 11.4 x 3.5 m, 2,850 tons maximum deadweight capacity), and a push-tow, licensed for the Danube corridor. Small inland vessels are not considered. Instead of minimum salaries, annual salary estimations are used to compute the costs of labor.

PLANCO (2007) mostly relies on averages for the calculation of the overall costs for a wide range of inland ships. It considers nine tonnage classes of dry cargo and tanker vessels, in addition to six different tonnage categories of barges and five types of towboats, each with a different engine power. In contrast to PINE (2004), the model does not rely on estimations for the calculation of labor costs, but makes use of tariff standards to determine the crew costs. Other cost categories considered include depreciation and capital, consumption, insurance, and administration.

A software application by Kantoor Binnenvaart (2000) offers another way of calculating the costs of inland waterway transport. The program is based on the user's input for all calculations, and does not rely on any average values or regulatory data. As such, this specific model requires its user to already have quite accurate information on the annual figures for most cost categories. General input values of the tool concern the ship's year of construction and its tonnage capacity. The tool is further divided into separate tools for input relevant to calculate fixed and variable costs. Input parameters for the calculation of fixed costs include the ship's insured value, the interest expense, the depreciation period, the insurance premium, the ship crew's remuneration, maintenance costs, and miscellaneous expenses. The application relies on different input parameters to determine variable costs. These include the cost of commissions, fuel, lubricants, waterway, lock, and port charges, as well as other expenses related to the trip. In addition to input on the number of days of vacation and without service per year, information on the trip is also required. The tool's output values are fixed, variable, and total costs of the trip, total costs per day, and costs per ton transported. Labor costs are calculated through the user's input of the annual cost per crew member, depending on the qualification. Consequently, legal requirements, such as minimum salaries or a ship's manning requirements are not taken into account.

According to the demo shown on its website, the online application Logos (2015) relies on the user's specification of the trip, concerning the points of origin and destination and the distance between them, the average speed, the type and tonnage of the freight transported, and the freight rate per ton, to calculate the revenue per trip and year. The calculation utilizes the user's information on the ship used. In contrast to cost calculation models, the tool focuses on pricing and revenue. It does, however, take cost into account, by indicating the level of profitability of a freight rate specified by the user.

Since Logos (2015) requires a subscription, only available to ship owners with a valid ship registration ID, the tool's functionality cannot be thoroughly assessed in this paper. As such, it remains unclear if or how it calculates labor costs.

Table 2 summarizes the main characteristics of a selection of studies, models, and applications developed for the calculation of the overall cost of inland waterway transport. It also specifically addresses the basic methodology behind the calculation of labor costs.

Table 2. Models and applications to calculate the overall cost of inland waterway transport (own composition)

Source	Year	Main target group	Labor cost: Method of calculation/ estimation	Number of pre-defined ship types
Kantoor Binnenvaart	2000	Inland navigation businesses	Exact calculation based on user input	No pre-defined ship type, calculation for single vessels
PINE	2004	Researchers and policymakers	Consideration of manning requirements, estimation of salaries	Dry cargo ships only, 4 types of single vessels in the range of 1,190-2,850t, push-tow with 6,000t capacity
PLANCO	2007	Researchers and policymakers	Consideration of manning requirements and tariffs on minimum/ standard salaries in the German inland navigation sector	9 types of dry cargo and tanker vessels, ranging from less than 400t to more than 3,000t capacity, six types of barges, ranging from less than 650t to more than 2,500t, five types of towboats, ranging from 300hp to more than 3,500hp
Beelen	2011	Researchers	Consideration of manning requirements and tariffs on minimum/ standard salaries in the Belgian inland navigation sector	8 types of dry cargo and tanker vessels, ranging from 350t to 4,500t of capacity
NEA/ Panteia/ Rijkswaterstaat	2009/2014	Researchers and policymakers, inland navigation businesses	Consideration of manning requirements and tariffs on minimum/ standard salaries in the Dutch inland navigation sector	All ship and convoy types according to a classification by Rijkswaterstaat, four different freight types
Logos	2015	Inland navigation businesses	Unknown, web subscription only open to owners of a ship with a valid number of registration	Unknown

3. The labor cost calculation framework

This paper is part of the development of a model for the calculation of the cost of inland waterway transport in Belgium. The entire model is expected to be converted into a web application, to serve local inland navigation businesses as a tool to determine the cost of their service. It is being developed as a highly customizable application, relying on average and regulatory data, but also allowing the user to adjust a wide range of input parameters. As such, it seeks to combine the advantages of simulation models based on pre-set values and those completely reliant on the user's input. The model can be used for professional and scientific purposes. As such, it is similar in functionality to the model by Beelen (2011). Consequently, it can also be used for case studies.

