DEPENDABILITY OF THE TIME OF THE DELIVERY PROCESS ON THE LAST 100 METERS IN THE CITY CENTER FROM THE ENERGY EXPENDITURE OF THE SUPPLIER

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Abstract

This article presents a proposition of classification of work of the supplies in the time of the delivery process at the last 100 meters in the city center. Based on fieldwork with 900 points is has been shown how the energy expenditure of supplier depends on the technology used to unload and the movement of goods to the customer. This article presents a proposition for creation of the computer software to calculate the energy expenditure of the supplier.

Keywords: City logistics, delivery process, energy expenditure, ergonomic

1. INTRODUCTION

Energy expenditure of work of the supplier under of the time of delivery is strongly connected with the technology used for unloading and the movement of goods to the customer.

Based on the fieldwork with 900 points it has been shown in the previous research of the change of the actual total time of delivery, depending on the technology used for the unloading and movement of goods to the customer [10].

2. AREA OF INTEREST

The energy expenditure of human labor is very important for the planning of the work of the delivery of goods in the city center. The fatigue of suppliers has influenced the total costs of reliability of the delivery process in the city center. The cost of reliability of delivery is commonly analyzed based on reliability strategies [1], usage of the LCC method (Life Cost Cycle) [2], or analysis of the costs.

The reliability of the delivery in the city center is linked with the reduction of the unloading time by using the technical solution for the handling of the materials. The reliability of the delivery we can describe thus uses the formula 7 R, which is well known in the area the logistics [3]:

a) right product,
b) right quantity,
c) right condition,
d) right place,
e) right customer,
f) right price.
g) right time.

Reliability is the right time when we expect the ordered cargo from the supplier. In area of interest of the city logistics is very often described of the terminology of the delivery. The delivery process is the last phase of the supply chain - from the last warehouse to the recipient. Here due to the difficult conditions for the delivery vehicle, problems with stopping and the obstacles with the accessing time to the city center [10] exist. The urban goods movement (UGM) that is integrated with modeling of the effort needs to address issues

associated with congestion and the air quality with respect to the interaction of the urban structure to land transport [16]. Goods movement is the last phase of the delivery process in the city center (**Figure 1**).

