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## Evaluating Investments in Emerging Automation Solutions for Logistics

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According to a recent survey the great majority of players in logistics are planning to adopt one or more robotic solutions until 2019. Technical solutions for automation of processes in logistics are often available as a market-ready product, but the lack of standardization and skepticism towards long term investments are often the reasons why these solutions are not implemented on a large scale. This paper is set to bridge the gap between the world of technologies and the one of applications in order to help investors, robot producers and system integrators to decide on which branch of logistics to set their focus. The three main branches Courier Express Parcel (CEP), contract logistics and production logistics are briefly defined and distinguished through their characteristic factors and parameters. Then a method based on the analysis of three parameters (operative costs, required performance and flexibility) in the three branches is set to identify the most convenient branch of logistics for investing in new technologies, namely the one in which the risk of investment is lower, the return is higher and faster. The conclusion of the method shows that higher labor costs, strict regulations and higher standardization make the production logistics the most suitable branch for investments in emerging automation solutions.

**Keywords:** Automation, Investment, Production logistics, Emerging Technology

# 1 Introduction

A recent study of the Bremer Institute for Production and Logistic Ltd. stresses the need for automation in the logistics field. In particular, the study refers to robotic solutions for the optimization of the internal material flows and processes. The trend shows that the use of robotic solutions in the logistics area is increasing, with cost efficiency of material flow and higher competitiveness being the main drivers for investing in these technologies. In 2007, 41% of the participants of the study had used robotic solutions, while seven years later the number has increased to 67% and an additional 68 % of the participants see a need for investing in robotic solutions in the next five years (BIBA, 2015).

Companies are therefore keen to evaluate investments in robotic solutions for logistic tasks, but the challenge is to set the right focus, understanding in which scenarios such investments will create the best return minimizing the risks. This paper is set to help investors, robot producers and system integrators to focus on the right scenario for the investment. In the remaining part of this section a taxonomy of the branches of logistics is introduced, which will be used later in the paper to identify the logistic scenario with the best return and minimum risk. In section 2 of the paper the relevant parameters (operative costs, required performance and flexibility) for automation in the logistic field are explained and divided in factors; in section 3 the branches of logistics are described again through the factors (and parameters) of section 2 and a qualitative impact of each factor on the return of investment in automation is given. In section 4 a method is presented that qualitatively evaluates the suitability of each branch for long

term investments in automation technology. Result are then discussed in section 5 and conclusions are drawn.

In the following taxonomy logistics is divided into four main branches: Courier Express Parcels (CEP), wholesaling/retailing, contract logistics and production logistics. This taxonomy is then simplified by merging the wholesaling/retailing into the contract logistics and for the rest of the paper the focus is put on three logistic branches: CEP, contract logistics and production logistics.

## **1.1 An Automation-oriented Taxonomy for Logistics**

In this section a taxonomy for logistics is introduced, which divides the field in branches representing different scenarios for the investment in automation.

### **1.1.1 Courier Express Parcel**

The CEP service sector has been ever growing over the last 40 years. Beginning in the mid of 1970s, pioneers of the express market, such as FedEx or DHL expanded at a rapid pace. Because of their unique position these integrators achieved in service and prices sufficient revenue in order to establish international networks including in their offer also courier and parcel services. On the one hand the standardization of the transport processes and on the other hand the economic development of the share of high value goods encouraged the growth of the traffic of high value and light weight packages. New requirements of fast, reliable and punctual deliveries became more and more important with the development of strategies

for increasing the efficiency of the processes, as for instance the lean production based on the Just in Time (JIT) principle. The growing demand was also fostered by the Schengen Agreement, the economic unification of Europe and the rising of online market places for both business and private commerce (Helmke, 2005). In 2012 the turnover of the European B2C E-Commerce market was € 112 billion and according to the study it will reach € 191 billion in 2017. This underlines the rapid growth of the CEP branch (Stallmann and Wegner, 2015, p.86). A different study from the German Federal Association E-Commerce and Mail Order Business (BEVH) also indicates a notable growth of the B2C E-Commerce business and points out that the increased volume of parcel shipments leads to a higher significance of the CEP branch (Manner-Romberg, et al., 2014, pp.4-7). The CEP branch includes mainly parcel shipments with a low weight (2 kg until 31.5 kg), limited volume and a shipment often consists of only one unit. The reason for the weight regulations of parcels is that the parcels are mostly handled by people (Kille, 2012). The CEP system, in countries where the e-Commerce is strong and in growth such as Germany, seems to have reached the boundaries of its technological capacity; if the throughput can be increased by using new and more powerful sorting technologies (such as rubber cross-belts), still remains the bottleneck of the loading and unloading of swap bodies, trailers and containers. In the past this problem was solved by increasing the number of loading and unloading docks, but this is in trade-off with the costs generated by the necessary additional surface and the necessary additional conveying technology needed to cover the larger distances. DHL is searching a solution for loading and unloading, which