In contrast to the aforementioned model, however, it does not only rely on averages and regulatory values but also allows the user to specify custom data for most input parameters. It also considers a wider range of input parameters, such as push-tows and coupled trains of different dimensions. All of this is also reflected in the labor cost module presented in this paper.

Figure 1 presents the structure of the entire model currently in development. The labor cost component is the only module considered further in this paper.

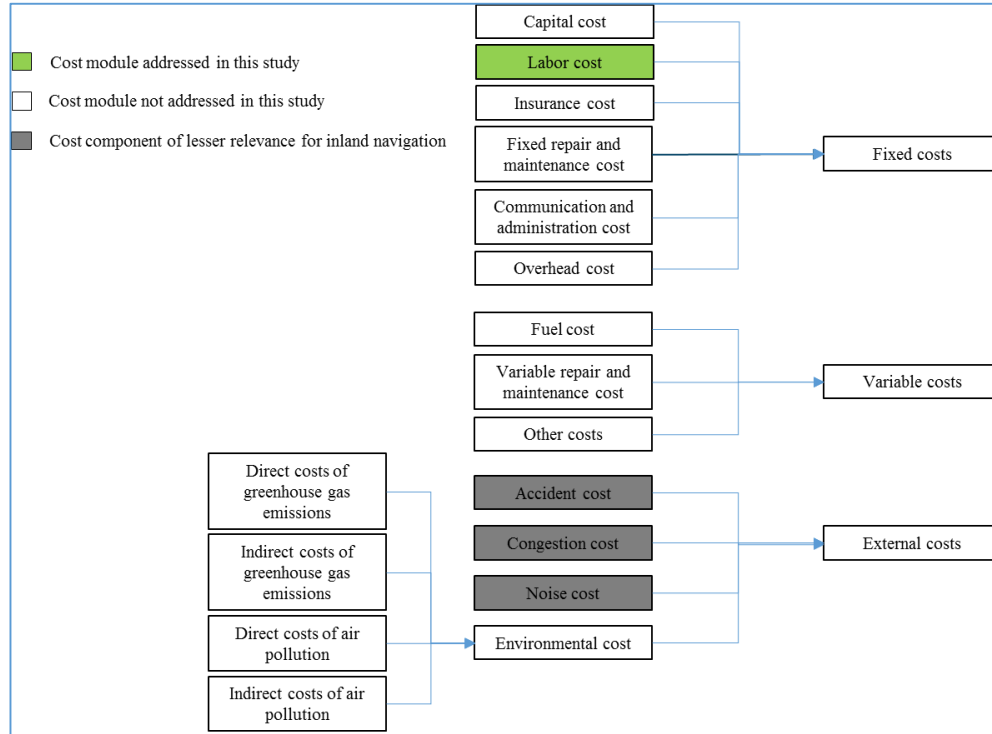


Fig. 1. Structure of the cost-calculation model for the Belgian inland navigation sector

According to the formulae and calculations found in the relevant literature and applications (see, for instance, PINE, 2004), the cost of a crew operating an inland ship mostly depends on regulations governing the minimum size and composition of the crew, required to operate a certain type of vessel, as well as the crew members' salaries, depending on their qualification and function aboard. In addition, the self-employment of a ship owner, usually as a boatmaster, also needs to be taken into account, and valued as an opportunity cost (Beelen, 2011). Equation 1 (based on Beelen, 2011) defines the labor cost of inland waterway transport as follows:

Eq. (1)

$$Clab = LABem * CS_{e,o} + OPPself$$

Where:

$Clab$ = Cost of labor

$LABem$ = Labor cost of employees

CS = Number of crew members per ship/convoy

$OPPself$ = Opportunity cost of self-employed ship owners

e = Type of equipment

o = Type of operations

Different types of equipment and operations can be distinguished among inland waterway transport. Ships sailing on European inland rivers and canals are required to meet either of the two equipment standards, S1 or S2. Moreover, three basic types of operations can be distinguished, A1, A2, and B, each referring to the maximum number of hours allowed for sailing per day. Along with the length of the ship, or dimensions of the convoy, both the types of equipment and operations are major factors used to determine the required number and composition of the crew. The manning requirements were defined by the Central Commission for the Navigation of the Rhine (CCNR), and communicated by the United Nations Economic Commission for Europe (UNECE, 2002).