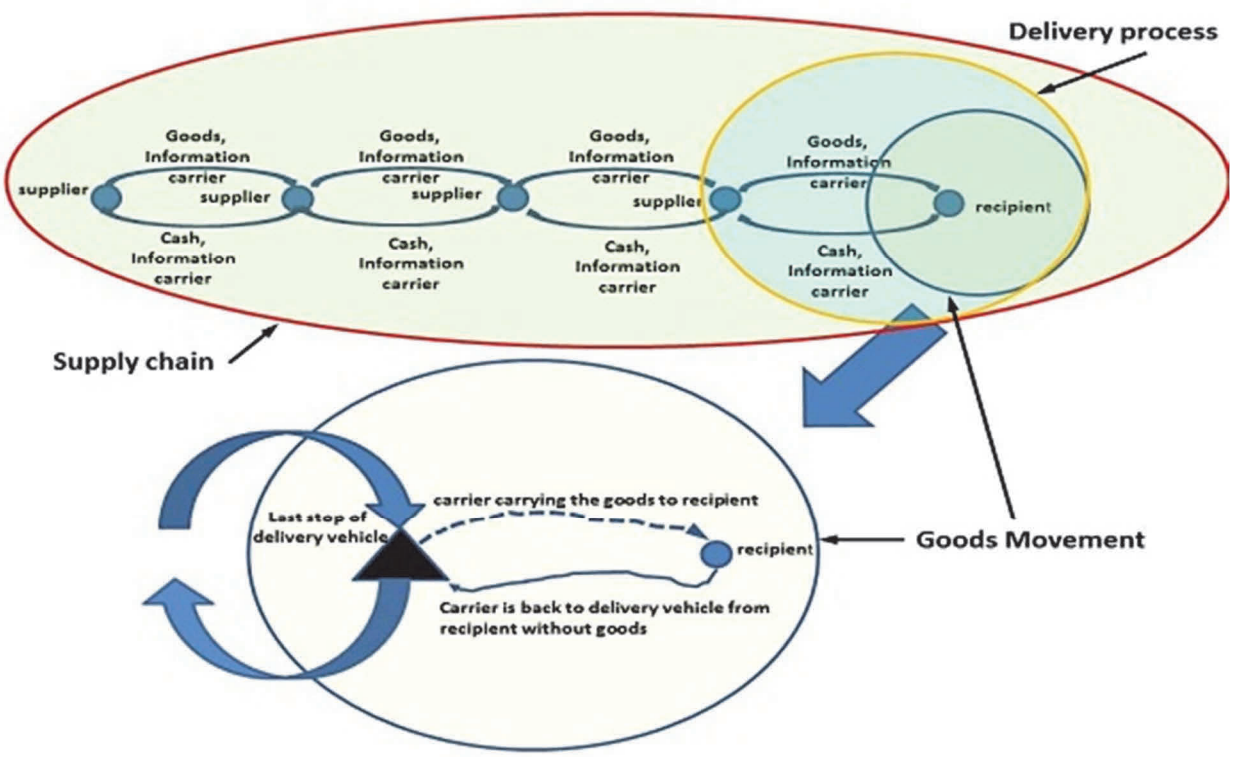

Figure 1 Place of the movement of goods in the supply chain and delivery process (own work).

3. DEFINITION OF THE PROBLEM

It indicates how technology is used and the method of unloading the goods to the customer movement affects the energy expenditure of supplies in the city center. This limits the reliability of the time of delivery. This model shows the relationship between the proportion of the time for unloading goods to the energy expenditure of the supplier. This has an influence on the condition of the supplier, who may be tired if his energy expenditure during the time of delivery is more than the legal regulations. The tired person may work slower and, as a result, we may obtain a delay of ordered cargo for the customer. The proposed methodology allows for delivery managers in the city center to calculate the profit or loss of money and time, through the introduction of appropriate technology for the delivery of supplies in the city center. It was pointed out that with the appropriate preparation of the ordered consignment, a few minutes at unloading and delivery to the customer can be saved as well as good protection of the health conditions of the supplier.

Additional care must be taken when inserting the formula, figures and tables. The following paragraphs directly quote excerpts from [4].

4. CONDITIONS THAT DETERMINE DELIVERY TIME TO THE CUSTOMER

We take into account the former example of delivery cargo for 8 customers with change of the cases of the delivery process. The main elements that determine the total time of delivery are [11]:

a) Vehicle type Rs:

- Maximum payload / tare weight limit,

- Whether it has a floor equal on the entire width and length; this affects whether a EUR pallet without unloading of goods can be used; if you need the goods spread out on the vehicle,

b) Vehicle equipment Ws:

- Is equipped with racks as in the warehouse inside the cargo space; if the racks for the goods before delivery must be extended; if not, the goods can be loaded directly onto pallets as long as the floor is equal on the entire width and length
- Is equipped with a self-unloading device, lift gate or HDS crane,

c) The equipment of the driver for unloading Wkpsr auxiliary equipment, trolley with two or four wheels, etc.

d) The actual conditions of traveling to collect goods Fwrd:

- Whether a dealer has his own place for the supply of goods,
- If access to the site for delivery of goods is always ensured,
- Whether the place of delivery for goods is not occupied by other vehicles,
- Does trading allow the use of the pallets, i.e. whether its door openings are not too narrow for passing pallets 800mm wide.

e) Equipment of the recipient with the auxiliary unloading equipment, trolley with two or four wheels, etc. Wopsr

f) The size of the portion of the delivery Wd.

Therefore, the delivery time to do so can be saved, depending on the aforementioned variables:

$$Td\{Rs, Ws, Wkpsr, Fwrd, Wopsr, Wd\} \quad (1)$$

Consider a hypothetical delivery of goods with a total mass of 250 kg [13].