could increase the throughput in each unloading/loading dock to 3.000 parcels per hour, hence more than 4-5 times the current manual rate.

### **1.1.2 Wholesaling and Retailing**

The retailing branch of logistics refers to those companies selling products or services directly to final consumers for their personal, non-business use. Example of this category are: Tschibo, Aldi, Amazon and H&M. Wholesaling, on the other hand, relates to those companies, such as Metro, selling goods and services to those buying for resale or business use.

### **1.1.3 Contract Logistics**

Contract logistics companies take over comprehensive logistic services for the whole supply chain, such as the central warehousing for the procurement and distribution, internal and external tasks of the production logistics and wholesaling/retailing or the collection and distribution of shipments. These providers are also defined as Third Party Logistic Service Providers (3PL). An additional characteristic of the contract logistics is short term (usually 2-4 years) contractual commitment between the company and the service provider, where the upper boundary is usually touched when the service provider needs additional investments for the realization of the service (Gleißner and Femeling, 2008, p.85). Consequently a 3PL has to adapt to the business of its contract partner, which leads to constantly changing business environments and processes. Additionally, the defined contract between the two parties always starts with precise outline of process requirements, formalized in a document and presented by the party requiring services through a bidding process, to which each interested third

party logistics company answers offering the required services for a specific price (specification of services). Often the process requirements are so rigid and non-negotiable, that there is little margin for the 3PL providers to influence the processes of their customers.

#### **1.1.4 Production Logistics**

The production logistics, which is in between the procurement and distribution logistics, can be defined as everything that is intralogistics and not outsourced to a contract logistics service provider. As soon as the processes are outsourced, they fall in the branch of contract logistics. Examples for these processes are: feeding of production lines, handling or stocking between different productions or assembly stations (of the same facility) and loading/unloading of containers. Production logistics represents a central function of the single logistics sections of a company. The main task is the planning and control of the material and information flow, which means starting from the raw material stock to the finish goods stock. The complex task shows the crucial importance of the production logistics in controlling the supply chain. Fulfilling the main goal of customer satisfaction is challenging in the production logistics as it faces increasing product variety and shorter delivery times (Pawellek, 2012, p. 466).

### **1.2 Simplifying the Taxonomy of Logistics**

The branch of wholesaling and retailing is added to the taxonomy for the sake of completeness, but its parameters and factors (see section 2 of the paper) are not different than those of contract logistics. Core competences



of companies operating in this branch are, for instance, warehousing, commissioning, cross-docking, milk-runs and delivery; the focus is set on logistics and handling, much like in contract logistics. The only point of difference between wholesaling/retailing and contract logistic is that in the first there are no short term contract limiting long term investments. However the relevant presence of on-line wholesaling and retailing (e.g. Amazon) makes this sector extremely dynamic and increases the need for flexibility necessary for the survival in the branch. This is true both for players who take active advantage of the e-business as for those who are passively subdued to the first category and need to react on its marketing decisions. As a consequence, with a relatively short notice, warehousing/commissioning facilities of wholesalers/retailers can be moved or their purpose (type of stocked goods, customization, re-branding, re-packaging etc.) can be changed. As a result, long term investments in this branch preserve the high risk character that, for different reasons, characterizes also the contract logistics branch. For this reason hereinafter in this paper, this branch will be treated as merged with the contract logistics, and every conclusion drawn for contract logistics applies, in the authors' opinion, also to the wholesaling and retailing business.

For this reason the taxonomy of branches analyzed in the remaining part of the document is simplified to three branches: CEP, contract logistics and production logistics.

## 2 Relevant Parameters for Automating in Logistics

In this section the most relevant parameters for automating logistic processes will be described and deployed into factors. This is functional to the detailed description, in section 3, of the three main branches mentioned in section 1.