The standards governing the ship equipment, S1 and S2, allowed for sailing on European waterways, match in most aspects, but are different in a few key areas. They generally concern technical specifications and safety installations. Aside from everything applicable to Standard S1, cargo ships of the standard S2 need to meet a number of additional requirements, for certain specific purposes. An important case concerns sailing alone. As such, Standard S2 is, among other aspects, a prerequisite for ships manned by only one person. For this specific purpose, a ship's bow rudder needs to be controllable from the wheelhouse.

The three standard types of operations in the inland navigation sector are A1, A2, and B, each specifying a different maximum for the hours a ship can sail per day. They are defined as follows:

- A1: maximum of 14 hours of sailing per day
- A2: maximum of 18 hours of sailing per day
- B: sailing allowed for 24 hours per day

The three standard operation types do not only specify the duration a ship can sail per day, but also give an indication of the time the crew is given to rest, which is usually presumed to be at night.

3.1. Rules on minimum crew size

The types of equipment and operations have both been implemented in national legislation on inland waterway transport in European countries (for Belgium, see Belgisch Staatsblad, 2007). Both are relevant for understanding the legislation on the minimum number of crew members, each with a certain qualification, operating an inland vessel or convoy.

The rules governing the crew composition distinguish among the following professions:

- Boatmaster
- Helmsman
- Leading crewman
- Able crewman
- Ordinary crewman
- Engineer or engine minder

Depending on whether a single vessel or a convoy is used for sailing, a different set of rules applies. Along with the types of equipment and operations, the ship length is the decisive factor for the specification of the minimum crew manning a single vessel. More factors are relevant for convoy formations. These concern the length and beam, as well as the number of ships sailing in a formation.

Ships manned by one person only need to fulfill a number of conditions. As such, sailing alone is only possible on dry cargo ships with a length of up to 55m, and on tanker vessels which do not exceed 35m in length. Only ships of the equipment standard S2 can be manned alone. It is also noteworthy that the type of operation needs to be A1 in such cases, with a maximum of 12 hours of sailing per day (Belgisch Staatsblad, 2007).

3.2. *Salary tariffs and social security contributions*

Aside from the number of crew members and their functions aboard a ship, the salaries per person play a crucial role in determining the labor cost of a vessel or convoy. Since the tariffs differ from one country to another, but usually depend on the profession, binding remuneration schemes in Belgium will be used for the description and calculation of labor costs in this research paper (see Appendix A, B, and C).

Different remuneration schemes exist, and the application of each scheme depends on a range of factors. First, the remuneration of a crew of a single vessel is generally based on different standards than those applicable to the salaries of the crew of a convoy formation. The latter can further be divided into convoys with a horsepower of less than 300 in total, and those with more than 300hp. It is, furthermore, noteworthy that crews of single vessels sailing on a continuous basis, according to operations of the type B, are remunerated according to the scheme applicable to the crews of convoys. Moreover, boatmasters of single vessels, sailing in the A1 or A2 regime, receive different salaries, depending on the load carried by their ships, with a distinction being made between dry cargo and tanker freight, and the tonnage capacity of their ships. Crews of convoys and vessels sailing according to the B regime receive additional compensation. A monthly salary top-up is paid for meals on board of the ship, in addition to a food allowance paid per day of operations, in the case of no meals being served for free. Additionally, resting allowance is paid on a monthly basis, with the amount depending on the crew members' marital status (BTB, 2013a & 2013b).

An alternative remuneration scheme exists, referred to as systematic sailing. It is applicable for crews who do not only work on the ship, but live there as well. In these cases, crew members work on an 'on/off'-basis, and have an equal amount of working and resting days on board, resulting in an overall increase of the number of working and resting hours (BTB, 2013c).

For the labor cost calculation, the employer's contribution to the employee's social insurance also needs to be taken into account. This additional cost usually amounts to a percentage of the employee's salary (Beelen, 2011; VBO, 2014).

3.3. *Opportunity costs and social security*

Self-employment of ship owners plays a great role in the inland navigation sector. It is not unlikely that ships with a capacity of up to 2,000 tons are manned by self-employed ship owners and their families, who accept an income well below the regular industry levels. This approach significantly reduces the cost of labor associated with manning a ship (Blauwens, De Baere, & Van de Voorde, 2010).

Cost studies and models take self-employment into account, valuating it as an opportunity cost. The latter can be estimated in different ways. It can, for instance, be considered equal to the wage or salary of an employee, or to a fixed amount for the compensation for entrepreneurship. Beelen (2011) considers both options in a scientific cost model developed for a study on decision-making in the inland navigation sector.

