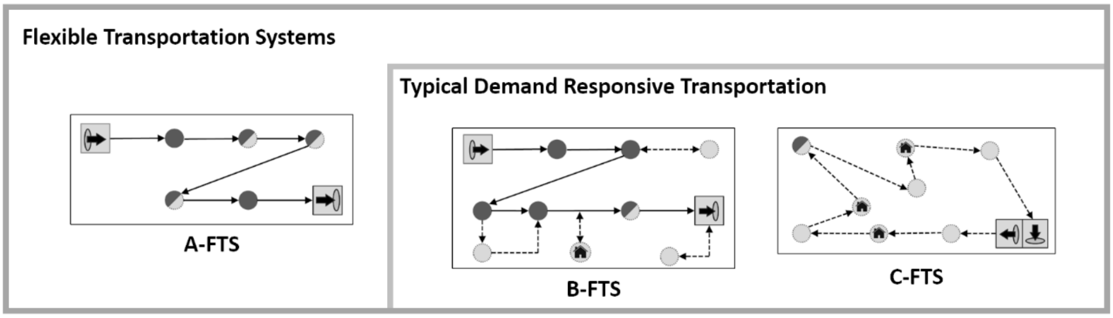

16th International Doctoral Students Workshop on Logistics, Supply Chain and Production Management

20 June 2023, Magdeburg

Institute of Logistics and Material Handling Systems

Conference Proceedings

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16th International Doctoral Students Workshop on Logistics, Supply Chain and Production Management

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Foreword

Dear Ladies and Gentlemen,
Colleagues and Friends,

We are thrilled to announce the 16th International Doctoral Students Workshop on Logistics, taking place this year. As a gesture of our appreciation, we are delighted to present you with a comprehensive collection of conference proceedings.

2023 brings exciting developments to the workshop: Firstly, the workshop has expanded its title and focus to incorporate the realms of “Supply Chain and Production Management”. This expansion recognizes the growing interconnection between logistics and production in the industrial sector, along with the design and development of supply chains. By adopting this holistic approach, we can explore broader horizons. Secondly, in light of applied universities being granted the authority to award doctorates, Saxony-Anhalt has witnessed the establishment of new doctoral centers. Notably, our esteemed colleagues, Professors Trojahn, Behrendt, and Sackmann, are actively engaged in the "Doctoral Center for Social, Health, and Economic Sciences”, which represents and involves three out of the four universities of applied sciences: Magdeburg-Stendal, Köthen and Bernburg locations, and Merseburg. With the integration of representatives from this doctoral center, we not only benefit from the strong technical and economic competencies in logistics at Magdeburg's Otto von Guericke University but also embrace competencies and topics that enable us to address complex tasks in line with sustainability. Thirdly, after adopting a hybrid format in 2022, we are excited to return to an in-person event in 2023. Personal interactions foster essential professional exchanges and discussions, leading to valuable synergies. Unfortunately, our meeting is overshadowed by a war in Europe. However, we stand together, firmly rooted in the European spirit of freedom and peaceful coexistence among all people. Finally, in our ongoing efforts, we strive to enhance the visibility and accessibility of contributions through digital open-access publications. This applies to both the conference proceedings as a whole and individual contributions, ensuring wider reach and greater discoverability.

Our introductory academic paper serves as a guide, explicitly highlighting logistical thinking. By doing so, we aim to broaden perspectives on individual research work and expand research methodologies. The published papers presented at the workshop encompass a wide range of research topics. These include the design of logistical objects such as packaging, novel processes like the control of transportation and robots, transport evaluation, the advancement and application of new methods (e.g., prediction and VSM), supply chain design, and the substitution of materials with significant improvement effects in production and logistics. The workshop serves as an invaluable platform for doctoral students to present their research and engage in discussions with experts. This not only strengthens the education of young researchers but also contributes to the advancement of research itself. As always, we extend a warm welcome to our international participants and reviewers hailing from Cuba, Hungary, Ukraine, Austria, and Germany.

We hope our readers will gain fresh insights and ideas from the workshop proceedings. We encourage you to reach out to us with any comments or suggestions for improvement. Looking ahead, we eagerly anticipate hosting the 17th International Doctoral Students Workshop on Logistics, Supply Chain and Production Management in 2024. We sincerely hope to have the pleasure of welcoming all of you to Magdeburg, the captivating capital city of Saxony-Anhalt, next year.

Sincerely,

Prof. h. c. Dr.-Ing. Dr. h. c. (UCLV) Elke Glistau

Prof. Dr.-Ing. Sebastian Trojahn

Scientific Papers

Evaluation of the digital transformation from VSM to Value Stream Management 4.0

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Abstract
As recent shocks, e.g., the COVID-19 pandemic and international conflicts prove, the environment of supply chains gets more volatile and static configurations suffers from fragility. Higher variety, shorter product life cycle, increasing competition, fragility of supply chains and further issues present companies with new challenges. The application of information and communication technologies plays an important key role for companies in solving today's challenges. In this context, the combination of conventional methodologies like Lean Management (LM) and modern technologies according to Industry 4.0 is an important field of recent research. Especially, the application of Value Stream Management (VSM) in dynamic environments is widely investigated and different approaches are provided for taking information logistics into account as well as utilizing data for improving the methodology at all. Limitations of the conventional VSM are the basis for justifying the transformation to a VSM 4.0. A critical evaluation of measures for the transformation from the conventional VSM to VSM 4.0, based on a comparison of benefits and efforts for reasoning the transition from a company's perspective is missing. Aim of the paper at hand is the provision of an evaluation framework for companies, already applying the conventional VSM.

1. Introduction
Businesses face a high volatile and uncertain environment, which necessitates an adjustment and realignment of companies to the changed conditions to ensure future existence and a stable market positioning in the medium and long term. [1], [2] These changed conditions are caused by internal factors, e.g., disruptive changes in the system and process landscape and skills shortages, as well as external factors, e.g., shorter life cycles and higher product variety, and require greater flexibility under consideration of economic aspects.

Conventional business models and management approaches, such as Lean Management (LM), must be verified with regard to their topicality and validity against the background of a changing environment in general and increasing digitization and digitalization in particular. As examined in various studies, the fundamental principles of LM are still valid in the context of Industry 4.0. Rather, it is recognized, both approaches are mostly complementary and support each other. By the combined application, synergies can be created. On the one side, fundamental principles of LM, e.g., standardization and elimination of waste are the basis for a technology-based automation of processes. On the other side, the targeted application of modern information and communication technologies enables new opportunities for monitoring, analyzing and designing business processes by the utilization of important business data. The gain in additional information and transparency as well as the possibilities of data processing have a positive effect on the lean management methods. [3]–[5]

1.1. State of Research

Due to the amount of application potentials, the concept of a structured combination of well-known LM practices and modern technologies in the area of Industry 4.0 is a wide field of research. Especially, the investigation on Value Stream Management (VSM) as part of Lean Management is highly discussed in recent research. In the reviewed studies several limitations of the conventional VSM approach are pointed out, e.g. static nature, effort-intensive and time consuming procedure, inefficient in dynamic environments and similar ones. [6]–[8]. These limitations are taken as a basis for justifying a digital transformation. All considered studies in common is a missing critical evaluation of measures for the transformation from the conventional VSM to VSM 4.0, reasoning the transition from a company's perspective. The technical and related application potentials are consistently elucidated in detail, whereas the concrete benefit on the methodology on the one hand and the cost-related efforts on the other hand are not a subject of consideration.

1.2. Research Gap and Research Question

As mentioned above, a structured reasoning of the transformation from conventional VSM to VSM 4.0 is missing in regard to the reviewed studies. This is proven by a systematic literature review according to PRISMA [9], [10], which is carried out as part of a preliminary study. The scope is briefly outlined in this section. The literature is explicitly based on the scientific platforms ScienceDirect (https://www.elsevier.com), Google Scholar (https://scholar.google.com), IEEE Xplore (https://ieeexplore.ieee.org) and ResearchGate (https://www.researchgate.net). Further platforms and libraries are implicitly covered by cross references from Google Scholar. As search strings a variation of selected key words related to VSM 4.0, e.g. "dynamic value stream management", "value stream management 4.0" and "value stream mapping 4.0", combined with terms and phrases in the context of measure evaluations, e.g. "cost-benefit-analysis"/"CBA", "evaluation of digitalization measures" "and "assessment framework". In addition, the search string is extended by refining expressions as "key performance indicator" and "return on investment".
In summary, the reviewed studies can be divided into three categories regarding the impact of digitalization in the context of VSM 4.0 from a company's perspective.
The studies of the first category refer to the application potentials of VSM 4.0, focused on the utilization of technologies. A quantitative evaluation of the proposed digitalization measures is not taken into account, e.g. [11]–[13]. For an overview of technologies, see [14]. The second category refers to studies, which provide indicators for evaluating the information logistic, considering e.g., the digitization rate, data availability and data usage. The data are used for evaluating digital waste in the value stream (VS) with focus on production and logistics, e.g. [15]–[18]. The third category contains studies, providing a maturity model for assessing the digital mature in the process based on, inter alia, vertical and horizontal integration, automation rate and digitization rate. [19]–[21] In addition, the correlation of LM tools in general and Industry 4.0 technologies [22] as well as the correlation between production targets (costs, quality, time and flexibility) and technologies [23] are investigated, but without relation to VSM 4.0. In summary, the identified evaluation frameworks are merely related to the VS, but not to the methodology itself. According to the first category, the proposed technologies are missing a quantitative reasoning or impact evaluation. This leads to the central research question of how the impact of a transformation from the analog methodology VSM to the digital one VSM 4.0 can be evaluated, especially against the background of maximizing the benefits of digitalization measures.

1.3. Aim of the Paper at Hand

Aim of the paper at hand is the provision of an implementation framework for assessing the impact of transformation measures in comparison to the conventional VSM methodology. Therefore, a key performance indicator (KPI) system is provided, consisting of a selection of possible indicators, grouped by various perspectives of consideration. Due to different business models, products, strategies and operational targets it is necessary to design a universal master model. The choice of applicable KPIs, matching the company's strategy is company-specific.

2. Applied Methodology

The applied methodology is divided into two phases, which are visualized in the figure below.

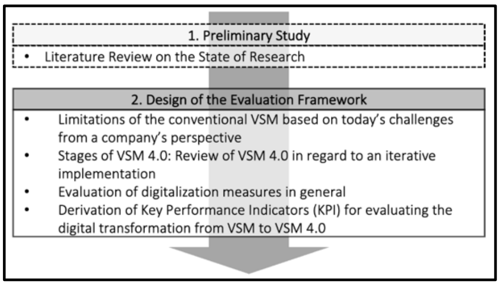

Figure 1: Applied Methodology

2.1 Phase 1 – Preliminary Study

The first phase of the applied methodology is the conduction of a preliminary study to identify the recent state of research related to the paper's topic. As pointed out in the previous section, the VSM 4.0 related studies, identified in the literature review are not directly suitable for achieving the paper's aim. For this reason, the design of the evaluation framework follows a deductive approach, reviewing the evaluation of digitalization measures in general and deriving a framework for VSM 4.0 in particular.

2.2 Phase 2 – Design of the Evaluation Framework

In the following sections the activities, mentioned in accordance to phase 2, are elucidated.

2.2.1 Limitations of the conventional VSM

The environment of supply chains is in change and therefore, companies must meet arising requirements to ensure the company's existence in the future. Table 1 shows a selection of challenges, companies face in their today's business.

Table 1: Selection of Business Challenges

Challenge	References
Increased Product Variety	[7], [24], [25]
Decreased Lot Sizes	[6], [7], [26]
Shorter Product Life Cycle	[17], [25], [26]
Increased Volatility	[17], [21], [27]
Higher Complexity	[21], [24], [25]
Digital Transformation	[3], [17], [28]

Based on the business challenges, the characteristics of the conventional VSM is investigated. The major limitations, requiring a redesign with focus on digitalization, are listed in Table 2.
In summary, the methodology of the conventional VSM is characterized as inflexible, inefficient and too simplified. Furthermore, the considered information in the Value Stream Map is incomplete in the context of information logistics and the application of information and communication technologies.

Table 2: Limitations of the conventional VSM

Limitation	References
Effort-Intensive	[29]–[31]
Time-Consuming	[6], [29], [31]
Manual (Pen & Paper)	[7], [30], [32]
Static (unable to capture dynamics)	[7], [33], [34]
Past Snapshot (no Real-Time)	[6], [21], [35]
Reduced Accuracy due to averaged Values	[29], [35], [36]
No Capturing of Product and Process Variants	[6], [29], [35]
Lack of digital Data Processing due to analog Data	[12], [30], [37]

2.2.2 Stages of VSM 4.0

The present paper aims at the provision of an implementation framework for assessing the impact of transformation measures in comparison to the conventional VSM methodology. In this context, it is necessary to examine the VSM 4.0 concept with regard to a phased implementation.

Based on the reviewed literature, two stages of VSM 4.0 can be differentiated, whereas the conventional VSM forms the core, as visualized in Figure 2.

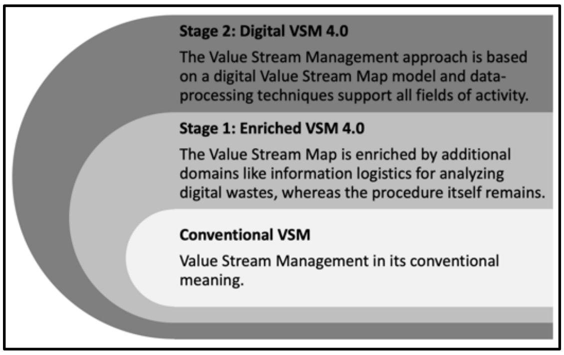

Figure 2: Stages of VSM 4.0

Stage 1 - Enriched VSM 4.0: The Value Stream Map is enriched by additional information, especially concerning information logistics, as described by [38]–[40]. Target is the visualization of digital waste by assessing the storage media for information, its usage and similar information. In this context, 8 types of information logistic waste are distinguished. The methodology itself remains unchanged compared to conventional VSM. [18]
Stage 2 – Digital VSM 4.0: The application of stage 2 is a disruptive transformation of the procedure in comparison to the conventional due to the transition from an analog paper-based model to a digital data model of the Value Stream Map, but it also offers new opportunities, e.g. the simulation of improvements, continuous data gathering and monitoring, as well as the utilization of data processing techniques like data and process mining. [41]–[43]

It is pointed out, that stage 1 and stage 2 are independent from each other. For example, the conventional Value Stream Map can be transformed to a digital model without data enrichment. The corresponding selection of additional information must be tailored to the needs of the company.

2.2.3 Evaluation of Digitalization Measures in General

In regard to its impact, digitalization measures can be evaluated value-based in three different ways, all based on a comparison of an initial state and the improved state (predicted or measured). The measurement of KPIs is suitable for both, processes as well as methodologies. [44]–[46], [47, pp. 43–46, 63]

Direct comparison of indicators, e.g., cycle time, resource utilization, output. An overall evaluation is made more difficult by the different units, e.g., seconds, percentage and pieces. By this approach a holistic assessment is difficult due to different units. Therefore, a further option is the application of utility values, which have a value in a defined range, e.g., 1 to 10. By the application of weighted utility values an overall evaluation under consideration of priorities on specific dimensions is supported.

Ratio of two indicators for determining the proportionate change, e.g., effectivity increase, also classified as index indicator.

Cost-orientated comparison, for which all changes are brought to a cost level, e.g., the time saving multiplicated with a rate per period is equal to the cost savings. By this approach an overall evaluation is possible due to a standardized reference value.

For a holistic evaluation it is necessary to compare the benefits of digitalization measures on the one side with its costs on the other sides. Measures with low costs / high benefits are preferable to measures with high costs / low benefits. The related KPI is mentioned as costs-benefits analysis (CBA), defined as difference between costs and benefit. On this occasion, one-time costs, e.g., the implementation costs for a software and ongoing costs, e.g., license costs are distinguished and have an impact on the amortization period. In addition, in the area of accounting the calculation of the indicator return on investment (ROI), defined as ratio of benefits and costs, is used. [48], [49, pp. 20–28]

2.2.4 Derivation of KPIs for Evaluating the Transformation to VSM 4.0

In regard to the previous section, the KPIs for evaluating the impact of digitalization measures against the background of a transformation from conventional VSM to VSM 4.0 are distinguished into four main dimensions, shown in figure 3.

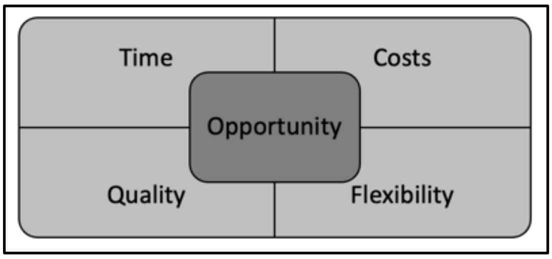

Figure 3: Dimensions of an VSM 4.0 Evaluation Framework

It is about the dimensions of time, costs, quality and flexibility, whereby a dependency between the dimensions can be determined. For example, a reduction of cycle times leads to a cost reduction. Furthermore, there is a fifth dimension, impacting all four dimensions. This is opportunity, which only arises from the operational application of technologies according to stage 2 of VSM.

The following listing shows a selection of suitable KPIs for evaluating digitalization measures in the context of the transformation from conventional VSM to VSM 4.0.

2.2.5 Selection of KPIs regarding the dimension time

Value Stream (VS) Mapping time: Absolute indicator, defined as time, required for mapping an entire VS. Used for comparing the time for manual recording and mapping by person and the time for automized recording by data / process mining based on events.

VS Analysis time: Absolute indicator, defined as time, required for analyzing an entire VS in regard to wastes. Used for comparing the time for manual analyzing by person and the time for automized analyzing based on machine learning (ML) / artificial intelligence (AI)

VS Design time: Absolute indicator, defined as time, required for designing a target VS in regard to wastes. Used for comparing the time for manual designing by person and the time for automized designing based on simulations as well as machine learning (ML) / artificial intelligence (AI)

VS Planning time: Absolute indicator, defined as time, required for planning and applying improvement measures for achieving the target VS. Used for comparing the time for the conventional PDCA-cycle (Plan-Do-Check-Act) based on a physical mock-up (PMU) and the time a

system-supported PDCA-cycle, simulating measures at a digital mock-up (DMU) for validating its impact before its implementation.
Time Effectivity: Ratio of the time for the improved state and the initial state for evaluating the effectivity of the measure on the dimension time.

2.2.6 Selection of KPIs regarding the dimension costs

Costs: The generalized indicator costs refers to all cost factors, e.g., the labor costs for lean manager as well as the costs for the operation of data platforms as storage area for process data, gathered according to the digital VSM 4.0 approach. In this context, partial and total costs can be considered.
Savings: In contrast to costs, saving refer to the elimination of costs, e.g., due to time savings in the processing.
Cost Effectivity: Ratio of the costs for the improved state and the initial state for evaluating the effectivity of the measure on the dimension costs.
Costs-Benefits: According to CBA the difference of benefit and costs is calculated. A value greater than zero (benefit is greater than the costs) is advantageous, whereas a value less than zero is disadvantageous. A value of zero shows, that benefits and costs are equal.
Return on investment: The ROI is defined as ratio of benefits and costs and is a measurement for the return in dependencies from the capital investment.

2.2.7 Selection of KPIs regarding the dimension quality

Accuracy / Data Quality (in general): The conventional VSM is based on a pen-and-paper procedure. To avoid measurement errors, a few production cycles are recorded and the values averaged. However, each recording is a snapshot of the production. By a continuous data gathering according to the digital VSM 4.0 approach, an entire overview including a data history is captured. Statistical methods can be applied to evaluate the data quality, e.g., mean and variance.
Sample Size: Number of gathered values, recorded for an indicator, e.g., process time.
Currency: Time after the last VS validation / last mapping.
Process coverage: Ratio of recorded VS and production cycles in a specific period.

2.2.8 Selection of KPIs regarding the dimension flexibility

Variance: Ratio of number of production cycles, following the standard VS (or alternatives VS) and total number of production cycles.
Variety: Number of variances of the production cycle.
Responsiveness: Time between a change in the VS and its capturing in the Value Stream Map.

2.2.9 Opportunities

The enrichment of the Value Stream Map according to stage 1 does not require a digital data model as described for stage 2. Therefore, the opportunities of enriching the Value Stream Map by indicators for analyzing information logistical wastes are not considered at this point due to the focus on evaluating digitalization measures.
Automizing the Mapping Procedure: A digital Value Stream Map model enables the automation of the mapping procedure and vice versa. In this context technologies such as IoT [50], [51], digital twin[11], [52], business application systems [53], [54] and cyber-physical systems (CPS) [55], [56] are mentioned in recent research.
Real-Time Monitoring: Enabled by the automized mapping procedure, process data are gathered in real-time. This enables a real-time monitoring by a continuous comparison of the target VS and the actual one. [56], [57]
Data and Process Mining: Based on the gathered data, the Value Stream Map is created by techniques of data and process mining. Furthermore, variants of the VSM can be visualized. [32], [41]
Simulation: Based on the digital Value Stream Map simulations can be applied for a virtual evaluation of digitalization measures before testing in practice. This opportunity saves time and efforts as proved in the context of digital engineering.[12], [30], [37]
Big Data / AI / ML: Big Data, AI and ML can support or automate the activities in the areas of Value Stream Analysis and Value Stream Design by the identification and evaluation of correlations. [26], [51]

3. Results and Discussion

The paper at hand aims at the provision of a framework, supporting a critical evaluation of measures for the transformation from the conventional VSM to VSM 4.0, which is based on a comparison of benefits and efforts for reasoning the transition from a company's perspective. The target group for such a framework are companies, which already apply the conventional VSM approach.

As a systematic literature review against the background of a preliminary study proved, a proposal for such a framework is missing in the recent research. By the paper at hand this identified research gap is closed. Different KPIs, related to the dimensions time, costs, quality and flexibility are provided. Furthermore, opportunities arising from the transition to a digital Value Stream Map are pointed out, which are not covered by applying the conventional methodology.

By the paper at hand, a two-stage implementation plan for the transformation from VSM to VSM 4.0 is provided. Whereas the first stage is restricted to the consideration of information logistical data in the Value Stream Map without improvement of the methodology itself, but at least taking the digital landscape of companies into account, the second stage takes advantage of all potentials of a fully-digitalized methodology.

At this point, two limitations of the consideration are pointed out.
The evaluation framework is derived from approaches for evaluating digitization measures in general. A higher reference to VSM 4.0 requires an aligning of the KPIs with the pursued goals and challenges of companies, which already apply conventional VSM and undergo a digital transformation.
Recent studies are focused on proposing application potentials, considering different technologies and approaches. Missing is a universal proposal for merging the heterogenous data for further data-processing operations, which is mandatory for estimating efforts related to the VSM 4.0 transition, especially in regard to a BCA and ROI consideration.

4. Conclusion and Outlook

Value Stream Management is a well-known methodology for improving end-to-end supply chains. But the environment of companies is in change, which leads to arising new challenges. Against this background, the conventional VSM suffers several limitations, which are overcome by the proposed application of modern information and communication technologies according to VSM 4.0, as detailly discussed in various studies.

Due to the diversity of companies in regard to strategy, business model and products as well as the internal configuration, especially process and system landscape, companies differ in terms of their competencies, strengths, weakness and needs. For this reason, the decision for a digital transformation from the conventional VSM to VSM 4.0 requires a critical evaluation. As proved by a systematic literature review, such an evaluation framework is missing in recent studies. By the paper at a universal evaluation framework is introduced, covering the dimensions time, costs, quality and flexibility. Furthermore, opportunities in regard to VSM 4.0 are listed.

As pointed out in the previous section, there are some limitations, which lead to further research questions:
What is the concrete demand and the expected benefit for a transition from conventional VSM to VSM 4.0 from a company's perspective? What goal is being pursued?
How can a technical concept for the realization of VSM 4.0 be designed, providing a solution for merging all data from heterogenous data sources, like sensors and business application systems for further data-processing operations?

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A-FTS Flexible routing planning program design

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Abstract

Currently, there is no widespread and free validation tool for examining flexible public transportation systems and testing theories. In transport, the application of reimagined flexible passenger transportation systems, which generate lower energy need and provider's cost, is becoming more and more popular. Based on previous own research results and new flexible transportation management theories (A-FTS), this validation program will be described. The flexible transport systems currently in use provide the design concepts on the basis of which a full validation system can be developed. This will provide the basis for starting to explore and implement flexible transport systems to exploit their potential.

1. Introduction

DRT (Demand Responsive Transportation) is a type of public transportation service that operates on a flexible schedule based on passenger demand. In contrast to traditional fixed-route transportation services, DRT services are designed to be more responsive to the specific transportation demands of the community, particularly in rural or low-traffic period where traditional public transportation is not feasible. DRT services typically use smaller vehicles, such as vans or minibuses, and can be booked in advance or on demand via phone or mobile app. Routes and schedules of DRT services are often determined by passenger demand and can vary based on time of day, day of the week, and specific passenger demands [1].

Moreover, the DRT services are often used to transport senior citizens, people with disabilities and people on low incomes who do not have access to private cars or traditional public transportation. DRT services can also provide transport for commuters in areas with limited public transportation options.

Because of scientific knowledge and our own research, the facts described in the previous paragraphs can also be said in general about FTS (Flexible Transportation System) systems [2]. FTS and DRT systems are used in the same social cases, but different tools and problem-solving procedures are used. Figure 1 is intended to illustrate this correspondence.

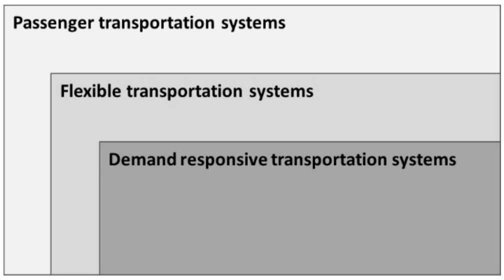

Figure 1: Sets of different transportation service systems

From this perspective, passenger transportation service systems form the largest group, which includes all mobility options, but in this case only FTS and DRT are considered. FTS is also a broader term that includes various types of transport services, including DRT. DRT is a type of FTS that uses small-capacity vehicles to provide transport services that adjust to meet the actual demands of travelers [3]. Therefore, while DRT is a type of FTS, not all FTS are DRT. As FTS is a passenger transportation system in a wider terminology, systems can be found in the literature operating under ready-made FTS systems and sold as a service [4]. Since all DRTs are FTS, but not all FTS

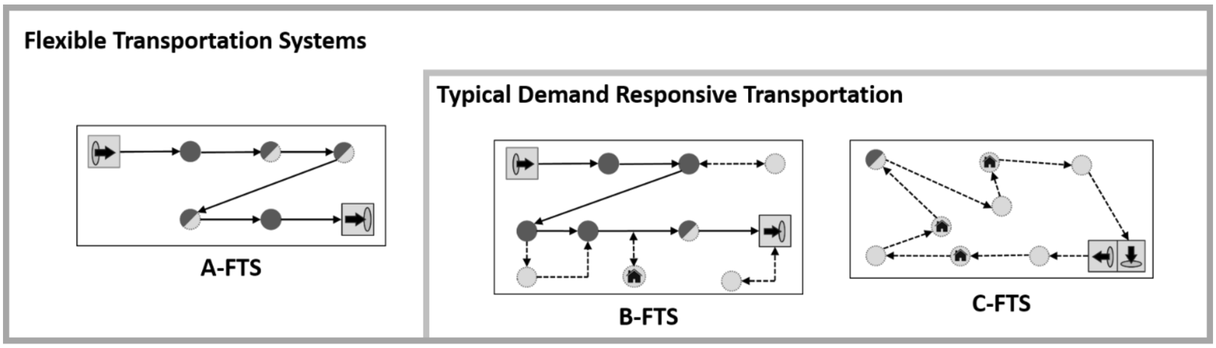

Figure 2: Group of FTS systems based on [3], [5]

are DRT systems, the methods and implementation concepts used in DRT systems can be transferred to the practical design project of the FTS.
According to our previous research [3] and [5], according to the above terminology, A-FTS is an FTS system that cannot be DRT, but B-FTS and C-FTS embody the conditions for DRT. It can be concluded that DRT schemes provide both temporal and spatial flexibility in route planning (B-FTS and C-FTS are such) as shown in Figure 2.
As far as FTS that are not DRT (such as A-FTS) are concerned, only temporal flexibility appears. Furthermore, DRTs can operate in smaller service areas if an A-FTS-like FTS system can operate at the macro-regional level.
In order to start to illustrate the journey route-planning of an FTS system through a practical example, it is necessary to review what solutions are already in use in the world and what approaches have been used in the literature. Therefore, the aim of this research is to find out what software solutions exist to support flexible transportation management (mainly in Europe and North-America). Examine the systems that have been found and are widespread and popular, what special services they provide, whether special tools are required, etc. In addition, using the results of the above research, the goal is to implement a flexible transportation scheduling method that can manage the schedule and communication of a passenger train → running in the low-traffic period. Therefore, the paper continues with an overview of software supporting flexible transportation systems in the next paragraph. It will be followed by a description of a previous research on A-FTS flexible transport concept design.

2. Literature review

The literature database will be defined as the research begins. The literature for FTS systems can be drawn from both scientific databases such as the Web of Science (WoS), Scopus, etc. and by analyzing the DRT and FTS service support systems available on the Internet [3]. In the second case, Google can be a great help in finding flexible transportation planning software and applications. As they are products of market-based businesses, advertised through marketing tools via the internet. Such marketing descriptions tend to list only the positives and benefits of a system. This is why it is essential to check the systems found in scientific publicist databases. It should be ascertained whether the DRT systems in discussion have been tested.

a) The first is **MOIA**, which is a "carpooling" application. It is a fully self-organized system, where you can enter travel requests via a phone app. The requests received are assessed by the driver of the minibus and the route of the vehicle is modified accordingly [6]. What changes is the travel distance and travel time. It can handle the demands of several passengers at the same time on an ad hoc basis, but no information is available on flexible tariffs. It could be used to calculate a more favorable fare for some travelers as the distance and time of the journey increases. The MOIA solution in Hamburg is already integrated into the urban public transportation system. This has a major advantage for the passenger, which is the one-stop fare system [7]. The future perspective for providers is seen by owners as a shift towards e-mobility and autonomous vehicles.

b) The second is **Pantonium**, which provides macro-level transportation services in a wider service area. As a result of the demand reports, the transportation vehicle is affected by the stops and they can optimally select the stops to be served [8]. An important feature of this system is that the stops are pre-defined, so that boarding and/or alighting can be easily predicted (Figure 3.).
It is important to note that the Pantonium system has managed to use excess capacity during periods of low-traffic utilization [8]. Consequently, the fixed stop and forecasted demands can be met by the system, which has been applied at the macro level.

Figure 3: Pantonium journey plans [9]

c) **Liftango** is a complex management system solution for flexible transportation planning. The company helps you from the start, if your service provider is just thinking about using flexible transportation in its own network [10]. Using similar solutions as for the previous products, a system has been developed that can integrate with the existing public transportation network [11].

Figure 4: Different user platforms of Liftango [12]

Furthermore, Liftango is not only a service for flexibility, but also for planning and providing other mobility and transportation alternatives. For example, the company is also involved in the sensing of existing public transportation systems, followed by data collection and digitization solutions. As a result, by processing Big Data [13], the company can propose optimal operations [14] and increase the efficiency of the system.

d) **Drip** is a complete booking and planning system for passenger transportation and scheduled trips according to your travel needs. The system is cloud-based where booking and planning can be done. This system is mostly used to organize collection and distribution journeys efficiently [15]. There is no automatism, because it is a ride-pooling system that the individual can specify the free seats in the car that can be reserved when he or she has his or her own commuting habits. It differs from the first system in that you have to follow the route you have been given, or you can negotiate your way in and out of the car.

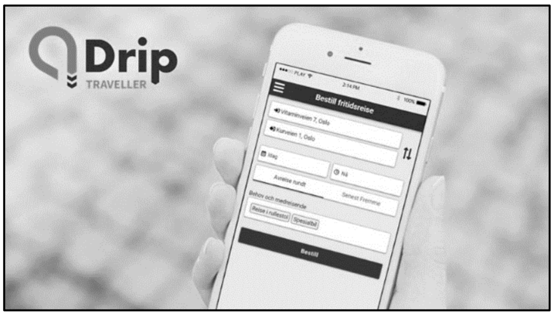

Figure 5: Drip DRT user interface [15]

It can be used to drip to school to work or even to connect a large shopping trip together in scattered villages where traditional public transport is not available. This also shows that this is a Swedish application and that in Sweden, outside the large cities, there are scattered municipalities from which access to the city is difficult and cannot be served by public transportation. The Nordic (Scandinavian) countries have a low population density, ergo low population density and dispersed municipalities [16].

e) **Spare** is the result of a Canadian-Norwegian collaboration and its products are already used in Asia, America and Europe. The solution is not specifically designed for providers. Rather, it is designed to extend and improve the service of existing transportation systems. To this end, they provide software solutions the development of software solutions tailored to the needs of the service provider is their task. At the same time, they provide access to analyses such as the potential for demand responsive transportation on a traditional public transportation route. Spare can also make multimodal transport possible within its own system, where there is overlap between the two mobility support solutions it develops. In addition, it provides services for microtransit, paratransit, ride-sharing, ride-hailing and NEMT (non-emergency medical transport). However, the website (as a marketing platform) gives little insight into the exact operation and application of Spare solutions [17], and no literature is available.
f) **Padam Mobility** provides DRT to transit operators, local and transport authorities. Their smart and dynamic solutions optimize DRT services for efficient itineraries [18] and vehicle occupancy, utilizing powerful algorithms and artificial intelligence [19]. Their aim is to get users, operators, and public authorities moving efficiently. Typical ese cases: Off-peak hours,

Paratransit, Business areas, First and last mile, suburban and rural, regional mobility.

g) **Via** is a transportation network company that offers shared rides in cities around the world. Via's mission is to provide affordable, efficient, and sustainable transportation options that reduce congestion and improve access to mobility [20]. Via's algorithm matches multiple passengers traveling in the same direction into a single vehicle, reducing the number of cars on the road and lowering emissions. Via also partners with public transit agencies to offer on-demand, first-mile, and last-mile solutions that integrate with existing transit infrastructure. Via's platform is available through a mobile app and web interface, and the company also offers a suite of enterprise solutions for corporate travel and logistics [20].

h) **Moovit** is a smart urban mobility app that offers a comprehensive on-demand transportation solution [21]. The service includes multimodal trip planning, mobile ticketing, and real-time transit information for buses, e-bikes, scooters, and ride-hailing services. Moovit's Mobility as a Service (MaaS) pilot project in Tampa aims to optimize and simplify urban mobility for riders. The city is seeking 200 people to take part in the pilot project, which includes surveys and feedback on the app's functionality over a six-month period. Moovit's MaaS solutions provide cities [22], transit agencies, and corporations with new opportunities to improve connectivity between modes of transport and address gaps in access to transit.

3. Literature review conclusion

When designing and implementing flexible transportation systems, it is important to have an action plan for the user interface and the operational concept. This is necessary because if there is no transparency in the operation of the FTS, the flexible transportation concept will not be popular during the incubation phase due to bad impressions. In many cases, this is why flexible transportation systems have not spread so widely around the world. At the same time, the limited availability of software to support DRT is not conducive to widespread adoption. Designing with supporting software is costly and ongoing product support and maintenance is an ongoing cost. And transportation companies do not always operate on a profit-oriented basis, so there is no financial scope for DRT services other than traditional transportation as a basic service. At the same time, it can be seen that most DRT solutions try to take advantage of the benefits of digitalization technology, such as live tracking via phone app, fast response to travel needs, etc. Several of the DRT solutions listed are available in the literature and have been the subject of research, but the mathematical models and algorithms used in their solutions are not available. This is obvious, as the scientific and innovative activity of these companies is to solve optimization method in transportation planning to serve travel demand, so they treat mathematical models as a business secret. If we consider the literature review in [3] and [5] and the present survey, it can be seen that the major differences in DRT systems are not in the vehicle route-problem search performance and response time. Therefore, the following points should be considered when designing efficient and popular FTS systems: (i) define a transparent operational concept, separating the user and the service provider/operator side; (ii) integrate the system as much as possible with the existing public transportation ecosystem; (iii) design a simple and transparent platform, i.e. user-friendly interface. In addition, there are a few FTS guidelines that can be developed to assist in conscious FTS planning [9]:

- declare service territory: micro, meso, macro, macro-regional;
- the proper selection of the service area and period;
- the system must be prepared to cope with extraordinary travel needs;
- adequate automation of system operation (this is not a barrier nowadays);
- use existing infrastructure as a baseline.