The automation of logistic processes is a serious challenge, not only because the complexity of technologies is increasing in order to cope with a larger variety of unconstrained scenarios that logistics presents, but also because processes often need to be slightly modified in order to fully exploit the new available technologies. Every logistic process can be described through three main parameters: cost, performance and flexibility (Bonini et al., 2015). Unfortunately these parameters are often in trade-off and it is not always immediate to find the right balance among them in order to take advantage of automation. This trade-off can be seen from two different, but intimately related points of view: (1) from the point of view of the technology provider or (2) from the one of the investor. The technology provider (1) strictly relates these parameters to the technology, meaning that the cost represents the price of the system, the performance the handling rate and the flexibility the ability of the provided system to cope with different scenarios and situations. On the other hand, the investor (2) interprets the same three parameters in order to describe the current processes at his own facility; in this way the trade-off among parameters will steer the choice of the technology and influence the economic evaluation of the investment. Considering the point of view of an average investor assessing the possibility of automating a logistic process in order to fulfill emerging requirements, it makes sense to deploy the parameters into factors in order

to better understand the characteristics of a scenario in which the investment in automation would be more convenient. The remainder of this section is dedicated to the interpretation of the three parameters (costs, performance and flexibility and their deployment in factors) from the point of view of a potential investor seeking to invest in his facility.

## 2.1 Cost

This parameter aims to describe the costs of the manual process. Two factors are considered to be have the highest influence, namely (1) the wage (company gross) of the operator directly involved in the manual process and (2) the operative time. The wage factor (1) has a high influence on the total costs in logistics, for instance, in Germany it is accounted for the 21.19% of the total costs (Statistisches Bundesamt, 2014, p. 10). Anyway it is strictly related to the context. Wages may be really different depending on the country, the region within the country, the qualification of the considered labor and other parameters. With operative time (2) is meant the time the company is operating. In general the higher the wage and the longer the operative time, the higher are the operative costs and the sooner the investment in automation will be paid back.

## 2.2 Performance

The performance of the manual process can be directly linked to the handling rate required by the process. It can be influenced and limited by the interface with neighbor processes, both up-hill and down-hill, in order to avoid bottlenecks and sub-optimal solutions. The implicit requirement of

not damaging the good while performing the manual handling holds always true.

## **2.3 Flexibility**

Flexibility is a complex parameter that represents the variety of scenarios that could be encountered while accomplishing the handling task and how often these scenarios are expected to change. Whereas it is relatively easy for a human operator to handle a large variety of items or move from one point to the other of the facility, those task are not trivial when it comes to automation. The higher the flexibility required by the process, the more complicate and expensive will be the new automated solution. The factors that define flexibility are mainly four (4) hereafter listed and briefly described.

### **2.3.1 Standardization**

This factor describes the standardization level of the items to be handled. It is strictly related to the kind of material, the shape and the weight of the goods and depends on the numbers of different items, object of the handling, which are flowing through the facility. High standardization level implies a small variety of goods (even with large volumes). For instance in facility where 20 types of goods are handled standardization is lower than in facility that has to deal with only 5 types of goods.

### **2.3.2 Homogeneity of the Batch**

It evaluates how often the kind of good changes in the process. A flexible system is able to cope with all the goods the business is dealing with, but it

is also true that this has an impact on the efficiency. For this reason dedicated processes, not subjected to recurring changes, are highly desirable. For instance in the CEP branch no batch exists, as parcels, for instance, flowing on a sorter have most likely different origins and destinations. On the contrary in the production logistics, goods flowing on a conveyor belt are likely to flow in batches, reflecting the production series.

### **2.3.3 Continuity of the Flow**

In order for the automation to be economically convenient the utilization of the automated solution must remain high and levelled. In other words the system should be always fed during the whole operative time. The stream of goods has to be wide enough to assure the continuous exploitation of the automation technology. This factor should be carefully evaluated especially in businesses affected by seasonal variation in demand or where the volume of traffic is hard to forecast.

### **2.3.4 Continuity of the Business**

Investing in automation make sense only if the business is supposed to last long enough to fully exploit the benefits of the investment. For this reason the continuity of the business is a factor that must be taken into account. Usually in the logistic sector investors are evaluating the risk of investing through the indicator of the payback period. A shorter payback period means an investment with a lower risk and the threshold of acceptance is set between 2 and 3 years. This threshold can vary with the nature of the automation which is being evaluated: in case of new cutting-edge technology the rigid lower bound of the threshold is applied (2 years), because the

risk is supposed to be high. If an investment in some well-established equipment (such as an Automatic Storage and Retrieval System) is instead being evaluated, the cut-off could fall on the longer term (even more than 4 years), because the investment is deemed to be less risky. The timeframe in which the investment is not profitable could vary from case to case, but generally is much longer in scenarios which are adverse to automation. In the next section the parameters and their factors will be used to describe the logistic branches introduced in section 1.