Case 1 - We assume that delivery truck gets a load in the form of packaging arranged in packets orders for each recipient. The delivery vehicle does not have a smooth floor of the load box over the entire width and length (**Figure 2**). The supplier uses only his hands for the entire process.

Figure 2 Delivery truck equipment with a lift gate with packages of cargo on pallets for each recipient (Own work).

Case 2 - Loading is done in the warehouse, and pallets are loads of packages in the form of homogeneous cargo so that the same type of goods are on each pallet (**Figure 3**); the supplier shall for realization of the complete of the delivery process of consecutively with each pallet individually. The supplier uses only his hands for the entire process.

Case 3 - Loading is done in the warehouse, and pallets are loads of packages in the form of homogeneous cargo that on each pallet there are the same type of goods; the supplier realizing the supply uses a platform hand truck with a capacity of 150kg (**Figure 4**).

Figure 3 View of load box overloaded delivery vehicle with homogeneous cargo without the lift gate [14].

Figure 4 Delivery vehicle with hand truck on a street in Wroclaw (Own work)

Case 4 - Loading is done in the warehouse, and on pallets - i.e., each pallet is placed in packets for successive orders; the carrier realizing supply uses a mechanical device for self-unloading and a hand fork truck for pallets, self-propelled or not. The carrier does not wait for unloading pallets. The recipient and store owner participate actively in the implementation of delivery (**Figure 5**).

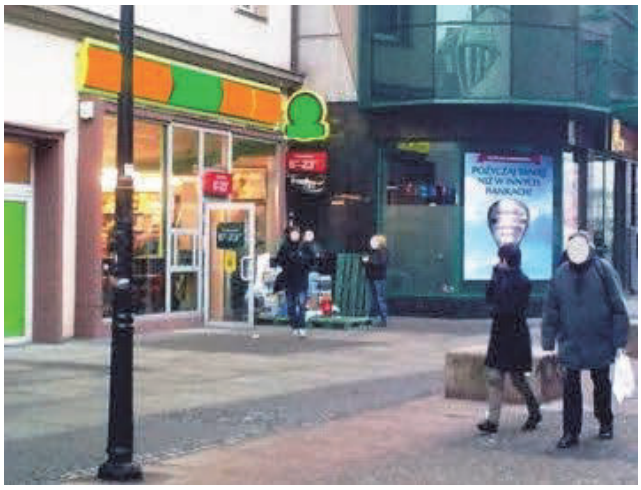

Figure 5 Scene in front of a store in Wrocław, Świdnicka street, when the supplier does not wait for the unloading of pallets.The recipient and store owner participate actively in the implementation of delivery (Own work)

Figure 6 Pallet at the threshold of the store (Own work)

Case 5 - Loading is done in the warehouse, and pallets are loads of packages in the form of homogeneous cargo that on each pallet there are the same type of goods; the carrier shall for realization of the complete of the delivery process of consecutively with each pallet individually. The supplier is obliged to charge for transfer across the threshold of the store (**Figure 6**).

We can collect these data to analyze delivery time from the longest to the shortest time (**Table 1**).

Table 1 Unloading time depending on unloading technology, from longest to shortest time (Own work)

Case of delivery	case2	case5	case1	case3	case4
Unloading time for 5 m distance (min)	51.875	29.725	28.875	24.05	9.1
Unloading time for 5 m distance (h)	0.864583333	0.495416667	0.44791	0.400833333	0.151666667

Based on the field research, the conclusion is that the conditions that determine the delivery time to the customer depend on the technology used for unloading and the movement of goods.

5. ANALYSIS OF ENERGY EXPENDITURE OF THE SUPPLIER

Without auxiliary transport equipment, the person who works as a driver and supplier at the same time is exposed to being very tired. For analysis of the workload, we can use ergonomic tools.

In Poland, the regulation for handling work is described as the maximal energy expenditure for man per one workday is for light-medium-hard work 6300 [kJ] ([kcal]). The maximal distance of handling the cargo is 25 m, with 25kg. This regulation suggests that the maximal mass of handling less than 1 m will be less than 120kg per 1 minute, 7000kg per 1 hour and 12000kg per one workday. Maximal energy expenditure per man should be no more than 8400 kJ [8].