In Hungary, there are no reports of the use of software supporting flexible transportation management such as the above. Therefore, the use of flexible transportation systems is not widespread (neither in a spatial not in a temporal context).
For this reason, there are plans to design A-FTS at a level that would provide time flexibility for off-peak passenger services, especially on rail.

4. FTS software developing advices

One important fact should be pointed out before going into the details of A-FTS. Systems supporting flexible transport must satisfy several software requirements in order to operate efficiently and satisfy the needs of users.
The software should have an **intuitive and user-friendly interface** that allows users to easily browse the system, enter the desired travel parameters and monitor actual journeys. The user interface should be simple and easy to understand, especially for non-technical users. [23]
Flexible transportation software should be able to **integrate** with other systems and services, such as map applications, payment systems, APIs for traffic data and internal company databases. [24]

The software must have efficient **algorithms** for route planning, passenger coordination and efficient vehicle utilization. **Optimization** can help to minimize empty journeys, reduce waiting times and optimize transportation costs. [25]
The software must ensure efficient **data management**. Data must be stored and retrieved quickly and reliably. The database must be able to store and process large datasets, since traffic management systems generate a lot of data, such as vehicle information, routes, passengers, etc.[26]
The software must include appropriate security measures to protect the data and the security of users' personal data, including encryption and access authorization management. [27]
This summary was necessary for the A-FTS system, which will be presented in the next chapter. It should be noted that scheduling information is received and processed through software solutions, from which the system makes decisions and communicates with users.

5. A-FTS journey planning parameters

Previous research results on the A-FTS flexible transportation concept have been published in [5]. However, for the purpose of the following chapters, the A-FTS will be presented in the following paragraphs based on the research in [5].
A-FTS is a transportation concept that can be used to meet travel demand during low-traffic periods. It is a novel approach to the organization of transport, which differs from inflexible ("traditional") transportation in that the passenger vehicle stops only at stops where there is a demand for travel from the pre-announced schedule. During high-traffic periods, flexible transport such as A-FTS cannot be used effectively. Effective long- and short-term demand forecasting is necessary to identify dead periods. The A-FTS covers essentially the same distance (fixed in spatial terms) but reduces travel time to an optimum by making stops according to travel demand. This means that the transport vehicle (in this case the train) stops at the relevant stop/station when there is a demand for passengers to alight and/or board. The assessment of travel demand and the corresponding transportation management and communication is an important part of a functioning FTS. Therefore, the A-FTS flexible transportation concept includes 3 subsystems that perform different functions during operation: (i) PDMS (Passenger Demand Management Subsystem), (ii) VRTMS (Vehicle Registration-Tracking Management Subsystem), (iii) RTIS (Real-Time Information Subsystem).
The VRTMS subsystem is the vehicle and tracking module, which is informationally linked to the train scheduling system and the HR planning software. For this research, the PDMS subsystem is of primary importance and the RTIS subsystem is of secondary importance. Travel demand from the period pre-departure for the j-th journey ($\overline{PD}^{j}$) and ad hoc travel demand ($\overline{AHD}^{j}$) are received via the PDMS subsystem.
Figure 6 shows the timetables before the departure time of a given train j, which provide information at different levels. $\overline{SCH}_{0}^{j}$ is identified based on the long-term passenger demand forecast, which includes stops with higher boarding/ alighting passenger volumes during the low-traffic periods. In the days before departure, the system starts the registration of travel demand PD(j) which is used to automatically generate the $\overline{SCH}_{real}^{j}$. This schedule already includes the stops indicated by the claim, and $\overline{SCH}_{0}^{j}$ and $\overline{SCH}_{real}^{j}$ create a time window (MIN-MAX) schedule. This is the norm according to which ad hoc travel demands for the $\overline{SCH}_{act}^{j}$ i.e. actual schedule can be accepted if the later arrival time included in the $\overline{SCH}_{0}^{j}$ schedule cannot be generated at the position.

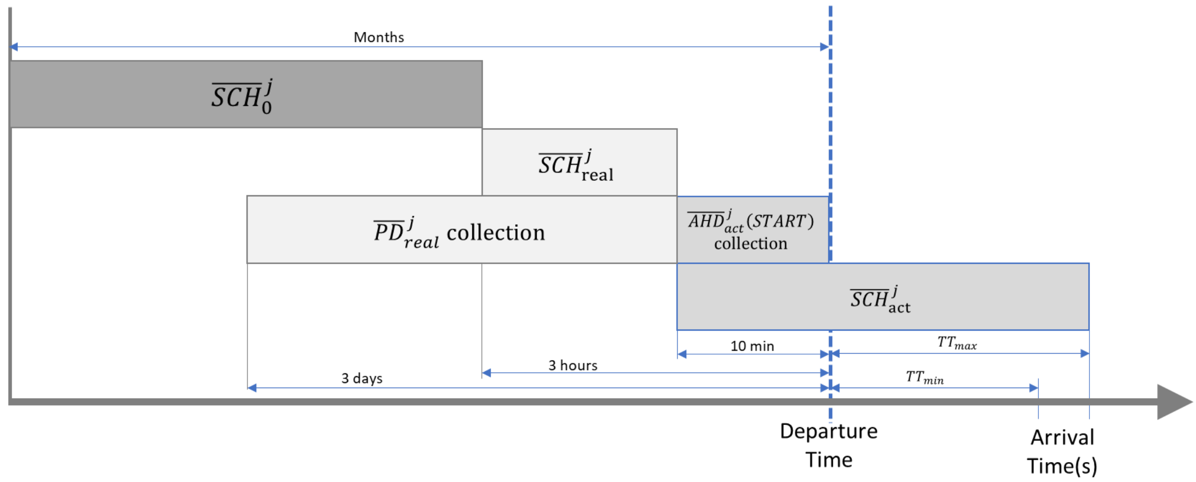

Figure 6: A-FTS scheduling plan based on [5]

Thus, it is a safety design constraint to ensure predictable transportation management for the system's existing journeys.
The schedule variations briefly described must be able to be handled by a system that calculates, manages, and evaluates the information (passenger side and provider/crew side).

6. Further research directions definition

The availability of open-source systems and database structures for flexible transportation can increase the popularity of this research area. Compared to the last 5 years, technology has developed a lot, which can open new research directions for this field. These directions are worth following as energy costs has increased and transport providers must rationalize the use of resources. Depending on this, a partially demand-responsive flexible transportation system can be well parameterized. If you like, it is a nice transition between inflexible scheduling and full demand responsiveness.

7. Conclusion

The paper demonstrates that it is possible to distinguish between DRT and FTS systems. The flexible transportation systems currently in use in the brain are constantly evolving, so it is worth keeping an eye on them in the future. It can be concluded from the analysis that the efficient and safe operation of flexible systems depends on software solutions. The A-FTS framework is presented in the context of such software solutions.
The A-FTS validation system has already been accepted in a prestigious scientific journal, but the main goal is to put it into practice. To prepare a pilot, this literature and practice review was necessary. It provides a good basis for testing a pilot A-FTS system. At the same time, the expectation of automated operation can be conceived as management and control from generated datasets.

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Academic thinking in science Logistics

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Abstract

The scientific discipline of logistics has existed at universities and colleges for about 45 years and trains young academics for the industry and for logistics tasks in all other areas (e.g., trade, transport, hospital, administration, military. hazardous goods logistics, disaster logistics). Subtly and yet noticeably, logisticians are characterized by a special way of thinking. The task is to make this academic logistical thinking explicit, but not retrospectively, declaratively, but on the state of the year 2023.
This work is intended to contribute to basic research and academic teaching in logistics.
The authors characterize logistical thinking and then provide some guidance accordingly, that can be used, for example, in the analysis, design, optimization, improvement and planning of logistical solutions and have a high degree of general validity.

The research is based on the authors' many years of expertise in the field of Supply Chain Management, Logistics and Material Handling combined with a comprehensive German literature review and the evaluation of current academic education, research projects and trends.

1. Introduction: Logistics - Definitions: Status 2023

The authors propose following definition for logistics, based on [1]:

Logistics is the holistic analysis, planning, management, coordination, implementation, control and improvement of all flows of information, people, goods, finance and energy. In addition to flows, business models, logistical objects, logistical systems and logistical infrastructures are also considered individually and in their interaction.
Supply chain and demand management, the intelligent configuration, planning and control of logistics and value creation networks are an important sub-area of logistics.

In June 2010, the BVL Scientific Advisory Board developed a basic understanding of logistics as a scientific discipline in the form of a position paper [2]. As of 2023, the following recommendations result for updating based on [2]:

- Basic definition of logistics (see above)
- The primary scientific issues of logistics relate to the analysis, configuration, organization, control or regulation and improvement of these networks and flows with the claim of enabling progress in the balanced fulfilment of economic, ecological and social objectives (sustainability). The fulfilment of customer needs sets the objective and dynamic standard. In addition, safety becoming increasingly important.
- In addition to flows, business models, logistical objects, logistical systems and logistical infrastructures are also considered individually and in context.

In addition to this basic understanding of logistics, innovations (e.g., digitalization and networking) and social framework conditions (e.g., Supply Chain Act) have a decisive influence on logistics goals, options for action and solutions. Ten Hompel characterizes, for example, with regard to the trend "digitalization": "Logistics is on the threshold of the Silicon Economy. The complete digitalization of our supply chains and infrastructures with the help of artificial intelligence is without alternative in order to make the mobility of people and goods sustainable and to achieve our climate goals." [3] In [4], exemplary research questions are raised in relation to Logistics 4.0. In [5], the effects of current trends on logistics are listed and characterized.

2. Characterizing logistics as a science

Note: This paper cannot and does not refer in detail to the philosophy of science. (Cf. e.g. [6] for more details).
First of all, the term "science" is defined by Bendel [7] as follows: "Science aims at gaining knowledge (research) and imparting knowledge (teaching), using recognized and valid methods and publishing or incorporating results. In a certain sense, it is unconditional and open-ended."
For the establishment of logistics as an applied science, the examination of relevant characteristics is necessary. (Cf. [2] [8] [9] [10] [11])
Sciences are primarily distinguished by their object of knowledge. The goals of knowledge and the use of recognized research methods are also frequently mentioned. (Cf. [12])

1. Objects of knowledge in logistics are:

- Flows in networks [2]
- Logistical business models
- Design of the life cycle of logistical objects
- Design of the life cycle of logistics systems including networks as MTO systems
- Design of the life cycle of logistics infrastructures
- Linking the design objects to logistics solutions
- Academic qualification and training of logisticians

2. The knowledge goals of logistics are the discovery and formulation of model solutions, laws, rules, theories and hypotheses concerning the objects of knowledge.
3. Important research activities and research methods in logistics are in extension of the logistics definitions (Cf. [13]):

Perceive, inform, describe, invent, analyze, model, plan, optimize, improve, explain, perform, evaluate, reflect, recognize and decide.

In addition, there are a number of other indicators (e.g., social, economic and ecological relevance, specialist language, own scientific community and career structures, own scientific teaching at universities and colleges, number and quality of doctorates and habilitations as well as recognized academic publications and media) that prove the existence of a science, which cannot and should not be discussed in depth here.

The thesis is put forward that logistics as a science is characterized by a specific type of thinking by which it can also be designated, other examples being e.g., mathematical thinking or economic thinking. In addition to a variety of general types of thinking that are available to all disciplines as a repertoire, some types of thinking and models of thinking are particularly required and promoted by an individual scientific discipline. In addition, individual models of thinking are developed and used to solve typical thinking tasks. The research gap is to make this logistics thinking explicit. Following John H. Flavell [14], this is called metacognition, "thinking about thinking itself" and is applied to the science of logistics. "This ability to control, monitor and organize one's own thinking, or to correctly classify memories, perceptions and decisions, and to reflect on and evaluate them, can help people make better decisions, formulate achievable goals, but also clearly recognize strengths and weaknesses." [15]
The concrete research questions are:

1. How does/should an academic logistician think?
2. What are important models of academic thinking in logistics?
3. How should academic thinking be trained in logistics?

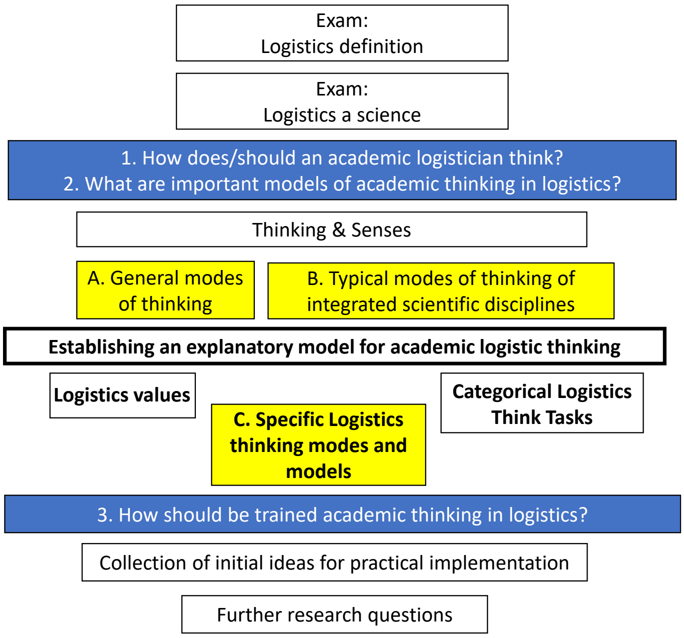

Figure 1: Systematic approach to research

3. Methods

The research is based on the authors' many years of expertise in the relevant scientific field combined with a comprehensive literature review, the evaluation of current academic education, research projects and trends.

A systematic approach with focal points was formulated. (Fig. 1) The starting point is first to look at the concept of "logistics" and "logistics as a science" (cf. bullet points 1 and 2 and Fig. 1). Subsequently, the term "thinking" is defined. In order to characterize the types of thinking, three approaches are to be applied (marked in yellow):

A. General ways of thinking that are available to all people.
B. Typical thinking of other sciences used in Logistics. (Types of thinking that are primarily used by logistics as an interdisciplinary science. Here the limitation should be on typical ways of thinking, a logistician would call them "A ways" of thinking.)
C. Special "logistics maps". This raises the question of the special nature of logistics.

As an aid, an explanatory model for logistical thinking is to be described and categorically filled with reference to logistics. These thinking aids are to be designed openly and can be used as a kind of checklist.

Once the explanatory model has been used to qualitatively describe logistic thinking, the task is to derive ideas and approaches for academic education and training.
Open questions are derived from the documented state of knowledge, which can and should be addressed through further research.

The chosen, systematic approach (Figure 1) is methodically underpinned in the following:
Preparation of own expert knowledge (thinking, questioning, documentation)
Analysis of existing publications on:

1. Thinking and senses (literature analysis)
2. General ways of thinking (literature analysis)
3. Typical ways of thinking of other scientific disciplines relevant to logistics (Thinking, expert survey, documentation)
4. Explicit research on logistic thinking (thinking, literature analysis, expert knowledge)

The literature analysis carried out can be characterized as follows:
Language: German
Search Terms:
Denken; Sinne; Denkart;
Denkart + Wissenschaftsdisziplin;
Logistikdenken, Logistisch* Denken,
Denken in der Logistik, Denkmodelle der Logistik
Period: 1990 - 2023
Search locations: Google Scholar, SpringerLink, ResearchGate

Explanatory model: Conceptual research work
Ideas for training senses and logistic thinking: creative research work
In terms of novelty, this research builds on existing knowledge. The intended added value is to reflect logistic thinking at the level of 2023 and to provide guidance for targeted academic training.

4. Results and Discussion

4.1. Status: Thinking and sense

"Thinking is the processing in the brain of information perceived by our body and its sense organs." [16]
It can be roughly divided into three phases: Sensory impressions that initiate and accompany thinking processes, the actual thinking processes and the thinking results.
Thinking processes are thus initiated by one and/or more sensory perception(s).

While in other scientific disciplines, e.g. the sense of smell (chemistry), the sense of touch (medicine) and the sense of taste (food technology) also play a role in academic education, the sense of sight (perception of the scene, environment, images, photos, animations, videos, reading) and the sense of hearing (spoken word, sounds, tones) are particularly relevant for academic logistics of the five basic senses.
For further information in this area, we refer to the explanations on mechanisms of perception on [17]. Accompanying the thinking process, communication and further information gathering can take place. Individual personality types and thinking styles are not considered in this publication.
As a finding, the following tasks arise:

- to learn to see logistically
- to listen logistically with the best possible understanding, and
- to communicate with others.

4.2. Stand: common thinking models

The following Table 1 is the compilation of an open list of general features to characterize thinking. They are referred to as types of thinking, whereby actually every thinking process has several of these characteristics. In this sense, the characteristics are more descriptive than delimiting or classifying.

Table 1: State of knowledge on logistics-relevant, general types of thinking [18] [19] [20} [21]

Aspect	Examples
Conscious-ness	conscious, ~~preconscious~~, ~~unconscious~~
Logic	logical, dialogical, causal-logical, final-logical analogical ~~paralogical, counterfactual~~, lateral
Thought process step	discursive (in steps of thinking), argumentative, ~~intuitive (by leaps and bounds)~~
Reference	narrative, pictorial, analogue, associative
Abstract--ness	abstract, concrete
Science reference	~~psychological, theological~~ technological, ecological, biological, sustainable **logistical,** technical, economic, informatic, mathematical, legal, sociological
	academic, non-academic, pragmatic, empirical, heuristic
	Interdisciplinary, monodisciplinary, transdisciplinary
Cultural circle / Region	occidental, western, ~~eastern~~
	global, regional
Belief	~~ideological, christian, jewish, islamic, atheistic~~
Time reference	operational, tactical, strategic, visionary
	retrospective, present-orientated, forward-looking
	Life cycle (idea, development, construction, commissioning, use, dismantling/disposal)
Emotio-nality	~~emotional~~, ~~intuitiv~~
Complete-ness	holistic, incomplete
Rationa-lity	rational, irrational
Structure	linear, causal, networked, control loop-based (cybernetic), case-by-case, complex
Direction	analytical, synthetic
	inductive, deductive, discursive
	vertical, lateral
Quality	quantitative, qualitative reproductive, productive
Basic setting	idealistic, optimistic, pessimistic, realistic
Practical relevance	theoretical, practical
Gender reference	~~male, female, diverse, gender-independent~~
Flexibility	flexible mindset, changing mindset, inflexible mindset
Criticism	critical thinking ~~uncritical thinking~~

In Table 1, the types of thinking that are not relevant to the academic training of logisticians have been marked with a cross out.

In the following, a literature source will be presented and discussed as an example. This is not done in full in order not to go beyond the scope of the paper. The International Center for Studies in Creativity distinguishes seven types of thinking in relation to creativity [22]:

- Visionary thinking (ideal state)
- Strategic thinking (concrete direction)
- Tactical thinking (concrete action)
- Contextual thinking (environment, supporters & threats)
- Diagnostic thinking (facts & open questions)
- Thinking in ideas (4 principal options [22])
- Evaluative thinking (assessing quality and feasibility).

After evaluation and classification, the following statements emerge:

1. Visionary, strategic and tactical thinking: These types of thinking have already been listed under the general "types of thinking under time reference".
2. Analytical (diagnostic) thinking also belongs to the general types of thinking.
3. A contextual reference must be established in every thinking process and is thus fundamental and not specific.
4. Thinking in ideas is generally called creative thinking. This is what is actually specific.
5. Every thinking process should reflectively evaluate the thinking and the thinking results. This is also more general.

From Table 3, it can be deduced that these general types of thinking are available as broad thinking options alone or in almost any combination. They thus form the general basis of the logistician's thinking. In order to generate a broad repertoire, many types of thinking should be required and made conscious in the training of logisticians.

4.3. Status: Sciences relevant to logistics and their typical way(s) of thinking

Logistics is characterized as an interdisciplinary scientific discipline. This means that it synergistically uses different perspectives from other scientific disciplines. Table 4 names scientific disciplines that are important for logistics. Exemplarily, the respective, salient, science-specific thinking is characterized. This is based on expert knowledge from the authors' point of view. These properties are referred to as characterizing properties because they are characteristic of the individual scientific disciplines, which does not mean that all the other types of thinking listed in Table 1 are not also (frequently) used.

Table 2: Sciences relevant to logistics and their typical way / ways of thinking

Science	Typical thinking
Mathematics Statistics, Stochastic, Logic	analytical logical infer
Physics **Mechanics**	dynamic movement & flow-oriented
Science	**Typical thinking**
Economics	economic model-based time-related (visionary, strategic, tactical, operational life cycle)
Engineering (general) Construction Production engineering Traffic engineering Material flow technology Electrical engineering Electronics Systems Engineering Automation Technology Environmental Technology Energy Technology Safety Engineering Maintenance Materials technology	creative analytical critical systemic systematic reflective flexible practical
Labour Science **Ergonomics**	human-centered ergonomic
Cybernetics	control loop based
Informatics	algorithmic
Law	contextual evaluative
Organizational Sciences	structural process-oriented
Social science	dialogical communicative
Artificial intelligence	artificial mechanical

4.4. Explanatory model: Logistical thinking

An explanatory model of logistical thinking was developed from the experiential knowledge of the logistics experts involved, supplemented by the results of the initial literature studies (Figure 2). It will be explained in the following:

Figure 2 sets up a triangular framework of thinking that includes:

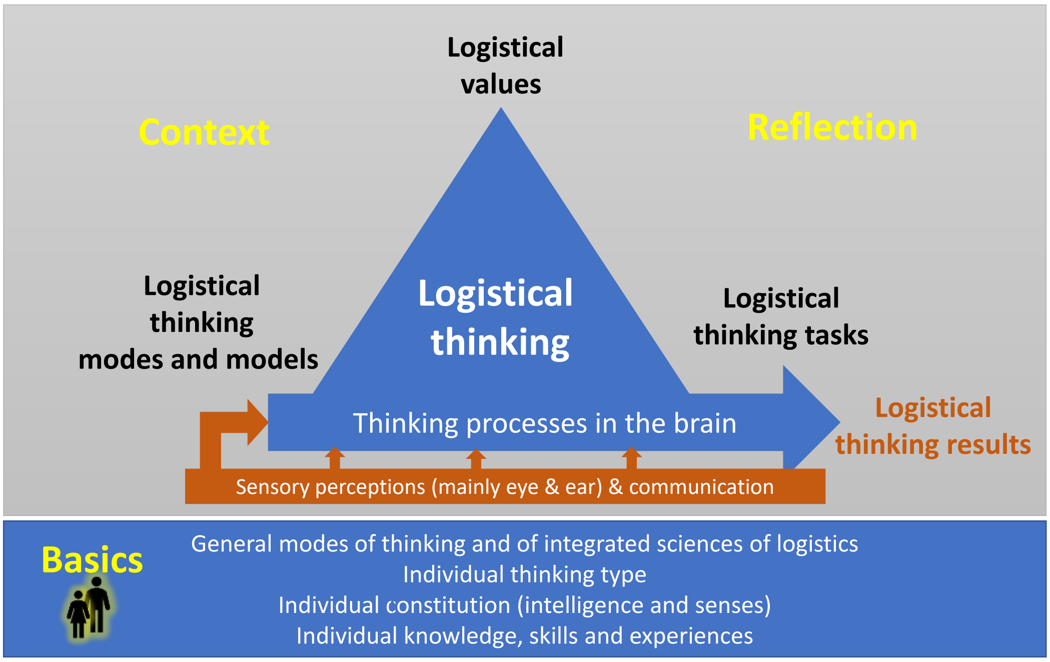

Figure 2: Explanatory model of academic logistical thinking

1. the quality criteria (value measure)
2. the appropriate logistics thinking maps, which are due to interdisciplinarity, are supplemented by types of thinking and thinking models of relevant scientific disciplines and
3. the application reference in the form of typical logistics problems & tasks.

This results in a network of possible thoughts and thought processes. Logistical thinking always establishes contexts. This concerns e.g. allocations, obstacles and promoters. These contexts concern both the values, the tasks and the appropriate thought models, as well as the solutions worked out through the thinking process. This in turn indicates that the same thinking constellations can and will lead to different solutions in different contexts. Reflection is equally important for the evaluation of the thinking process and results.

4.5. Results of the literature review on logistic thinking

At all colleges and universities that train and educate logisticians, the question of how academic, logistical thinking can be taught and trained is addressed consciously or unconsciously. A rough review of German-language logistics literature revealed that many academics look to the past and explain the logistical thinking of past decades. This view of the past is deliberately not taken here. From the authors' point of view, it is more important to deal with the logistics of the present 2023 and the near future (until 2030) and beyond.

The following summarized findings regarding current logistical thinking emerge from the literature review (selection):

Basic understanding of logistical thinking:

"Logistical thinking and action are in demand today in all industrial, commercial and service companies and state institutions and authorities." [32]
What is needed is ... "a new way of thinking about logistics, a paradigm shift away from reduced thinking about transport, transshipment and warehousing to an approach of holistic consideration and shaping the future - not only in relation to the logistics industry, but to the economy and society as a whole.

Competitiveness and quality of life in many areas are largely dependent on the performance of logistics. Logistics can and must therefore assume even greater responsibility in the future than it has in the past - in an economic, ecological and social sense." [29]

Important ways of thinking and characteristics of logistical thinking are:

- **Flow-oriented** (flow principle and flow perspective); "Structure follows Process [30] [31] [33] [37] [38] [40] [42] [43] [46]
- **Value chain thinking** [27] [28] [29] [37] [45]
- **Life cycle thinking** [29] [43] [45]
- **Customer perspective, competition and service thinking** [29] [31] [33] [35] [36] [37] [40] [43] [45] [46]
- **Society orientation** (stakeholder management) [29] [45]
- **Functional optimization** (resource orientation) [31]

- **Technical-economic thinking**
  - Total cost thinking [33] [43]
- **Systems thinking** [30] [31] [38] and **networks thinking** [33] [42] [43] [49]
- **Organizational task and thinking** [30] [36], **coordination** [31]

- **Holistic** [23] [26] [30] [32] [36] [40] [44] [46]
- **Interdisciplinary** (but also monodisciplinary and transdisciplinary) [44]
- **Integrative** [30] [38]
- **Time related:**
  - **Time factor** [30] [38] [40] [46]
  - **3 Levels of time, thought and action** of the management: normative, strategic and operative [41]
  - **Future-oriented** [39]
- **Complex** [49]
- **Analytic** [36]
- **Critical** [48] includes: Changing perspectives, asking questions, contextualization, open discourse, listening, reading, writing as thinking [48]
- **International** [36]
- **AI-based, integrated** [47]

The presentation of further realized evaluations is not included here.

4.6. Ideas of logistical thinking

The following open lists of values and tasks are generated to support Figure 2.
Examples of typical logistics values are:

- Quality-oriented
- Effective
- Sustainable (efficient, ecological, social)
- Safety & secure,
- Fast
- On time
- Holistic
- Resilient
- Digital & networked
- Transparent
- Innovative
- Integrative
- Weighing
- Flexible
- Law, compliant
- Simple
- Realizable
- Adaptive
- Scalable

and many other more.
The values can be used for:

- Goals
- Options for thought and action and
- Evaluation variables for the results.

Table 3 lists categorically important thinking tasks in logistics as an open list.

Table 3: Important thinking tasks of Logistics (Ex.)

Thinking tasks	O	P	S	I
Recording and assessing the situation	x	x	x	x
Identify and describe problems & tasks	x	x	x	x
Thinking about goals	x	x	x	x
Design solution, calculate (estimate/calculate), design and plan	x	x	x	x
Practical, implementation oriented	x	x	x	x
Analytical, improving, optimizing	x	x	x	x
Generating new ideas	x	x	x	x
Generating variants	x	x	x	x
Critical thinking (cf. [48])	x	x	x	x
Reflect (cf. [31])	x	x	x	x
Developing visions	x	x	x	x
Decide	x	x	x	x

Explanation: O = Object; P = Process; S = System; I = Infrastructure

The crosses in the columns prove that all tasks actually exist.

4.7. Ideas to create and train logistical thinking

In the following, the third research question, how to develop and train logistic thinking, will be answered. Table 4 contains a first collection of ideas for training the senses.

Table 4: Training the senses for science Logistics

Sense	Training approach
Sense of sight	Learning to see logistically
Sense of hearing	Logistic understanding Practice listening
Reflect sensory impressions	Practice reflection

Table 5 contains initial ideas on logistical thinking.

Table 5: Developing logistical thinking

Metacognition	Addressing and developing logistical thinking
Explanatory model (Figure 2)	Communicate and use the explanatory model
General models of thinking (Table 1)	Design training tasks, that allow the use of a variety of thinking styles

	Reflect on the completed thinking and the quality of the thinking results together with the students
Logistical tasks	Know and recognize logistical tasks; Train assignments to thought models
Context	Make people aware of the context and practice it: Values - context Tasks - context Models of thinking - context Solutions - context
Logistical thinking models	Know and master these science-typical categorical models of thinking. (open list)
Logistical values	Know current logistical values Know or develop options for action Derive and use qualitative and quantitative valuation parameters

5. Conclusion and Limitations

What are the most important results of the research?

- The concept of logistics was modified, expanded and sharpened.
- The self-conception of logistics as a scientific discipline was briefly characterized and confirmed.
- The relevant senses as triggers of thought processes in logistics were identified.
- A selection of logistics-relevant ways of thinking (general, science-specific and logistics-specific) was made, that offers a variety of potential thinking alternatives.
- An explanatory model for academic logistical thinking was established:
  - It includes a triangle of values, task and ways of thinking.
  - In addition, context setting and reflection are very important.
  - The thinking triangle is based on individual thinking prerequisites. (Cf. Fig. 2)

To underpin the explanatory model of academic logistical thinking, exemplary lists were drawn up. Ideas were collected on how relevant senses and logistic thinking can be specifically promoted and trained in academic education and training. (Cf. Tables 4 and 5)
Methodological alternatives are:
Regarding the type of literature analysis:

- Extension of the language area
- Extension of the relevant databases
- Modification and altered combination of search terms
- Deepening the knowledge of related sciences.

As an alternative to the literature analysis and the expert knowledge of the authors, other logistics experts (national, international) could be interviewed and their views compiled, for example. In this sense, the results published initially in this paper represent a starting basis that should and must be discussed, supplemented, expanded and modified.
Although the evaluation is still pending, the research results could be evaluated against the following criteria using the following methods:

- Accuracy (verification)
  through expert consultation and scientific discussion,
- Correct setting/selection of priorities
  through expert consultation and scientific discussion,
- Sufficient completeness
  through expert consultation,
- Comprehensibility
  through survey of students
- Unambiguity
  by interviewing students
- Applicability (validation)
  by means of logistic case studies and
- Usefulness
  through interviews after application.

The limitations lie in the knowledge and experience of the authors. Opportunities exist in the publication of the results and their direct incorporation into the academic training of logisticians, thereby raising awareness and promoting logistical, systematic thinking. The explicit aim is to increase both the quality of the thinking process and the quality of the results.
What are the next steps in the research project?
Professional discussion and reception as well as processing of professional criticism.
Completion of the open lists of relevant values, problems & tasks and models of thinking.
Development of a sample table on essential criteria for contexts.
Elaboration of a list of questions for reflection on logistical thinking

Development of suitable thinking tasks for academic education and training.
Extension of the methodological approach to the various application areas
An exploitation perspective for the research (business case, product, service, technology etc.) is the following:
Inclusion of a chapter on "Logistical Thinking" in the book "Fundamentals of Logistics".
Making the paper available and publicizing it in other countries (e.g. Austria, France, Italy, Slovakia, Hungary, Ukraine, Cuba).
Share the paper at the BVL (German) and the ELA (German and English).

Examples of further research questions are:

1. How to categorize the problems and tasks of logistics?
2. How can logistical values, potential courses of action and key figures be systematically and clearly linked?
3. Theorizing logistics: what are, for example, the most important theories, laws, hypotheses of logistics?

True to the principle: "If you go with the flow, you go down the drain", this research paper wants to leave the mainstream and provide some new insights. We look forward to the critical, professional discussion!

6. Use of the findings for doctoral students

For doctoral students, in addition to the possible self-reflection of the thinking process, the following special follow-up possibilities of the results achieved are offered:

1. Conscious training of the senses "seeing" and "hearing" on the acquisition of data and information relevant for logistics.
2. Use of the compiled scientific disciplines relevant to logistics as potential evaluation aspects (checklist of table 2) of one's own research work
3. Helping to describe the scientific task & problem in terms of:
   - Values: objectives, options for action, evaluation criteria, results.
   - Categories of the task and classification of the research task (table 3)
   - Consideration of the context of research
   - Use of ways of thinking to compile a most suitable approach (potential solutions and their evaluation) by using tables 1 and 2 and the collection of logistical thinking.

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Implementation of a procedure to improve warehouse logistics

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Abstract
The procedure developed allows self-assessment according to the level of certification chosen. Quality management tools are used, the application of which increases in complexity as excellence in product storage is sought. In addition, the aim is to test the adaptability of the applied tool and to analyze the data obtained from the different entities. Once the procedure is applied, it allows to analyze and improve the logistics of the warehouses in the studied entities. It is also carried out the survey of the logistics status of warehouses to initiate the implementation of logistics 4.0 in Cuban entities of products and services. This procedure incorporates the knowledge of logistics 4.0 to the tools, and highlights the importance of updating logistics processes. The research is applied: in the Central Ronera Agustín Rodríguez Mena, in the beverage and liquor warehouse of the hotel "Las Cuevas", in the UEB #1 Tabaco Torcido de exportación Santa Clara and in the warehouse of the commercial unit La Sandalia. The problem to be solved is to obtain the level of certification of the warehouse in the different entities according to the preceding level they had certified, allowing to check the adaptability of the applied tool and to analyze the data obtained from the different entities A procedure is offered to search, analyze and provide solutions to the problems faced by entities in countries with fewer resources in the process of achieving the objectives of logistics 4.0. Among the main limitations are: little knowledge of logistics 4.0 on the part of the workers and managers of the entities, as well as resistance to change on the part of the workers of the entities. The application of the selected procedure concludes with an analysis of the problems detected and proposed solutions to achieve the improvement of logistics in the warehouse so that it can be certified at the current level or at a higher level.