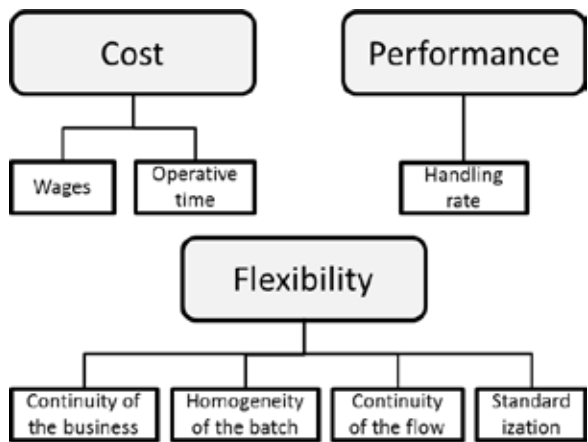


Figure 1 Relevant parameters and factors for automation in the logistic field

### 3 Comparing Logistic Branches through Automation-relevant Factors

In this section each one of the three major branches of logistics introduced with the taxonomy of section 1 will be analyzed through the parameters and factors that have been described in the previous section.

#### 3.1 Courier Express Parcel

The CEP branch addresses the largest array of customers, ranging from the end (non-business) user who ships something from point A to point B (Customer2Customer service), to the company delivering products directly to the customers (B2C) or to other companies (B2B) using the existing infrastructure put in place by the CEP service providers. The increasing of the material flow due to the e-business, as explained in section 1.1.1 of this paper, creates new bottle-necks in the CEP branch, highlighting that existing systems are often under-dimensioned and overwhelmed by a continuous stream of goods. The short delivery requirement typical of the CEP branch makes things even more critical: pushed to the limit this requirement becomes the so called “same day delivery”, offered by some providers. Because of the required short delivery time, CEP service providers are inclined on the one hand to extend the operative time to 24/7, on the other hand to reduce as much as possible the cycle time, namely the time one item remains in the system, optimizing the logistics processes in order to keep high performances, which is only possible by levelling all bottlenecks. Especially in environments characterized by a low level of standardization, the required flexibility is only achievable with high investment in advanced

technologies, which often are not reliable and fast enough to cope efficiently with the variety of scenarios (Bonini et al., 2015). Whereas there are no doubts about the longevity of this business, which makes long term investments possible, the easy nature of the handling task enable the employment of low qualified cheap manpower; wages in the CEP branch for handling tasks are probably the lowest in logistics, hence the hardest to replace through automation. The required high flexibility is due to the lack of restrictions in terms of processed items; the only restrictions that contribute to the improvement of the standardization level are limitations on weight and dimension of the items (usually parcels). However, setting an upper limit to weight and dimensions reduces, but not completely removes the need of flexibility. There are no rules concerning the homogeneity of the items belonging to the same batch (in this case a batch can be considered a cargo, which is a rather different concept than a production batch) both considering inbound and outbound. This is due to the fact that items coming from different customers, having in common an intermediate destination, have different shapes and sizes, but they are nevertheless aggregated in the same container in order to exploit all the advantages related to cargo consolidation. In other words, observing a stream of good in a CEP facility, at the inbound, at the outbound or in each process in-between, the probability of finding two items in row having the same characteristics (weight, shape, quality and type of surface) are close to zero.



### 3.2 Contract Logistic

Since logistics is the core business of companies operating in this branch, processes are usually optimized in order to obtain high efficiency and handling rate. Peculiar characteristic of the contract logistics is the contractual commitment between customer and service provider, usually result of a bidding process won by the provider offering the best service for the lowest price. According to the customer requirements the service provider shapes his processes and develops, if necessary, customized solutions in order to profit, operating into the usually narrow margin that the contract allows and therefore seeking costs optimization. The standardization level varies with the customer, but normally goods, unit loads, packaging, homogeneity of the batches and the volumes are usually punctually described in the contract, hence known a priori. This means that, within the same contract, normally providers operate with a rather high degree of standardization and batches of products are homogeneous. Handling rates are rather high; manpower is low qualified, hence cheap and flexible short on-demand contract for personnel can be set-up in order to answer to peak seasons. Due to the shortening of the product life cycles, contractors tend to lower their risk pushing for relatively short time framed contracts of three or four years (Doll, et al., 2014, p. 26). For this reason the continuity of the business cannot be guaranteed on the long term, but only within the contract duration, which does not favor long term investments in new technologies.