On the one hand, the opportunity cost can be estimated to be equal to the wage or salary of an employee, with the deduction of the contribution to the social security. Mandatory social contributions for self-employed people are usually taken into account, however (MULTIPEN, 2015).

On the other hand, the opportunity cost of self-employment can be considered a fixed profit, gained after taxes. Beelen (2011) estimates the latter value to approximate € 60,000 of annual profit before taxes, based on interviews with the sector. This value is similar to an estimation by PINE (2004), according to which an independent ship owner and his family members, sailing according to the A1 regime, earn between € 50,000 and € 60,000 per year. In contrast to the estimation by Beelen (2011), however, the latter study does not distinguish among the self-employment of one or two persons.

3.4. Ship exploitation

The exploitation of the ship considers the intensity of its use. It is significantly affected by the type of operations, A1, A2, or B. These do not only affect the number of working hours per day, but also the number of effective days, and hours of operations per year (Beelen, 2011). The latter, however, do not equal the number of sailing hours per annum. These are estimated to be at around 43% of the yearly hours of operations for dry cargo ships, and at circa 75% for tanker vessels (NEA, 2003; Panteia, 2014). Since crew costs are considered to be largely fixed, however, they are mostly affected by the number of effective days.

Although the general operation type defines a maximum for the number of effective hours per day, it is not necessarily equal to the actual hours of work. For this reason, Beelen (2011) distinguishes among seven types of operations typical for the inland navigation sector, as shown in Table 3. The table only shows figures related to the calculation of labor costs. As such, the sailing hours per year, and other relevant values for the calculation of distance costs are not presented here, but considered for overall cost-calculation tool.

Table 3. Typical operation types in the inland navigation sector and their implication on ship exploitation (own composition, based on Beelen, 2011)

Operation type	A1 8h	A1 12h	A2 14h	A2 16h	B 14h	B 20h	B 24h
Hours per day	8	12	14	16	14	20	24
Effective days per year	303	303	303	303	340	340	340
Effective hours per year	2,424	3,636	4,242	4,848	4,760	6,800	8,160
Hours overtime per year	-	648	864	1,080	864	-	-
Number of crews	1	1	1	1	1	2	2

3.5. Model functionality and current limitations

A range of input parameters is relevant for the computation of the labor cost of inland waterway transport. Table 4 summarizes the model's input values, additional specifications, computation parameters, and output values.

The salary tariffs included for the calculation of minimum labor costs refer to inland navigation in Belgium. However, tariffs for other countries, such as The Netherlands, Germany, and France can also be implemented, since manning requirements are mostly common across these countries.

Certain functions mentioned in the regulation on crew composition do not match the professions listed in the salary tariff sheets, however. Neither ordinary nor leading crewmen are named as such in the tariff sheets. For this reason, the minimum labor cost calculation considers ordinary crewmen equivalent to 17 year-old and older cabin boys, in the case of inland, Rhine, and tanker sailing, to crewmen under tow and continuous sailing, and to crewmen with less than one year of service, in the case of systematic sailing. Leading crewmen are assumed to be paid the salary of crewmen with more than two years of service under inland, Rhine, and tanker sailing, the salary of crewmen, in the case of tow and continuous sailing, and the salary of crewmen with two to three years of service under systematic sailing. Engine-minders are assumed to be paid according to 1-2 years of experience, in the case of systematic sailing (UNECE, 2002; BTB, 2013a, 2013b, & 2013c).

Since the current model calculates the cost of labor as a time cost, not changing with vessel activity, compensations for certain activities are not considered. These concern the cleaning of barges and tanks, as well as the warming of the load. Special compensation is also attributed to estuary sailing in certain cases (BTB, 2013a & 2013c). For the cost-calculation tool currently in development, these additional components will be considered variable costs, under the category of 'other costs', and will, accordingly, be calculated per trip.

Table 4. Functionality of the labor cost calculation model for the inland navigation sector