1. Introduction
Today's business world is becoming increasingly complex and unpredictable for global companies. The accelerated development of science and technology, together with the globalization of the market, make all organizations, especially Cuban ones, face a race to find solutions that ensure the satisfaction of the needs of the population, optimize their processes and improve their competitiveness.
In this scenario, logistics plays an important role since it has been established in recent years as a new way of approaching business management, having become a competitive tool within the development strategies of companies.
Authors such as [1],[2],[3] state that the supply chain today includes from the design and administration of all the activities necessary for the acquisition of resources and their channeling for transformation to final distribution or delivery. This in turn is interrelated with aspects of quality, customer loyalty, timely presence in the market, sales momentum, operating costs, foreign trade,

and the design and redesign of the product or service itself.
Taking into account the author's idea, [4], [5]companies require a rational use of limited resources (inventories, human capital, equipment, space and economic resources). Either in the administration of medicines, industrial supplies, perishable products, electronics, fabrics, food, beverages and others. It is not only important to maintain optimal inventory levels, but also to keep your properties in good condition and make sure that the worker performs their work in safe environments, so that the offer to the client is correct. Based on their concept of “due diligence” (the ability to be able to demonstrate that all reasonable measures have been taken to avoid an incident), European retailers have established specific rules to ensure the quality of goods in logistics food (and non-food) products, safety and legality in the SC of food and beverages. Food safety standards such as:
The English British Retail Consortium (BRC)
The German International Features Standards (IFS)
The Australian Small Quantity Generator (SQG)
The Dutch Hazard Analysis Critical Control Point (HACCP)

These standards are safe and operational management systems, applicable to both food and non-food products. They were created to ensure supplier compliance, taking into account storage, transportation and distribution, to ensure the skills of the retailer and guarantee the quality and safety of the food products they sell [6]. All these certifications have one point in common, the standards for storing the products to be evaluated. This is caused by the different priorities that countries give to products and their storage conditions.
Since the new millennium, different norms and resolutions have been created in Cuba to regulate the procedure for certifying storage systems in the country, as well as those who were authorized to categorize them. Since 2007, with Resolution 153 MINCIN (2007)[7], one of the first steps was taken in the creation of a logistic file (EXPELOG) that allows the evaluation of storage systems in companies; later it is complemented with other ministerial resolutions that consolidate the implementation in Cuba. In 2020, the procedure for accreditation of storage systems and the requirements to obtain certifications are updated in Resolution 47 MINCIN (2020)[8]. In addition, Resolution 64 MINCIN (2020)[9] creates the National Commission of Experts in Warehouse Logistics, with the objective of controlling and certifying everything related to the category obtained by warehouses in the country and the content of the warehouse logistics improvement courses.
The research is carried out in four entities where they have the need to evaluate their warehouses to obtain the second level of certification. These companies are:

1. La Ronera Central "Agustín Rodríguez Mena" produces high volumes of rums with the premise of satisfying the requirements of its customers, ensuring the quality and innocuousness of the productions. Expansion plans include entering new markets in Europe, but there are weaknesses, including the fact that the finished product warehouses are not certified by any international European standard for food and beverages. [10]
2. The commercial unit La Sandalia, belonging to the Central Division of the CARIBE Chain of Stores in Villa Clara, which shows some difficulties and insufficiencies in warehouse logistics, increasing the expenses associated with this activity, specifically in its warehouse.[11]
3. The warehouse or "showcase" of UEB #1 Twisted Tobacco for Export in Santa Clara. This center is dedicated to producing and marketing hand-twisted tobacco for both domestic and international consumption. This warehouse is of utmost importance to obtain an excellent cigar with permanence in the world market. [12]
4. The Hotel Cubanacán "Las Cuevas" is a three-star city hotel that welcomes most of the transit tourists who visit the city of Trinidad. Its warehouse was categorized in 2019 with the first technical level, which is not satisfactory for its aspirations, since this is the lowest of the categories. There are also several points regarding the overcrowding of goods.[13]

Cuba does not have qualified agencies to certify with these specific international standards; but the new regulation aims those warehouses are evaluated by standards comparable to the standards or systems most used in the world, to generate confidence in the customer and preserve the final quality of the stored product.
Among the methodological tools consulted, several were found to be provided by the authors in the international and national arena.[14] From their study, it was found that they have relevant aspects such as Lean Logistics and the different national procedures for the improvement of warehouse logistics. In the latter, it is always necessary to adjust considering the types of products stored, aspects related to the warehouse itself, international experiences and the emergence of new national regulations, in addition to the fact

that this procedure can be better structured. The entry into force in May 2020 of the new regulation places these companies in a position to improve, since they were certified at the first technical level. In Cuba, there is already some research on the subject of warehouse certifications, considering only national standards and focusing only on the characteristics of these entities. However, the proposed procedure is different from the others, due to its versatility and ease of adaptation to different fields of action. This procedure has been applied in service entities, in a production company and in a food production chain, showing satisfactory results by allowing the entities to prepare and obtain the certifications of the evaluated warehouses.
In accordance with the above, the general objective is defined as: to improve the logistics of the warehouses of the companies under study in order to obtain the second level of certification.
In order to achieve the general objective, the following specific objectives are established:

1. To carry out a deep bibliographic review, which allows to have all the theoretical bases and fundamental applications linked to the subject of the research.
2. To design a procedure for the improvement of the storage logistics of the different companies.
3. To apply the proposed procedure to the warehouses under study.

In order to meet the objectives, set out in the research, the current storage system in the finished products warehouse of the entities studied was evaluated. In addition to complementing the evaluation with the review of the reports of the audits carried out. Possible corrective actions that can be taken to improve the system will also be considered.

2. Methods or experimental part

The procedure developed is the result of the bibliographic analysis carried out, as it contains in a rational manner what has been proposed by the different authors with respect to warehouse logistics, the different resolutions in force in the country related to this activity and the different certifications studied. Figure 1 shows the procedure for improving the storage of Ron Cubay.[10]

2.1. Preparation of the Study

The characterization of the current situation, as the first step or stage of the work, is important in order to have a general knowledge of the organization and in particular of the warehouse under study. For this purpose, it is necessary to describe a whole set of aspects that are detailed below: the corporate purpose, mission, vision, integrated management policy, product lines, strategic analysis of the organization, warehouse layout, analysis of storage technology, technical condition of the equipment, among others.
When assessing the requirements and restrictions demanded by the stored products, compliance with the standards and resolutions established for each type of product stored or to be stored should be considered, as well as the specifications described by the manufacturers regarding handling, storage and conservation. It is necessary to evaluate all the activities that take place in the warehouse in order to guarantee the correct handling and conservation, since this result can lead to a significant reduction in logistics costs.

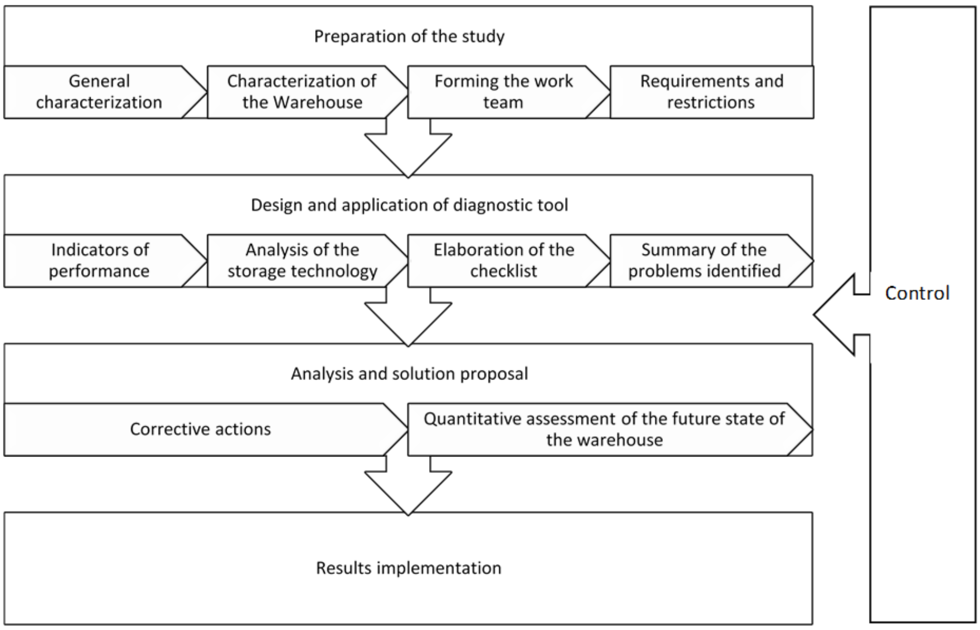

Figure 1: Methodology

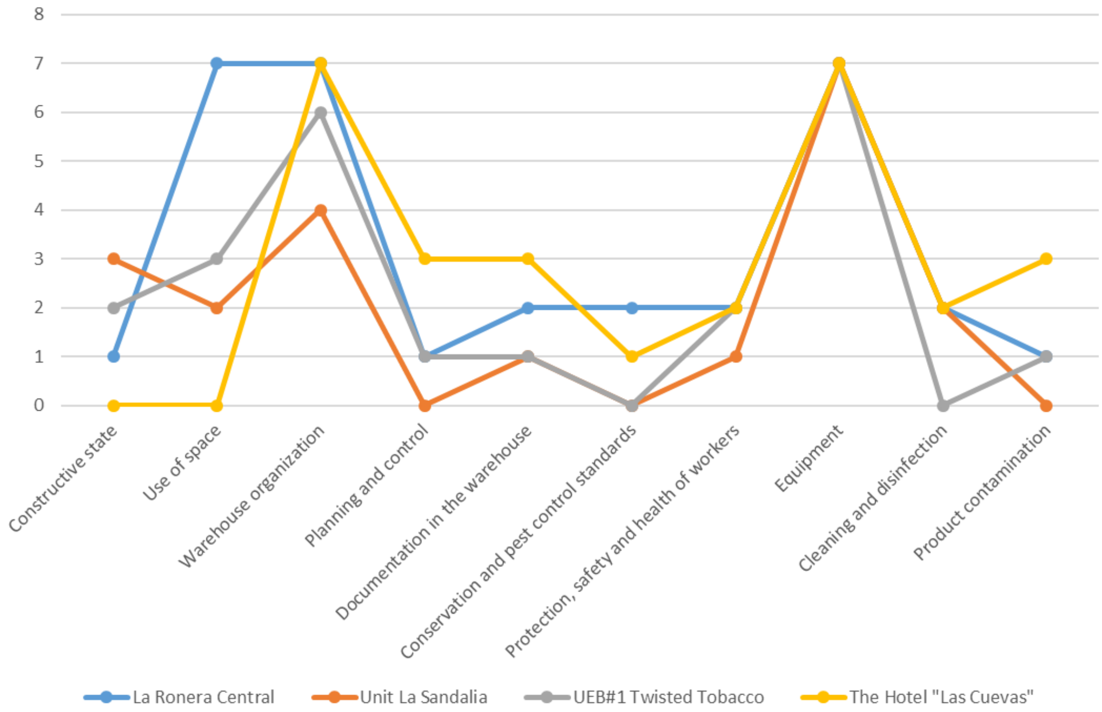

Figure 2: Problems affecting the warehouses of the entities under study

The result of this assessment will make it possible to evaluate the efficiency of the type of installation selected and to propose the optimal-viable technological variation to achieve the best results in management. All the requirements and restrictions demanded by the products and the warehouse under study.

2.2. Design and application of the diagnostic tool

This stage of the work is the core of the diagnosis of the warehouse and covers the study of the physical installation and its management, preferably qualitatively and quantitatively. The aspects to be analyzed are: space utilization, warehouse organization, receipt and dispatch of goods, planning and control, documentation, safety and security, and conservation standards. For the evaluation of these aspects, several essential tools were used, which are analyzed in the system. These are: checklist (developed to detect problems from a qualitative point of view), storage space utilization indicators, warehouse operation and customer service indicators, and cause-effect diagram, which is a qualitative tool recommended in this case to integrate all the problems detected graphically. Table 1 shows a summary of the checklists and their scores by key areas.

It is important to point out that in order to reach a level of categorization, all aspects of the previous level and the level for which it is chosen must be fulfilled. This is represented in the checklists, as it avoids losing achievements that have already been reached. The three checklists will have a value of 100 points each, although the values of the evaluated areas and aspects vary according to the technological level.

Checklist 2 is applied in the research, by way of example some of its unique characteristics are highlighted, in the points that most affect the evaluation of the warehouse. These are:

2.2.1. Use of space

- Digital organization of the warehouse.
- Working with scanner and codes on secondary packaging.
- Use of machinery to avoid double handling.

2.2.2. Warehouse organization

- Efficiency of control methods.
- Building facilities for reception and dispatch.
- Procedures or technologies to reduce handling.
- Training of workers in logistics and in the use of equipment in their work area.

2.2.3. Warehouse documentation

- Traceability.
- Computer and data processing skills.
- Equipment
- The equipment on the technological floor is connected by network or Wi-Fi in the warehouse.
- There is human-machine interaction in the automatic or semi-automatic activities in the warehouse.

It should also be noted that as the level of certification increases, the areas to be evaluated increase and the scores between the areas in the different levels of certification change as well.

Table 1: Summary of the areas and evaluations in the checklists

Checklist 1	Checklist 2	Checklist3
Aspects to evaluate	Aspects to evaluate	Aspects to evaluate
Constructive state	Constructive state	Constructive state
-	Use of space	Use of space
Warehouse organization	Warehouse organization	Warehouse organization
Planning and control	Planning and control	Reception and dispatch of merchandise
Documen-tation in the warehouse	Documen-tation in the warehouse	Planning and control
Conservation and pest control standards	Conser-vation and pest control standards	Documen-tation in the warehouse
Protection, safety and health of workers	Protection, safety and health of workers	Conservation and pest control standards
-	Equipment	Protection, Safety and health of workers
-	Cleaning and disinfection	Equipment
Product contamination	Product conta-mination	Product conta-mination; Cleaning and disinfection

2.3. Analysis and proposed solutions

For the development of corrective actions, the starting point is an analysis of the storage technology. This factor is a determining factor in defining the form of storage to be selected.
Once the problems have been identified, a set of actions aimed at eliminating or minimizing the problems detected are proposed. For the execution of the corrective actions, the conditions of the warehouse and the product of the factory must be considered, where the possible solutions tend to increase the economic results and the customer service.
For the generation of corrective actions, the use of the expert method known as Brainstorming is recommended, in which workers, specialists and managers should participate, being essential the following: quality specialist, warehouse clerks, economic specialist, commercial manager (recommended as facilitator), members of the inventory commission, commercial analyst, distribution specialist.

2.4. Implementation of the results

his work step constitutes an ordering of the results of the previous step. It involves drawing up an implementation plan for the proposed corrective actions. At this stage, the implementation of the technological reorganization design of the warehouse is proposed for a trial period of 6 months. The sales manager will systematically bring together those responsible for applying each measure and verify compliance with the implementation plan. If any corrective action requires staff training, this manager will coordinate with the Human Resources area.

2.5. Control

The last step of the procedure is a control loop to rectify any deviations detected during the 3-month period of operation of the warehouse. The checklist and indicators proposed in the diagnostic stage are used again to verify whether the problems have been mitigated or eliminated and the indicators meet the requirements of Resolution 47/2020. If this does not occur, return to the corresponding work step of the procedure and repeat the rest of the procedure. On the other hand, if the warehouse is ready for categorization, the EXPELOG is prepared in the format suggested in the aforementioned resolution.

3. Results and Discussion

Using the information obtained from the diagnostics in the warehouses analyzed, it is possible to visualize and summarize the main problems affecting the warehouses and their main causes. Figure 2 shows the number of problems detected in each of the aspects of the checklists.

3.1. Deficiencies found in the warehouses

3.1.1. Warehouse organization

This aspect includes deficiencies such as: the aisles and access doors to the warehouse are not free of products or objects that obstruct or hinder the passage of handling equipment and personnel, due to the organizational problems of the warehouses, so it is sometimes necessary to place goods in the aisles, which also leads to blocked products in the warehouse. In addition, there is no procedure to reduce handling, nor are the loading schemes for each product defined, and the warehouse does not have a defined area for the repair and maintenance of the unitizing equipment.

3.1.2. Planning and control

Compatibility between stored products is not guaranteed, also due to overcrowding, since due to lack of space, products are sometimes placed in other areas that are not the right ones.

3.1.3. Documentation in the warehouse

There are no procedures for receiving, storage and dispatch. In practice, the personnel in charge know how to proceed, but the procedures are not designed as such.

3.1.4. Storage and pest control standards

Despite compliance with the fumigation program established for the warehouses and products, rodents are occasionally present.

3.1.5. Product contamination

There is currently no cross-contamination in the warehouses and there are strategies to prevent it, but there is no structured procedure in place.

For the analysis of the deficiencies detected in the warehouses, they are grouped into five fundamental problems, considering their similarity:

3.1.6. Overcrowding of goods

- The aisles and access doors in the warehouses are not free of products or objects that obstruct or hinder the passage of handling equipment and personnel.
- Blocked products are observed in the warehouses.
- Compatibility between stored products is not guaranteed.

3.1.7. No written procedures

- There are no procedures to reduce handling.
- There are no procedures for reception, storage and dispatch.
- There are no procedures to avoid cross contamination.

3.1.8. Impossibility of repair area for unitarizing media

There are no constructive facilities to define a repair area for unitarized media.

3.1.9. Vectors presence

Despite the existence of a fumigation and pest control program, there are still rodents in the warehouses.

3.1.10. Lack of loading schemes

There are no loading plans for each product.

3.1.11. Equipment

- The equipment on the technological floor is not connected by network or Wi-Fi in the warehouses.
- There is no human-machine interaction in automatic or semi-automatic activities in the warehouses.
- IT resources are not connected to the equipment on the technological floor.
- No data analysis or data mining is performed on the results obtained.
- There are no automated tasks in the warehouse.
- Not all warehouses are connected to the factory computer network or the company's cloud.
- Warehouse workers are not trained to work with automated equipment.

In addition, the Cause-Effect or Ishikawa diagram with a similar approach highlighting the main problem areas is shown in Figure 3.
Once the fundamental causes of overcrowding of merchandise in the warehouse have been analyzed in the Ishikawa diagram, a series of measures are proposed in order to attenuate or eradicate the overcrowding:

- Search for a place with the appropriate constructive characteristics to establish it as the central warehouse of the hotel complex and that it works only for the insurance of the hotel "Las Cuevas", so that each unit of the complex carries its logistic management independently.
- Organize the warehouse by substituting some direct pallets for shelves to place the merchandise without secondary packaging, whenever possible, in such a way as to optimize the space used.
- Keep a strict control of the rotation of products in the warehouse so that there are no idle or expired products.
- Train workers with basic computer courses, handling and working with automatic machines and courses on updated logistic models (cross docking).
- Establish and leave in writing all the procedures that are currently absent, such as: a procedure to reduce handling, procedures for the reception, storage and dispatch of goods, as well as establishing the loading schemes for each product.

It is also proposed to analyze and solve in the short term the other deficiencies detected by the study, for which no significant resources are necessary. The way to validate the result is the application again of the checklist for the second level, considering that most of the problems are solved.

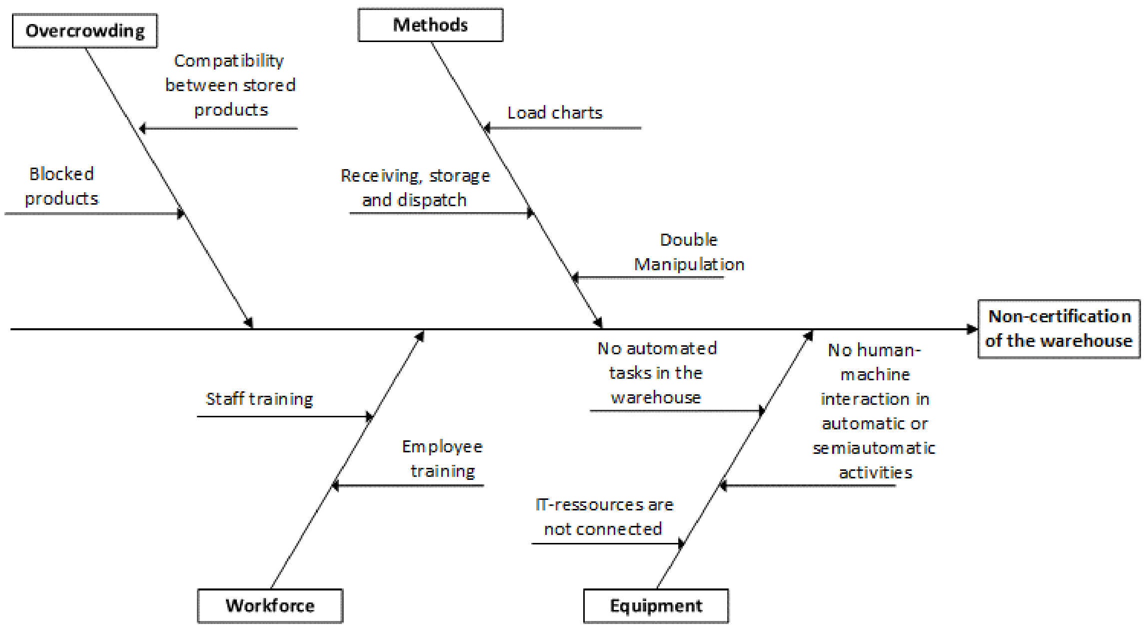

Figure 3: Modified Ishikawa diagram of the warehouses of the entities under study

Figure 3 summarizes the results of the application of the checklist in the warehouses, revealing that the main problems are in the use of computer equipment:

- There are no automated tasks in the warehouse
- The warehouse is not connected to the factory computer networks or the company's cloud.
- Warehouse workers are not trained to work with automated equipment.

4. Limitations and Conclusion

The procedure used, contains methods and instructions for the categorization of the warehouse, as well as qualitative and quantitative tools valid for its application in different entities or companies or warehouses, varying only small details; also, this allows proposing improvements to the deficiencies detected.

There are several deficiencies that affect the logistics management of the warehouses, highlighting the absence of written procedures and that the most important problem to be solved with the highest priority is the updating of logistics methods in the warehouses to improve the organization.

Many of the problems detected are soluble in the short term and do not require significant resources. In addition, their detection and subsequent solution is important to maintain the current level of certification and to work towards certification at a higher level, with the current regulations.

Resistance to the use of computer and automatic technologies by workers and some older administrative staff.

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Manufacturing of a logotype on NC machine in Autodesk environment

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Abstract

Nowadays, automation of manufacturing advertising frameworks gains particular relevance. Currently, NC machines are widely used at enterprises in various production branches, which requires a specialist that could exploit them with the highest efficiency.

This design is aimed at the developing a technological solution to the problem of automation of manufacturing processes involving NC machines on the example of manufacturing a logotype for the Department of Applied Mechanics at National aerospace university "KhAI". The main parts of the logo are: a gear wheel, a gripper, a sub gripper, a hinge joint (2), text, a backside, an accessory part, a bearing. The department logotype was designed in Solid Works environment. The designed patterns of the logo were adopted for the Autodesk environment by saving files in DFX format. This makes it possible to write a part processing program. The logo processing technology is framed considering the type of manufacturing procedure and with the use of high-yield equipment. Mechanical processing is fixed, the path of the tool is demonstrated and the control program for milling operations is received. In case the logotype is manufactured as an exterior decorative element, while designing it is necessary to consider the model of the cutting tool and the cutting depth in order to visually specify some fragments of the parts and their mutual bracing. The design of the framework can be considered as a sample of automation of manufacturing outdoor advertisement by means of a modern machine – tool with NC operation system.

1. Introduction

Nowadays, it is hardly possible to imagine a modern city without outdoor advertising, which has become an integral part of an interior. Outdoor advertising is the catchiest of all types of adverts. Apart from this, it involves light, animation and colors. While other types of adverts have to find the way to get to the consumer, outdoor advertising effects people at shops, at work and on holidays round the clock and raises the profit on selling advertised products. The number of formats of outdoor advertising has grown up; among the most popular are: billboard, lightboX, wallscapes, citylight, streetfurniture and pointofsaledisplay [1, 2]. Having analyzed the existing methods and ways of designing the concept of the advert [3] it was proposed to introduce it as a lightboX.

Since it is one of the oldest types of advertisement, it can easily transform and gain new forms due to up-to-date manufacturing technologies. As products ought not only to have an attractive outlook and be well manufactured, reliable and efficient equipment is necessary to organize

profitable production. One of the essential methods of increasing labour productivity and ensuring the reissue of qualified goods is automation of operation processes on the base of NC machine. The main distinction of this type of equipment is that processing follows a predesigned program, which ensures operation flexibility and makes it possible to use the program repeatedly [4, 5]. Engraving milling NC machines are widely used in outdoor advertisement manufacturing. They help cut sheets easily as well as produce flat and three-D objects: signboards, letters, fastening, stalls etc. Equipment selection is essential as it is necessary to consider a range of factors. But, the factor of cost is not principal. Attention should be paid to the characteristics and equipment of the machine. NC mill ought to be chosen considering the type of material, the desired size of rough parts and oncoming manufacturing operations. The main raw stuff for advertising constructions is acrylic, PVCs (with standard dimensions 2x3 m), composite panels and polycarbonates (with the length up to 6m). The dimensions of the working surface are important for cutting the sheets as well as a large working desk with vacuum fastening which is also suitable for thin or nonstandard parts. Also, it should be mentioned that, whereas there are machines with the length of their working space 4m and 6 m, it is possible to process massive materials on a smaller working space (e.g. operating 6m composite panels is possible on a 3m, however, it is more time consumable).
The program for a NC machine can be uploaded from external drivers or common customized flash storages. Furthermore, modern equipment and machines can be attached to computer networks of an enterprise, which enables uploading the program by sending it through the commercial network [6, 7].
The automated creation of control programs is necessary for producing parts with complex geometry and/or high precision. Corresponding programs, such as CAD/CAM/CAE systems, can handle these tasks. The main advantages that a technologist gains when interacting with the system include work visualization, convenient geometry selection, high calculation speed, and the ability to verify and edit created trajectories. Their implementation in production is becoming increasingly necessary and allows for a new level of production [8, 9]. On the other hand, a problem lies in the exchange of information between digital models created using different technologies (SolidWorks, Autodesk) and the transmission of geometric and topological information.
This work has significant practical value in constructing 3D models of complex geometry in SolidWorks, as well as integrating designed models from the SolidWorks environment into the Autodesk environment.
The project is focused on the working out a technological solution of automation of manufacturing processes using NC machines on the example of manufacturing a department logotype for the Department of Applied mechanics at National aerospace university “KhAI”. The task for designing a certain advertising product is shown in figure 1.

Figure 1: Sketch project of the logo

2. Experimental part

In general, the CNC machining process can be divided into four stages: first, a model is created using 2D drafting or 3D modeling software. Then, the tool trajectory should be prepared using automated production (CAM). Although it is theoretically possible to cut the model using a CNC machine at this stage, it is always useful to check the correctness of the cutting trajectory with simulation. This allows for making the necessary corrections. When everything is checked, and it is time to cut the part, control software is needed that communicates with the CNC machine via G-code to instruct it on what to do. At each stage of the process, the correct software is of paramount importance. The software used for modeling: Fusion 360, AutoCAD, Inkscape, SolidWorks, Aspire. The following software is used for generating and modeling G-code: eCam, HeeksCNC, G-Wizard Editor, CNC Simulator Pro, NC Viewer, PlanetCNC, ChiliPeppr, OpenCNCPilot, OpenBuilds Control, LinuxCNC, TurboCNC, and others.
The department logotype was designed in Solid Works environment. Having studied the draft specifications, we decompounded it so that it would be possible to manufacture it on a NC machine. The main parts of the logo are: a gear wheel, a gripper, a sub gripper, a hinge joint (2), text, a backside, an accessory part, a bearing. The pattern of a gear wheel for the logo was taken from the Toolbox library. To make the logo more

attractive the gripper (Fig. 2) was decompounded to the hinge joints, the laid-on part and the gripper itself. It enables its volume image on the future board. The proportions were chosen in accordance with the logotype scaling.

Figure 2: Gripper, laid on part, hinge joints

The backside was added to support the main parts as well as to join the logo to the hanger and to create the image background.
The size of the part was chosen visually to match the proportions of the logo using the overlay technique on the completed part of the gear wheel in joint assembly.
In the end, the bearing (Fig. 3) was built up in the center of the logo. Due to the “Round Array” process it was managed to minimize the designing time and the whole image matched the pattern of a real bearing the best.

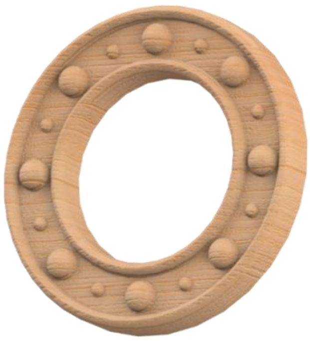

Figure 3: Model of bearing

A joining part was designed for the backside. This part is mounted between the backside and the gear wheel. The LED strip for lighting the board will be fixed along its side edges. The assembly process of all designed parts is shown in Figure 4.

Figure 4: Assembly of all designed parts

The designed patterns of the logotype were adopted for the Autodesk through saving files in DFX format. This makes it possible to write a part processing program. Fig. 5 all patterns are shown lay open to properly place the parts in the assembly. The dimensions of the logo were verified by overlapping the parts.

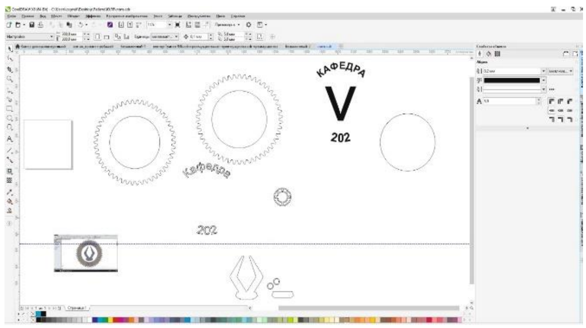

Figure 5: Parts of the logo in Autodesk environment

Figure 6 gives some sample results of the assembly. It shows the test result of an assembly of general view dimension parts and placing them relatively to each other. After the integration no demand for changing the dimensions was found, the arrangement of the components satisfies the sketch-task.

Figure 6: Arrangement of parts in assembly

For this small-scale production, it was decided to use a «Filato Optima 1325 MTV-E» CNC machine. The machine is designed for high-quality planar milling of parts from plate materials (2D milling) and for applying various engraving on the surface of parts (2,5D milling). Also, the design of the machine allows using it for milling three-dimensional parts in 3-dimensional space (3D milling). The DNC mode enables executing the program of processing directly from a computer or another external device without recording it in the system memory.

Milling operations were adjusted by means of the window “Engraving”. Figure 7 shows the configuration of the gear.

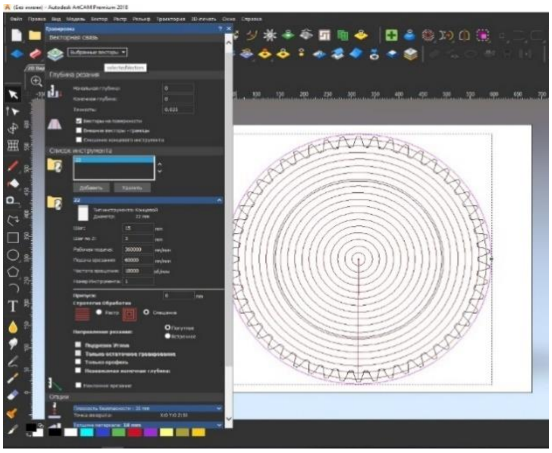

Figure 7: Setting up milling of the gear

Table 1 shows the names of each setup and the parameters that were inputted into the control program for processing.

The cutting tool path, the return point and possible deviations have been checked and adjusted. The cutter was chosen depending on the required future appearance. For example, for the gear, it was decided to first process it with a sharp 45° cutter and then with a straight cutter along the same contour. Thus, it was possible to make the edges of the gear naturally shaped. The configuration could be obtained by engraving, but it would take much more time on the machine, which is not profitable for this type production. All the operations with the change of the tool were described in the control program in advance.

The mill is replaced on a machine manually, thus, when replacing a cutting tool in the control system, it is necessary to identify this so that the control program would go to the next cutting tool and its settings.

The most difficult to manufacture was the bearing part. To make it look as an actual bearing, it was decided to engrave the workpiece. The path of the movement can be seen in Figure 8.

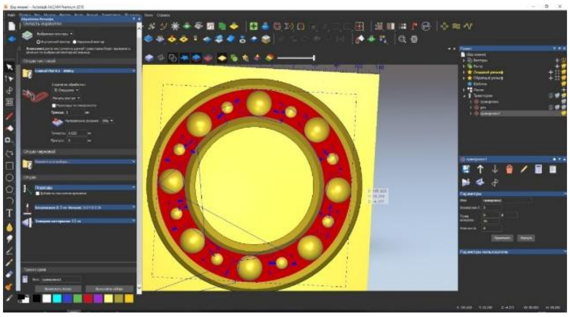

Figure 8 – Engraving path of the bearing

3. Results

In case the logotype is manufactured as an exterior decorative element, while designing it is necessary to take into consideration the model of a cutting tool and the cutting depth in order to visually specify some fragments of the parts and their mutual bracing.

Table 1: Setup and the parameters that were inputted into the control program for processing

Operation number	Cutting tool	Spindle rotation speed, mm/min	Tool feed rate, mm/min"	Cutting depth, mm
Setup 1, Gear Processing				
1	Conical Milling Cutter (∅ 22 mm)	15 000	30 000	1
2	Sharp-edge cutter 45°	18 000	12 000	30
3	Straight end mill (∅ 3mm)	20 000	15 000	10
Setup 2, Manipulator Gripper Handling				
1	Sharp-edge cutter 45°°	18 000	18 000	10
2	Straight end mill (∅ 22mm)	18 000	30 000	6
Setup 3, Bearing treatment				
1	Straight end mill	50 000	0-30 000	0-17
Setup 4, Text processing				
1	Straight end mill	50 000	0-30 000	0-17
Setup 5, Treatment of the rear panel				
1	Straight end mill	50 000	0-30 000	0-17

To synchronize the «Filato Optima 1325 MTV-E» machine with its control system, a decision was made to use NCStudioPCIMC-3D. Systems such as NC (Numerical Control) perform addressing of commands, interpolation of intermediate coordinates and implementation of typical cycles according to strictly defined algorithms.
Information is entered into the NC system from the control program by separate frames. The system works properly in Windows XP/7 32 bits and has an intuitive user –friendly graphical interface, which makes enables simulating and debugging a control program with enhanced functionality for the efficient use of a CNC machine. The NC Studio system supports 3 axes, 3 end sensors and discrete spindle control (7 steps). The technological process of manufacturing the logo is designed with the most appropriate sequence of operations and transitions applying the most rational milling methods.
The cutting modes and processing techniques are assigned which include common tool feed, spindle rotation speed, selection of the tool path selection and cutting depth and allowances. Finally, the program calculates the processing path using the previously configured parameters. For starting work on the machine, it is necessary to configure the zero point of the machine and the workpiece and measure the cutting tool.
The end product of the logo is given in Figure 9.

Figure 9: End product of the departament logotype

4. Conclusion

The main programming language of the control system is defined in ISO6983 by the International Standards Committee and is called ‘G-Code”. This means that the system uses standard G-codes, which allows us to work out processing programs by applying various popular software products. However, despite the fact that manufacturers of CNC systems follow the standards in describing the main functions, they allow deviations from the rules when it comes to some special characteristics of their systems.
This development will increase the efficiency of the entire enterprise by introducing CNC advertising into the industry.
The proposed method for creating an automated control program for a CNC machine in the process of creating a new product allows for predicting the behavior of the system and comparing a range of different alternative design solutions with minimal time and cost. As a result, the amount of experimental work and finishing of the product is reduced, its quality is increased, and the design process is accelerated and made more cost-effective.

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Effects of CO2e measures for the transport logistics sector

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Abstract

Nowadays logistic service providers (LSP) are facing more and more regulations and political measures concerning sustainability. This paper presents the first results and discussions of a simulation on environmental policy measures in the transport sector. The additional costs of these measures were calculated for two ideal truck models over the next four years. Besides higher fuel costs due to a gradual increase in certificate costs, which translates to additional costs of €6,949 or 4.9 cents per km for a EURO 6 truck with an annual mileage of 140,000 km, the new published truck toll costs for 2024 cause a high increase of additional environmental costs. All measures combined result in additional costs of €61,806 for a EURO 6 and €65,638 EURO 5 truck. The study also calculates the total cost of ownership (TCO) for a single truck and finds that the additional environmental costs would cause additional costs of 53.74% to 57.07% for the selected truck model. The study notes that the cost difference cannot be integrated in current transport prices due to an average profit margin of only 3,4% for LSP companies. Therefore, the authors point out the importance of an overall simulation model.

1. Introduction

In march 2023, the new IPCC report announced that the global temperature increase already reached 1,1°C compared to 1990 [27]. In the transport and traffic sector, greenhouse gas emissions have stagnated for years. In Germany, emissions in this sector amounted around 145 million tons of CO_2- equivalent (CO_2e) in 2020 [19]. In 2021 emissions already raised up to 148 Mio. tons of CO_2e [26]. The goal of a significant CO_2e reduction in this sector becomes tangible taking the year 2020 as an example: even with its Covid lockdowns only around 7% of greenhouse gases could be saved [10].

In addition, according to the "Verkehrsverflechtungsprognose 2030", freight transport performance is expected to increase to 838 billion ton kilometers by 2030, which means that an increase in emissions can also be assumed, irrespective of technical progress [8]. Furthermore, the long-term worldwide trend of increasing transport volumes due to growing trading demand must also be considered [5]. This indicates how ambitious the recently communicated cross-sectoral targets of 65% savings by 2030 in Germany and 55% within the EU are [16].