On the basis of the ergonomic calculation, we assume to analyze the parameters of energy expenditure in the time of the delivery in the city center (**Table 2**).

Table 2 Parameters of energy expenditure under delivery in city center. Own work

Operation	Energy expenditure [kJ/min]	Index	Source
Driving delivery vehicle in city center	10.0	$Esdvc$	[4]
Loader	23.8	$Eload$	[7]
Warehouse man	26.2	$Ewrhs$	[7]
Preparatory activities	10.47	$Eprac$	[7]
Going without weight	12.9	$Egmc$	[9]
Pulling 150kg trolley	35.6	$Ep150kg$	[9]
Pulling 250kg pallet truck	45.6	$Ep250kg$	[9]
Pulling empty trolley	20	$Emp150kg$	Own work
Pulling empty pallet truck	25	$Emp250kg$	Own work

The maximal of the energy expenditure in the time of the delivery in the city center is strongly connected with the case of delivery. We can calculate this based on the use formulas.

Case 1 and Case 2

$$\mathrm{Eed} = \mathrm{to1} * \mathrm{Eprac} + \mathrm{n} * \mathrm{vpzl10kg} * \mathrm{l} * \mathrm{Ewrhs} + \mathrm{n} * \mathrm{vp} * \mathrm{l} * \mathrm{Egmc} + \mathrm{n} * \mathrm{to2} * \mathrm{Eload} + \mathrm{tzd} * \mathrm{Eprac} \quad (2)$$

Case 3

$$Eed = to1 * Eprac + n * vjzl150kg * l * Ep150kg + n * vjp * l * Emp150kg + 2 * n * to2 * Eload + tzd * Eprac \quad (3)$$

Case 4

$$Eed = to1 * Eprac + n * vjzl250kg * l * Ep250kg + n * vjp * l * Emp250kg + n * to2 * Eload + tzd * Eprac \quad (4)$$

Case 5

$$Eed = to1 * Eprac + n * vjzl250kg * l * Ep250kg + n * vjp * l * Emp250kg + n * to2 * Eload + tzd + \mathrm{troz\ palety} \quad (5)$$

Where

Td - delivery time

to1 - the time of the carrier to the customer, checking invoices, an indication of the view loads in the store or in front of him,
n - number of complete cycles of cargo transfer from the vehicle to the store,

vpzl10kg - the speed of the human walking distance with a 10kg load

vp - a speed of the man walking on this distance without load

l - distance between the place of delivery to the point of receiving

to2 - time of opening of the doors of load box on the car, retrieve the cargo, and the closure of the cargo box from 2 = 0.5 min

tzd - time to close the load door of the box truck after delivery of the last batch, checking documentation, the passage of the carrier to the cab driver, taking a seat behind the steering wheel to check the next trip, setting driving directions, starting the engine.

to2 - opening time of load box

vjzl150kg - the speed of the man pushing a the truck with a 150kg load

vjp - the speed of the man pulling of the empty the truck

vjzl250kg - the speed of the man pushing the truck with a 250kg load

vjp - the speed of the man pulling of the empty the truck

troz pallets - the pallet unloading time at the threshold of the store.

Other parameters are given from the former example (**Figure 8**). Energy expenditure of delivery 250kg with a change in the distance between the box of the delivery vehicle and the doors of the trade point is in **Figure 9**.

Now, we do the calculation of the total energy of the expenditure of delivery for eight trade points with a change in the distance between the box of the delivery vehicle and the doors of the trade point from 5 to 30 meters. For the each trade point, carrying one pallet with a total mass of 250kg is placed on the typical delivery vehicle with 8 EUR pallets (**Figure 10**).