Input values	Additional specifications	Computation parameters	Output values
Type of load: Dry cargo or bulk liquid		Boatmaster's salaries for: ➤ Dry cargo ➤ Tanker freight	➤ Crew costs: ➤ Salaries ➤ Social contributions ➤ Overtime payment, incl. social contributions ➤ Compensation: ▪ Food allowance ▪ Meals ▪ Housing ➤ Opportunity costs: Self-employment of: ▪ Ship owner ▪ Ship owner's partner ➤ Fixed profit ➤ Employee's salary and social insurance ➤ Overtime payment, incl. social insurance All cost measures: ▪ Per month ▪ Per year ▪ Per hour of exploitation
Single vessel or convoy		Manning requirements/ composition of crew Salary tariffs for:	
Type vessel/ convoy	➤ 8 vessel types ➤ 6 convoy types	➤ Single vessels ➤ Convoy/ exploitation B	
Ship/ convoy length		➤ Sailing alone: Yes/ no	
Engine power		Convoy/ exploitation B tariffs: ➤ Up to 300hp ➤ 300hp and more	
Ship capacity/ tonnage		Boatmaster's salaries for: ➤ Dry cargo ➤ Tanker freight	
Type of exploitation: ▪ A1 ▪ A2 ▪ B		➤ Manning requirements/ composition of crew	
Type of equipment: ▪ S1 ▪ S2			
Hired or self-employed boatmaster	➤ Self-employed partner: Yes/ no	➤ Self-employment remuneration, deduction of salary otherwise paid for employee from total personnel cost	
Opportunity cost: ▪ Employee salary ▪ Fixed profit per year	➤ Amount of fixed profit per year ➤ Overtime remuneration ➤ Continuous sail compensation		
Systematic sailing: Yes/ no		➤ Salary tariffs for: Systematic sailing	
Sailing alone: Yes/ no		➤ Reduced crew	
Overtime hours paid at overtime wage: Percentage		➤ Adjusted payment of overtime hours	
Adjustment of: ▪ Non-working days ▪ Sailing days ▪ Working hours		➤ Adjustments to exploitation	
Adjustment of: Composition of crew		➤ Adjusted composition of crew	
Adjustment of: Salaries/ compensation	➤ Percentage adjustment ➤ Detailed adjustment per crew member	➤ Adjusted salaries/ compensation	

4. Model application: Labor cost analysis of convoy operations

In a series of analyses, Beelen (2011) studied the most relevant cost components of inland waterway transport for eight types of self-propelled vessels. Changes to total costs were studied with the utilization of a sensitivity analysis, a strategic analysis, and a systems analysis. Relevant parameters of labor costs adjusted in that study included wages, the overtime remuneration of self-employed ship owners, and the type of remuneration for self-employment.

As a first application of the labor cost module, which is part of the new overall model in development, this research paper analyzes the effects of similar parameter changes, on the labor cost of convoy operations. A sensitivity analysis of wages or salaries, however, is not undertaken, for the reason that only labor costs are considered as output, and any percentage change of the basic payment would result in exactly the same change of the total labor costs. Instead of the remuneration for overtime hours of the self-employed, a salary top-up for continuous sailing, self-paid to the ship owner, is taken into account. Table 5 provides an overview of the parameters considered.

Table 5. Model parameters for labor cost analysis

Parameters	Type of analysis
Self-employment of ship owner	Systems
Self-employment of ship owner and partner	Systems
Remuneration entrepreneurship	Systems
Salary top-up for continuous sailing for the self-employed	Strategic

The analyses assume that the smallest class of convoy, specified in the manning requirements (abreast formation with a maximum length of 37m and a maximum beam of 15m, UNECE, 2002), can be powered either by engines with less than 300hp, or by those with more. For the other convoy categories, only a minimum engine power of 300hp is considered. It is, furthermore, assumed that the convoys operate with equipment of the type S2, and sail under a continuous regime of 24 hours per day (B 24h, see Table 3). Most push-tows sail on a continuous basis (Beelen, 2011). Consequently, the analysis utilizes the salary tariffs for tow and continuous sailing (see Appendix B). Table 6 provides an overview of the trajectories considered for the analyses.

Table 6. Trajectories for labor cost analysis of push-tow operations

Number trajectory/ type of convoy	Engine power	Type of equipment	Type of operations
1) Abreast formation with the dimensions $L \leq 37\text{m}$, $B \leq 15\text{m}$	<300hp	S2	B 24h
2) Abreast formation with the dimensions $L \leq 37\text{m}$, $B \leq 15\text{m}$	$\geq 300\text{hp}$	S2	B 24h
3) Abreast formation with the dimensions $37\text{m} < L \leq 86\text{m}$, $B \leq 15\text{m}$	$\geq 300\text{hp}$	S2	B 24h
4) Pusher + 1 barge of $L > 86\text{m}$ or abreast formation with the dimensions $86\text{m} < L \leq 116.5\text{m}$, $B \leq 15\text{m}$	$\geq 300\text{hp}$	S2	B 24h
5) Pusher + 2 barges, self-propelled vessel + 1 barge	$\geq 300\text{hp}$	S2	B 24h
6) Pusher + 3 or 4 barges, self-propelled vessel + 2 or 3 barges	$\geq 300\text{hp}$	S2	B 24h
7) Pusher + more than 4 barges	$\geq 300\text{hp}$	S2	B 24h

The systems analysis studies the effects of the self-employment of the ship owner, and possibly his or her partner. The effects of the decision on the remuneration of self-employment, addressing whether a fixed amount of yearly income should be considered, instead of an opportunity cost, are another part of this analysis. Based on the estimations in the literature studied (see, for instance, PINE, 2004; Beelen, 2011), the fixed amount is assumed to account for about € 60,000 per year, or € 5,000 per month, respectively. In this analysis, it is assumed that only the ship owner is self-employed.