In January 2021, the Fuel Emissions Trading Act (BEHG) came into force in Germany, and a national emissions trading scheme (nEHS) was launched [22]. The price for a national allowance has been set to €25 per ton of CO_2e for 2021 and should gradually increase to €55 by 2025, after which it can be freely traded within a price corridor of €55–€65. For 2023, the increase of the national CO_2e price will be suspended and for 2024 and 2025 discounted to €35 and €45, respectively due to the increased energy costs and rising inflation [20]. In 2021, the German Emissions Trading Authority at the Federal Environmental Agency calculated a price increase of 7 cents per liter of diesel fuel as a consequence of the CO_2e price of €25 [11]. For currently €30 CO_2e price an impact of 10 cents per liter of diesel fuel is calculated. Besides, the EU Commissions announced in their Fit-For-55 strategy that they are planning to set up a second European emissions trading system (ETS2) for the transport and building sector by latest 2026 [7]. This trading scheme will also be implemented as an upstream principle like the nEHS and come along with a CO_2e price between €45-€50 [7]. The current CO_2e price in the ETS1 scheme is €89.78 (ISIN: XC000A0C4KJ2, 01/30/2023). The maritime cargo sector will be already covered within the ETS1 in 2023 [15]. For the air cargo sector, the emissions trading system will be implemented in the ETS1, for all inter-European or non-CORSIA flights, starting in 2024. The rail cargo network is already covered indirectly through either the ETS1 (Electrical engine) or will be covered via the ETS2 (Diesel fuel engine). Besides the integration of transport sectors into the EU ETS, several other political instruments, including a change of the environmental component inside the truck toll, more rules concerning environmental reporting (CRSD) or a stronger fleet regulation to archive the national climate law, are currently discussed [30]. These effects inevitably lead to the following research question:

RQ: What is the financial impact of environmental policies on the cost of transport?

The aim of the research is to develop a decision model, which can reflect the effect of different governmental measurements like CO_2e pricing or additionally CO_2e truck toll for different HGV-models to calculate a sustainable transport price, which covers also the additional environmental costs or a flexible floating system to pass the costs to value chain partners. Furthermore, the model should show first ideas of how additional carbon pricing costs can be forwarded inside the value stream, as well as to calculate when a swapping point is reached to invest in a different HGV-model.
Initial calculations have already been carried out in the two ILM research projects "Logistics Emissions Trading System for Green Optimization (LETS GO)" and "Combined Emission Controlling Instruments for Road Freight Transport (COMECON)". Various scenarios were used to determine how additional costs would behave as a result of the downstream principle, the upstream principle or an energy tax [9] [24] [39]. At the time of the research projects, a final political decision on the introduction of ETS2 certificate trading had not yet been made. Accordingly, it also had not yet been investigated how this would affect transport prices in concrete terms with higher CO_2e prices and in combination ("instrument mix") with other measures such as the HGV toll. This is especially true when considering alternative engine systems such as the battery electric truck (BEV). Initial approaches to the total cost of ownership (TCO) of different engine technologies, considering such an "instrument mix", have recently been published in a study by the German Federal Environment Agency (Umweltbundesamt, UBA). However, this study did not take different CO_2e price paths or individual cost units into account [40] [31]. There are already numerous frameworks in the literature for calculating individual cost units. The number of cost units and their values vary widely [25] [36] [35]. In summary, it can be said that individual calculation models already exist that show the effects of single environmental policy measures, also for the individual logistical sub-services. However, the research gap of a comprehensive model that also shows the interaction of the individual measures has not yet been closed. This is the aim of the author's doctoral thesis. In this paper the general approach and first calculations of individual measures are presented. Therefore section 2 briefly describes the used methods for this research. In section 3 the major results will be presented and discussed. In the last section 4 limitation and conclusion of my research will be described.

2. Methods or experimental part

The calculation model has been developed based on the VDI 3633 standard "simulation of systems in materials handling, logistics and production". The steps are:

1. initial situation,
2. target description,
3. task definition,
4. system analysis,
5. data collection,
6. model formalization,
7. data preparation,
8. implementation,
9. experimentation and analysis,
10. documentation.

They are processed sequentially [23]. The steps 2) goal description, 4) system analysis, and 5) data acquisition will be exemplarily described in detail in the following chapters.

2.1. Goal description

The calculation of transport costs is based on the cost model of the "Bundesverband Gueterkraft-verkehr Logistik und Entsorgung (BGL)" with 24 cost units, which are re-weighted at regular intervals by a quantitative survey of the BGL, thus providing a neutral and generally valid basis. The total transport costs, including a profit margin or risk surcharge, can then be offered as a transport price on the transport market (secondary market). This is usually referred to as the cost-plus method. On the other hand, transport prices can also be influenced on the market side by an increased demand for transport resulting from an increased

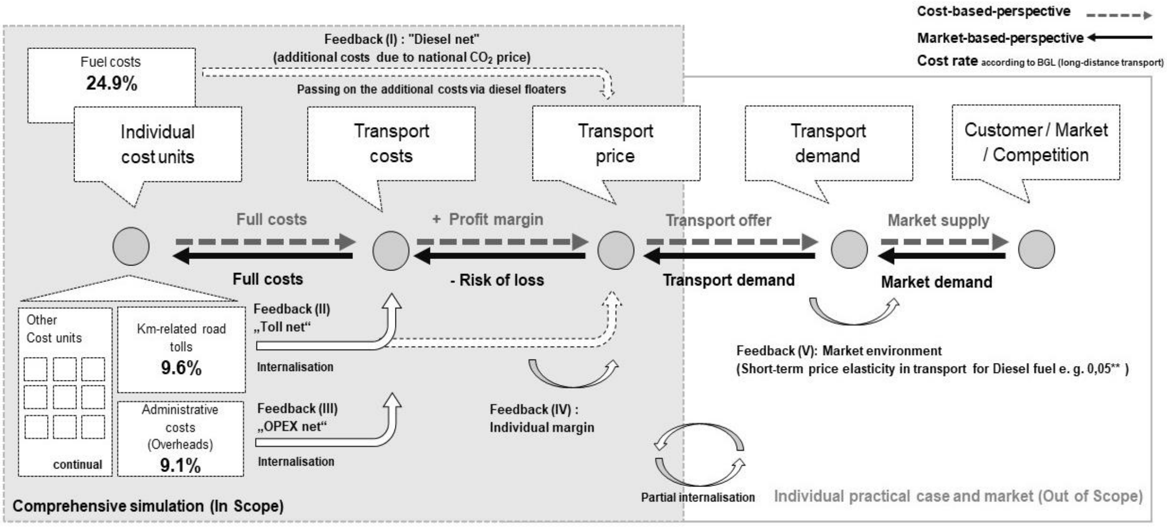

Figure 1: Impact of transport cost calculation; Own visualization with data from [3] [13]

volume of trade on the primary market. Also due to insufficient publicly available data on price elasticities in the transport market, the simulation model should focus on internal transport costs (see grey area in figure 1).
Within this internal cost calculation, the following cost items should be focused on

- fuel costs,
- kilometer-based road tolls, and
- administrative costs

as these alone account for 40% of all costs. Therefore, the first effects of environmental policy measures on these cost types can be identified. The fuel and toll costs can be passed on to the customer in individual cases via a variable system separated to the actual transport price. This additional margin from a diesel floater system has already been analyzed for the entire German road transport industry under the new indicator "diesel net", which is described as the difference between the "price index for road haulage, removal transport (WZ 2008:49.4)" and the corresponding diesel price for large consumers [28].
In order to simplify the complexity of individual business cases and to show the maximum effect of environmental policy measures, this floating system should be omitted in a first step in the model. The effects of two selected environmental policies are analyzed in more detail in the next section.

2.2. System analysis

Two major environmental policy measures are often analyzed in more detail in the literature under the term "instrument mix". These are the national or upstream CO_2e certificate price and the

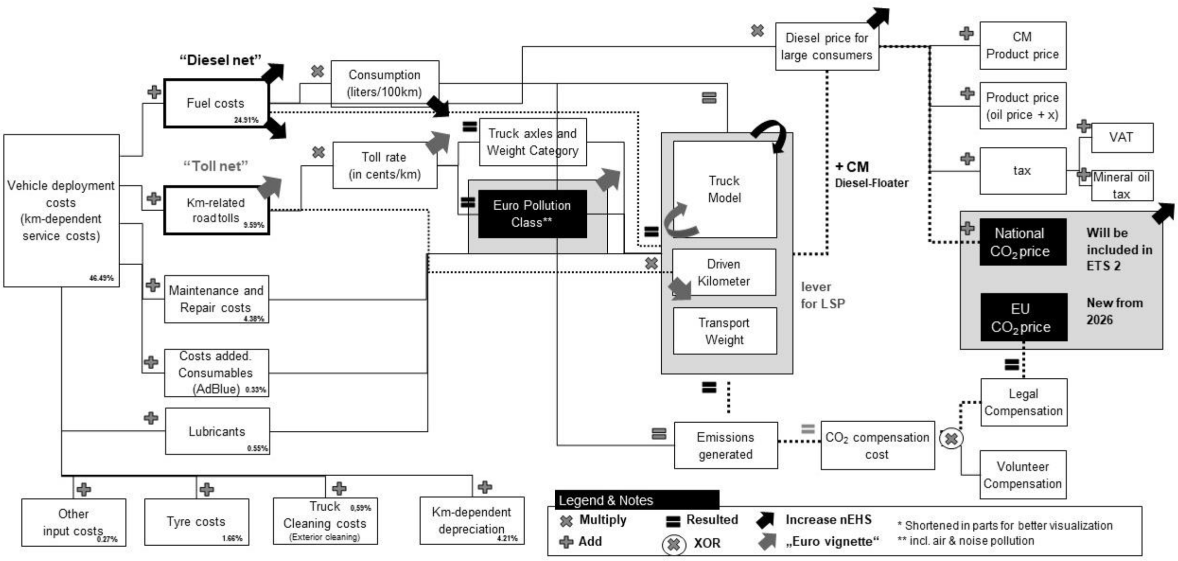

Figure 2: Effect of environmental policy measures; Own visualization with data from [3][2]

extension of the truck toll to include a separate CO_2 component [40]. Since the focus in this study is on land transport, which accounts for the largest share of greenhouse gases of CO_2 the term CO_2 equivalent is not used further [33].
Looking first at the options of setting a price for CO_2, there are different approaches used around the world [37]. The two most prominent are a CO_2 or energy tax and a CO_2 certificate trading system [38]. In Germany, the BEHG was introduced in 2021 and will be integrated into the European ETS2 certificate trading system in 2026 [34]. Both systems operate according to the so-called upstream principle, which means that the distributor of the fuel must purchase a CO_2 certificate for every ton of CO_2 generated during the production of this substance (nEHS). In the case of diesel, the certificate price forms the new diesel price, in addition to fuel tax, VAT, the price of crude oil and the manufacturer's profit margin. An increase in the price of CO_2 certificates is therefore only indirectly perceived by the consumer through an increase in the price of diesel since the consumer of the fuel does not have to purchase his own certificates for his individual CO_2 emissions any longer [34].
Truck tolls in Germany currently consist together of three components:

1. infrastructure costs,
2. noise pollution costs,
3. air pollution costs.

The individual cost rates for these three components depend on the selected truck model with a specific number of used axles, a defined pollutant class and a maximum weight load of the HGV. In the new version, valid from January 2023, these cost rates vary from the current 19 cents per kilometer (EURO 6, 4 axles, >18 tons) to 35.4 cents per kilometer (EURO 0 & 1, 4 axles, >18 tons). Trucks under 7.5 tons and battery electric vehicles (BEVs) are currently exempt from the toll. In Germany, EURO 6 and EURO 5 HGVs accounted for 99% of the toll kilometers driven, with EURO 6 trucks accounting for the much larger share (90%) [1].
These toll rates are changed periodically by the German government. One of the most important influencing factors is the result of the "Road Cost Report" [6]. In Addition, the EU Directive 1999/62/EC obliges its member states to introduce a CO_2 component into their national toll systems in due course. Under the "Euro-vignette-directive", additional toll costs of between 8 and 16 cents per km for a diesel truck (EURO 6, 4 axles, >18 tons) are currently being discussed in Germany [4]. In March 2023 the German government decided to add a CO_2 component to the national toll system of €200 per ton of emitted CO_2 and included trucks with a maximum weight above 3.5 tons. This leads to additional cost of €0.158 (EURO 6, 4 axles, >18 tons) and €0.160 (EURO 5, 4 axles, >18 tons) [14]. An increase in both types of costs would have a steering effect on the investment decision of an individual HGV or the strategic composition of a vehicle fleet (summarized in figure 2 as a truck model) [2]. In order to represent the exact amount of additional costs in a later TCO model, different data sources have to be used. Section 2.3. summarizes the data collection and scenario building process.

2.3. Data acquisition

For this paper, CO_2 prices from the current legal norm of the BEHG and the current truck toll from the BMVI were chosen (see table 1).

Table 1: Cost rates for the calculation

Year/ Truck Model	**CO_2 price & expected diesel price**		**Truck Toll [cents / l]**	
	CO_2 price [to]	**diesel price [l]**	**EURO 5**	**EURO 6**
2023	€30	€1.84	22.9	19.0
2024	€35	€1.85	38.9	34.8
2025	€45	€1.88	38.9	34.8
2026	€65	€1.93	38.9	34.8

In chapter 3, the results of the simulation with these cost rates are simulated for an ideal EURO 5 and EURO 6 truck with an average diesel consumption of 29.8 liters per 100 km (EURO 5) and 28.6 liters per 100 km (EURO 6), and an annual mileage of 140,000 km [18] [17].

3. Results and Discussion

The environmental policy measures described in chapter 2.2 and quantified in chapter 2.3 were calculated for two ideal truck models for the next four years. Table 2 shows the additional costs for the three measures. These additional costs can then be added to the already existing individual vehicle costs.

3.1. Additional costs or strategic potential

The largest cost block is accounted for the increased fuel costs, which, with an initial diesel price of €1.84 per liter, rises to a final price of €1.93 in 2026 through a gradual increase in the certificate costs to €65. Since a liter of diesel emits emissions amounting to 267 grams per liter (Tank-to-wheel), an allowance price of €65 per ton of CO_2 corresponds to a price premium of 0.17 cents per liter of diesel. Transferred to a EURO 6 truck with 28.6 liters per 100 km, this results in additional costs of €6,949 or, with an annual mileage of 140,000 km, an average of 4.9 cents per km.

Table 3: Vehicle Data

Measures (Assumptions)	National / EU CO_2 price over diesel fuel		Increase of the CO_2 component in the national truck toll (80% of the annual mileage)		Sum of additional costs (Per year, per HGV)	
	EURO 5	**EURO 6**	**EURO 5**	**EURO 6**	**Euro 5**	**Euro 6**
Starting 2023	€3,342	€3,207	€3,136	€627.2	**€6,478**	**€3,834**
From 2024	€3,899	€3,742	€14,336	€14,157	**€18,235**	**€17,899**
From 2025	€5,013	€4,811	€14,336	€14,157	**€19,349**	**€18,968**
From 2026	€7,241	€6,949	€14,336	€14,157	**€21,577**	**€21,106**
Sum	**€19,494**	**€18,709**	**€46,144**	**€43,098**	**€65,638**	**€61,806**

In addition to these increased fuel costs, there are additional costs of €627.2 for the increase in the HGV toll from 18.3 cents to 19 cents for a EURO 6 HGV in 2023. For 2024 up to 2026 an additional increase from 19 cents to 34.8 cents is calculated. If one puts these in relation to possible additional costs for an existing EURO 5 truck, one obtains a cost difference of € 3,831 or on average €957.75 per year. However, this cost difference is largely dependent in the first year on the difference in diesel costs and the different diesel consumption of the selected HGV models and the basic diesel price. In the following years, the high increase in truck tolls compensates for this difference. If one adds up the additional costs for all two environmental policy measures, one obtains additional costs of €65,638 for a EURO 6 (see table 2).

Table 2: Summary Impact BEHG, Truck toll and CSRD

Parameter	**Unit**	**Value**
Mileage truck	km / Year	140,000
Working days	Tag /Year	245
Vehicle purchase price	Euro	135,924.13
Period of use	Year	5
Remaining value	Euro	20,000
Toll share of the mileage	%	80

The additional costs for a first-time CRS reporting in 2025 due to the implementation of the CSRD regulation in Germany are estimated up to €2,666 or 4 consulting days in the first year and €1,333 or 2 consulting days in the second year, assuming a cost of €1,000 per consulting day and an average fleet number of 1.5 trucks. These costs are not included in the calculation as they are independent from the chosen truck model and should more considered in future TCO calculations.

3.2. TCO for a single truck

Many different data sources and measurements from scientific and non-scientific sources are available in the literature for calculating TCO costs. As a first step, the following publicly available data from DVZ and DEKRA were used to calculate the TCO costs of a EURO 6 HGV [12] (see table 3). Based on this information, TCO costs of €172,835 per year were calculated with the BGL cost scheme and compared to the additional environmental costs. It is noticeable that these would cause additional costs of between 2.2% (€3.834 in 2023) and 35.76% (€61.806 in 2026) for the selected truck model. With reported TCO costs of only €115,000, these would even cause additional costs in 2026 of up to 53.74%. Assuming the same TCO costs of
€115,000 for a EURO 5 HGV we would have in 2026 additional cost of 57.07% (€65,638).
The overall profit margin (EBIT/Sales) for national transport companies was calculated to an average rate around 3.4% [29]. This means that if environmental policy measures are implemented as calculated or if there is a significant increase in diesel prices, logistics service providers will be forced to recalculate their transport prices in order to avoid the risk of making losses.
In addition to the active use of a diesel floater, consideration should also be given to externalizing the costs, especially the very high increased truck toll, of environmental policy measures, either by means of a floating system or by passing them on in the value chain.

4. Limitations and Conclusion

The expected research results allow the conclusion that the necessary decarbonization measures of the federal government and the EU will lead to a cost increase within the road transport sector and especially within the distribution logistics.

The current scenarios in this article still assume rather low costs for these environmental policies. However, it can be assumed that as climate change progresses, social pressure on policymakers will increase, leading to stricter measures or higher costs for logistics providers. Therefore, in the future it will be even more important to plan the fleet management strategically and to include CO_2 pricing measures in investment decisions and transport cost calculations.

4.1. Limitations

The simulation is only carried out on a simulation model basis using two representatively selected truck models in long-distance transport. If the simulation model is to be used for other modes of transport networks such as local or regional transport, the underlying cost structures must be adapted. Furthermore, only national decarbonization measures are currently priced in. However, if there is a need to map European or even international supply chains, further environmental policy measures would have to be included.

Furthermore, at the moment the simulation model does not contain future scenarios as different CO_2 pricing values or additionally CO_2 truck toll components. In order to allow a better strategic planning of a fleet, these best case and worst-case scenarios should be added to the simulation.

In addition, also the possibility to have different diesel prices through different transport roads in Europe would be interesting to see, as we are currently facing the problem of "grey emission imports" inside of the EU, as not all of the EU member states already implemented a CO_2 price on their fuels.

4.2. Conclusion and further search

From this paper we can conclude first ideas of how big the financial impact of environmental policies on the costs of transport are and how important it is to find European or even global standards for these measurements like CO_2 pricing in order to allow a decarbonization of the transport sector without preventing an unfair market situation for these transport companies, which are included in the ETS2 market and those ones, which are not.

But in order to get a deeper understanding on the financial impact some further research and model improvements are needed. Therefore, future research should investigate first whether CO_2 compensation costs should be completely included in transport costs or whether they could be passed on to the customer or value chain partner as it is currently happening with a floating system for fuel costs.

Secondly, the carbon balance in general should be further investigated. Up to now, it is not fully clear if and to which amount logistic service providers will have to cover their emissions as separate scope 1 emissions in there CSR(D) reporting or if their emissions are already covered and paid in scope 3 of the production company.

Thirdly, future research should examine whether investment decisions regarding new trucks could be made more attractive to carriers with Carbon Contracts for Difference (CCfD). Along with fuel costs, other cost carriers should be evaluated. For example, one can assume that administrative costs will increase due to additional corporate sustainability reporting (CSR) obligations [3]. For example, the "act to strengthen nonfinancial reporting by companies in their management and group management reports" will be discussed on a national level [21]. Should this directive come into force, companies that fulfill at least two of the three characteristics (i.e., balance sheet total ≥ €20 million, turnover ≥ €40 million, or number of employees ≥ 250) will have to prepare a sustainability report. This seems to be another challenge in the logistics industry, as McKinnon's and Toelke's recent study indicates, that only about 22% (N = 811) of the freight forwarders in Europe can calculate their CO_2 emissions at all [32].

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Determination of asymmetric information in multistage agricultural Supply Chains: A sequence of research activity

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Abstract

Due to the increasing globalization and the resulting emergence of new market participants, the issue of information asymmetries is of immense importance. Based on globalization, increasingly complex network supply chains are emerging in which information transparency between the actors is insufficiently pronounced. The occurrence of information asymmetry (IA) is particularly pronounced in agricultural supply chains, where different types and sizes of actors, such as small farmers, large producers, or small retailers etc., are involved in the supply chain. The insufficient information transparency in the food value chain, is the result of IA, which leads to mistrust between the actors involved and ultimately to opportunistic behavior among the actors. In this regard, it was of utmost necessity to identify, define and reduce the IA in food supply chains between the actors. The aim of the research project will be to extend the current state of knowledge regarding the topic of information asymmetries by defining variables influencing asymmetric information and calculating information asymmetries. To be able to achieve the goal of the research project, quantitative (e.g., surveys) and qualitative (e.g., expert interviews) empirical methods were used. Prior to this, an extensive literature review was undertaken to identify possible variables influencing asymmetric information, which also served as a basis for the quantitative and qualitative analysis in which the entire supply chain, starting from the seed producer to the end customer, was considered. In the course of this, "neutral actors" such as consulting companies, agricultural cooperatives and food networks were also consulted. They were able to provide extensive insight into possible variables influencing information asymmetry. Through the presentation of the research gap as well as the definition of these variables a comprehensive influencing variables model could finally be created. Furthermore, essential future research actions such as the explorative investigation of variables influencing information asymmetry and a possible IA calculation method, which could be useful, were roughly outlined. In conclusion the topic of information asymmetries in food value chains is highly complex, but this research project allows us to structure IA and make it more informative (or: accessible) for science.

1. Introduction

One of the essential realities of today is the emergence of globalization [1, 2]. With globalization, numerous new networks of international markets and the accompanying increase in the interaction of market participants have emerged [3]. Numerous industries, such as the automotive, chemical, electrical, mechanical engineering, and even the food industry, exhibit internationalization of markets [4]. Especially the food industry shows an extensive internationalization of its market, which is driven by increasing prosperity and urbanization as well as the growing importance [5]. Due to the changing market structures of the food industry, consumers have extensive access to food products which can be sourced out of season [6]. Although globalization brings many benefits to the food industry, it also creates many challenges over time, which are of concern to many market participants. One of the main challenges is the food value chain. In recent decades, the food value chain has evolved from a simple value chain with linear processes, where raw materials and products are delivered directly to the consumer, to a complex network-like value chain, which is characterized by an immense opacity resulting from the multitude of interconnected actors, starting from the seed producer and its associated sub-suppliers to the end customer [7]. Numerous challenges result from this constellation of the value chains, such as guaranteeing the sustainability of the product to the end customer, since the complexity of the value chain makes it difficult to ensure quality and product safety when processed and transported by a multitude of different actors [8]. Consequently, one of the main challenges of the food industry is the emergence of information asymmetries, especially at the level of small low-turnover actors, which have less access to information and resources than larger and more diversified companies [9]. Not only the IA within the food value chain, but also the IA at the level of end consumers is supposed to be very high, which is due to the increasing opacity and lack of transparency in the supply chain. Uncertainty of the end consumer about the food production, the ingredients as well as the origin of the food represent the central and essential causes of the emergence of IA on the part of the end consumer [10]. Basically, IA means that there is an inequality of information on the side of one market participant (e.g., supplier) compared to the other market participant (e.g., buyer). The seller’s side is characterized by an information advantage and the buyer’s side by an information deficit, which ultimately represents the basic understanding of IA [11]. The emergence of IA and the associated information inequality can bring various con-sequences for the market. For example, market prices can be based on imperfection of information, which is ultimately a disadvantage for the final customer [12]. Not only is this the consequence of IA, but also the emergence of opportunistic buying behavior, which results in market failure and the emergence of a welfare loss [13]. Several decades ago, the economist Mr. G.A. Akerlof addressed the issue of the emergence of IA and published his book "The Market of Lemons". Ref. [14] established the main structures of information asymmetries. Akerlof stated that there are two main types of IA, namely ex-ante information asymmetries (information asymmetries that occur before a contract is initiated; he called them ‘adverse selection’) and ex-post information asymmetries (information asymmetries that occur after a contract is initiated; he called them ‘moral hazard’). In line with the above-mentioned types of information asymmetries, Akerlof defined some possible solutions that could lead to a reduction of IA. Ex-ante information asymmetries should be counteracted by signaling, self-selection or screening and ex-post information asymmetries by monitoring or bonding [14]. One of the most important theories, which is essential when considering information asymmetries, is the principal-agent theory. The principal-agent theory enables the characterization of the cooperating market sides. Thus, the principal represents the market side that has an information deficit (e.g., buyer) and the agent represents the market side that has information advantages (e.g., seller) [15]. Thus, the current state of research can define the types of prevailing IA as the associated solution approaches, which can be invoked to reduce each type of IA. Not only this, but also the characterization of the pairs of actors cooperating with each other and the occurrence of the IA can be enabled by the principal-agent theory. However, the current state of research neglects this essential point in the consideration of information asymmetries, namely the identification of the information asymmetry influencing variables (IAIV), in other words, those variables which are responsible for the development of IA. Not only the aspect of the identification of the IAIV received insufficient or even no attention, but also the aspect of finding a possible computation model aimed at computing the IA between the pairs of actors as well as the entire creation of value chain. Calculating the IA could help to determine the concrete level (degree) of the foreseeable IA, making statements about its intensity between the pairs of actors and enabling a more precise approach of possible solutions in order to reduce the prevailing IA [16]. Thus, this paper describes an advanced research project considering the following points:

- Identification of the Research Gap.
- Definition of the IAIV based on the literature available.
- Explorative investigation of the IAIV.
- Formulation of the model to calculate the prevailing IA.

The aim is to present the research project in terms of divided stages (see above) of the procedure as well as the individual results achieved and still to be achieved in order to enable a theoretical treatment of the following research questions (1-3):

1. Which influencing variables can lead to the development of information asymmetries within a supplier-buyer relationship?
2. What impact do certain influencing variables have on the frequency and intensity of information asymmetries in supplier-buyer relationships within the food industry?
3. How can information asymmetries that may occur in the context of food industry be identified within supplier-buyer relationships?

Finally, from the results already achieved so far and the research results yet to be achieved, the basic understanding towards IA can be enhanced. This paper is organized as follows: First, the procedure of literature review to identify the research gap and its results are presented. Subsequently, the procedure of identifying IAIV and the resulting outcome of the influencing variable model is summarized as well as empirically verified. Finally, a hypothetical view of the IA computation model is provided following a critical discussion and a summary.

2. Research Methodology

The topic of information asymmetries belongs to the most complex as well as intangible theories, which finds its existence in almost every research area [17]. Due to the complexity of the topic of information asymmetries, the current state of research only deals with the definition of the types of information asymmetries, the appropriate assignment of solution approaches and the use of the principal-agent theory for the more accurate characterization of the cooperating actors [14, 15]. In order to make the topic of information asymmetries more understandable, tangible, and accessible to the scientific community, a structured approach is targeted, as in Figure 1, as well as a comprehensive research methodology is applied, see Table 1.

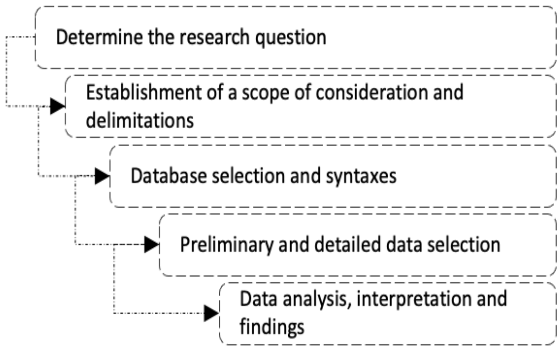

Figure 1: Systematic Approach of the Methodology

Table 1: Methodology depending on the sub-research project

(1) Research Gap Analysis		
Paper-Title	**Methodology**	**Phase**
Asymmetric Information in Agriculture Supply Chain Management	*Structured Scientific Paper Content Analysis*	*Done*
(2) Identification of Asymmetric Information in Agricultural Supplier-Buyer Relationships: A Theoretical Analysis		
Research Question	**Methodology**	**Phase**
Which influencing variables can lead to the development of information asymmetries within a supplier-buyer relationship?	*Structured Scientific Paper Content Analysis*	*Done*
(3) Empirical Analysis of the Identification of Asymmetric Information Variables in Agricultural Supplier-Buyer Relationships		
Research Question	**Methodology**	**Phase**
(1) Which influencing variables can lead to the development of information asymmetries within a supplier-buyer relationship? (2) What impact do certain influencing variables have on the frequency and intensity of information asymmetries in supplier-buyer relationships within the food industry?	*Qualitative and Quantitative research methodology based on expert interviews from seed producer to retailer*	*In Pro-gress*
(4) Calculation Method of Potential Information Asymmetries		
Paper-Title	**Methodology**	**Phase**
Quantifying of Asymmetric Information in Multi-Level Value Chain through the operationalization of information	*Algorithmic information content calculation method*	*Off*
"How can information asymmetries that may occur in the context of food industry be identified within supplier-buyer relationships?"		

Figure 1 shows the basic procedures for the consideration of the individual research steps, but each sub-research project has a minimally different methodological approach, which was defined for the achievement of the goal. In Table 1, the individual sub-research projects with the associated methodology are presented in broad terms, which will be discussed in more detail in the course of the paper.

Ultimately, the last research question presented can be answered through stages 1-4, Table 1.

How can information asymmetries that may occur in the context of food industry be identified within supplier-buyer relationships?

The following is a detailed examination of each research stage and its sub-results, beginning with the research gap analysis.

3. Results and Discussion

3.1 Sub-Result 1: Research Gap Analysis

In order to analyze the information asymmetries in the field of the sustainable food industry and its value chain, an extensive research of possible research gaps in this field is required. Thus, sub-result 1 presents the approach as well as the results of the research gap.
In Paper 1, problems caused by asymmetric information in food value chains, especially in the organic food market, will be investigated in a comprehensive analysis.

- The main reason for considering sustainable food is the exponentially increasing consumption of sustainable food and consequently the ever-increasing demand for sustainably produced products [18].
- Another major reason for considering the food value chain is the presumed complexity of the value chain, justified by the numerous different actors from seed producers to retailers, as well as processes such as processing, packaging, storage, transportation, and sales. This complex design of the considered supply chain makes it difficult to obtain a comprehensive understanding of the food value chain as well as to identify possible problems [19].

Thus, the transparent design of the food value chain is of utmost necessity to make the problem of IA in the organic food market tangible to the scientific community. In order to provide comprehensive information on the topic under discussion, the paper intends to introduce the principal-agent theory as a basic model for understanding IA in the food value chain. In order to gain a comprehensive insight into the current research in the field of information asymmetries applying the principal-agent theory, a structured literature review was conducted, and significant sources are shown in Figure 2.

3.1.1. Sub-Results 1

The topic of information asymmetries based on the principal-agent theory has gained immense progress in recent decades, as the topic of information asymmetries is becoming increasingly important, and its study is considered a necessity [21]. Nevertheless, the extensive literature review has revealed numerous research gaps that the current scholars have insufficiently considered:

- In order to keep the complexity of the IA in check, the principal-agent theory was only used for the analysis of a pair of actors and neglected the application in complex multi-stage value chains [22].
- The basic model of the principal-agent theory neglects in its analysis neighboring disciplines, such as the transaction cost theory or game theory approaches, which makes the principal-agent theory insufficient [23].
- Numerous literature sources take up the topic of the IA quite extensively, however, mostly on a theoretical basis and neglect the empirical view [24].
- What is completely neglected in literature is the identification of variables influencing IA as well as the possibility of calculating the IA between the actors in order to receive information about whether the IA present represents a low, middle, or high characteristic of the asymmetry.

3.1.2. Future Research

In section 3.1.1, several points were identified which can be defined as potential research gaps. Future research should be dedicated to the identification and calculation of information asymmetries on the level of multi-stage food value chains and to disprove them by means of an empirical investigation.
A detailed consideration of the literature analysis for the identification of IA influencing variables follows in section 3.2.

3.2. Sub-Result 2: Identification of information asymmetry influencing variables

Paper 1 (see above) has laid down a directional path with which scholars should look at information asymmetries in future. Paper 1 could show various research gaps which can only be analyzed by a structured approach. Thus, as a subsequent step, the identification of IAIV is required. Information asymmetry influencing variables are factors which affect the characteristic of the IA by their presence or nonexistence both on the part of the supplier and on the part of the buyers.
Depending on whether a certain factor

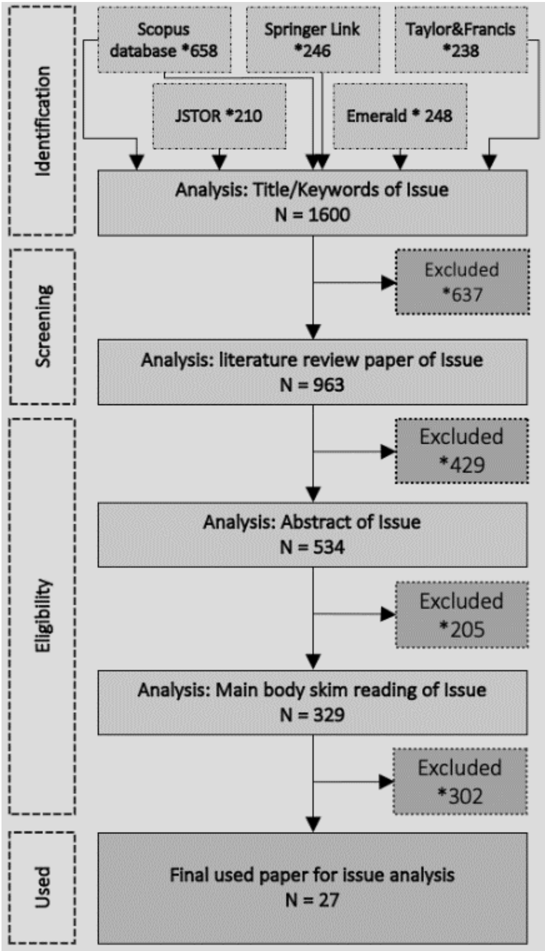

Figure 2: Systematic literature review to find the research gap (Modified from [20])

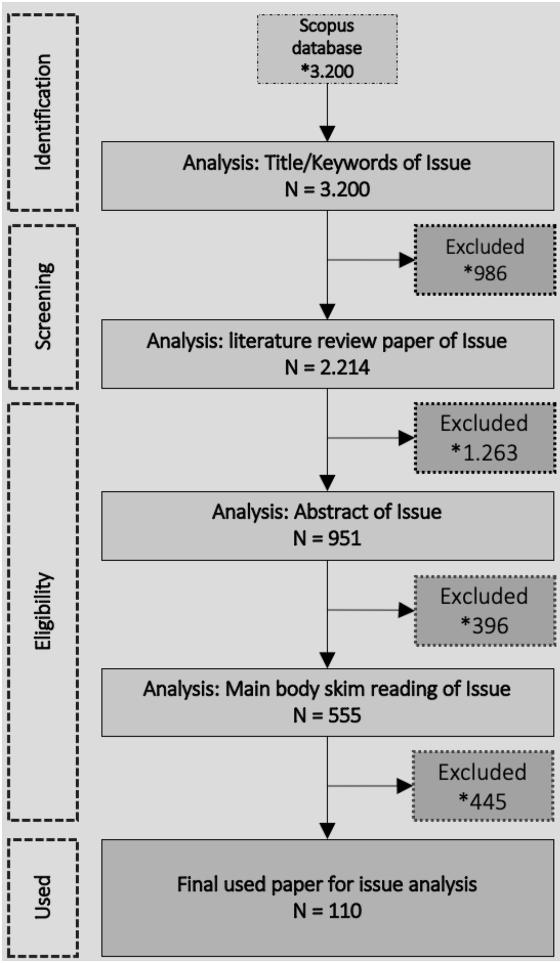

Figure 3: Systematic literature review for identification of information asymmetry influencing variables (Modified from [20])

(e.g.: the presence of ERP systems with the supplier or vice versa) is of importance to the seller or the buyer and is not observed by the supplier or buyer, it can be assumed that this leads to a pronounced IA on the side of the supplier or buyer concerned. In order to be able to identify the described hypothetical consideration of the IA influencing variables, an extensive, detailed literature analysis was carried out. In order to use the Scopus data base purposefully and finally to receive the necessary literature, 17 syntaxes (e.g.: Information AND Asymmetry AND Food) were provided, which finally resulted in a structured literature analysis, figure 3.