### 3.3 Production Logistic

The main distinguishing characteristic of this branch is that the core business is not logistics, but production; logistic tasks are internally carried out,

instead of being outsourced, mainly for the irrelevance that they cover in respect to the production processes. Some of the production companies do not outsource logistic tasks because they don't want third party workers looking around in the facility where they are producing novel products often not yet on the market. The first results of this choice are (1) the job rotation and (2) higher wages. In order to keep high focus and attention, in most companies the task of production workers is changed in regular intervals (few hours): in some of the production companies, which handle logistic processes (palletizing, de-palletizing, packaging, labelling, warehousing, commissioning), the (1) job rotation can include a mix of logistic and production tasks (such as assembly, quality check feeding of lines and similar tasks). In combination with regulation of trade unions, the job rotation makes it impossible to distinguish the salary of production task (traditionally higher, such as in the metal-mechanic sector) with those of logistic ones (traditionally lower as in the CEP and contract logistics). Considering a same task (e.g. palletizing), this creates considerable (2) higher wages in production logistics than in the other described logistic branches. A secondary effect of the job rotation is the low handling rate (performance) that is characteristic of production logistics; workers are often not specialized in one single task and are therefore less efficient. Nor the need of high handling performance is really relevant in the branch, being the rhythm of logistics a consequence of the mostly levelled production stream: for instance in case of a make-to-stock strategy, both the production and the connected logistics can be thoroughly planned in advanced. Production logistics not only acts with a continuous and levelled stream of goods, but, in general, also with a high level of standardization of items, a 24/7 operative

time and homogeneous batches (compatibly with the productive mix and relative customizations). This is true for a stream of goods in output to a general production facility, for every stream in-between production processes and also (less trivial) for the inbound flow of goods (e.g. supplied parts to be assembled): a relatively high standardized and levelled inbound flow is a luxury that production companies can afford thanks to their normally long term contract and to the negotiation power against suppliers. In addition, the business of production logistics is as durable as the connected production business, with no time contractual restrictions, nor bidding processes.

All of these factors make the production logistics the most appealing candidate for long term investments in automation technology in logistics. In the next section all considerations leading to this conclusion are quantified and compared with the other two logistic branches.

## **4 Quantification of a Qualitative Comparison**

In this section a method for quantifying the convenience of investing in each of the logistic branches introduced in section one is first exposed. Then the method is applied and the results are reported.

### **4.1 The Method**

The introduced method is based on the technique of Multiple-Criteria Decision Analysis (Figueira, Greco and Ehrgott, 2005); in particular a decisional matrix is used as an instrument to define in which of the three main branches of logistics long term investments in automation technology are

more appealing. The criteria evaluated for the decision are the factors of the three parameters (cost, performance and flexibility) described in section 2 and, because it is extremely hard to decide a priori which factor is more important, they are considered to have all the same weight for the decision (non-weighted multi-criteria decisional analysis). For each of the factors a question has been formulated to which four possible answers can be given; to each answer is associated a double plus (++), a plus (+), a minus (-) or a double minus (--), respectively when the answer is "almost always" (++), "sometimes" (+), "rarely" (-) or "nearly never" (--). The decisional matrix is then compiled for each factor and each branch; because of the non-weighted approach, the pluses and minuses are in the end simply counted for each branch and a score is assigned subtracting the total number of minuses to the total number of pluses. For graphical reasons first intermediate results grouped per parameters (costs, performance and flexibility) are reported in table 1, 2 and 3 and commented; then overall results are summarized in table 4. According to the method, the logistic branch with the highest score is the one in which long term investments in automation technology are most appealing.

## 4.2 Results Grouped per Parameters

In this section the results of the method are reported and commented grouped per parameter; partial scores are given to each parameter as a sum of pluses and minus evaluating the factors through the asked question. Questions have been qualitatively answered based on the considerations reported on section 3.