The results shows for us (**Figure 11**) that if the supplier did a delivery using case 2, the total energy expenditure is obtained at the 6th pallet for a distance 5 meters between box of the delivery vehicle and the doors of the

trade point. If between the box of the delivery vehicle and the doors of trade point is about 30 meters, the total energy expenditure is obtained at the 4th pallet. In this moment, the supplier must have rest time and a meal so he can physically refuel.

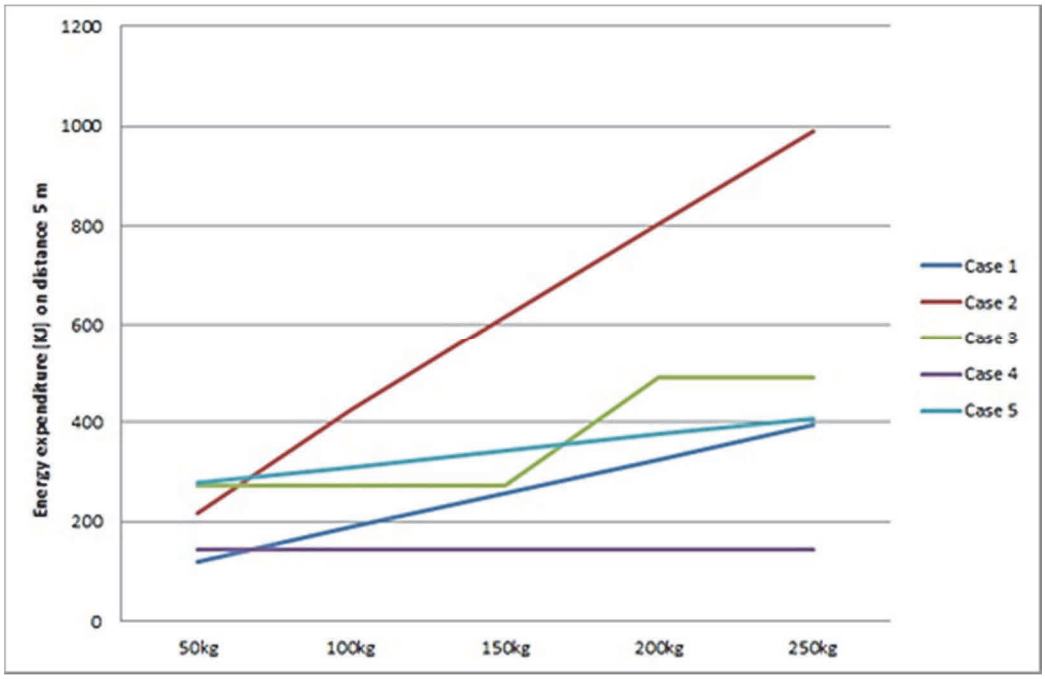

Figure 8 Energy expenditure of delivery up to 250kg to one trade point at a 5m distance