3.2.1. Sub-Results 2

In the analysis of the individual papers, it already became apparent that the IA and its emergence can be attributed not only to the food value chains, but also to various other areas such of physics, computer science, etc. [17]. In this regard, an operationalization model had to be created as framework to select the necessary literature from the set. The framework model consists of three factors, namely the (1) measurement method of direct and indirect survey methods (social behavior), (2) management systems (3) further IAIV. The intensive and detailed analysis of the paper according to these points led to the identification of numerous IAIV. Thus, this analysis resulted in a total of 8 IAIV groups with a total of 63 IAIV. Finally, based on the content analysis, a preliminary influence variable model could be created in which the 8 influence variable groups and selected information asymmetry influencing variables were recorded, Figure 4.

3.2.1. Future Research

After an extensive literature analysis, a detailed influence variable model could be created, which is only based on theory. Therefore, for future considerations of information asymmetries within the supplier-buyer relationship in the food value chain an empirical verification of the model in figure 4 is required.

3.3. Sub-Result 3: Empirical Analysis of the Identification of Asymmetric Information Variables

In the following, after having identified a great number of IAIV on the basis of an extensive literature research, an empirical investigation of

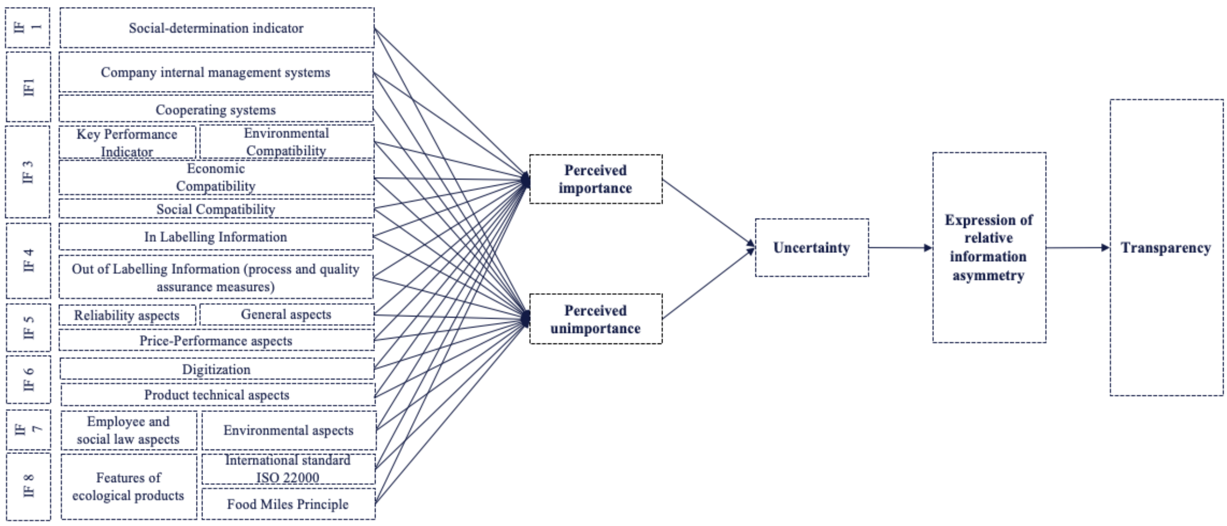

Figure 4: Information asymmetry Influencing variable model

the influencing variables as well as of the entire influencing variable model will be undertaken. The empirical investigation intends to answer the following research question:

"*Which influencing variables can lead to the development of information asymmetries within a supplier-buyer relationship?"*

3.3.1. Qualitative analysis of the information asymmetry influencing variables

In the qualitative study, the IAIV discovered in literature (Figure 4 no. 1) are to be confirmed and additional influencing variables should be determined. As the prevailing data basis for the determination of information asymmetric variables is small, the Mixed-Methods-Analysis was used for the creation of a new data basis, for which expert interviews as well as surveys are conducted, since this is an explorative research project. In order to gain a comprehensive insight into the influencing variables, expert interviews of an entire food supply chain were carried out, starting from the from the seed producer to the retailer [25]. In addition, expert interviews were also conducted with so-called "neutral actors", such as consulting companies, food networks and agricultural cooperatives, as they have a more comprehensive overview of the entire food supply chain and have information on both the suppliers and the buyers. Finally, 16 expert interviews and surveys were conducted in total. The expert interviews were recorded for the analysis and transcribed afterwards and analyzed in the WinReLan analysis tool to finally determine interlinked and common statements of the experts regarding the influencing variables [26].

Sub-Results 3

As the analysis of the expert interviews is still in progress (February 2023), only some of the IAIV identified in literature can be determined at this stage, such as the existence of management systems. In addition, a great number of other influencing variables have been determined, for example political conflicts, but these are currently subject to a more detailed investigation.

Future Research

Since the identification of the IAIV is still at an early stage of the analysis, only hypothetical projects can be undertaken for future research. After numerous variables based on literature have been determined and, in addition, new variables not previously considered have been identified, the future research project requires an empirical analysis of (Figure 4 no. 2), as well as the entire model of influencing variables, in order to ultimately make statements about the extent of IA within a supplier-buyer relationship. This requires answering the following research question:

"*What impact do certain influencing variables have on the frequency and intensity of information asymmetries in supplier-buyer relationships within the food industry?"*

3.3.2. Quantitative analysis of the information asymmetry influencing variables

Approach and Methodology

The quantitative section of the following presentation is based on a hypothetical analysis since the results of the qualitative analysis from section 3.3.1 are necessary for this. In the quantitative analysis, the individual steps of the influence variable model in Figure 4 are analyzed:

- Perceived importance (IAIV that are perceived as important)
- Perceived unimportance (IAIV that are perceived as unimportant)
- Unimportance (importance (IIV) in relation to presence)
- Expression of IA
- Transparency of the supply chain under consideration

The objective of this analysis is to answer the following research question:

“What impact do certain influencing variables have on the frequency and intensity of information asymmetries in supplier-buyer relationships within the food industry?”

In order to determine the frequency and intensity of the IA and ultimately to confirm the influence variable model, the transcripts and surveys from the qualitative analysis are used and processed for quantitative analysis.
The transcriptions and the surveys are subsequently adjusted with regard to their data structure and made available for the analysis tools R-Studio and Python. Thus, by performing principal component analysis, factor analysis, regression analysis of the IAIV (Figure 4 no. 1), the influences on the factors (Figure 4 no. 2) can become visible. Ultimately, the analysis should allow the adjustment as well as the confirmation of the influence variable model to predict IA.

Future Research

In section 3.2.2, the influencing variables model derived from literature could be determined, starting with the IAIV and ending with the characteristics of the IA. In the analysis of the influence model, only the view of the actors within the food supply chain has been considered so far. Information asymmetry and its possible manifestation at the level of the consumer at the end of the supply chain as well as the possible calculation of the degree of IA in order to determine whether there is a low, medium, or high degree of IA in the supplier-buyer relationship have not been considered to date.

4. Conclusion and future work

The topic of information asymmetries concerns various scientific disciplines in numerous contexts. Ref. [14] has done the fundamental work to distinguish the information asymmetries by their nature and to define a suitable solution approach to reduce the prevailing IA. Furthermore, the principal-agent theory is used by considering the IA which enables for the characterization of the supplier-buyer relationship. The determination of IAIV as well as the calculation of IA has been insufficiently researched until now and should be the basic objective of subsequent studies on the subject of information asymmetries. Due to progress in current research (point 3) it will be possible in the foreseeable future to determine potential influencing variables which are responsible for the expression of IA in supplier-buyer relationships. Future studies should build on this research status to further analyze the IA at the level of the retailer towards the end-customer and test the following hypothetical assumption: "It can be assumed that the IA along the food value chain is at its peak in the supplier-buyer relationship." In addition, as previously described, future research should address the possibility of calculating IA. The reason for this is the following: If the IA within a supplier-buyer relationship could be determined in terms of its degree, then an appropriate solution can be applied to it in a targeted manner, rather than by arbitrary generalized solution approaches. Furthermore, the exploratively modeled calculation model of IA should be subjected to an empirical analysis based on a multi-stage value chain. Finally, the main research question "How can information asymmetries that may occur in the context of the food industry be identified within supplier-buyer relationships?" should be answered.

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Obtaining and evaluation of abrasive materials

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Abstract
During the manufacture of flats and terrazzo, grinding and polishing operations are compulsory, which are carried out with abrasive wheels. The work deals with the obtaining and evaluation of abrasive materials from aluminothermic processing of solid industrial waste and Cuban minerals. Different mixtures composed of mill scale and aluminum chips to which different proportions of limestone are added are studied. As a result of the process, a high hardness ceramic is obtained as the main product, and a metal as a by-product. The results of the process are evaluated from the metal and slag yields. The behavior of the ceramics as an abrasive material is evaluated by means of scratch tests on glass, and the behavior of the powders during setting with P-350 cement is also evaluated. Finally, an assessment is made for the possible assembly of a Pilot Plant for the manufacture of abrasive powders, which guarantees the possibility of producing these materials on a pilot plant scale where all the construction and logistical aspects for their subsequent exploitation are assessed.

1. Introduction
Abrasive materials are substances whose purpose is to act on other materials with different kinds of mechanical stress (crushing, grinding, cutting and polishing), they are of high hardness and are used in all types of industrial and craft processes where hardness, grain size, composition and structure are of fundamental importance for the choice of the appropriate material [5].
They can be found on the market in multiple forms (wheels, discs, paper, powders, pastes, etc. [8].
The structure of these materials is generally divided into three parts: backing, mineral (abrasives) and the adhesive or binder [2].
The combination of logistics and quality assurance creates the conditions for a change in production and services [4]. In order to work in this direction, the country's management prioritizes science and technology work, which is carried out by increasing university-industry links in order to obtain concrete results.
Similarly, the choice of type of infrastructure and the way in which it is designed, regulated and the services provided over it are operated, determine the price, timing and quality of products [2].
In Cuba, the polishing of floor and terrazzo elements is carried out with grinding wheels, which are manufactured using abrasive powders imported at high costs on the international market. The absence in the country of an industrial process to obtain abrasive materials with national raw materials for use in the manufacture of grinding wheels used in the polishing of floor and terrazzo elements, together with the cost of importing these materials, are aspects that limit the fulfilment of the production plans of the Villa Clara Construction Materials Company, affecting the social and economic development of the territory. This makes it necessary to develop an economically

feasible alternative for the manufacture of these materials.
From a mixture consisting of: mill scale, aluminum shavings and the addition of limestone, it is possible to obtain by aluminothermy a ceramic with a high alumina content and high hardness, which can be used in the development of grinding wheels. Pyrometallurgical processing is carried out using the energy generated by the redox reactions that take place, with more than 90 % of the materials used being industrial waste and all of the products generated being used.
The proposed methodology constitutes a scientific novelty for the country, since the process uses Cuban industrial waste and minerals as raw materials [3].

2. Methods or experimental part:

2.1. Raw materials

The raw materials used in aluminothermic processing are as follows:
- Mill scale, from the Acinox-Tunas company.
- Aluminum shavings, from the Empresa de Recuperación de Materias Primas de Villa Clara.
- Limestone (stone dust), from the El Purio deposit, belonging to the Villa Clara Construction Materials Company.

Table 1 shows the chemical composition of the raw materials to be reacted.

Table 1: Chemical composition of the raw materials to be used

<table>
<tr><th colspan="9">Aluminum shavings</th></tr>
<tr><td>Si</td><td>Fe</td><td>Mn</td><td>Cu</td><td>Mg</td><td>Zn</td><td>Cr</td><td>Ti</td><td>Al</td></tr>
<tr><td>0,5</td><td>0,2</td><td>0,1</td><td>0,1</td><td>0,2</td><td>0,2</td><td>0,1</td><td>0,1</td><td>report</td></tr>
<tr><th colspan="9">Mill scale</th></tr>
<tr><td>Fe_2O_3</td><td>Fe_3O_4</td><td colspan="2">FeO</td><td>Fe</td><td>Fe</td><td colspan="2">O_2</td><td>Impure</td></tr>
<tr><td>20-30</td><td>40-60</td><td colspan="2">15-20</td><td>2-5</td><td>70,3</td><td colspan="2">24,1</td><td>5</td></tr>
<tr><th colspan="9">Limestone</th></tr>
<tr><td>CaO</td><td>MgO</td><td colspan="3">SiO_2</td><td>Al_2O_3</td><td colspan="2">Fe_2O_3</td><td>Ignition loss</td></tr>
<tr><td>55,20</td><td>0,68</td><td colspan="3">0,34</td><td>0,23</td><td colspan="2">0,17</td><td>44,38</td></tr>
</table>

Mill scale is a solid residue generated during hot rolling processes in the steel industry. The iron oxide (mill scale) has a very variable grain size, therefore, it was crushed and sieved until all the residue had a grain size of less than 2 mm.
Aluminothermy requires the use of aluminum with low granulometry, so the shavings used were sieved below 3 mm.
Limestone ($CaCO_3$) is marketed in Cuba in different grain sizes, according to the requirements for its use, using in this case the fraction called stone dust, which has a grain size of less than 1 mm.

2.2. Formulation of the loads

The research strategy consisted of formulating five charges, from 0 to 4, according to the amount of heat generated per unit mass of each charge, so that the amount of heat released by the reactions would be sufficient to ensure the self-sustainability of the process and the adequate separation of the metal from the ceramic. The data are shown in Table 2.

Table 2: conformation of aluminothermic charges (g)

	Mill scale	shavigs	Limestone
0	150	52	0
1	150	52	15
2	150	52	30
3	150	52	45
4	150	52	60

Once the melting process is finished, the mixture is left to cool in the reactor for its later extraction in a tray, leaving the metal in the lower part and the ceramic in the upper part, which are separated manually.
Finally, charge 1 was reproduced 20 times to obtain a larger amount of ceramic, which will be evaluated in the manufacture of abrasive materials. Table 3 shows the charge conformation for the large casting.

Table 3: Conformation of the aluminothermic caster large

Mill scale	shavigs	Limestone
3000g	1040g	300g

2.3. Obtaining the abrasives

The different components of the load, once weighed on a balance technical, are introduced into a drum mixer in increasing order according to their density: aluminum chips, limestone and mill scale. Mixing is carried out for 30 minutes. Subsequently, each mixture was preheated in an oven between 250 and 300 °C for 1 h, then it was placed, hot, in the graphite reactor, starting the reaction by the action of the electric arc. The process of obtaining the termites is shown in Figure 1.

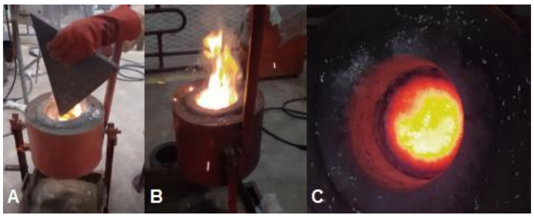

Figure 1: Obtaining of the Termites: A) Reactor feed and ignition of the reaction, B) Self sustainability of the reaction, C) Cooling of the termite

3. Results and Discussion:

3.1. Mass balance

From the charge conformation data shown in Table 2 and 3, the chemical composition of each of the raw materials (Table 1) and the fundamental chemical reaction to occur between Fe_2O_3 and aluminum (Equation 1), a mass balance is performed to estimate the potential outputs of each of the charges, assuming that all the iron present in the scale is in the form of Fe_2O_3.

$$Fe_2O_{3(s)} + Al_{(s)} \rightarrow Fe_{(s)} + Al_2O_{3(s)} \quad (1)$$

The balance is carried out on the basis of the principle of Conservation of Mass, the general expression of which is shown in Equation 2, [1].

Accumulation = Input - Output + Generation - Consumption (2)

From the results obtained in the mass balances, the theoretical quantity of metal, ceramics and gases to be obtained in each of the loads is determined.

3.2. Calculation of heats of reaction

The determination of the heats of reaction allows the assessment of the feasibility of occurrence of the chemical reactions that develop during metallurgical processing [7], results that allow the prediction of the feasibility of self-sustaining the aluminothermic reaction. These results are shown in Table 4.

Table 4: Amount of heat generated by the charges (cal/g)

	0	1	2	3	4
Qr	-930,9	-867,2	-811,4	-762,5	-719,19

These values for all loads are above 700 cal/g of pyrometallurgical mixture, which guarantees the self-sustainability of the aluminothermic process without the supply of additional external energy, and all mixtures are above 650 cal/g, which guarantees the adequate separation between metal and slag [7].

3.3. Results of the metallurgical processing of the small batches

In general, the small casts behaved satisfactorily, the ignition process went smoothly, good ignition of the reaction developed in a self-sustained way until the end of the process. Metal and ceramics separated adequately.

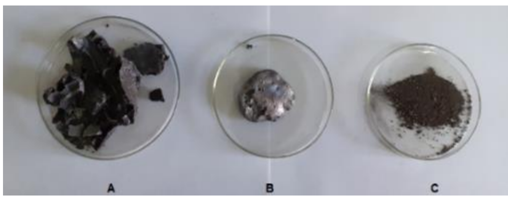

Figure 2: A) slag, B) metal, C) unreacted mixture

The quantitative results of the processing of all small loads in terms of: amount of metal, slag and unreacted mass of mixture are shown in Table 5, showing also the yield values, which are determined from the ratio between the actual amount obtained and the theoretical amount determined from the mass balance.

Table 5: Masses of molten metal, slag and unreacted mixture of the termites small

	Metal		Ceramic		Unreacted
	Mass (g)	**(%)**	**Mass (g)**	**(%)**	**Mass (g)**
0	93	87,5	97	101,4	5
1	91	85,6	108	103,7	6
2	85	79,9	116	103,1	16
3	80	75,2	128	105,7	18
4	58	54,6	131	101,1	47

To evaluate the process on a larger scale, charge 1 is selected because of its good pyrometallurgical behavior, good yield and lower amount of limestone incorporated into the mixture.

3.4. Processing of the large charge

The ignition process went smoothly, with a good reaction rate, resulting in metal with a uniform and smooth appearance (see Figure 3).

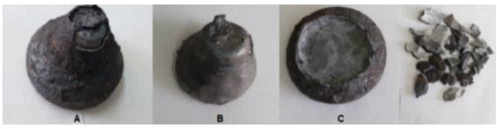

Figure 3: A) products obtained, B) metal, C) slag

The results of the processing of the large charge in terms of metal and slag quantity are shown in Table 6.

Table 6: Results of the processing of large thermite

Product	Theoretical mass (g)	Actual mass (g)	(%)
Metal	2124,95	1995	93,9
Ceramic	2082,83	2120	101,8

Table 6 shows that the aluminothermic processing of the large charge yielded more than 2 kg of ceramic and more than 1 kg of metal, which represents 102 and 94 % yield respectively. Comparing these results with those obtained in casting 1, it can be seen that when the amount of metal processed increases, the metal yield increases significantly and the ceramic yield decreases slightly, with a marked decrease in the amount of mixture that stops reacting, which contributes to improving the pyrometallurgical processing results. These results allow the possibility of scaling up the process to be assessed.

3.5. Evaluation of abrasives

3.5.1. Valuation of the scratch test

The objective of the test is to evaluate and compare the quality of the ceramics obtained in terms of their hardness. The test consists of scoring a crystal by the action of the abrasive with a constant load of 2 kg, following the principles of tribology [3], see Figure 4.

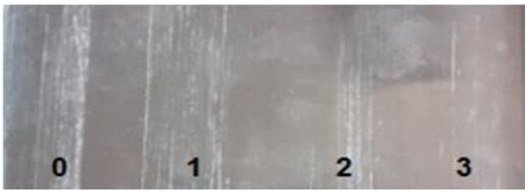

Figure 4: Abrasive action on glass

As shown in Figure 4, all ceramics have a higher hardness than glass, with the hardness of glass on the Mohs scale being 5.5 [6], which validates their use for the manufacture of abrasive powders.

3.5.2. Production of grinding wheel specimens

When casting 1 was selected as the one with the best results, it was necessary to evaluate the behavior of the different granulometric fractions during setting, as these ceramics will be used for the development of grinding wheels, using P-350 cement as a binder.
The aim of this test is to evaluate the possible reactivity of the abrasive grains (ceramics obtained) with Portland P-350 cement.
Therefore, all of the ceramics obtained in the load large were manually crushed and classified granulometrically, being manually crushed in a mortar until a grain size of less than 0.315 mm was achieved. The product obtained was then sorted into 5 fractions so that they could be grouped according to the particle size requirements of the grinding wheels.
Table 7 shows the results of the granulometric classification of the crushed ceramics and the average grain number, according to the granulometry obtained.

Table 7: Results of the granulometric classification process of the crushed ceramics

	Grain size fraction	**Numb er. Grain**	**Mass (g)**	**%**	**% Accumu -lated**
1	-0,315 +0,21	60	540	30,3	30,3
2	-0,21 +0,16	80	188	10,5	40,85
3	-0,16 +0,08	100	715	40,1	80,97
4	-0,088 +0,05	180	230	12,9	93,88
5	-0,053	240	109	6,12	100

The results shown in Table 7 show that it is possible to obtain abrasives with different grain sizes, which makes it possible to manufacture the grinding wheels needed to carry out the grinding and polishing operations on floors and terrazzo. When the test specimens shown in Figure 5 were made, it was confirmed that they behaved satisfactorily, and the problems presented in previous studies [8] were not observed, which was achieved by substituting limestone for ceramic in the composition of the mixtures.

Figure 5: Test tubes manufactured with the 5 particle size fractions obtained.

3.6. Production strategy

On the basis of the previous studies, an economic evaluation is carried out to determine the techno - economic feasibility of the possible setting up of a pilot plant for the manufacture of abrasive powders. The evaluation allows us to determine that it is feasible from an economic point of view to carry out these productions, as all the indicators are favorable.
In order to materialize the research, a technology transfer contract is signed between the companies SICTE SA and Materiales de la Construcción de Villa Clara for the installation of the Pilot Plant. It is proposed to install a plant with a production capacity of 22.3 t/year of abrasive powders and 14 t/year of metal, for a total of 36.3 t/year of products, obtaining these production levels from the realization of 20 castings per month.
Figure 6 shows the layout of the equipment to be used within the plant, which is built in an old building that was refurbished to meet the proposed requirements.

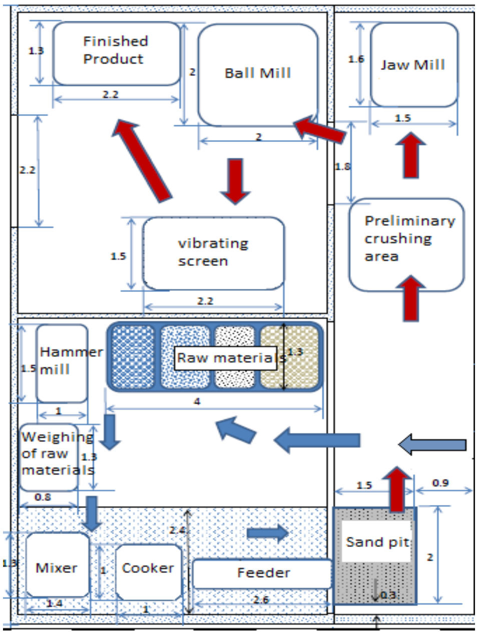

Figure 6: Distribution of equipment used for the manufacture of abrasive powders within the plant.

Figure 7 shows the processing scheme of the Abrasives Plant, which must be complied with for the proper functioning of the process and the production of good quality ceramics.

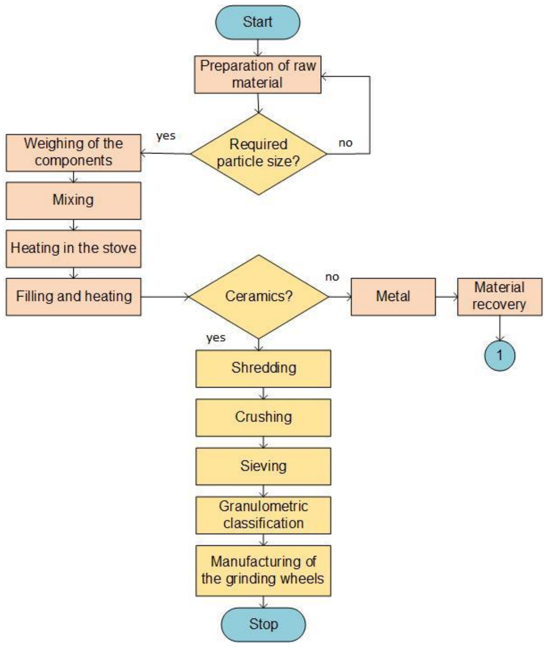

Figure 7: Flow diagram of the process of obtaining abrasive materials at the plant

Table 8 shows the forming of some aluminothermic casts which were processed, during the scale-up in the plant using the plant equipment. The pyrometallurgical performance was excellent which confirms the preparation of the workers. The results of the evaluation are given in Table 9.

Table 8: Forming of two casts in the Pilot Plant (in kg)

Casts	Husk	shavings	Limestone
1	76	26,4	7,6
2	136	46,2	13,3

Table 9: Results of the Pilot Plant scale evaluation

Casts	Metal		Ceramics	
	Mass (g)	(%)	Mass (g)	(%)
1	55	104,7	44	87,4
2	94	101,2	80	89

Pilot plant scale-up tests scaling were satisfactory, with a tendency for the metallic yield to increase and the ceramic yield to decrease as the amount of charge processed increases.

3.7. Results of the crushing and sieving process of a sample of abrasives obtained at the Cifuentes Pilot Plant.

Two samples obtained from the initial crushing and grinding process of the abrasive powders obtained at the Pilot Plant were subjected to a sieving process in an electric sieve for ten minutes, obtaining the results shown in Table 10.

Table 10: Results of the sieving of the abrasive obtained in the ball mill and retained between the two large sieves at the Cifuentes Abrasive Plant

Coarse grain (mm)	Retain-ed mass (g)	Re-tained (%)	Accu mulat ed (g)	Gri nd	%	%
-1	62	9,2	62	18		
+1-0,84	109	16,2	171	20		90,4
+0,84 -0,5	348	51,6	519	25, 30, 35	74,2	
+0,5-0,315	152	22,6	671	40, 45, 50		
+0,31 5-0,2	3	0,5	674	60, 70		
Total	674	100				

As can be seen in Table 10, 90 % of the abrasive powder is concentrated between 0.1 and 0.315 mm, of which 74 % is between 0.315 and 0.84 mm, a range that corresponds to a particle size range, with which different grinding wheels can be produced, mainly for roughing, the rest can be used for polishing and finishing operations. From the results of the grinding and sieving process, the final process scheme is drawn (Figure 7).
The study of the grinding and sieving process of the abrasives obtained in the plant allows us to affirm that with the appropriate use of the existing equipment in the plant, it is feasible to obtain all the particle size fractions required to cover the demand for grinding wheels used in the roughing and polishing operations of floors and terrazzo.
The selected particle size fractions were used for the manufacture of grinding wheels, which were evaluated under real working conditions and their performance was verified.

3.8. Project Considerations

3.8.1. Economic and market aspects (for technological innovation projects involving a large investment)

The Empresa de Materiales de Construcción de Villa Clara carries out artisanal production of grinding wheels made with imported abrasive grains and Portland p-350 cement, so having a technology that allows these products to be obtained in the country, with 100% national components, guarantees total sovereignty for these productions, as well as valuing the possible insertion of these products in the national market and in the Latin American region.

3.8.2. Assimilation and development capacity

The processing technology does not have a high degree of complexity and can be assimilated by the company's technical staff from the advice offered by the CIS, so that workers and technical staff can be trained in a relatively short time.

3.8.3. Energy

The proposed technology, unlike traditional methods, is based on the energy released by a chemical reaction between a metal oxide and aluminum, which is highly exothermic.

3.8.4. Raw materials and natural resources

All the raw materials involved in the abrasive powder production process are industrial residues [3] (> 90 %) and Cuban minerals (< 10 %).

3.8.5. Location of the Pilot Plant

For the construction of the pilot plant, the Empresa de Materiales de la Construcción decided that it should be located within the facilities of the UEB Combinado de Hormigón ¨Rolando Morales Sanabria¨ in the municipality of Cifuentes, Villa Clara, in order to minimize transportation costs, since the grinding wheels are manufactured in this factory. It was decided to name the plant Dr. Sc. Rafael Quintana Pichon.

3.8.6. Manpower

As this is a small pilot plant for the manufacture of abrasive powders, in addition to the interlinking of the processes within the plant, only three workers will be employed to carry out all the tasks.

3.9. Impact of the results studied

3.9.1. Scientific

Obtaining an abrasive grain that can be used in the manufacture of grinding wheels and a high-quality iron alloy that can be used in the manufacture of steel, through the use of a non-conventional technology.

3.9.2. Technological

The procedure for obtaining the abrasive powders is based entirely on the use of Cuban industrial waste and minerals, allowing the manufacture of grinding wheels with 100% national components. A technology, not previously used for these purposes, is proposed that does not generate other solid waste.

3.9.3. Economic

A process is developed and evaluated to obtain abrasive powders from Cuban minerals and industrial waste, which can be used in the manufacture of grinding wheels for polishing floors and terrazzo, thus avoiding the importation of these powders.

3.9.4. Environment

- Reduction of the pollutant load
- Use of waste materials
- Development of cleaner production

4. Conclusion

- The characteristics and chemical composition of the selected raw materials, as well as the proportions in which they were mixed, allowed the generation of heat quantities between 719.19 - 930.6 call/g, which guaranteed the self-sustainability of the process and the adequate separation of the metal and the slag, ensuring the proper development of the aluminothermic processing.
- The charges made up of mill scale, aluminum chips and limestone allowed obtaining metal yield values between 54.6 - 87.5 % and slag yield values between 101.1 - 105.7 %, with an adequate technological behavior during pyrometallurgical processing for all the mixtures, where the reproduction of charge 1 (larger volume) allowed considerably reducing the amount of unreacted mixture, obtaining a metal yield of 94 % and slag yield of 102 %, considerably improving the results of the process.
- The abrasiveness tests carried out with the abrasive grains obtained showed that they all have a hardness higher than glass, making it possible to use them to manufacture the grinding wheels used for polishing flats and terrazzo. On the other hand, no deformations were observed in any of the samples evaluated during the setting of the mixtures of abrasive powders with P-350 cement.
- The Pilot Plant Dr, Sc, Rafael Quintana Puchol set up in the UEB Combinado de Hormigón ¨Rolando Morales Sanabria¨ de Cifuentes, allows the production of the abrasive powders required by the Empresa de Materiales de Construcción de Villa Clara to satisfy its demand for grinding wheels for floor and terrazzo polishing.
- The technological proposal evaluated represents a contribution to the preservation of the environment and contributes to the substitution of imports, making the company totally independent from the international market.

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Test method for the optimal choice of packaging systems

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Abstract
This publication discusses the importance of selecting the most suitable packaging system for companies' logistics processes. This is a valid social and corporate expectation, as it can reduce environmental impact and improve the efficiency of logistics processes, which are key factors in a company's competitiveness. The appropriate packaging system can be selected based on experience, but there is a lack of integrated methods that can help choose the right packaging system. The publication proposes an innovative packaging system based on corporate needs. This can also improve the efficiency of sustainable supply chain processes. Packaging systems have an impact on the total cost and operational efficiency of the process.

1. Introduction
Logistics is undergoing significant changes aimed at ensuring smooth business operations. As part of the supply chain, logistics encompasses the principles, system rules, and processes that enable the flow of material assets. Modern logistics has become an important industry for economic development, but traditional packaging design may struggle to meet new challenges. Packaging is the starting point of logistics, and its optimized selection and proper planning are crucial for process efficiency and sustainability. Significant changes are taking place in the way goods are produced and useful information shared, thanks to technologies such as artificial intelligence, Big Data, the Internet of Things, and blockchain. Integrating these technologies and adopting a collaborative approach can promote supply chain efficiency. Digital packaging design offers the possibility of efficient and effective product packaging design using advanced computer technology. More efficient packaging design is possible with software, which can lead to actual reductions in logistics costs. Proper packaging is important for environmental protection and waste management. Selecting the right packaging system is a key factor in achieving efficient logistics processes. This study aims to identify research gaps and provide opportunities for future research.

2. Literature Review
The literature analysis was conducted using SLR (Systematic Literature Review) method. This method is used to identify, categorize, select, and analyze relevant articles on a given research topic. The analysis should be conducted transparently to result in a comprehensive overview of the topic [1]. Literature analysis strives for a comprehensive scientific presentation on the topic, minimizing bias [2].
The first step of the literature analysis was to select the appropriate databases, considering easy accessibility and structured searching. It is important to note that the search was conducted on March 14, 2023, so newer publications may have been published since then. The Scopus and ScienceDirect databases were selected. The initial search was performed using the keywords 'packaging' AND 'logistics', and the results were as follows:

- Scopus: 16223 pcs
- ScienceDirect: 32507 pcs

The second search combination was ’packaging’ AND ’logistics’ AND ’digitalization’, and the results were:
- Scopus: 470 pcs
- ScienceDirect: 8236 pcs

The search field was then reduced to only the title, abstract, and keywords. The result of this search:
- Scopus: 10 pcs
- ScienceDirect: 11 pcs.

Based on reading some of the abstracts, a summary was prepared on the current articles in the field. Publication [3] deals with the circular economy, focusing on maximizing resource utilization mainly in logistics. The study summarizes current knowledge on shared logistics and highlights areas that require further research. Article [4] examines the peculiarities of the operation of the agro-industrial complex in digitalization. Science [5] focuses on the opportunities offered by Industry 4.0 technologies in terms of digitalization. It outlines some possible ways of transforming traditional manufacturing and related service systems into cyber-physical environments in the era of Industry 4.0, in the manufacturing processes of the automotive industry, the collection and distribution systems of urban logistics hyper-connections, and the switch pool packaging logistics area. An overview is provided in the [6] study on the possible implementation of innovative solutions with collected digital elements, addressing the primary needs and issues of short food supply chains. The [7] paper presents the current status and future trends of innovative and environmentally sustainable technological solutions for the post-harvest food supply chain and the food industry, focusing eco-friendly packaging, active and/or intelligent packaging. The [8] research demonstrates the sensitivity of Life Cycle Assessment (LCA) results to transportation parameters, highlighting the importance of accepting digital twins in these complex logistics ecosystems to increase the accuracy of their environmental profiles. The [9] article presents a digital twin for supporting the dispatchers of trucks, enabling optimal dispatcher policies to be determined through simulation-based performance prediction. The [10] study reports on findings from an industrial survey in the general processing industry.
In the continuation of the paper, an innovative packaging management framework concept is presented, which can be optimized through simulation-based studies and is suitable for selecting optimal unit loading tools, considering corporate needs.

3. Description of packaging management system

The chapter presents the operational concept and application method of the packaging management system. The developed concept was created using inductive and deductive methods, considering the simulation testing needs in the industry and the operating mechanisms of electronic marketplaces. Structure of the framework operation.
The aim of packaging management is to select the optimal packaging system for designated product types at decision points in the chosen supply chain. The developed system concept is based on the structure of the framework and the definition of task to be carried out. At decision points, there is an opportunity to choose packaging systems, although there are operations where the type of packaging system to be applied is predetermined. The framework can be divided into three main parts: study participants, important tools to be applied, and necessary databases. The management defines the development guidelines and is responsible for making strategic and tactical decisions, while experts manage the entire examination process. The client utilizes the services of the examination system and, with the assistance of the experts, selects the optimal packaging system. The R&D group develops the operation of the framework according to the approved development guidelines of the management and maintains the necessary infrastructure for operation. Information providers are those who provide additional information which is necessary for the examinations carried out.