Finally, the strategic analysis examines the effects of the self-remuneration of a monthly salary top-up for continuous sailing. This top-up is assumed to amount to € 500 per month, or € 6,000 per year. Only the ship owner is assumed to be self-employed in this case.

Table 7 presents the results of the analysis. The trajectory numbers refer to the definition of the trajectories in Table 6.

Table 7. Results of the analyses of the labor costs of convoy operations

Number trajectory	Systems analysis: Self-employment of ship owner	Systems analysis: Self-employment of ship owner and partner	Systems analysis: Remuneration entrepreneurship	Strategic analysis: Salary top-up for continuous sailing for the self-employed
1)	-14,16%	-28,32%	19,00%	1,71%
2)	-14,15%	-28,31%	16,37%	1,58%
3)	-14,15%	-28,31%	16,37%	1,58%
4)	-11,30%	-22,60%	12,65%	1,22%
5)	-9,50%	-19,01%	10,43%	1,01%
6)	-8,24%	-16,49%	8,92%	0,86%
7)	-7,28%	-14,55%	7,79%	0,75%

The self-employment of ship owners has different implications for the total annual labor cost of convoy operations, depending on the size of the push-tow or coupled train. With increasing dimensions of the convoy, and the associated increase in the number of crew members, the savings through the self-employment of a ship owner, compared to operations with a hired captain, decrease. About 14% of savings can be achieved through the self-employment of one person sailing on a convoy with a length of up to 86m. For larger convoys, the savings through self-employment decrease significantly, accounting for about 7% for the largest category.

Since the manning requirements foresee at least two boatmasters to be on any vessel or convoy under continuous sailing, the self-employment of both the ship owner and his or her partner results in twice the amount of savings compared to only one self-employed crew member. As such, about 28% of labor costs can be saved in the case of smaller convoys with up to 86m in length, whereas the savings amount to more than 14% for large convoys.

A fixed remuneration of € 60,000 per year, instead of an opportunity cost based on the salary of a hired crew member, results in substantially higher costs of labor. These range from a 19% increase in the case of small convoys to an approximate 8% increase in the case of large ones.

A salary top-up of € 500 per month under continuous sailing for the self-employed results in only marginal changes to the total labor costs. It ranges from less than 1% to almost 2%.

In general, the analysis reveals that self-employment might be an option for a reduction of labor costs in the case of small convoy formations. However, this potential labor cost reduction, usually associated with a reduced entrepreneurial activity of the ship owner, decreases with an increasing size of the convoy.

5. Conclusion

This research paper presents a model to calculate the cost of inland navigation in Belgium and Western Europe. The methodology for the computation of the labor cost of inland waterway transport operations is presented in detail. Subsequently, the different drivers and factors relevant for the labor cost of inland navigation are presented. These include manning requirements for different dimensions of single vessels and convoys, as well as salary tariffs, which differ from one country to another.

Manning requirements specify the number of crew members of a certain profession required on board of a ship or convoy. They do not only depend on the dimensions of the latter, but also on the type of operations, and the type of equipment used for sailing.

Salary tariffs differ from one country to another. In the Belgian inland navigation sector, different tariffs apply, dependent on a range of factors. For instance, different tariffs are applicable for crews of single, self-propelled, vessels, than for those manning a convoy of a number of ships. Similarly, crews sailing under continuous, round-the-clock operations are remunerated in a different way than those sailing for a maximum duration of 12 or 18 hours per day.

As a first application of the cost-calculation model, this research paper examined the effects of various options of the self-employment of the owner on the labor cost of convoy operations. Based on the analysis conducted, it can be concluded that the labor cost of small-sized convoys can be significantly reduced, in the case of the ship owner joining the crew as a boatmaster aboard. The self-employment of the owner's partner results in twice the amount of savings. With increasing sizes of the convoy, and the associated increase in the number of crew members, however, the savings through self-employment, compared to operations with a completely hired crew, decline continuously. The analysis also reveals that a fixed amount of compensation for the self-employment likely results in higher costs of labor, compared to those in case of an opportunity cost assumed for the same activity. Finally, it has been found that a salary top-up for continuous sailing on top of the opportunity cost for the self-employed only has a minor effect on the total amount of labor costs.