4.2.1 Costs

As reported in Table 1, it is clear that production logistics is the best branch for long term investment in automation technology from the point of view of the cost parameter. This is due to the mostly higher wages (job rotation and trade union regulations) that are applied in production logistics. The higher are wages, the higher are, in turn, operative costs; this effect multiplies for the operative time. This means that the higher are the operative time and the wages and the shorter is the return of investment in automation technology.

Table 1 Evaluation of branches through the factors of the cost parameter

Factor	Question	CEP	Contr. Log.	Prod. Log.
Wages	Is the salary higher than the salary of a low qualified worker in logistics?	-	-	++
Operative Time	Is the facility operating 24/7?	++	+	+
Score		+1	0	+3

Legend: ++ = almost always, + = sometimes, - = rarely, -- = nearly never

4.2.2 Performances

A high manual handling rate poses a challenge for the automation technology to match. On the other way around the lower the performance of the manual handling, the more operators can be replaced with the automation technology making the investment appealing. Traditionally high handling rates are to be found where logistics is the core business of the company (CEP and contract logistics), while performances are lower when the core business of the company is different than logistics; hence the question in Table 2 and the score of the performance parameter.

Table 2 Evaluation of branches through the factors of the performance

Factor	Question	CEP	Contr. Log.	Prod. Log.
Handling rate	Is the company core business different from logistics?	--	--	++
Score		-2	-2	+2

Legend: ++ = almost always, + = sometimes, - = rarely, -- = nearly never

4.2.3 Flexibility

The parameter flexibility is composed of several factors which are better analyzed one at the time.

Table 3 Evaluation of branches through the factors of the flexibility

Factor	Question	CEP	Contr. Log.	Prod. Log.
Standardi- zation	Are the items standardized?	--	++	++
Homogene- ity of the batch	Are there batches of homog- enous items?	--	+	+
Continuity of material flow	Is the material flow levelled during the operative time?	++	-	+
Continuity of business	Is the business supposed to last more than 4 years?	++	-	++
Score		0	+1	+6

Legend: ++ = almost always, + = sometimes, - = rarely, -- = nearly never

The factor "standardization" and "homogeneity of the batch" naturally penalize the CEP branch, where any kind of item (dimension, weight and quality of box/envelope) can be found in the system and batches, when even existing, are made of a small amount of items having in common either the destination or the provenience, but rarely both. The penalty (--) is due to the clear disadvantage that this represents in terms of automation technology. On the other hand though, the CEP branch experiences a stream of goods mostly levelled in the operational time (with the exception of seasonality, such as the 2-3 weeks before Christmas) and an eventual automated solution would rarely remain idle (hence higher operative time), since the system is full and operating nearly 24/7. The same applies to production logistics, with a slight difference (one plus instead of two): although the production is levelled by nature, the consequent logistics could suffer of the elastic effect due to the change in the mix and the set-up time. Contract logistics stands in this regard a clear step behind; items can here be subjected to strong seasonality or trend, having a great impact on the process of warehousing and commissioning. Inbound and outbound processes (unloading, depalletizing, palletizing, loading, cross-docking, etc.) are mostly restricted, in the service contract, to specified time windows, often due to external constraints: this means that trucks can, for instance in a cross-docking process, arrive between 9 and 12 in the morning, while they have to be loaded and leave between 14 and 17, creating high traffic in specific hours with no hope to level the peaks due to the scarce negotiation power. As for the last factor, the continuity of the business, it has already been clearly explained how contract logistics is penalized; contracts have in most cases a short term (less than 4 years). On the contrary the business of



CEP is prosperous (capacity seems to be worldwide not enough due to the e-business) and the one of the production logistics is as durable as the connected production business.

Being overall production logistics the branch where flexibility is less required (hence the high score according to the posed questions), once again this branch appear to be the best for long term investments in automation technology.

4.3 Overall Results

Table 4 shows the partial results summarized and the final score of the three logistics branches with regard to the convenience of committing to long term investments in automation technology.

Table 4 Final results showing production logistics as the most convenient branch for long term investments in automation technology

Parameter	CEP	Contract Log.	Prod. Log.
Cost	+1	0	+3
Performance	-2	-2	+2
Flexibility	0	+1	+6
Total	-1	-1	+11

Overall the higher operative costs, due to the high cost of manpower, together with the generally lower handling performances and the lower required flexibility (in turn due to a high degree of standardization), make production logistics by far the branch in which it is more convenient to invest in long term automation technology.