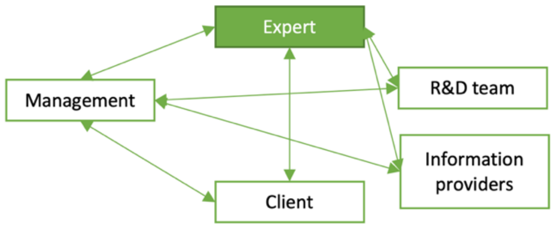

Figure 1: The study participants of the framework and the relationships between them (own edit)

The main tools to optimize the supply chain are described below. The simulation framework allows to model the supply chain under study and to analyze the impact of different packaging system combination with the optimal objective function value. The web-based data input interface enables data recording and uploading to the databases required for the examination. The tracking system provides the necessary quantitative and qualitative data for running the simulation model and allows for data uploading, from manual data recording to automated digitization solutions, which may affect the quality of the examination.
Three databases are necessary for the system to operate:

- the packaging system database,
- the logistics system database,
- the database related to optimization.

The first database contains packaging system data that are uploaded through a web interface by information providers and experts. The seconds database contains the data necessary for modeling the examination process, which are recorded based on the examined company and/or on-site surveys. The optimization database contains the data needed to select the right packaging system, such as decision variables, conditions and objective functions, which are captured partly by the experts and party by running the simulation study.

3.1. Description of test cases

To select optimal packaging systems, several logistics tasks must be defined and modeled. Supply chains can vary, which can influence the number of decision points and investigations. The basic types and their combinations determine changes in packaging systems throughout logistics processes. In practice, six basic types and their combinations occur, which can vary depending on the extent of the supply chains. The basic types are as follows [11]:

1. The packaging system remains unchanged during the process, such as when the same packaging used during product quality control as when the product was removed.
2. The packaging system changes in a process without splitting, such as when a different packaging system is required after laser cutting.
3. The packaging system remains unchanged when multiple processes converge, such as during painting.
4. The packaging system changes when multiple processes converge, such as during picking.
5. The packaging system remains unchanged in splitting, such as delivering a particular type of product to multiple customers.
6. The type of unit load device changes in splitting, such as after disassembly or sorting.

4. How does the packaging management system work?

The optimal packaging system is determined as a result of the operation of the packaging management system within a defined supply chain or material flow system. Based on pre-registered data in background databases, a limited simulation model is automatically created. The applicable packaging system is selected based on the configured objective functions and conditions.

Steps for using the system [11]:

1. The initial step in optimization projects is to determine the objective of the study. In this step, the client and experts define the system to be studied, including processes, products, and decision points that they wish to optimize or improve. The objective of the study and the magnitude of the study area must be clarified during this phase. Precisely defining the objective of the study helps in designing the project efficiently and structuring it appropriately.
2. In the second step, management the client, with the help of the expert, enter into a service agreement that specifies the tasks to be performed, expectations, and the mode of remuneration for the service. This step ensures the availability of resources and budget necessary for the project and officially records the expectations during service delivery. Contracting helps to ensure the effective implementation of the project and to solve problems that may arise during implementation.
3. During the process of familiarizing with the system under study, the expert, with the client's involvement, reviews and understands the logistics processes under study. The aim is for the expert to understand the system's operation, structure, material flow paths, as well as possible constraints and problems. Thorough understanding is essential for the development of later analyses and recommendations.
4. In the fourth step material flow diagram is creating. Within the defined system, fixed installations for material flow must be determined, as well as the connections between them, for each type of product.
5. Material flow processes are captured in this step. The material flow processes for each product type are recorded by the experts on a web-based interface, based on the material flow diagrams.
6. The delimitation of the examined packaging system is carried out in this step. Based on the data received from the client and/or information providers, experts enter the data of the examined packaging systems into the web-based data input interface, such as measured data, self-weight, load capacity, specific amortization cost projected on the transportation relation.
7. When determining the data of the packaging systems that can be applied at the material flow nodes, two types are distinguished. In one type, the packaging system remains constant for the passing product types, while in the other type, there is room for decision making. Experts work with the client to determine the testing options, and then they specify the types of packaging systems that can be applied to the product types passing through the respective nodes, as well as their loading quantity, loading time, specific logistics cost, and quality attribute data through the web-based interface.

8. When modeling material flow processes, it is important to specify the possible transport relations between the individual nodes. During this, professionals enter the data in the web application, which helps to make the material flow models more accurate. Data related to relations include, for example, transportation duration and quantity.
9. Parameters required for the operation of given technological equipment are specified. This includes the capacity and efficiency of the equipment etc. If modeling the equipment is extremely specific, further coordination may be required for the description or modeling of its operation. This data is important in the scheduling process as it helps to determine which equipment should be used and when.
10. The input data on material handling activities is carried out in this step, where we record the time factors and distances of material handling between individual workstations. This helps accurately determine the duration required for material handling and the route to execute material handling tasks. The accurate and proper recording of data on material handling activities contributes to making the production process more efficient and effective.
11. The scheduling task is the planning of the production process in terms of time, determining when and in what quantities of each product type will be launched at different nodes. The scheduling task considers available resources, such as machines, human labor, and raw materials, and aims to optimize duration and capacity. Proper execution of the scheduling task plays an important role in increasing production efficiency, reducing waiting time, and meeting deadlines.
12. In this step, the decision criteria influencing the selection of the packaging system are analyzed. Lead time measurement refers to the duration between objects within the system. The determination of the total cost of ownership is important in the selection of the packaging system, and the average usability and the quality of the packaging system are also important. The evaluation of packaging quality considers various aspects, such as packaging clarity, readability of shipping marks, proper packaging closure, and drop testing.
13. During the examination, not only the best packaging system combination needs to be determined based on the optimal objective function but also the conditions that the selected combination must meet. These can be, for example, lead time, cost, utility, or quality. These conditions are jointly determined by the client and the expert, and the expert then records the data. The goal is to select only those alternatives that meet these criteria.
14. The point of this step is to consult with the client on the criteria they would like to use to optimize the packaging system. Then the objective function is generated, the weighted amount of which is calculated for each packaging system combination. The objective function aims to minimize lead time and cost, moreover, to maximize usability and requirements.
15. The simulation model is automatically generated based on the data recorded by the experts. The simulation model runs based on the data uploaded to the web application. When creating the simulation model, it is important that the data is reliable and accurate. Automatic generation helps to save time during the simulation model building process and reduces the possibility of human error. The web application allows to upload data easily and quickly and run the simulation model easily, so you can get results quickly. Creating and running the model helps decision makers understand how the system works and makes predictions about possible outcomes.
16. Testing and validation of the simulation model are important steps in the development process. During testing, data, programming errors, and other conceptual errors are checked and eliminated by experts. The validation process involves comparing the model with reality for existing systems and verifying data and processes for future systems. Testing and validation of the simulation model ensure that the model accurately reflects the real world and provides reliable and valuable results for real-life situations.
17. A tested and validated simulation model can be used to predict which packaging system will be the most suitable for a given product. The model calculates the value of the objective function for each possible packaging combination, allowing the best option to be selected. Depending on the number of products, packaging systems and decision points under consideration, the number of variations being examined can significantly vary. It allows to increase the efficiency of the packaging process and reduce the costs of packaging.

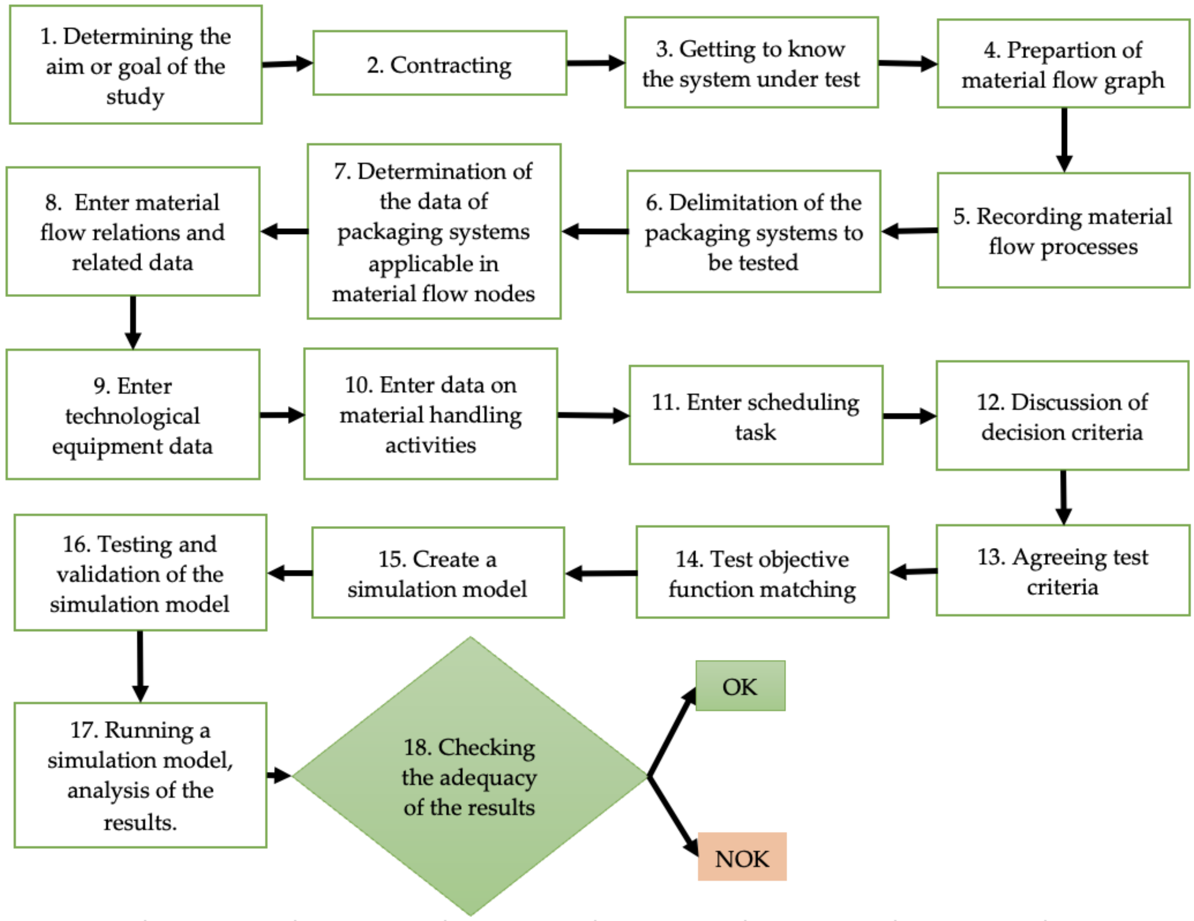

Figure 2: Steps for using the system (own edit)

18. During the examination of a given process or project, it is important to verify the accuracy of the results. If the results of the examination are feasible for the company, then the examination is successfully completed, and based on the results, further steps are taken towards implementation. If the results are inadequate or unfeasible, then it may be necessary to modify the examination model and conduct further examinations. The goal of the verification process is to ensure that the implementation process encounters as few errors and problems and that the projects produce the best possible results.

The method described allows the choice of packaging system to be made considering the interests of the company and the decision criteria. During the optimization process, it is also possible to integrate the processes they manage and to study the impact of different packaging options. However, the literature shows that such a complex system has not been developed in the field yet.

5. Summary

Based on the literature analysis, it was concluded that there is currently no framework that effectively defines the optimal packaging scheme for a given system as a service. However, given the increasing number of packaging systems and the growing complexity of logistics systems, the development of a science-based assessment framework could provide a significant competitive advantage for companies.

The paper presented the basic concept of a self-developed framework, which includes the actors, the applied tools, and the databases. In addition, as 18-step process defined to manage the selection of the appropriate packaging system.

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AMR: influencing factors and potentials of cloud-robotics

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Abstract

In recent decades, automated guided vehicles (AGV) have become the symbol of automated material flows in intralogistics. Technological progress helps AGVs to achieve an ever-higher degree of autonomy, enables free navigation and has led to AGVs nowadays increasingly being called autonomous mobile robots (AMR). This constant technological progress requires that the field and use of AMR be constantly reviewed and improvements sought. One potential approach, especially to make AMR fleets more efficient, flexible and scalable for future deployment, is cloud-robotics, whose main advantage is the on-demand provisioning of various IT-services. The aim of this paper is to determine the currently critical influencing factors regarding efficient AMR deployment and to highlight possible combinations of AMRs with a cloud. The influencing factors are determined by means of a systematic literature review (SLR) and completed and verified by means of an application-oriented reference process. The result is an overview of the currently critical influencing factors, prevailing deployment barriers and future potentials of AMRs.

1. Introduction

Since the decade of the 2010s at the latest, the terms automation, digitalization and networking, which are very often cited in connection with the generic term "Industry 4.0", have been the dominant trends of manufacturing companies. As a result, the field of logistics is also undergoing these developments [1]. In recent decades, AGVs have become a symbol of automated material flows in intralogistics. The exponentially increasing sales figures and the further predicted market growth of AGVs, show the still existing relevance of these technical solutions [2]. Technical developments such as laser-based free navigation or camera-based object detection have led to AGVs increasingly being referred to as AMR.
At the same time, the advancing automation of productions results in higher demands on the IT-system landscape [3]. Increasing process complexity (e.g. process time, container variance, etc.), increased transport volumes, and the desire for on-demand and rapidly adaptable material flow, require the exchange of a variety of data between network participants [4]. To cope with increased computational demands and the processing of larger data volumes, cloud-computing is finding more frequent application [5]. This involves powerful, flexible hardware and software infrastructures that a user can access on demand [6].
In sum, taking into account challenges such as process complexity, safety-related aspects and the influence of external environmental factors is a limiting, cost-relevant factor for AGV/AMR automation [7]. The networked exploitation of "Industry 4.0" potentials, which is given e.g. in the connection of an AGV with a cloud, represents an alternative course of action to counter these challenges and to secure the competitiveness of the manufacturing sector in a high-wage location as Germany [8,9].
There are already some SLR on the research area of AGV/AMR, which investigate higher-level aspects as well as detailed aspects such as navigation algorithms [10,11].
However, the described developments of industrial companies, the industry and the technology place the demand on a constantly updated view of the research area. In addition, the combination of the fields of AGV/AMR and cloud creates a new way of operating that needs to be investigated. In a first

step, current influencing factors of AGVs/AMRs are identified by using SLR. The determination of the influencing factors of AGVs/AMRs serves to identify current, central challenges and implementation barriers of these technical solutions. Finally, in a second step, potential fields and opportunities are uncovered that arise from the combined use of cloud-computing and AGV/AMR. In summary, the goal of this paper leads to the following question:

What are the factors that influence the use of AGV/AMR and how AGV/AMR be combined with cloud-technology?

2. Influence factor analysis with SLR

Oriented to the title of this paper and its objective, the following sections highlight the key features of the state-of-the-art in science and technology on AGVs/AMRs. The identification of influencing factors for AGV/AMR is derived here from the identified state-of-the-art, from an SLR and from an application-oriented reference process of AGV/AMR implementation and its operation. The potentials arising from the combination of AGVs/AMRs with a cloud are determined by mapping the opportunities and risks of cloud-technology in general and the AGV/AMR application.

2.1. AGV / AMR - Components

In order to identify key influencing factors and possible barriers to the introduction of AGV/AMR in the field of intralogistics, it is necessary to briefly describe the basic structure of the technology. According to “VDI Guideline 2510”, an AGV consists of a vehicle, a guidance control, devices for location determination and position detection, devices for data transmission, as well as infrastructure elements and peripheral devices [12]. In an automated guided vehicle system (AGVS), one or more AGVs act as the actual means of transport. The master control system acts as a superordinate and determines the complete system required to process a transport order. The vehicle control of the AGV is subordinate to the master control. Other components of the AGV are the navigation technologies, which are responsible for localization and route planning. Navigation here ranges from rigid methods, such as optical or inductive guidance, to free navigation methods, of which laser navigation is the main representative. This type of navigation is characterized especially by a high flexibility of layout changes of the driving course and enables the fast programming (teach-in) of routes. Data transmission usually takes place via local, Ethernet-based networks. By means of data transmission, communication between AGVS, AGV and master control and ultimately also interaction between AGV and the environment (e.g. humans) is ensured. Finally, infrastructure elements and peripheral equipment such as charging stations, position markers for better localization and navigation, or even terminals with user interfaces that form a human-machine interface complete the components of the AGVS [13].
The constant further development of technology, especially in the field of navigation and object recognition, have led to AGVs being able to be used increasingly in unstructured environments. This (partial) autonomy of the systems finally led to the devices also being referred to as AMR [14]. Since AMRs and AGVs are primarily used for transport processes from the user's perspective, both terms are used as synonyms in this paper.

2.2. Application of a SLR for AGV/AMR

The objective of the SLR is to identify the key influencing factors involved in the use of AGV/AMR. The SLR was conducted using Elsevier's Scopus database, which claims to be the leading database for peer-reviewed scientific papers. The search here is divided into three steps:

1. Search title, abstract and keywords
2. Plausibility check result with existing SLRs
3. Screening and categorization into "relevant papers" and "non-relevant papers".

First, the database was searched in the Title, Abstract and Keywords section with various logical links of keywords derived from the research question. The keywords are "automated guided vehicle", "autonomous mobile robot", "intralogistics", "influencing factors" and "barriers". In the first search, representing the intersection of "automated guided vehicle" OR "autonomous mobile robot" in combination with an AND-operation with the relevant application area, "intralogistics", 344 documents have been found. In a further selection step, namely the addition of the keywords "influencing factors" and "barriers", the number of relevant documents was finally reduced to 53.
The second step of the SLR is characterized by a plausibility check consisting of a mapping of already existing SLRs on the topic of AGV/AMR and the result of the Scopus search. If existing SLRs contain relevant papers that were not found by the described database search, this literature is added in this step.
Finally, in the third and last step, all papers are screened and classified into the categories "relevant" and "not relevant". The focus of this screening is on checking the abstract and the content of the paper. For the classification of the literature into "relevant" and "not relevant", the

level of consideration of this paper is the decisive criteria. This research paper is a preliminary study that examines the use of AGVs/AMRs at an aggregate, holistic level. Scientific papers that contain the keywords or are already listed in other SLRs but consider certain elements and functions of AGVs/AMRs (e.g. navigation algorithms) at too fine a level of detail are classified as "not relevant." Figure 1 illustrates the selection process of this SLR.

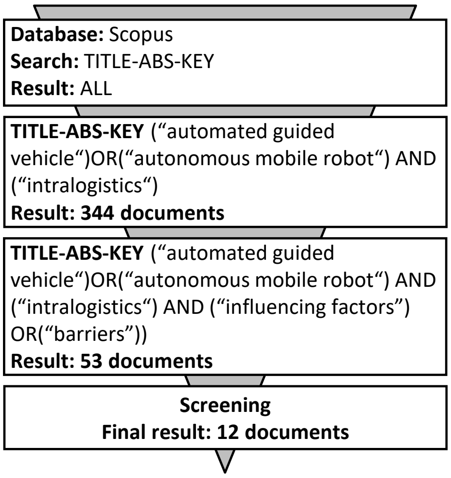

Figure 1: Selection process

2.3. Delimitation of a reference process

From the perspective of application-oriented research, it makes sense to define a reference process that serves to consider factors from practical projects in addition to literature-based factors influencing AGVs/AMRs. The reference process consists of the basic phases of the life cycle of an AGV/AMR or an AGV/AMR-project and ranges from the planning phase, through the implementation and commissioning phase, to the operation of an AGV/AMR.

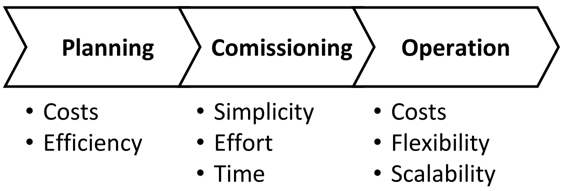

Figure 2: Illustration of reference process

From the different planning and lifecycle phases of AGV/AMR, practice-relevant influencing factors such as costs in the respective lifecycle phases, implementation effort or adaptability to new environmental conditions can be collected.

2.4. Influencing factors cloud

In recent years, there has been a noticeable trend towards shifting corporate activities to a digital space. At the same time, this development places higher demands on the performance of information technology and systems and requires high computing power as well as large storage capacities. One idea for resolving this conflict is flexible and scalable hardware and software infrastructures. Cloud-computing, to which this advantage in particular is attributed in comparison to other infrastructures (e.g. client-server model), appears to be a promising concept in the context of “Industry 4.0”, which focuses on flexible and demand-oriented resource utilization [15].
To describe the concept, the definition of the U.S. Institute of Standards and Technology (NIST) is increasingly being used, which sees cloud-computing as a model that enables one or more users to access a pool of resources via a network. Characteristic features are the demand-oriented use of resources and the user's expectation of constant availability. The word "cloud" and the associated metaphor indicate that the services provided are available via the internet or intranet [15,16].The term "cloud-robotics" was first used in 2010 and now refers to robotic or automation systems that use cloud-infrastructure to compute or provide data [17,18].
In general, cloud-approaches and the underlying IT-infrastructure are assigned the following strengths [15]:

2.4.1. Costs

- Low investment in IT-infrastructure
- Low maintenance costs

2.4.2. Operational

- Flexibility
- Scalability
- Fast realization of projects
- Availability regardless of location

2.4.3. Strategic

- Development of new business areas ("X-as-a-Service")
- Access to technologies also for SMEs
- On the other hand, there are risks that arise from the implementation of projects with a cloud:
- Central accumulation of data provides attack surface
- Single point of failure
- Lack of standards
- Data protection and data security

In the second part of the objectives and questions of this paper, the focus is on the possible combinations of the sub-areas “AGV/AMR” and “Cloud”. For this purpose, it is fundamentally necessary to make the strengths and weaknesses of both sub-areas transparent in order to derive suitable combination options in a next step.

Table 4: Overview about AGV/AMR influencing factors and potentials of cloud-robotics

Part	Category	Subcategory	Nr	Factor	Source	Literature
A	**Reason for AGV/AMR introduction**		1	Cost savings	SLR	[7,11]
			2	Skills shortage	SLR	[7]
			3	Quality	SLR	[7]
			4	Industrial safety	SLR	[7,13]
			5	Process stability	SLR	[7]
			6	Efficiency (productivity)	SLR	[19]
	AGV/AMR operations	**Project / overall system**	7	Simplicity of implementation	Reference process	[11,20]
			8	Scalability	SLR	[19]
			9	Robustness	SLR	[11,19]
			10	Flexibility	SLR	[11,19,21]
			11	(Project-)Planning	Reference process	[20]
			12	(Project-)Commissioning / Realization	Reference process	[20]
		Function / process	13	Navigation	SLR	[13,22–24]
			14	Route planning	SLR	[22,25]
			15	Localization	SLR	[19,22,24]
			16	Object detection	SLR	[22]
			17	Route optimization	SLR	[24]
			18	Order management	SLR	[13]
			19	Fleet management	SLR	[19]
			20	Traffic control / deadlock prevention	SLR	[10]
			21	Guidance control system	SLR	[13]
			22	Vehicle control	SLR	[13]
		Hardware	23	Battery - runtime	SLR	[10]
			24	Computing power (onboard)	SLR	[11]
			25	Sensors	SLR	[13,24]
			26	Mechanics	SLR	[13,24]
		Software	27	Artificial intelligence (e.g. machine learning)	SLR	[11,26,27]
			28	SLAM	SLR	[11]
			29	Sensor fusion	SLR	[22]
		Autonomy	30	Dynamic modeling of environment	SLR, reference process	[28]
			31	Driving on released areas	SLR, reference process	[28]
			32	Driving around obstacles	SLR, reference process	[28]
			33	Acting on object recognition and classification	SLR, reference process	[28]
			34	Dynamic route planning in mixed operation	SLR, reference process	[28]
			35	Detect and respond to vehicle condition data	SLR, reference process	[28]
			36	Guidance control functions in the vehicles	SLR, reference process	[28]
		Radio technology	37	Latency	SLR	[10,29]
			38	Reliability	SLR	[10,29]
			39	WLAN	SLR	[13]
			40	LTE, 4G, 5G	SLR	[10,13,29]
		Costs	41	Purchase price	Reference process	[30]
			42	Planning / commissioning costs	Reference process	[30]
			43	Operating costs - energy costs	Reference process	[20]
			44	Operating costs - Maintenance costs	Reference process	[20]
			45	Operating costs - repair costs (spare parts)	Reference process	[20]
			46	Costs computer hardware	Reference process	[29]
	AGV/AMR barriers		47	Flexibility	SLR	[11,21,31]
			48	Cycle time	SLR	[11,21]
			49	Speed due to safety	SLR	[20]
			50	Mixed operation	SLR	[13]
			51	Load pickup / load transfer	SLR	[13]
			52	Availability	SLR	[32]
			53	Variant variety container	SLR	[30]
			54	Costs	SLR	[31]
			55	Application area outdoor	SLR	[7,31]
			56	Manufacturer-independent control system	SLR	[33]
			57	lack of know-how, knowledge, competence	SLR	[31]
			58	Lack of guidelines, regulation, standardization	SLR	[31]
Part	**Category**		**Nr**	**Factor**	**Source**	**Literature**
B	**Cloud**		59	Efficiency increase	SLR	[29]
			60	Main application	SLR	[29]
			61	Outsourcing options	SLR	[10]
			62	Target architecture	SLR	[11]
			63	Single Point of Failure	SLR	[10]
			64	Incentives / Advantages	SLR	[29]
			65	Obstacles / Disadvantages	SLR	[29]

3. Framework of influencing factors

Derived from the question "*What are the factors that influence the use of AGV/AMR and how AGV/AMR be combined with cloud-technology?",* the results of identifying the factors influencing AGVs/AMRs and combining them with a cloud-technology are divided into two Parts. Part A summarizes the results of the SLR, and the investigation of the reference process for AGV/AMR. Part B focuses on possible combinations of AGVs/AMRs and cloud. Table 1 represents an overview about all identified influencing factors.

3.1. Influencing factors – AGV/AMR

Answering the sub-question "What factors influence the use of AGV/AMR?" is the focus of Part A. The influencing factors were mainly determined by an SLR and supplemented by taking the view of an application-oriented reference process. To provide a better overview of the influencing factors, the factors are further divided into main categories and subcategories. The main categories here are reasons for AGV/AMR introduction, AGV/AMR operations and AGV/AMR barriers. Since the sub-question primarily focuses on the use of AGV/AMR, the main category AGV/AMR operations is so extensive that sub-categories are necessary.

3.1.1. Influencing factors - reasons for AGV/AMR introduction

The influencing factors in the main category of reasons for AGV/AMR introduction summarize the main motives of users to introduce AGVs/AMRs. The corresponding motives are essential and form the starting point for advantageous and requirement-oriented combination options of AMRs with a cloud.

3.1.2. Influencing factors – AGV/AMR operations

The multitude of influencing factors related to the operation of AGVs/AMRs makes it necessary to specify the main category in a second level with subcategories. The subcategories are:

- Project / overall system
- Function / Process
- Hardware
- Software
- Autonomy
- Radio technology
- Costs

The subcategory Project / overall System comprises influencing factors that can either be transferred for a complete AGV/AMR project, e.g. (project-)planning, or describe characteristics of the overall system, such as robustness. The category Function/process, on the other hand, includes influencing factors that relate to AGV/AMR-internal running functions, such as navigation or localization. The Hardware and Software categories contain components and trends from the respective fields. The influencing factors and requirements that are discussed in the course of an intensifying autonomization of AMR/AGV are listed in the main category Autonomy. The main category Costs details the general block of costs incurred into different cost types. In order to connect the AGV/AMR area to a cloud, a radio link must be formed. Finally, these influencing factors form the subcategory radio technology.

3.1.3. Influencing factors - barriers

The category of barriers is aimed at influencing factors which are cited in the literature as preventing the use of AGVs/AMRs. The knowledge of currently existing barriers and automation hurdles is a necessary condition for a successful combination of AGVs/AMRs with a cloud, since in the best case the combined approach invalidates precisely these disadvantages.

4. Influencing factors - Cloud

Part B of the identified influencing factors deals with the second part of the question, namely *how AGV/AMR be combined with cloud-technology?"*. In addition to advantages and disadvantages of the combination, the points of increased efficiency, outsourcing options, main application, target architecture and the single point of failure are explicitly mentioned.

In the area of outsourcing options, the focus is on processes, services and workflows that are currently performed locally on an AGV/AMR. For example, it is imaginable to outsource computing operations to the cloud. The outsourcing of computing power can have two effects. Firstly, it can extend the battery runtime by outsourcing computationally intensive steps [29]. Although most AGV/AMR are electric anyway, this aspect can be an opportunity to further improve the sustainable operation of AGV/AMR. Secondly, it is possible to install less powerful computing units in the AGVs/AMRs, on the one hand to achieve cost effects via an AGV/AMR-fleet and on the other hand to possibly achieve faster computing time and thus ultimately process time in a very powerful and high-performance cloud environment. Finally, complete services can be realized via a cloud ("Function-as-a-Service").

A cloud also offers the possibility of setting up an AGV/AMR manufacturer-independent, higher-level control system. In this way, services such as a global map or order management, which are classically located in the manufacturer's own control system, can be provided for a heterogeneous AGV/AMR-fleet. Setting up a cloud as the global coordinator of an AGV/AMR fleet also makes it possible to equip the infrastructure with sensor technology and to connect it as a source of information. For example, process-critical areas such as crossings can be monitored with sensor technology and bring about better traffic control of AGVs/AMRs. In sum, all peripherals such as traffic lights and gates can be integrated in a comprehensive and meaningful way via a cloud platform.

On the other hand, the provision of services and the enrichment of a cloud platform with functions involves the risk of a single point of failure (cloud failure leads to AGV/AMR-system failure) and protection against external attack. The task here is to develop an overall concept that takes all influencing factors into account and ensures productive use.

Another issue raised by the establishment of combined operation of AGVs/AMRs with a cloud is the question of the control and target architecture. It must be evaluated in which way and at which point of the concept a centralized, decentralized or hybrid architecture is advantageous.

In sum, however, the combination of AGVs/AMRs and a cloud provides an opportunity to make AGV/AMR deployment more efficient.

5. Results

Table 4 represents the overall result of the SLR, serves as orientation and shows a complete enumeration of all relevant influencing factors as well as their origin. The influencing factors are well suited for a subsequent expert survey, e.g. in the form of a Delphi-survey, which can then provide an evaluation and a statement on the significance and importance of individual influencing factors.

Due to the good further differentiation possibility of the influencing factors into different characteristics, Part A shows a high suitability for closed questions of possible linking surveys, while Part B forms the basis for open questions.

6. Conclusion

This paper includes the identification of key influencing factors of AGVs/AMRs and their application in the form of a cloud-robotics approach based on the question "*What are the factors that influence the use of AGV/AMR and how AGV/AMR be combined with cloud-technology?".*

The determination of the influencing factors is carried out by means of SLR and taking the perspective of a reference process, which is to ensure in particular the aspect of an application-oriented research. The complete result of the research is summarized in Table 4.

The mere listing and compilation of the central influencing factors gives users an overview of the potential pain points in the operation of AGVs/AMRs and how they can combine these with the advantages of a cloud. In addition, the identification of the influencing factors lays a foundation for further research. Based on the table, a questionnaire can be developed that can be answered, for example, in the form of a Delphi-survey. By conducting a Delphi-survey, the user then receives, in addition to the transparency and listing of the factors, an exact evaluation and ranking of the factors for an efficient and successful AGV/AMR-deployment. In order to obtain creative and realistic possible combinations of AGVs/AMRs with a cloud-technology, the factors from Part B should be addressed in questions that are as open as possible. From the Delphi-survey, research will get more precise clues about how AGVs/AMRs can be operated more efficiently with the help of a cloud.

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Predicting processing times in high mix low volume job shops

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Abstract
Production planning is essential for any manufacturing company, especially when complex and varied processes must be considered. Accurate processing times play a critical role for scheduling production runs and allocating resources effectively. In practice, the respective master data from the ERP system is often used for this purpose. However, maintaining the master data is challenging, especially with large amounts of data in flexible environments. In this context, incorrect or outdated data quickly lead to significant planning inaccuracies. This paper presents a study that uses machine learning (ML) models to accurately predict the processing times of single operations of future production runs based on historical production runs. Various ML algorithms were trained and evaluated on a real-world dataset. In comparison to the master data the root mean squared error could be reduced by 23% using ML. Thus, these estimated times can be used for optimizing future schedules and incorporating such an ML model in the production planning process eliminates the need for master data.

1. Introduction
This section provides a brief overview of the motivation behind this study, summarizes the key findings and limitations of related research in the field and points out the contribution of the proposed work.

1.1. Motivation
Production planning is essential for any manufacturing company, especially when complex and varied processes must be considered [1]. Accurate processing times are crucial to effectively schedule production runs and allocate resources [2]. However, processing times can vary significantly in reality, which makes achieving optimal schedules difficult. Currently, simple estimates, such as the average time, are commonly used, but they can be imprecise and result in inefficient and suboptimal schedules, particularly for high mix low volume manufacturers with many products, resources and flexible processes [2,3]. Addressing the problem of varying processing times has been a subject of extensive research, with two approaches emerging: using simple probability distributions to describe the variation of processing times or using ML to predict the actual processing times [1]. In recent years, ML has become increasingly important in various fields, with rapid developments in algorithms and model architectures, decreasing costs of sensors and computing hardware, and an explosion in data volume fueling interest in ML applications in production [4]. ML enables computer programs to perform complex tasks, such as prediction, diagnosis, planning, and recognition, by learning from historical data [3].

1.2. Related Work
A considerable amount of literature has been published on production optimization. A great deal of research focuses either on developing effective scheduling algorithms or on the estimation of time-related KPIs in the production environment. The former presupposes given operation times without questioning their validity, such as [5–7]. However, valid processing times are needed for robust results of the optimization procedures. The latter focuses on estimating the cycle time instead of the duration of individual operations [3], such as [8–11]. There is a relatively small body of literature that is concerned with the prediction of processing times. Sobaszek et al. [12] provide a statistical approach to estimate the distribution of the processing times based on historical data. Both Mucientes et al. [13] and Ringsquandl et al. [2] utilized regression models to predict the actual processing times. A key shortcoming of these

studies is their reliance on expert knowledge. Since expert knowledge can be scarce and lacks scalability, there is a need for scalable and automated approaches to predict processing times in a production field. It should be noted that the data used in [2] was generated from simulation and thus, needs further validation with real-world data. Yamashiro and Nonaka [1] tested several ML models on a real-world dataset. Product ID, number of products, materials and material parameters were used as input features for the utilized ML models. They also suggest analyzing the importance of the input features for more scalability and generalizability.

1.3. Contribution

This paper presents a study that assesses several ML models, classic linear and non-linear ones, to accurately predict the processing times of single operations of future production runs based on historical production runs. As shown in Figure 1, the processing times in our dataset do not have a symmetrical distribution.