The cost savings observed through the analysis are likely to be experienced in the case of self-employment on coupled trains. Owner-operations are less common in the case of push-tows, with the majority of these formations being owned by companies operating a great number of barges.

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Appendix A. Salary tariffs in the Belgian inland navigation sector: Wages for inland, Rhine, and tanker sailing

Valid since August 1, 2013

Boatmasters			
	Inland and Rhine navigation	Tank navigation	
	Monthly salary	Monthly salary	
Tonnage			
-750	€ 2.176,72	€ 2.244,51	
750 - 1500	€ 2.444,25	€ 2.557,39	
1500 - 2250	€ 2.497,08	€ 2.591,32	
2250	€ 2.553,58	€ 2.666,66	
Helmsmen on each ship in inland, Rhine and tanker navigation			
	Monthly salary		
With license	€ 1.980,69		
Without license	€ 1.924,12		
Crewmen on each ship in inland, Rhine and tanker navigation			
	Less than two years of service	More than two years of service	
	Monthly salary	Monthly salary	
Crewmen	€ 1.829,79	€ 1.871,34	
Engine-minders	€ 1.863,78	€ 1.905,23	
Cabin boys (holiday work)			
	Less than one year of service	More than one year of service	
	Monthly salary	Monthly salary	
15 year-old	€ 1.298,40	-	
16 year-old	€ 1.452,98	€ 1.513,32	
17 year-old and older	€ 1.607,53	€ 1.679,10	
Minimum monthly income for 21 year-olds (both men and women):		€ 1.701,74	
In the case of the salary for the function aboard being below the minimum level, a 21 year-old shall be paid a monthly salary of:		€ 1.701,74	
The working hours are spread over the first five days at a rate of 8 hours per day.			
To determine the salary per day, the monthly salary is divided through 8/173,33.			
To determine the wage per hour, the monthly salary is divided through 173,33.			
To determine the wage per hour of overtime, the monthly salary is divided through 164,67 and multiplied by 150% or 200%.			
Compensation			
Cleaning of tanks	Per hour per man	Estuary sail	Per month
Gasoline & cement	€ 5,77	Boatmaster	€ 411,42
Diesel fuel & chemicals	€ 7,26	Helmsman	€ 296,05
Heavy oil	€ 7,62	Engine-minder	€ 238,39
		Crewman	€ 180,75
Warming of load	Lump sum		
Summer months	€ 53,86	Radar ticket	€ 43,45
Winter months	€ 63,47		

(translated from Dutch, BTB, 2013a)

Appendix B. Salary tariffs in the Belgian inland navigation sector: Wages for tow and continuous sailing

Valid since August 1, 2013

For ships and formations with an engine power up to 300hp			
Function	Salary	Crew surcharge	Meal surcharge
Boatmaster	€ 2.523,42	€ 265,31	€ 98,03
1 st helmsman	€ 2.323,65	€ 253,76	€ 89,61
2 nd helmsman	€ 2.206,77	€ 223,02	€ 84,99
Engine-minder	€ 2.180,40	€ 211,44	€ 80,77
Crewman	€ 2.093,71	€ 199,94	€ 76,91
Housing compensation			
For married crew members:	€ 188,38		
For unmarried crew members:	€ 138,40		
Food compensation			
€ 15,18	Per day, for boatmasters, helmsmen, engine-minders, and crewmen		
€ 7,65	From the beginning of the fourth hour of overtime, on top of the daily shift (only for deck-hands and assisting deck-hands)		
Compensation for cleaning of barges per man and per hour:			€ 0,13
Compensation for cleaning of tanks per man and per tank:			€ 16,97
Compensation for unloading of freight off the ship, per shift:			€ 4,08
To determine the wage per hour, the monthly salary + the crew surcharge are divided through 173,33.			
To determine the daily salary, the monthly salary + the crew surcharge are divided through 173,33*8.			
To determine the wage per hour of overtime, the monthly salary + the crew surcharge are divided through 164,67 and multiplied by 150% or 200%.			