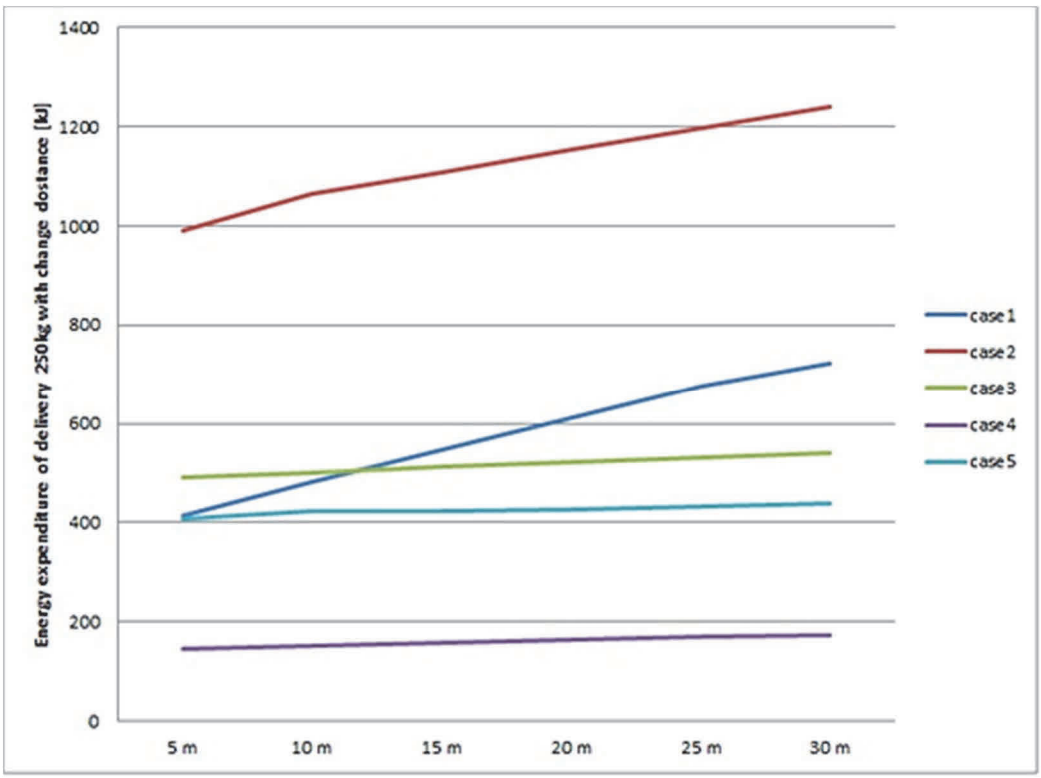

Figure 9 Energy expenditure of delivery 250kg with a change in the distance between the box of the delivery vehicle and the doors of the trade point

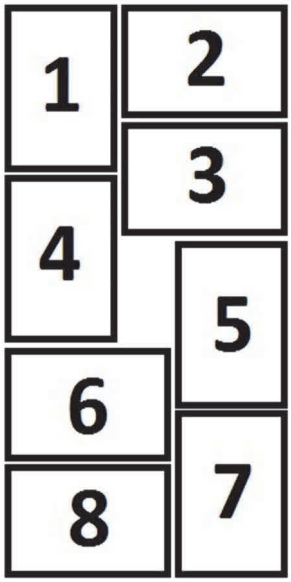

Figure 10 Location of pallets inside the delivery vehicle unless than 3.5 tons of the total mass [5]