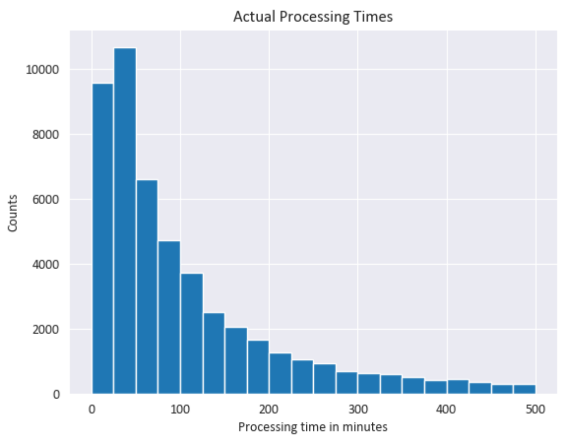

Figure 1: Histogram of all actual processing times of the real-world dataset

Since linear models such as LR require a normally distributed target variable [14], we opted to predict the deviation of the actual duration of an

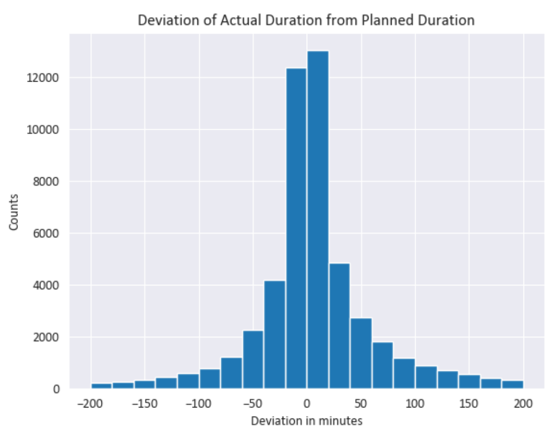

Figure 2: Histogram of all deviations of the actual duration from the planned duration

operation and the planned duration. The distribution of the deviation is approximately normal, as shown in Figure 2.

The task of predicting the deviation is treated as a regression problem. Based on several input features, which contain different information of a scheduled operation, the deviation is estimated as a continuous target variable.

Moreover, the trained ML models were utilized to determine features, that highly influence the deviation. The insights gained from the feature analysis for practitioners were also evaluated.

This article is organized as follows: In Section 2, the data preprocessing, the utilized ML algorithms and the results of the hyperparameter tuning are described. The results of the regression models, the influence of individual features, as well as strength and weaknesses of the model are analyzed in Section 3. Finally, in Section 4 the results are summarized, and potential future work is discussed.

2. Methods or experimental part

In this section, the dataset, the utilized ML models and the employed experimental design are described.

2.1. Dataset

The dataset to train and evaluate the ML models is provided by one of our industrial research partners. It is a medium-sized supplier company in the mechanical engineering sector, characterized by discontinuous high mix low volume production. The dataset consists of booking data from historical work processes from the flexible shop floor with machine tools, assembly stations, various qualified employees, external workbenches, and complex bill of materials. It contains about 52,000 operations from the last seven years and includes the following features: Actual start and end time, planned processing time, product, quantity, machine, assigned employee and job due date. Personal data has been anonymized so that no conclusions can be drawn about specific employees.

2.2. Data pre-processing and feature engineering

To ensure the quality of the data, we systematically cleaned it, removing errors and outliers. Due to the great variety of products, we used k-Means clustering to group the products based on weight, number of subparts, frequency of production and value. The results of the clustering were verified with a domain expert of the company. To improve the accuracy of the prediction, several features were engineered. The timestamps were used to create time-related categorical features such as day of week and month as additional input features and the deviation of processing time, as target feature. In addition, features to describe operation predecessors, employee utilization and machine breakdowns were modeled. The data was then standardized, and a univariate feature selection was performed to select the best 20 features. A more detailed analysis of the most influential features and their impact on the production planning processes can be found in Section 3.2.

2.3. Machine Learning

Several ML algorithms, specifically linear regression (LR), support vector regression (SVR), decision tree (DT) regressor, random forest (RF) regressor and multi-layer perceptron (MLP), were employed using scikit-learn [15] to predict the deviation of the processing time of an operation. To evaluate the performance of these models, we split the dataset into a training and a test set. For each algorithm, except for linear regression, which has no hyperparameters, hyperparameter tuning was performed on the training set using grid search with 5-fold cross-validation.

2.3.1. Linear Regression

Linear regression is a statistical regression method. Let us assume that Y denotes the target variable and x1, …, xn are the input variables. The objective is to find the parameters β0, …, βn for a prediction Y' with

$$Y' = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n \quad (1)$$

so that the sum of squared errors of prediction and target variable is minimized [16]. Since this algorithm has no hyperparameters, no hyperparameter tuning was performed.

2.3.2. Support Vector Regression

SVM is a ML algorithm initially developed for classification problems. The objective is to find the hyperplane that separates two classes of data points with the maximal margin. The width of the margin is determined by the smallest distance to one of the data points. SVMs can also be adapted for regression problems. The idea of margin is still present, but instead of classifying data points into two separate classes, the data points are now supposed within a margin around the regression line. Slack variables are associated with outliers that lie outside the margin, and the algorithm tries to minimize the sum of these slack variables. The support vectors, namely margin vectors and outlier vectors, determine the regression curve [17]. During the hyperparameter tuning, two essential hyperparameters were examined: the kernel function and the regularization parameter C. The kernel defines a mapping of the input data to a higher-dimensional space, which enables non-linear regression [17]. The regularization parameter controls the weights of the slack variables.

Table 1: Hyperparameter Tuning SVR. The best parameter value is marked

	Assessed parameter values
Kernel	Linear, **Polynomial**, Radial basis function, Sigmoid
C	**0.1**, 1, 10

2.3.3. Decision Tree Regressor

DTs are a commonly used ML algorithm for complex relationships between input variables and output variables. The algorithm works by constructing a tree-like model, where at each internal node in the tree a binary test is applied to one of the input variables to split the samples into smaller subsets [18]. Each split aims to minimize the residual sum of squares between the average value and actual values of the target variable of all data points belonging to the corresponding subset [17]. This process is repeated until a termination criterion is met. All data points are summarized in a leaf node, where the actual prediction is made. The predicted value is typically the average target value of all data points belonging to that leaf [18]. Since overfitting is quite common [17], we tested several stopping criteria: the maximal depth of the tree, the minimum number of samples required in the child node after splitting and the minimum number of samples required for a leave.

Table 2: Hyperparameter Tuning Decision Tree Regressor. The best parameter value is marked

	Assessed parameter values
Maximal depth	4, **6**, 8, 10, 12, 14, 16, 18, 20
Minimum samples split	10, 20, **30**
Minimum samples leave	**5**, 10, 15

2.3.4. Random Forest Regressor

A RF is an ensemble learning technique that consists of several DTs. Each tree is trained separately, and each node is split using a randomly selected subset of features. The final prediction is the average prediction of all trees [17]. In general, this technique is more robust to noisy data than a single DT [19].
The hyperparameter tuning covers the same hyperparameters as the hyperparameter tuning for the decision tree regressor and additionally includes the number of decision trees used for the ensemble learner.

Table 3: Hyperparameter Tuning Random Forest Regressor. The best parameter value is marked

	Assessed parameter values
Maximal depth	4, 6, 8, 10, 12, 14, 16, **18**, 20
Minimum samples split	10, **20**, 30
Minimum samples leave	**5**, 10, 15
Number of estimators	100, **1000**

2.3.5. Multi-Layer Perceptron

MLPs also known as neural networks, consists of several neurons, which are arranged in layers. The inputs of the MLP are weighted and propagated to the first layer of neurons, where each neuron passes the weighted sum of inputs through an activation function, typically the ReLu function. The outputs are passed as inputs to the next layer [17]. In the last layer, the so-called output layer, all inputs are combined for the actual prediction. This structure enables learning complex non-linear relationships between input and output variables. During the hyperparameter tuning, different structures and sizes of the hidden layers were tested, along with different initial learning rates and learning rate changes.

Table 4: Hyperparameter Tuning MLP. The best parameter value is marked

	Assessed parameter values
Hidden layer size	(300,200,100), (200,100,50), (50,50,50), **(100,100,100)**, (50,50), (100,100), (200,200), (200,100,50)
Initial learning rate	**0.0001**, 0.001, 0.01
Learning rate	**Constant**, adaptive, invscaling

3. Results and Discussion

The performance of the ML models and their applicability for the regression task and the importance of the input features are analyzed in this section. Additionally, the tree-based models are examined in more detail.

3.1. Regression analysis

All models were evaluated on a separate test dataset using the rooted mean squared error (RMSE) as evaluation metric. RMSE is a commonly used metric for evaluating the predictive errors of regression models. A smaller RMSE value indicates a higher model performance. The planned durations from the ERP system's master data were used as benchmarks. RMSE values for the deviation of the master data and all ML models are shown in Figure 3.

Figure 3: RMSE for predicted and actual deviation on the test set

The results show that all models exhibit a similar performance, which is significantly better compared to the master data. It indicates a great potential for the general use of ML models to predict the deviation of the processing time. In practice, the choice of model seems to be a secondary concern. However, the Random Forest Regressor generated the most accurate predictions on our test dataset. In comparison to the master data, the root mean squared error (RMSE) could be decreased by 23 % using the predictions of the RF. Furthermore, the standard deviation of the error could be decreased by 22%. It implies, that the model is capable of providing a more precise representation of the data and a more accurate prediction of the deviation.

3.2. Feature analysis

Further analysis of the influence of the input features on the deviation was conducted. Since the RF showed the best results, this model was utilized for the analysis. Scikit's RF has an in-build feature called feature importance. Every time a feature is chosen in a splitting node, it reduces the impurity. The normalized total reduction is equal to the feature importance [15]. The table below shows the five most important features according to the RF's feature importance.

Table 5: Five most frequently chosen features chosen by RF

Feature	Feature importance
Planned duration	**0.747**
Weekly workload	0.105
Lot size	0.0702
Operation thirteen	0.0202
Machine twenty-five	0.0170

All the features, except weekly workload, have a negative correlation with the predicted deviation. This means, that high values of the features lead to larger negative deviations. The planned duration exhibits the strongest negative correlation with the deviation with a correlation coefficient of -0.836. Thus, it can be concluded that in this practical use case especially long processing times were overestimated in the planning stage. Interestingly, only the feature weekly workload shows a positive correlation with the predicted deviation. In this case, the weekly workload describes the amount of work in hours that is already scheduled for the employee that is executing this operation. The findings indicate the necessity of conducting a comprehensive examination by practitioners to explore the underlying causes of the observed correlation. One possible approach to mitigate the effect could involve the implementation of an equitable workload distribution strategy among employees.

3.3. Detailed model analysis

Tree-based models are a popular choice in ML due to their high level of transparency. Thus, the decisions of the DT model and the strength and weaknesses of the RF model are examined in more detail.

3.3.1. Decision analysis

The DT model, which demonstrated a comparable performance on the test set, is highly interpretable and transparent. The tree structure enables easy visualizations of the decision-making process, as the paths from the root node to the leaf nodes represent a sequence of decisions that lead to the final prediction. Figure 4 depicts such a graphical representation of the first three tiers of the DT model. The representation was automatically generated by utilizing the open-source graph visualization software graphviz [20]. The representation reaffirms the importance of the planned duration as a feature in predicting the deviation. In the first two tiers the DT splits the samples into groups purely based on their planned duration. The largest group, comprising 95.2% of all samples, also contains the samples with the lowest planned duration. The samples in the other groups have a higher planned duration, indicating operations with a higher lot size or more complex operations. Interestingly, in the third tier the DT not only uses the planned duration but also the binary feature Operation thirteen for splitting. As can be seen, the tree is very complex and cannot be fully examined in this paper. Nonetheless, it is evident that the tree serves as a critical launching point for domain experts' discussions.

3.3.2. Performance analysis

Returning to the RF, we conducted a thorough analysis of the strength and limitations of the incorporated model. On the one hand, it demonstrated an outstanding performance for operations with a moderate lot size and planned duration. A moderate planned duration might indicate a decreased probability of interruptions, which unpredictably influence the processing time. Moreover, a moderate Lot size of products suggests that the products are usually not unique

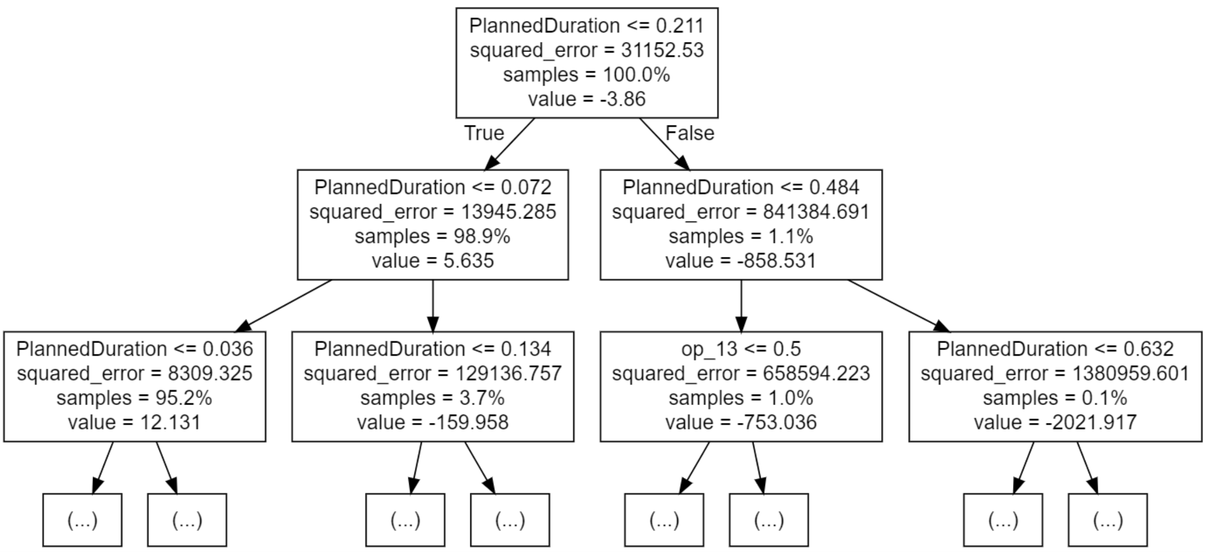

Figure 4: The first three tiers of the DT model, automatically generated using graphviz

items. As such, unique products are often characterized by their complexity and distinctive nature, making them difficult to compare with other known products.
On the other hand, the RF did not perform well in predicting outcomes for products belonging to cluster 20. This cluster is known for containing products that require significant amount of manual work and consists of multiple subparts. Thus, these products are exceptionally complex, and the model might need additional features to improve the accuracy of the predictions. We assume that this is a challenging problem, as even experts such as technicians, designers and production planners apparently struggle with estimating the time for complex custom parts. Nevertheless, we consider this to be an interesting and relevant research need for the future, as custom manufacturing and small lot sizes play an important role in the German industrial landscape [21].

4. Limitations and Conclusion

This study presents a novel approach for estimating processing times using ML. To the best of our knowledge, this is the first study in the field of processing time prediction that utilizes clustering to deal with the high variety of products. Thus, this approach is in practice particularly interesting for high mix low volume manufacturers. Additionally, this study is the only one so far that uses self-generated time-related features and information about machines and workers for the regression model in addition to product-related features. The results have shown that all models performed significantly better than the master data manually maintained in the ERP system. The RF performed slightly better than the other models, reducing the RMSE by 23% in comparison to the master data. Additionally, the standard deviation of the error could be reduced by 22%, which highlights the robustness of the proposed approach.
Since the regression model does not require expert knowledge, it enables a highly automated prediction process that can be used for optimizing future schedules online. Incorporating such an ML model in the production planning process leads to more efficient and effective use of resources and eliminates the extensive master data maintenance. Moreover, the additional feature analysis offers valuable insights for practitioners. Although these insights might not be directly transferable to other companies, the process is again completely automated and therefore transferable.
However, the study also highlights the importance of appropriate training data. The provided data is somewhat limited and noisy, underscoring the need for more comprehensive and reliable data in future studies to enhance the accuracy of the ML models [3]. Furthermore, with more available data, it would be possible to directly predict the processing time instead of the deviation. It would also be interesting to evaluate the influence on production schedules, that incorporate ML to predict the processing time.

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Collaborative framework in Cuban food supply chains

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Abstract

As a consequence of the COVID-19 pandemic, supply chains (SC) were interrupted, causing disruptions in the supply and demand of products. Food SCs in Cuba are also affected by high prices and limited integration among their activities. Specifically, the food SC of the basic food basket, which is the object of analysis of this paper. Moreover, the SC do not have a collaborative framework to manage the chain in the face of the impact of disruptions and make it more resilient. Therefore, the objectives of this research are: creating a collaborative framework that allows for integrated work in the SC of multiple companies. We also studied the papers that has been conducted in Cuba on this topic, their commonalities and limitations. The main contribution of this research is a methodology for the creation of a collaborative framework in the SC analyzed that enables integrated work and improves the resilience of the SC. To this end, the proposed methodology is subjected to the analysis of a group of experts using The Iadov technique. Subsequently, the overall satisfaction index is calculated, resulting in a level of 0.86%. With this work, it is possible to initiate the implementation of a collaborative framework for integrated work and increased resilience in the food SC analyzed. However, the effective application of this methodology requires the development of TIC platform and the training of its working personnel.

1. Introduction

Logistics plays a fundamental role in customer satisfaction. Within it, distribution management is considered one of the most important logistics functions and on which logistics costs depend to a large extent. Logistics service providers, seek alternatives to remain competitive in the market [1]. Transportation, with its decisive role, has experienced greater growth in recent years due to industrialization, technological advances, increased trade and human movements. It is shown by the fact that, in 2020, global expenditures on logistics reached nine trillion USD - about 11% of global PIB - according to the consulting firm Armstrong & Associates; third-party logistics, of which freight transportation is a large part, accounted for almost one billion USD [2].

As a result of the COVID-19 pandemic, all those companies that claimed to have a world-class distribution channel and logistics found themselves faced with a problem that put all their resilience systems to the test. Increased disruptions in global commodity production, mobility restriction and social distancing impacted labor, as well as freight and freight services, which were forced to reduce supply [3]. The war in Ukraine, more recently, has led to an imbalance between supply and demand, transportation instability and disruptions on major international routes, rising inflation and stagnant economies. The price of a barrel of oil on the world market rose from USD 77 to USD 115 from

February to May 2022. In Spain, for example, food prices have skyrocketed: sunflower oil, 75%; margarine, 35%; pasta, 31% [4]. The Food and Agriculture Organization of the United Nations (FAO) itself has stated that we are exposed to an imminent food crisis unless measures are taken quickly to keep global food supply chains active and mitigate the effects of the pandemic on the food system [5]. It has also recognized that the sharp slowdown in all the world's economies and particularly in the most vulnerable ones - such as Cuba's - will make it difficult for countries, especially those that depend on food imports, to have the necessary resources to buy food.
Cuba, in addition to dealing with all these consequences, lives a scenario aggravated by the intensification of the economic, commercial and financial blockade imposed by the United States, under restrictive measures that have tended to inflation and exchange rate differences, insufficient results of the development plans and a slow growth of the opening to foreign trade. In our country, not all the SCs show a satisfactory development; some of them suffer from certain problems. This is corroborated by studies related to the state of logistics in Cuban companies carried out by the Logistics and Production Management Laboratory of the Technological University of Havana since 1999, where the lack of integration and collaboration among the members of the chains is reflected as a weakness, with subcontracting of transportation services being a marked trend on the part of the companies in order to achieve the satisfaction of the final clients of the SC [6]. Authors such as [7] corroborate the need to design integrated logistics systems through analysis, characterizations and designs in Cuban organizations. Research in Holguin companies [8] have described that there are no references that many efforts have been made in the introduction of modern trends related to logistics systems, nor an integral conception of the subsystems that integrate it. In addition, aggravating factors are often detected that show that companies carry out their management independently, instead of working in an integrated manner to ensure the arrival of products in an efficient manner at the lowest possible cost [9].Marketing companies are not oblivious to this reality; on the contrary, they are subject to negative influences of all kinds. An example of this is the Wholesale Enterprise of Food Products and Other Consumer Goods (EMPA) of Villa Clara, which has among its main functions the distribution of the decent live family basket to the population. This supply chain is complex to analyze due to the large number of actors involved and the wide range of activities it encompasses. According to data presented by the Minister of Domestic Trade Betsy Díaz Velázquez, "the basic food basket today reaches more than 11 million registered consumers in Cuba and moves more than 100 000 tons of products monthly, which end up in 13 000 retail establishments that sell the basket (stores) and goes from ports to wholesale warehouses and then to the retail network" [10]. Currently, the EMPA has been presenting problems fundamentally linked to the issue of transportation, an activity that depends on the vehicles sent by the Santa Clara Cargo Base, subordinated to the provincial Transportation Company (TC). These have been analyzed since previous studies such as [11] and [12], who highlight its main irregularities. There is one main disruption that encompasses this problem: transportation problems due to the lack of collaboration between the actors in the chain; this is the focus of the research. Therefore, the general objective is to propose a procedure for collaborative management between the Wholesale Company of Food Products and Other Consumer Goods and the Transportation Company in Villa Clara. This document is structured in four sections. The next section describes the procedure and the tools to be used. The third section proposes the analysis of the tools used. Finally, conclusions, limitations and future research are proposed.

2. Proposed methodology

Collaborative SC is understood as two or more autonomous companies establishing relationships over the long term, working closely together and establishing common goals to plan, achieving more benefits than they could achieve if they acted independently [13].
From an operational and logistical point of view, there are three types of collaborative strategies, differentiated in terms of their structure: vertical collaboration, horizontal collaboration and lateral collaboration [14]. Collaborative practices between successive links in the same chain – supplier maker deliver - are called vertical collaboration (VC) and occur when two or more organizations such as manufacturer, distributor, transporter and retailer share their responsibilities, resources and performance information to serve in a relatively similar way the end customer [15]. Collaborative practices between firms at the same level in SC, i.e., between competing and non-competing logistics services providers, are generically referred to as horizontal collaboration (CH), and constitute a business arrangement between two or more firms at the same supply network level in order to further facilitate working and cooperating to achieve common goals [16]. Integrated logistics and intermodal transportation are examples of lateral integration application (combination of vertical and horizontal collaboration), which pursues the synchronization of carriers and

transportation users from multiple firms in an efficient and seamless freight transportation network [17].
According to [18] the functioning in recent years of the Cuban economy manifests a set of symptoms that reflect difficulties in the management of microeconomics, where the development of the structuring and integrated management of SC plays a fundamental role. Consequently, companies are making concerted efforts in achieving competitive advantages, through the implementation of the collaborative strategy along the logistics chain [9, 19].
Table 1 shows a comparison between some collaborative supply chain strategies that have been implemented in our country, highlighting which are those aspects where each one is most focused, and those that they have in common with the others. The aspects that do not have the cross (X) do not necessarily mean that they are not included in the procedures, but rather that they may be included because of other management techniques or tools beyond the procedure itself. Where:

- GOM: General Organizational Model [9]
- GGCPSC: General Guidance on the characterization of potential SC [18]
- VNRM: Value Networks Reference Model [6]
- MAPSC: Methodology for the analysis of production chains in Cuba[20].
- ISCMM: Integrated Supply Chain Management Model [21].

When we delve deeper into its contents, we see a weak deepening in the use of ICTs. Specifically, in the distribution processes, the use of information technology for route programming and combination of routes in external transport is not highlighted, nor is the use of quality tools. It is essential that collaborative management models in SCs include the use of software, systems and networks that optimize decision making and enable access to and exchange of information [22]. The use of technology-based management systems is an important part of the logistics cycle, to the extent that it allows finding a balance between costs and services [23]. These reasons support the need to propose new procedures for collaborative management between companies that take these requirements into account.
The proposed collaborative framework procedure for chain management aims to provide EMPA and the TC with the methodological tool (figure 1) that will enable them to manage their processes and activities in a way that will increase their effectiveness, efficiency and resilience. The phases and stages that compose it are explained as follows.

2.1. Definition of the object of study (Phase 1)

2.1.1. Strategic business and policy analysis of government agencies

The starting situation of the organizations must be known in order to trace the path towards the integration of their work systems and/or modify them in order to manage change. In order to analyze this information, a SWOT Matrix is proposed for each of the companies. This is the starting point for strategic planning and subsequent activities.

Table 1: Table comparing strategies for integrated supply chain management in Cuba

Aspects	**Strategies**				
	GOM	GGCPSC	VNRM	MAPSC	ISCMM
Strategic analysis of the environment		X		X	X
SC identification and characterization	X	X	X	X	X
SC mapping or design	X	X	X	X	X
SC diagnosis	X	X	X	X	X
Order management		X	X		
Capacity and inventory management		X	X		
Demand management		X	X		
Dynamic balance of the logistics system	X	X			
Coordination of process cycles and variables	X	X			X
Use and implementation of ICTs for process and activity management			X		
Evaluation of impact and/or performance indicators		X	X	X	
Definition of problems, risks and/or critical points	X	X		X	
Collaborative planning and training		X	X	X	X
Staff training and development.	X	X	X	X	X
Evaluation and implementation of improvement proposals	X	X		X	X
Follow-up and control of development projects		X			

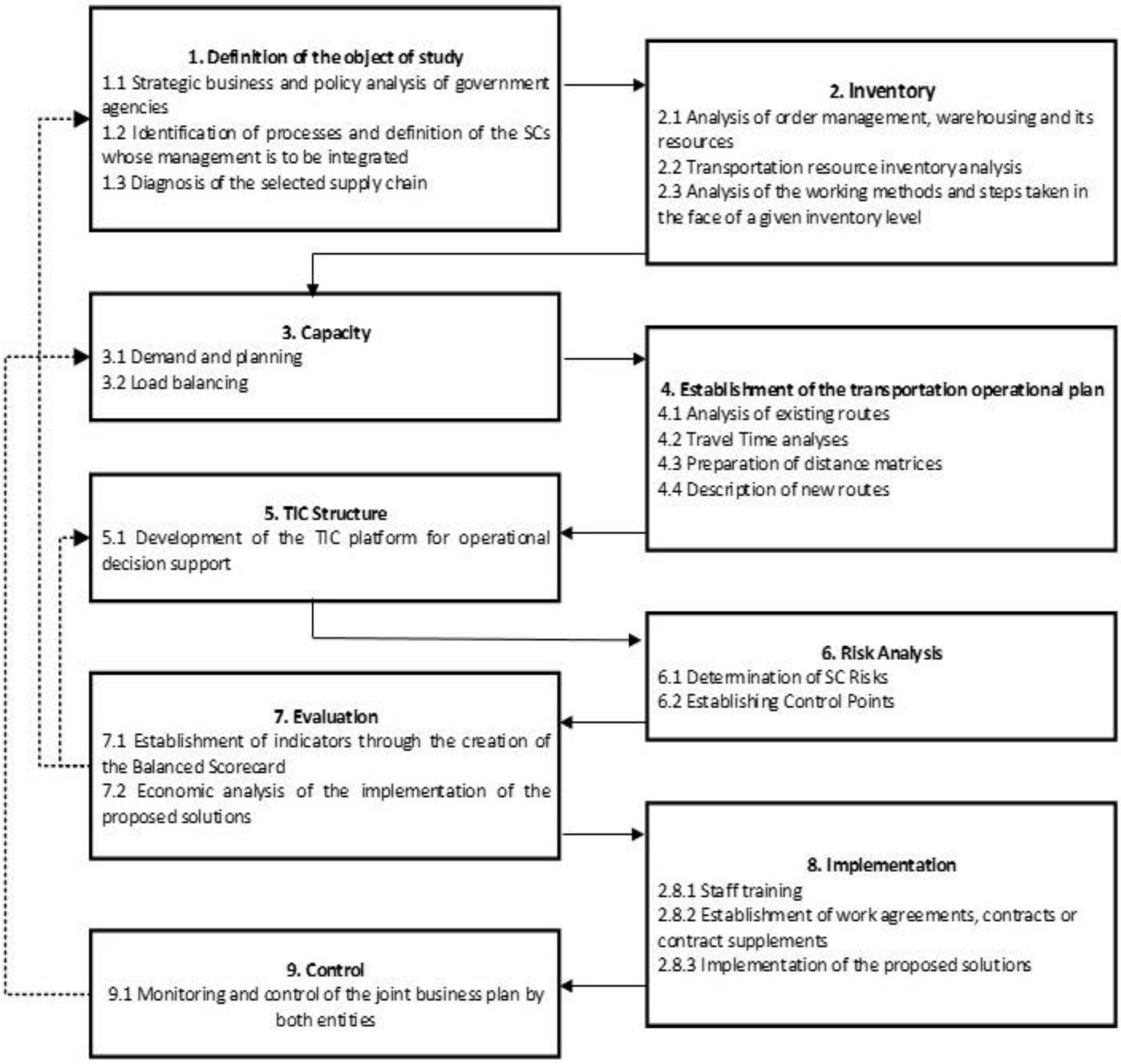

Figure 1: Proposed methodology

2.1.2. Identification of processes and definition of the SCs whose management is to be integrated

Using the SCOR (Supply Chain Operations Reference) model as a reference, the processes that support the SCs must be identified in the EMPA. Based on this information, a process map is drawn up for each SC of the entity, with its corresponding diagrams and process sheets. Next, a SC is selected for its development and collaborative planning among the companies under study.

2.1.3. Diagnosis of the selected supply chain

Once the SC whose management is to be integrated has been selected, the next step is the diagnosis. For this purpose, it is proposed to use as a tool the "Guide for the characterization of potential supply chains" of the Logistics and Production Management Laboratory of the CUJAE by [24].

2.2. Inventory (Phase 2)

2.2.1. Analysis of order management, warehousing and its resources

The elements to be considered for its analysis are: classification of the warehouse, technical-constructive characteristics of the warehouses, sequence of steps to be followed from the time the product arrives at the warehouse until it leaves, conservation procedure of the stored materials, quantity of storage means, quantity of handling equipment, labor force requirements, product location and localization system, product rotation, and work safety and hygiene. The storage demand-capacity balance is proposed. This step will provide a comprehensive characterization of the order and storage management activities, as well as the resources available.

2.2.2. Transportation resource inventory analysis

According to Model BC-1 and Model BC1-A of the load balance [25], an inventory of transportation capacities (in tons and cubic meters) is made for each means of transport, recording the type of vehicle, the make, the consumption standard in km/L, the technical condition, among other data. The work rhythms, schedules and maintenance cycles established for this equipment should also be analyzed, as well as whether they have the current technical inspection certificate and report and proof of the Transport Operating License.

2.2.3. Analysis of the working methods and steps taken in the face of a given inventory level.

Some of the issues to be analyzed are: storage standards, product traceability and rotation, priority relationship between destinations, priority relationship between goods, availability of schedules, transport planning, ways of grouping goods, compatibility of loads. At the end of this step, information will be obtained on other elements that must be considered because of their role as conditioning factors in the activity and which, together with transportation inventories and storage resources, will be fundamental when carrying out capacity studies and balance sheets.

2.3. Capacity (Phase 3)

2.3.1. Demand and planning

It is proposed to use analysis and forecasting by means of statistical tools or scheduling.

2.3.2. Load balancing

This step corresponds to the load balancing. An analysis of load flows and the demand-capacity relationship must be carried out in order to adopt measures to maximize the use of existing capacities and resources, particularly fuel, based on demand forecasts and resource inventories.

2.4. Establishment of the transportation operational plan (Phase 4)

2.4.1. Analysis of existing routes

The planning of distribution routes suggests a prior diagnosis of elements such as: the state of the distribution system, existing routes, travel times, fuel consumption, costs involved, loss indicators and customer experience. With this, the shortcomings and strengths of the current routes are identified.

2.4.2. Travel time analyses

Using the timing technique, loading and unloading times should be measured, as well as those associated with other activities that take place before, during and after the routes are completed, and which are directly linked to the distribution activity (dispatching, receiving).

2.4.3. Preparation of distance matrices

Here the distances between the stores under study are established.

2.4.4. Description of new routes

To plan the new distribution routes, it is proposed to implement a software adapted to the company's requirements, which facilitates the recording of the data obtained in the two previous steps, as well as information related to highways and roads: typologies, topographies, traffic levels and transit zones, distances, access limitations, among others.

2.5. TIC Structure (Phase 5)

2.5.1. Development of the TIC platform for operational decision support

In this stage, an integrated TIC platform must be developed to plan, design and optimize dispatch and delivery operations in the most efficient way by assigning schedules, product quantities and vehicles. To achieve total and efficient control of the operation, this platform would be made up of at least five modules. In order to achieve total and effective control of the operation, this platform would consist of at least five modules:

1. the inventory module would have updated and real-time information on warehouse inventory levels.
2. the routing module integrates the transportation software proposed above, and would allow the analysis of routes and the assignment of routes based on the adjustment of parameters according to the distribution, considering multiple criteria such as: type of vehicle, capacity and number of routes, fuel required, amount of cargo, weight, volume, fragility, compatibility, organoleptic characteristics in the case of food, delivery schedules and travel times.
3. The customer module would have updated information on their demand levels and would facilitate the establishment of historical records.
4. the communication module would provide a solid, secure and fast way for the exchange of information between companies, eliminating data redundancy and delays in the delivery of information, while facilitating planning and management in an integrated manner.
5. the indicators module would facilitate the calculation, recording and analysis of indicators that will allow managing the control of the fulfillment of strategic and operational objectives in the processes.

2.6. Risk Analysis (Phase 6)

2.6.1. Determination of SC Risks

In this case, it is proposed to use the Failure Mode and Effects Analysis (FMEA) method [26]. This is a tool aimed at achieving quality assurance.

2.6.2. Establishing Control Points (CP)

The logical and structured way of proceeding to identify the CP can be facilitated by the use of a decision tree [27].

2.7. Evaluation (Phase 7)

2.7.1. Establishment of indicators through the creation of the Balanced Scorecard

A Balanced Scorecard (BSC) is proposed because it allows to detect deviations from the strategic plan and to express the objectives and initiatives needed to redirect the situation. This step will provide control mechanisms at all levels, so that the implementation of strategies can be readjusted when necessary and appropriate [28].

2.7.2. Economic analysis of the implementation of the proposed solutions

This step involves carrying out a cost-benefit analysis, a very useful process to determine whether the decisions taken are economically sound or not.

2.8. Implementation (Phase 8)

2.8.1. Staff training

Training courses are to be conducted jointly with the university, and training plans on logistics, use of TIC and collaboration are to be established for workers and managers through workshops and meetings.

2.8.2. Establishment of work agreements, contracts or contract supplements.

According to the needs and characteristics of the institutions involved, a legal instrument will be applied in accordance with current law [29], although it is proposed that collaboration agreements be signed to support a cooperation contract.

2.8.3. Implementation of the proposed solutions

This is a fully operational stage in which it must be considered that resources must be managed efficiently. What was established in the previous phases is put into practice: techniques, working methods and, mainly, the use of the TIC platform for distribution management.

2.9. Control (Phase 9)

2.9.1. Monitoring and control of the joint business plan by both companies

It is crucial that both companies keep a systematic watch on the functioning and evolution of the solutions implemented as part of the collaboration strategy, as well as the agreements signed for integrated work.

3. Results and Discussion

It is applied with the objective of validating the proposed procedure for collaborative framework management among the companies under study. The selection of the sample, in order to determine its distribution with respect to the population, was by strata and intentional, which allowed the direct and explicit selection of the specialists who were considered likely to offer the greatest amount of information. They belonged to different work groups of the EMPA, the TC and the university. The questionnaire applied has a total of five questions. It is based on the relationships established between three interleaved closed questions (1, 3, 5) whose relationship is unknown to the subject. At the same time, the open or complementary questions (2, 4) serve as an introduction and support of objectivity for the respondent, who uses them to position himself and contrast the answers. The three closed questions are related through Ladov technique [30], shown in table 2; the resulting number indicates the position of each subject on the satisfaction scale, that is, his or her individual

Table 2: Ladov technique

Question 5: Do you believe that by applying this procedure, an effective and efficient integration of the management of the actors involved in the development of the EMPA's supply chains will be achieved and the proposed objectives will be met?	*Question 1: Did you find the design of the phases and stages functional and adequate?*								
	Yes			I DO NOT KNOW			NO		
	Question 3: Do you feel that this procedure covers the aspects necessary to organize work methods, plan the management of resources, optimize the application of techniques and tools, and achieve an adequate exchange of information among the actors in the EMPA's supply chain?								
	yes	I do not know	no	yes	I do not know	no	yes	I do not know	no
Clear satisfaction	1	2	6	2	2	6	6	6	6
More satisfied than dissatisfied	2	2	3	2	3	3	6	3	6
Not defined	3	3	3	3	3	3	3	3	3
More dissatisfied than satisfied	6	3	6	3	4	4	3	4	4
Clear dissatisfaction	6	6	6	6	4	4	6	4	5
Contradictory	2	3	6	3	3	3	6	3	4

satisfaction. The satisfaction scale used is as follows: 1) clear satisfaction, 2) more satisfied than dissatisfied, 3) not defined, 4) more dissatisfied than satisfied, 5) clear dissatisfaction, 6) contradictory.
This technique also makes it possible to obtain the Group Satisfaction Index (GSI), and is calculated by the following equation:

$$GSI = \frac{A(+1) + B(+0.5) + C(0) + D(-0.5) + E(-1)}{N}$$

where A, B, C, D, E, represent the number of subjects with individual index 1, 2, 3 or 6, 4, 5 respectively, and where N represents the total number of subjects in the group. The GSI value obtained in this research was approximately 0.86, which indicates a high satisfaction with the proposed procedure and validates its usefulness (being in the interval between 0.5 and 1). This indicates that the procedure is apt to be implemented and contribute to improvement in the organizations under study
These results of the specialists' satisfaction with the procedure were reaffirmed by their answers to the open-ended questions (Question 2. What problems, in your opinion, limit collaboration between the companies mentioned above and hinder the proper functioning of EMPA's supply chains? Question 4. How important do you think it is to establish a collaboration strategy between the TC and EMPA? What results would it bring?).
Among the most frequent criteria were that the low level of computerization of both companies and the differences in their interests according to their fundamental activity limit their collaboration and the proper functioning of the SC of the EMPA. Likewise, the establishment of a collaboration strategy between the TC and EMPA would result in greater financial savings for both entities and greater agility in the provision of services, which would have an impact on increased customer satisfaction.
Other opinions are linked to the current economic situation in the country (fuel availability and technical condition of vehicles) and to supply disruption, a premise that was initially put forward as one of the causes of the problems in EMPA's SC, but which goes beyond the scope of this research. In fact, it is ideal for studies to be carried out in response to supply problems, since their solution is a prerequisite for the successful implementation of this procedure. In a general sense, it is considered that the respondents are satisfied with the proposed procedure.