For ships and formations with an engine power of 300hp and more			
Function	Salary	Crew surcharge	Meal surcharge
Boatmaster	€ 2.760,86	€ 292,24	€ 107,68
1 st helmsman	€ 2.538,48	€ 265,30	€ 99,26
2 nd helmsman	€ 2.410,38	€ 248,03	€ 93,86
Engine-minder	€ 2.372,59	€ 234,54	€ 88,82
Crewman	€ 2.274,61	€ 221,09	€ 83,38
Deck-hand	€ 2.387,70	€ 228,74	
Assisting deck-hand, more than 18 years old	€ 2.255,79	€ 213,40	
Assisting deck-hand, 18 years old or younger, with more than one year of service	€ 1.980,68	€ 182,68	
Assisting deck-hand, 18 years old or younger, with less than one year of service	€ 1.796,01	€ 163,42	
Housing compensation			
For married crew members:	€ 188,38		
For unmarried crew members:	€ 138,40		
Food compensation			
€ 15,18	Per day, for boatmasters, helmsmen, engine-minders, and crewmen		
€ 7,64	From the beginning of the fourth hour of overtime, on top of the daily shift (only for deck-hands and assisting deck-hands)		
Compensation for cleaning of barges per man and per hour:			€ 0,13
Compensation for cleaning of tanks per man and per tank:			€ 16,97
Compensation for unloading of freight off the ship, per shift:			€ 4,08
To determine the wage per hour, the monthly salary + the crew surcharge are divided through 173,33.			
To determine the daily salary, the monthly salary + the crew surcharge are divided through 173,33*8.			
To determine the wage per hour of overtime, the monthly salary + the crew surcharge are divided through 164,67 and multiplied by 150% or 200%.			

(translated from Dutch, BTB, 2013b)

Appendix C. Salary tariffs in the Belgian inland navigation sector: Wages for systematic sailing (1 on/1 off)

Valid since August 1, 2013

	Monthly salary	Surcharge of 18.5%	Monthly salary incl. surcharge of 18.5%	Yearly salary (11 months paid by employer)	Gross-weighted monthly salary, 12 months per year
Boatmaster on each ship under systematic sailing (1 on/ 1 off)	€ 2.666,66	€ 493,33	€ 3.159,99	€ 34.759,91	€ 2.896,66
Helmsmen on each ship under systematic sailing (1 on/ 1 off)					
With license	€ 2.269,37	€ 419,83	€ 2.689,20	€ 29.581,24	€ 2.465,10
Without license	€ 2.009,27	€ 371,71	€ 2.380,98	€ 26.190,83	€ 2.182,57
Crewmen on each ship under systematic sailing (1 on/ 1 off)					
Crewmen					
Less than 1 year of experience	€ 1.905,23	€ 352,47	€ 2.257,70	€ 24.834,67	€ 2.069,56
1-2 years of experience	€ 1.957,25	€ 362,09	€ 2.319,34	€ 25.512,75	€ 2.126,06
2-3 years of experience	€ 2.009,27	€ 371,71	€ 2.380,98	€ 26.190,83	€ 2.182,57
3-4 years of experience	€ 2.061,29	€ 381,34	€ 2.442,63	€ 26.868,92	€ 2.239,08
Engine-minders					
Less than 1 year of experience	€ 2.021,35	€ 373,95	€ 2.395,30	€ 26.348,30	€ 2.195,69
1-2 years of experience	€ 2.074,41	€ 383,77	€ 2.458,18	€ 27.039,93	€ 2.253,33
2-3 years of experience	€ 2.127,48	€ 393,58	€ 2.521,06	€ 27.731,70	€ 2.310,98
3-4 years of experience	€ 2.180,54	€ 403,40	€ 2.583,94	€ 28.423,34	€ 2.368,61
Minimum monthly income					
For 21 year-olds	€ 1.905,23	€ 352,47	€ 2.257,70	€ 24.834,67	€ 2.069,56
In the case of the salary for the function aboard being below the minimum level, a 21 year-old shall be paid the minimum income.					
To determine the salary per day, the gross-weighted monthly salary is divided through 164,67 * 6,33.					
To determine the wage per hour, the gross-weighted monthly salary is divided through 164,67.					
To determine the wage per hour of overtime (150% and 200%), the gross-weighted monthly salary is divided through 164,67 and multiplied by 150% or 200%.					
<u>Cleaning of tanks</u>			<u>Per hour per man</u>	<u>Estuary sail</u>	<u>Per month</u>
Gasoline & cement			€ 5,76	Boatmaster	€ 411,42
Diesel fuel & chemicals			€ 7,26	Helmsman	€ 296,06
Heavy oil			€ 7,62	Engine-minder	€ 238,38
				Crewman	€ 180,75
<u>Warming of load</u>			<u>Lump sum</u>		
Summer months			€ 53,86	<u>Radar ticket</u>	€ 43,45
Winter months			€ 63,46		

(translated from Dutch, BTB, 2013c)