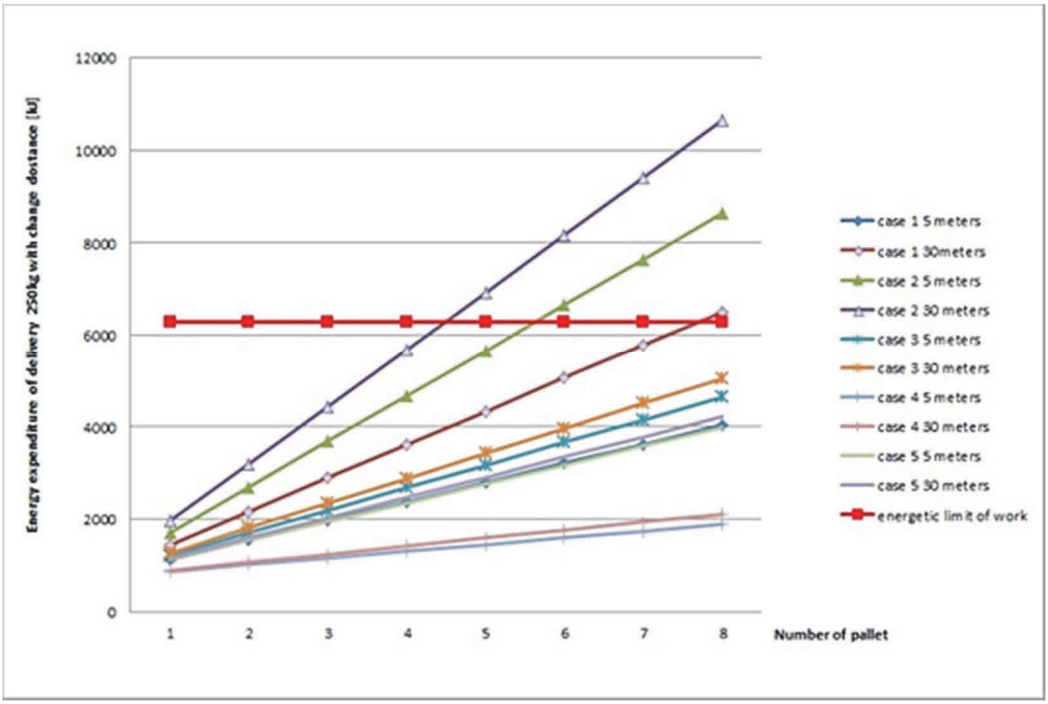

Figure 11 The energy expenditure of delivery for eight trade points with changes in the distance between the box of the delivery vehicle and the doors of the trade point from 5 to 30 meters

6. DISCUSSION

Simulation of the total energy expenditure of delivery to eight trade points suggest classification of the work of suppliers as the light-medium-hard work with 6300 [kJ]. Tired individuals have weak concentration [12][15]. In the time conditions of the traffic in the city center, the delivery vehicle very often stops at random places [10][12], which could change safety conditions for the supplier. There is higher possibility of accidents happening.

This changes the dependability of this process. It is shown how technology used for the moving of goods influences the total time of the delivery process and the health conditions of the supplier. It suggests the creation of a mandatory law that in all delivery vehicles without any technical equipment, there must be a second person - the loader.

7. SUMMARY

Through analysis of the work of the suppliers in the delivery process on the last100 meters in the city center, there is a suggestion to create a software program to calculate for analysis of the risk of the dependability of the time of this process from the energy expenditure of the supplier (**Figure 12**).

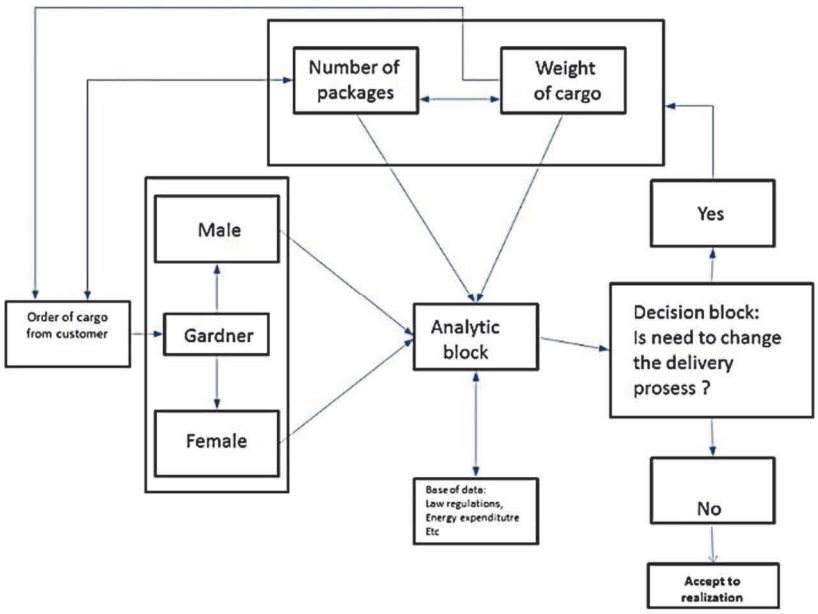

Figure 12 Proposition of the functional structure of software to calculate the energy expenditure of the supplier

The time of unloading of the goods depends on the technology used for unloading and the movement of goods to customers and the energy expenditure of the supplier. It may explain why the ordered cargo is delivered with the delay. Ergonomic studies have shown proposition of the classification of work of the supplier in the time of the delivery in the city center [7]. It is indicated in the associations between inputs and economic effects of the delivery in the city center from the dependability of this process from the ergonomic effort of the supplier.

A similar situation occurs in the time of collecting municipal waste [6]. This model may be used to improve of work of personnel.

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