4. Conclusion

The procedure proposed for collaborative framework management offers the methodological instrument that will allow them to manage their processes and activities, so as to increase effectiveness, efficiency and resilience. The process of validation of the procedure in the food wholesale company and the transport company, by means of the Ladov technique was satisfactory, expressed quantitatively in the high Group Satisfaction Index obtained (GSI=0.86) and qualitatively in the criteria issued by the experts that demonstrate the usefulness they grant to the procedure for its future application.
As future research, it is proposed to continue working on the TIC platform that will allow the development of the collaborative framework between both institutions. In addition, it is intended to apply this procedure to other institutions with collaborative work characteristics with a transportation company.

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Application potentials of a data-based Value Stream Map model in production and logistics

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Abstract

Value Stream Management in its conventional methodology underlies several disadvantages, especially in the context of effort and flexibility. The approach is characterized as time- and resource-consuming due to a mainly pen-and-paper based procedure, causing inflexibility in an increasing dynamic environment. Taking these findings into account the term static VSM in contrast to a dynamic VSM or VSM 4.0 is introduced in some studies. The fundamental principles of VSM are recognized as still valid, whereas the procedure requires improvements in regard to flexibility and accuracy to ensure a future-viability in today's environments. Recent studies show the relevance and importance of this topic and provide proposals for improving the methodology by the application of information and communication technologies. All reviewed studies have in common a selective consideration of one or more technologies for improving the methodology. Missing is a holistic analysis of the potentials of a digital value stream map, implemented as data-based model with reference to the Value Stream Management phases value stream mapping (VSM), value stream analysis (VSA), value stream design (VSD) and value stream planning (VSP). Based on a literature review for analyzing the state of research in a holistic way, the paper aims at providing a framework, consolidating all recent researches in one model.

1. Introduction

Value Stream Management in its conventional meaning foresees the pen-and-paper-based recording of process steps, work-in-process stocks and cycle times during an on-site-visit. [1]–[3] Ensuring a valid data base, several production cycles are measured and documented for calculating an average value, aiming at minimizing measurement errors and process deviations. Changes in the process require a new recording, which shows additionally the lack of flexibility and the high level of effort in an increasing dynamic environment. [4], [5] For this reason, recent studies differentiate between static VSM, describing the conventional procedure, and dynamic VSM or VSM 4.0, proposing a technology-based approach, e.g. [6], [7]
The entire Value Stream Management approach follows four steps, which are visualized in the following figure. It is pointed out, the term-related usage is not consistent, e.g. in some studies value stream mapping is abbreviated to VSM and used as term for the whole value stream management approach (according to dynamic VSM and VSM 4.0) [8]. But VSM is also defined as Value Stream Management [9], [10] and Value Stream Method [11]. Furthermore, VSM and VSA are used synonymously, describing the mapping and analysis of the current value stream, as well as the procedure at all [12]. The paper at hand refers to the phases as defined in the following figure 1.

In general, the core elements of Value Stream Management, e.g. pull, customer-orientation, demand-driven production and further ones are evaluated as still valid, but the necessity of improvement is claimed to overcome the pointed-out deficits. [13] Several research studies in recent years follow the approach to improve the conventional methodology by combining it with information and communication technologies with the aim to reduce efforts and increase flexibility. Furthermore, new possibilities are enabled by applying a data-based model. An overview of these studies including the considered technologies is given in [14].

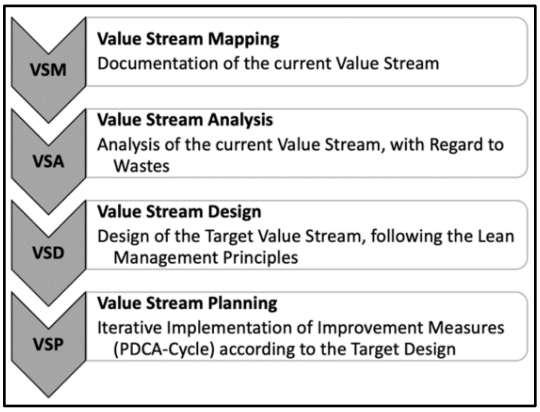

Figure 1: Phases of Value Stream Management

All reviewed studies have in common a limited view on the Lean Management approach, focusing on one or a mix of selected technologies, e.g. [15], [16] as well as on single aspects of Value Stream Management, e.g. the mapping procedure [17], [18]. Also new opportunities, e.g. a simulation-based decision-making [19], [20] , real-time monitoring and scheduling [21], [22] and the application of data-processing techniques, such as data and process mining [23], [24] are provided. But a holistic overview of all opportunities, evoking from of a digital value stream map is missing. The paper at hand aims at closing this research gap by analyzing the state of research and consolidating the findings into a framework.

2. Applied Methodology

The applied methodology is shown in the figure below and described in the following section.

2.1. Phase 1 – Literature Review

In the first phase a structured literature review according to PRISMA [25] is applied. The literature review is a preliminary study and forms the basis of the paper at hand. Therefore, the procedure is not detailly described at this point, but the main conditions are pointed out.

In a first step potential sources are identified. Therefore, the key words for search and the data basis are defined. The search result consists of sources, which are screened in the second phase. In the context of this study the key listed words were considered:

Phase 1 – Literature Review according to PRISMA
1.1 Identification of Sources 1.2 Screening of Sources 1.3 Analysis of Sources
Phase 2 – Consolidation of the Findings into one Value Stream Map Framework
2.1 Determination of Domains and specific Indicators 2.2 Identification of potential digital Data Sources 2.3 Mapping of the Data Structures to the Indicators 2.4 Consolidation of the content-based Findings into one Value Stream Map Framework
Phase 3 – Consolidation of the Findings into one Value Stream Management Framework
3.1 Description of Data Processing Techniques 3.2 Assignment of Techniques to the Value Stream Management Phases

Figure 2: Applied methodology

- “VSM 4.0” / “DVSM”
- “Value Stream Management 4.0” / “Dynamic Value Stream Management”
- “Value Stream Method 4.0” / “Dynamic Value Stream Method”
- “Value Stream Mapping 4.0” / “Dynamic Value Stream Mapping”
- “VSA 4.0” / “Dynamic VSA”
- “Value Stream Analysis 4.0” / Dynamic Value Stream Analysis”
- “VSP 4.0” / “Dynamic VSP 4.0”
- “Value Stream Planning 4.0” / “Dynamic Value Stream Planning 4.0”
- “Wertstrom 4.0” / “Dynamischer Wertstrom”
- “Wertstrommanagement 4.0” / “Dynamische Wertstrommanagement”
- “Wertstrommethode 4.0” / “Dynamische Wertstrommethode”
- “Wertstromanalyse 4.0” / “Dynamische Wertstromanalyse”
- “Wertstromdesign 4.0” / “Dynamisches Wertstromdesign”
- “Wertstromplanung 4.0” / “Dynamische Wertstromplanung”

Based on the available quantity of sources and the types of publications in regard to the search terms, three scientific knowledge libraries were identified as suitable source bases (accessed in February 2023):

- ResearchGate (https://www.researchgate.net)
- GoogleScholar (https://scholar.google.com)
- IEEEXplore (https://ieeexplore.ieee.org/)

In total, 2.551 potential sources are screened by the application of inclusion and exclusion criteria in a second step.

- The source is a scientific study, published as conference paper.
- The source is available as full-text.
- The language of the source is English or German.
- The source is relevant to the topic of a digital value stream map.
- Redundancies are eliminated.

53 papers, published during 2012 and 2023, are considered for further analysis. The key results of the analysis are summed up in the following tables. Due to the fact, one paper can refer to different topics, it is noted, the sum of all categories does not reflect the total number of papers.
The main focus of the reviewed paper is on the application of a digital value stream map for automizing the mapping of the value stream and the technologically supported analysis of wastes, referring to the first two phases value stream mapping (N=50) and value stream analysis (N=41). The third phase value stream design is considered in 27 papers, whereas the fourth phase value stream planning is considered in several studies, but not a subject of research in regard to Value Stream Management against the background of a procedure's digitalization and digitization, e.g. [26]. In contrast, the application of a digital value stream map for improving the operations is mentioned in 11 papers.

Table 1: Quantitative distribution of papers, referring to the phases of Value Stream Management

Category	Papers
Value Stream Mapping	46
Value Stream Analysis	37
Value Stream Design	26
Value Stream Planning	0
Operations	10

Two approaches can be distinguished on a higher level of consideration. On the one hand, a content-related extension of the conventional value stream map is proposed. The types of extension differ and relate to different domains in process management. On the other hand, potentials for the application of data-driven techniques on a digital value stream map model are investigated. Both research directions are also mentioned in [27] with focus on the mapping procedure. The proposed approaches are linked to the phases VSM, VSA and VSD as well as the utilization against the background of operations in production and logistics.

Table 2: Quantitative distribution of papers, referring to the underlying concept

Category	Papers
Extension of the conventional Value Stream Map (contend-based)	28
Application of data-driven techniques (function-based)	36

The consolidation of the findings in detail is described in the following two sections.

2.2. Consolidation of the Findings into one Value Stream Map Framework

The conventional value stream map consists of six elements according to [28, pp. 25–30], [29, pp. 31–38] and form the value stream. These elements are

- Customer
- Production process
- Supplier
- Business process
- Material flow
- Information flow

The content-based extensions, proposed in the reviewed studies, are related to the production process and can be assigned to three different domains, visualized in the following figure.

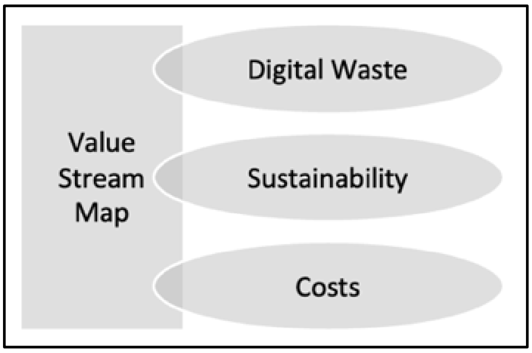

Figure 3: Modular extension of the conventional Value Stream Map

The quantitative distribution of papers is shown in the table below.

Table 3: Quantitative distribution of papers, referring to the domains of Value Stream Map extension

Category	Papers
Digital Waste	15
Sustainability	8
Costs	7

2.2.1. Digital Waste

Wastes in the context of Lean Management are mainly contributed to material handling. But due to the growing digitization and digitalization in the fields of production and logistics, the logistics of information gets increasingly important. Considering this fact, the term information logistical waste is introduced to take the logistics of information into account. Two examples for digital waste are media interruptions and data redundancies, requiring manual synchronizations. As indicators storage media, flow direction and usage are applied. [30], [31] Furthermore, digital KPIs, describing, inter alia, the horizontal and vertical integration, are defined for evaluating the maturity of digitalization and analyzing improvement potentials. [18], [32]

The domain of digital waste requires a cross-system view on the information logistics to create a holistic overview of the related information flows, the origins of the data and its usage. In this context, event-driven process and data-mining supports the automated mapping and analyzing. Prerequisite is a framework, as it is proposed at the end of this section.

2.2.2. Sustainability

Recent developments towards higher awareness for ecology are considered by the domain Sustainability. To identify the activities with the highest ecological improvement potential, the consumption of water, gas and electricity as well as the CO_2 (carbon dioxide) and NOx (nitrogen oxide) emission is documented with assignment to the related activity. Value Stream Management approaches with focus on sustainability are also mentioned under the terms of sustainable VSM (SVSM) and energy VSM (EVSM). [12], [33], [34]

In regard to the consumption of resources and emissions, sensor / process data are potential data sources. Modern machines with a PLC (programmable logic controller) control provide the export of consumption-related information, which can be analyzed with refence to specific machine operations. Furthermore, retrofits of sensors and consumption meters for machines without a PLC control are offered by several suppliers. The data gathering based on such a measurement also supports the integration of manual workplaces, e.g. for assembly. The logical interpretation of the raw data requires calculation rules. [35, pp. 152–153]

2.2.3. Costs

The third domain refers to costs and aims at the identification of cost drivers in the areas of production and logistics. In this context, the arising expenses for rates, e.g. labor, machining and transportation, consumed and scrapped materials, energy (in relation to sustainability) and similar ones are tracked. Furthermore, opportunity costs, e.g. for the non-utilization of capacities are defined. [36]–[38] In cases, a value stream is not deterministic, but different variants of the value stream exist, e.g. due to alternative technologies or multiple production lines for one product, the application of event-based process-mining enables the monitoring of variant-specific costs as well as the determination of the cost-optimal variant. [19] Costs for material consumption can be calculated by the material and quantity, withdrawn on the production order and the material price. Work center related costs can be derived from the actual confirmed activities on one operation. Based on the confirmed time exposure on an activity, e.g. setup, machine or labor, the activity type, formula and cost center specific rates, the actual costs are calculated. The derivation of both cost factors is visualized in figure 4.

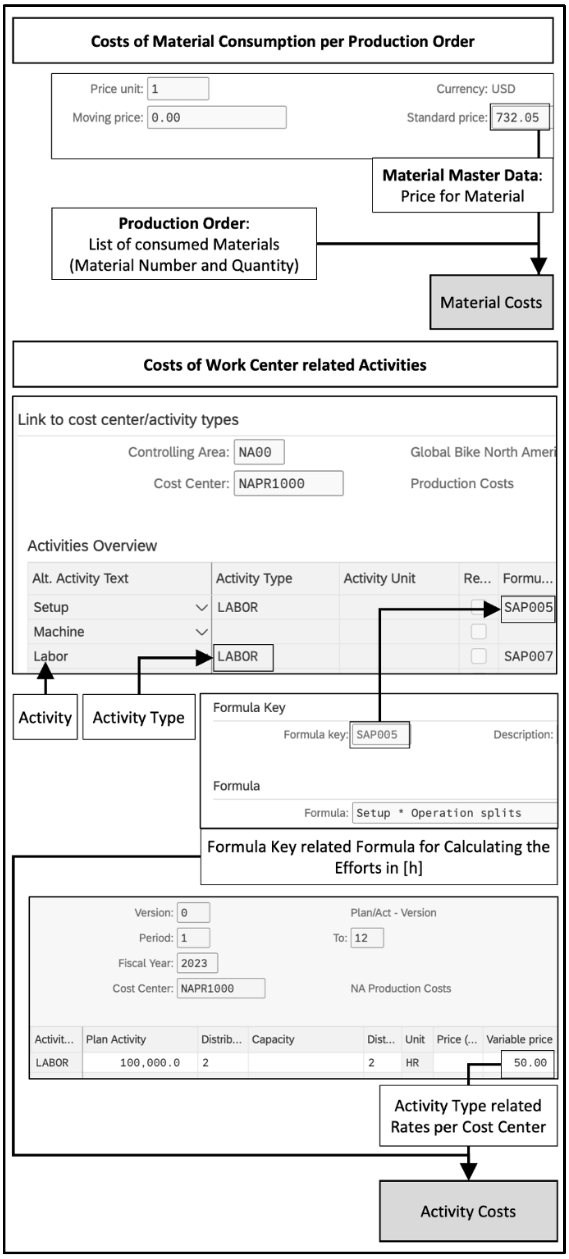

Figure 4: ERP-based cost mapping for activities and material consumption

Potential data sources are cost-tracking business applications systems, e.g. enterprise resource planning (ERP) and manufacturing execution system (MES).

Value Stream Map Framework

As pointed out at the beginning of this section, the content-based extension of the value stream map by the three domains is limited to the production process. For this reason, residual elements remain and are explicitly not considered. To merge the three domains into one framework, the framework, described in [39] is adapted (see figure 5). Companies that apply Lean Management in general and Value Stream Management in particular differ from each other in regard to products, business model, system and process landscape. Therefore, companies follow different strategies and aims. The corresponding requirements for the use of a tool or management approach like Value Stream Management are also various. Following the Lean Management philosophy, the gathered information should match the required data base and not exceed the necessity in terms of waste. For this reason, the proposed value stream map framework is designed in a modular way. According to the company's environment only the data are gathered, which are necessary for improving the value stream. To the same extent it is possible to adjust the proposed framework according to the company's need.

Consolidation of the Findings into one Value Stream Management Framework

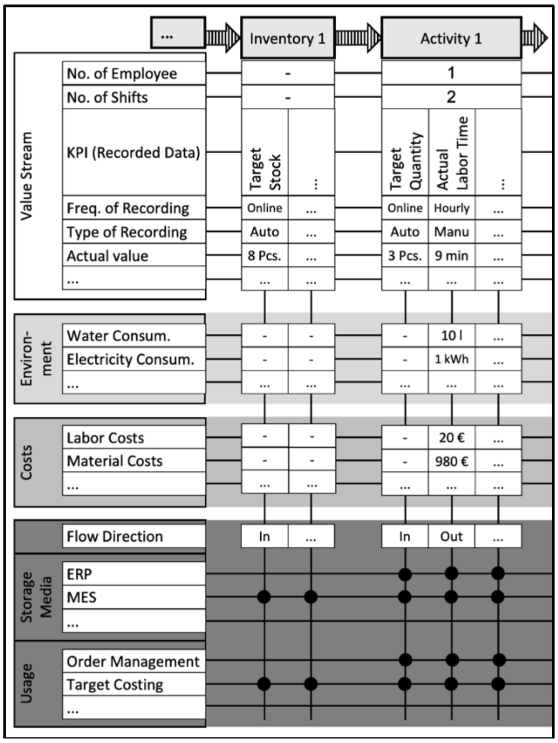

Figure 5: Modular Value Stream Map framework

The implementation of a digital value stream map is not limited to the value stream mapping, but also opens opportunities in regard to the residual phases of Value Stream Management as well as the operations of logistics and production. In this context, data-driven techniques enable the automation or at least the part automation of information processing. Figure 6 visualizes the four areas of application potentials, which are detailly elucidated in the following section.

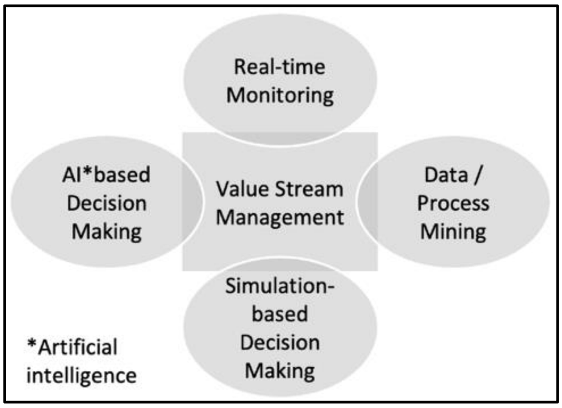

Figure 6: Data-processing techniques in the context of Value Stream Management 4.0

The quantitative distribution of papers is shown in the table 4.

Table 4: Quantitative distribution of papers, referring to the categories of data-processing techniques

Category	Papers
Real-Time Monitoring	8
Data / Process Mining	17
Simulation-based Decision Making	27
AI-based Decision Making	3

2.2.4. Real-Time Monitoring

To avoid high costs for rework and disposal, deviations, e.g., quality issues must be identified as early as possible. A continuous tracking and tracing of material along the entire value stream including specific process data in real-time supports a deviation management based on a steady comparison of planned and actual parameters. [40, pp. 116–124] In this context, the digital value stream map model is the to be observed framework. The implementation of technologies like digital twins, internet of things (IoT), RFID (radio frequency identification) and similar ones for identifying material according to the lot size one concept, is proposed to enable the real-time monitoring. The gathered data are referenced to the unique material and used for deriving the trace. Furthermore, the availability of current data opens opportunities towards dashboarding functionalities. For this reason, the application of real-time monitoring is appropriate to the operations of production and logistics as well as VSP, especially the documentation of impacts on the value stream, emerging from applied improvement measures. [22], [41]–[43]

2.2.5. Data / Process Mining

During the production process different types of data are gathered. The available raw data must be structured, assigned and interpreted for usage. This is done by the application of data and process mining techniques. For this reason, the technique is suitable for the initial, but also continuous VSM as well as VSP. [17], [23], [41], [44]

2.2.6. Simulation-based Decision Making

The implementation of a digital value stream map opens opportunities in regard to simulative techniques. The quantitative simulation supports the creation of different solution scenarios and the reasoned selection of the optimal one. The term simulation describes in this context the conscious adjustment of model parameters, e.g., the increase of capacities. For this reason, the fields of application refer to the phases VSD and VSP in particular. In contrast to physical mock-ups (PMU), which are often used in the context of value stream planning, following the iterative improvement according to the Deming-circle, the design parameters of digital mock-ups (DMU) can be adjusted and validated with less efforts, whereas PMUs require a physical adaption and can be damaged or destroyed during a validation process. Due to this characteristic of DMUs the simulation based decision-making saves time as well as costs. But also in regard to operations, the simulation of alternative value streams can be applied against the background of disruption management, e.g. the failure of a machine in a production line and the transfer of a production process to an adjacent resource. [20], [45]–[47]

2.2.7. AI-based Decision Making

Like the simulation-based decision making, the AI-based one supports the decision-making process by the utilization of the available data. But in contrast to simulations, which require a simulation model with entities and defined relations, the AI-orientated approach aims at the application of data analytics for the identification of correlations in the data pool. Therefore, it is appropriate for VSA, VSD and VSP as well as for operations, especially in the context of gaining a deeper system understanding and making predictions. [43], [48], [49]

3. Results and Discussion

Aim of the paper at hand is the determination of recent developments in the fields of research in regard to Value Stream Management 4.0 and its consolidation into one framework. By the structured literature review two major approaches are identified – one aiming at the content-based extension of the value stream map and the other one proposing data processing techniques on a digital value stream map model for improving the methodology at all. Both approaches are subdivided into different categories, representing the thematic focus of the considered studies. The resulting categories are summarized in the following listings.

Extension of the Value Stream Map

- Digital Waste
- Sustainability
- Costs

For each domain potential data sources and mappings are derived. Furthermore, a modular framework, consolidating the findings, is provided.

Data-processing Techniques in the Context of Value Stream Management 4.0

- Real-time Monitoring
- Data / Process Mining
- Simulation-based Decision Making
- AI-based Decision Making

All techniques are elucidated and according to its application potential assigned to the different phases of Value Stream Management 4.0 as well as to the operations of logistics and production.
As pointed out in the abstract and introduction, in regard to the reviewed studies a holistic overview of all opportunities, evoking from of a digital value stream map is missing, because of the limiting focus on one topic. By the paper at hand this research gap is closed and the recent research is brought together in one study. There are limitations, which must be mentioned at this point. The paper at hand is limited to the consideration of recent research fields. As pointed out, the provided frameworks are modular and its application requires an adjustment according to its purpose. Missing is an evaluation of the digitalization measures in comparison to the conventional Value Stream Management. Therefore, a deeper analysis of the resulting or expected benefits is missing. Furthermore, a technical concept for integrating the different data sources into one data pool as data basis for the data processing techniques, mentioned in this paper, is required.

4. Conclusion and Outlook

Different fields of research in the context of Value Stream Management 4.0 exists, making various perspectives on the topic a subject of discussion. The number of relevant publications proves the topic's relevance. Missing is an entire overview for all research streams. By the paper at hand this identified research gap is closed, as reasoned in the former section, but there are still issues, which require further research. The reviewed papers are focused on the provision of individual solutions, addressing a sub-area of Value Stream Management 4.0. The application is reasoned by limitations of the conventional ones and arising opportunities by modern technologies, but a proposal of indicators for an overall evaluation of the benefit from a company's perspective is missing, reasoning the transformation from the conventional procedure to the digitalized one. Furthermore, a technical solution for merging the recent researches into one framework is missing. Currently, different technologies are considered independently from each other, but a successful implementation requires a holistic solution, taking all types of technologies into account. Dealing with the above-mentioned issues is topic of future studies.

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Participating Institutions

Otto von Guericke University Magdeburg

The Otto von Guericke University (OVGU) was founded in 1993 from three institutions of higher education: The Technical University Magdeburg, the Teacher Training College and the Medical Academy of Magdeburg. It is named after the famous scientist Otto von Guericke, whose research on the vacuum, especially his hemispheres experiment, earned him fame beyond German borders.
Consisting of 9 Faculties, OVGU offers more than 100 academic programs. About 13000 students are enrolled at OVGU; about 4000 of them are international students. OVGU is one of Germany’s youngest universities. Its innovative fundamental research contributes to the city’s and the country’s social and scientific development.
The Institute of Logistics and Material Handling Systems is part of the Faculty of Mechanical Engineering and looks back on more than 65 years of experience in training and research in the field of conveying technologies, logistics and material handling systems.

The fields of logistics research include diverse research projects on the topics of logistics, mobility and sustainability:

- Fundamentals of technical logistics, in particular reference and calculation models
- Diagnosis, modelling, simulation and design of logistics processes and systems
- Information systems in logistics, especially identification, ERP, trace and tracking systems
- Planning methods and tools in logistics, especially module-oriented problem-solving processes as well as cooperative and internet-based planning processes
- Process chains for supply, production, trade, logistics service providers as well as supply and disposal transport chains
- Further education, business games and in-house training in logistics Modelling and simulation of procurement, production and distribution networks
- Industry 4.0 and Logistics 4.0
- Logistics-oriented factory planning and operation
- Holistic and differentiated analysis and optimisation of logistics processes
- Planning of logistics systems
- Development of methods and tools for the evaluation, planning and design of logistics networks
- Interactive education and training concepts for the qualification of logistics systems
- Application of artificial intelligence (AI) in production and logistics
- Virtual commissioning of cyber-physical systems (CPS)

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Universidad Central “Marta Abreu” de Las Villas

The Universidad Central »Marta Abreu« de Las Villas (UCLV) was founded in 1948 in Santa Clara. Approximately 9500 students are enrolled at the university, which consists of 12 faculties. The green, spacious campus is located on the outskirts and makes up its own small student town that could be reached by car, bus or train. UCLV is the third-biggest university of Cuba. It has ranked on top places in all national evaluations of the quality of teaching and research. UCLV is part of several national and international research networks and has scientific cooperation with 130 institutions around the world. Intensive collaboration with the OVGU in Magdeburg focuses on the departments of manufacturing, engineering and quality management, mechanics, construction, computer science, automotive technology, process and environmental technologies and especially logistics and material handling systems.
In 2016, the university immersed in an integration process where industrial engineering and mechanical engineering came together in a single faculty named Faculty of Mechanical and Industrial Engineering.
Of the 90 teachers of the faculty, 60% have a Doctorate in a specific science, while 70% have already reached a higher teaching category. The faculty has two teaching departments (Mechanical Engineering and Industrial Engineering), two Study Centers (Center for Energy Studies and Environmental Technologies, Welding Research Center).

The Department of Mechanical Engineering most important fields of research pertaining to logistics and material handling systems are:

Technical logistics,
Quality management, quality engineering, metrology, measurement uncertainty
Manufacturing (manufacturing engineering and welding technology),
Environmental technology.

Furthermore, researches conducted in the fields of biomechanics, mechatronics, development and construction. The central fields of research pertaining to logistics and material handling systems at the Department of Industrial Engineering are:

Quality management, quality engineering,
Mathematical statistics, operations research, design of experiments, statistical simulation,
Reliability and safety,
Logistical networks.

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National Aerospace University “KhAI”

National Aerospace University, Kharkiv, Ukraine (KhAI) was established in 1930. Its history is closely connected with the development of aircraft engineering and science. The University is well-known for its achievements in aviation industry, namely for the creation of the first European high-speed airplane with a retractable landing gear and the design of the turbojet engine. At present about 9.500 students and 160 post-graduate students are trained at the University; 650 teachers and 2.500 employers work here. Among them there are 120 Professors and PhD. This makes KhAI one of the leading institutions of higher education in that trains specialists for aerospace industry in Ukraine and abroad. During the period of its existence the University has trained about 80000 engineers. More than 80 % of the experts with higher education who work in Ukrainian aerospace area are the graduates of the NAU KhAI.
The NAU KhAI is a member of International Association of Universities, EASN, PEGASUS organizations as well as is a signatory of Magna Charta Universitatum. Together with European partners it received the highest number in Ukraine of scientific and educational grants TEMPUS FP-7 and the European Union. The NAU KhAI is a co-executor of many scientific and educational programs which are carried out with universities and companies of EU, Mexico, China.
In 1994 KhAI signed a partnership agreement with OVGU, thus setting new joint educational and research tasks in aircraft design, composite component design, technologies for rapid processing of steel structures etc.
National Aerospace University is persistent in raising its bar, being always ready to welcome and support students and young researchers from all over the world.

https://khai.edu/en/university/

University of Miskolc

The history of the University of Miskolc refers to Mining and Metallurgy back in 1735. Since those times, the organization of the University changed and was extended several times with new faculties, now being named since 1990 the University of Miskolc. While technical education has the longest tradition at the University of Miskolc, during the recent decades the institution was transformed into a true university. Currently it has eight distinct faculties. At present, faculties have more than 8000 students, who are assisted in their academic advancement by an educational staff of more than 550 and a non-educational staff of more than 650 members.
On most faculties, B.Sc. and M.Sc. programs are both offered for the students. The University of Miskolc started Ph.D. programs on the basis of accredited doctoral programs on October 1, 1993. Currently six Faculties of the University offer doctoral programs and award Ph.D. degrees in seven disciplines: Earth Science, Materials Science and Technologies, Engineering Science, Information Science, Law, Economics and Management Science, Literary Studies.
The University of Miskolc is the largest higher education institution in Northern Hungary. With its highly qualified experts, instrument infrastructure and laboratories, it contributes to scientific research and technical development in Hungary.
The Institute of Logistics is part of the Faculty of Mechanical Engineering and Informatics. The Institute has a wide range of educational activities at 3 Faculties of the University of Miskolc in the frame of full time and part time trainings. The focus of research activities of the institute lies in the following fields:

- Design of materials handling machines,
- Controlling and planning methods for modular materials handling systems,
- Computer integrated logistics, information logistics,
- Production and service logistics,
- Warehouse logistics, stock management,
- Recycling logistics,
- Maintenance and Quality assurance logistics,
- Optimization of complex logistics systems,
- Simulation-based process improvement,
- Global logistics, supply and distribution systems,
- Industry 4.0 and logistics,
- Lean logistics.

www.uni-miskolc.hu

Anhalt University of Applied Sciences

Innovation, cosmopolitanism, creativity and culture are traditions of the Anhalt region to which the Anhalt University of Applied Sciences with its three campuses in Bernburg, Dessau and Köthen and its seven departments feels particularly committed. Therefore, since its foundation in 1991 the university feels responsible for making a significant contribution to the economic and social development of the region and the state of Saxony-Anhalt through its practice-oriented education and applied research. The bachelor's and master's degree programs at the various departments have one thing in common - in addition to imparting specialist knowledge, they prepare the 8.000 students of the Anhalt University of Applied Sciences, from whom 2.000 have an international background, for a successful start to their careers.
In May 2021, the extension of the right to award doctorates to universities of applied sciences in Saxony-Anhalt gave rise to the "Social, Health and Economic Sciences" doctoral center at Anhalt University of Applied Sciences, which is a collaborative effort between Anhalt University of Applied Sciences and three other universities in the state.
The Chair of Business Administration, in particular Supply Chain Management, Operations Management and Digitization, situated at the Department of Economics at Anhalt University of Applied Sciences and headed by Prof. Dr.-Ing. Trojahn, deals with current developments along entire supply networks with regard to various thematic research focuses such as:

- Supply Chain Network Design, Planning & Operations
- Operations Research
- Process Optimization
- Digitalization and Logistics 4.0
- Resilience
- Sustainability

www.hs-anhalt.de

Magdeburg-Stendal University of Applied Sciences (h2)

Since the Magdeburg-Stendal University of Applied Sciences was founded in 1991, it has earned an excellent reputation for a well-founded academic education and for a committed student body. Prospective students can choose from around 50 courses at three departments in Magdeburg and two departments at the Stendal site. Around 130 professors guarantee a very good supervision rate for around 3,700 students in Magdeburg and more than 1,800 in Stendal.

The research profile at the Magdeburg-Stendal University of Applied Sciences is characterized by future-oriented research and development activities tailored towards key markets in the state of Saxony-Anhalt and the requirements of regional businesses and institutions. To this end a large number of innovative research and development projects in the fields of engineering, economics, public health, communications and the social sciences is implemented. By concentrating specific skills in a number of competence centers it is possible to take a holistic, cross-disciplinary approach to research themes.

At the Magdeburg-Stendal University of Applied Sciences there are a total of 9 main research areas, from electrical engineering and information technology, innovative technologies, machines and components to water and recycling management. In the concrete field of application of the economy, the focus is on the following research topics:

- Management in the fields of public health, service provision, and demographics
- Entrepreneurship and risk management
- Production and process management and simulation
- Logistics and Digitalization
- Technology and investment management
- Marketing, especially for regional enterprises, institutions, and networks
- Change and sustainability management
- Staff development and inter-cultural competence

Since 2022, the Magdeburg-Stendal University of Applied Sciences has made it possible to do a PhD in the cross-university doctoral center "Social, Health and Economic Sciences" in association with the universities of applied science of Anhalt (HSA), Harz and Merseburg and in the university's own doctoral center "Environment and Technology". Already in the first phase of the acceptance applications, four doctoral projects in the context of logistics and under the supervision of Prof. Behrendt (h2) and Prof. Trojahn (HSA) were approved.

https://www.h2.de/home.html

Merseburg University of Applied Sciences

Study. Research. Live. – This is far more than just the motto of Merseburg University of Applied Sciences. As a center for applied sciences located in the south of Saxony-Anhalt in an industrial and cultural region, steeped in tradition, the university offers everything necessary to guarantee that students can enjoy success in their studies on a vibrant, green campus.

With approximately 3,000 students, Merseburg University of Applied Sciences (HoMe) is one of the smaller universities in the federal state of Saxony-Anhalt. This creates a friendly atmosphere on campus, conducive to studying as well as personal and uncomplicated support from the professors - you can easily approach them and ask for help. In addition to this, the International Office and the Registrar's Office provide help and support for international students.

Merseburg University of Applied Sciences offers students a wide range of bachelor and master programs, run by three departments:

- Department of Engineering and Natural Sciences
- Department of Social Work.Media.Culture
- Department of Business Administration and Information Sciences

At HoMe students can study in modern lecture halls, in small working groups and in practice-oriented projects. Here we place great importance on independent, team oriented and problem-solving work. The technical equipment of our laboratories, workshops and practical training rooms is state-of-the-art, thus providing students with an excellent education.

So, benefit from the pleasant studying and learning atmosphere on our green campus and become part of the HoMe!

https://www.hs-merseburg.de/

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