## **5 Interpretation and Discussion of Results**

In this section the results are discussed and an interpretation is given from two points of view, namely from the investor side (section 5.2) and from the technology provider side (section 5.3).

### **5.1 Validation of the Simplified Approach**

In this paper assumptions and simplifications of complex factors have been made in order to ease the demonstration of the thesis. One instance of such simplification is to be mention in regards to the difference in average wages among the three branches, which plays a fundamental role in demonstrating the thesis of this paper. It could be argued that wages strongly depends on the country, the region and the specific arrangements with the unions; the statement presented in this paper (i.e. that wages in CEP and contract logistics are rather similar to each other and averagely lower than in production logistics) is indeed a simplification of the variety of wages that can be found in these branches. Even though wages may differ from country and region, hereafter the tendency of the wages in the three branches is reported with the example of West Germany (North Rhine-Westphalia).

Table 5 Comparison among wages in the three logistics branches in West Germany (North Rhine-Westphalia)

CEP	Contract Logistics	Production Logistics
11,31€/h (MAIS 2015)	11,31€/h (MAIS 2015)	14,83€/h (Metall NRW 2015, p.1)

As shown in table 5, wages of West Germany in the production logistics are 31.12% higher, for the same job, than in contract logistics or CEP. Simplifications and generalizations like the one in the mentioned example are based on the experience of the group of writers concerning automation of processes in various logistic fields. They could be demonstrated in a context specific environment, but ultimately it is up to the reader to contextualize the results based upon his/hers specific experience and to deduct therefore their validity.

5.2 Interpretation of Results for Investors

The taxonomy proposed in section 1 of the paper is general and based upon simplifications and generalizations; the presented method for evaluation of the convenience of committing to long term investments for automation technology however can be applied independently on the universal validity of the taxonomy. The question of tables 1, 2 and 3 can be asked to every company dealing with logistic processes and, depending on the answer, a score (++, +, - or --) can be given for each factor. The higher the total score the more convenient can be long term investments in automation technology. In case the score is negative or low, generally long term investments in

automation are discouraged; nevertheless some punctual specific task, regarding probably a part of the process or a sub-set of items, could still be effectively automated.

### 5.3 Interpretation of Results for Technology Providers

From the point of view of technology providers who seek in the results of this paper a guideline for the market segment where to focus their product, the interpretation of the findings is two-sided, indicated with (1) and (2) in the following text. In case the technology provider is evaluating the penetration on the market of a cutting edge technology (e.g. autonomous robots in logistics), the skepticism due to the novelty of the solution represents inevitably a strong barrier to those branches with a low score (CEP and contract logistics). In this case it is advised to (1) focus on a branch with high score (high convenience of committing long term investment in automation technology), hence production logistics. On the other hand the production logistics often requires a rather customer-specific approach: each automation technology sold is somehow customized to the specific requirements and the reproducibility of the specific conditions is improbable. Quite oppositely, if an automation technology is sold to a CEP customer, the volume of ordered systems is most probably going to be high enough to justify the costs of customized engineering. Especially in case of emerging automation technology, in order to win over the skepticism due to the novelty of the solution, a quick return of investment is of essence; in the CEP branch, where manpower has high performance standards and low costs, the only way to achieve a fast return on investment is to keep the price of the automation low. For this reason it makes sense to (2) develop

technology with the target cost of the CEP branch, being this environment the most hostile for automation technology: if, thanks to the low price, the technology can penetrate the CEP branch, success in the other two more automation-favorable branches is guaranteed and the market potential for the developed automated solution results higher.

## 6 Conclusions

In this paper first an automation-oriented taxonomy for logistics has been given, which results in three main branches: CEP, contract logistics and production logistics. Then a method for evaluating the convenience of committing to long term investments in automation technology for logistic processes has been presented. The method is based on the identification of logistic-specific parameters (costs, performances and flexibility) having a strong impact on the convenience for automation; these parameters are then divided in factors (wages, operative time, handling rate, standardization, homogeneity of the batch, continuity of the flow and continuity of the business) that lead to the evaluation of the convenience depending on the logistic context. The method has been applied to the automation-oriented taxonomy for logistics; production logistics has been evaluated as the most convenient branch for committing to long term investments in automation technology. Results have then been discussed from the point of view of potential investors (users) and from the one of technology providers.

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