Proposal of a digital maturity model for e-commerce carrier

Nicollas Luiz Schweitzer de Souza[12][0000-0001-7718-1266], Davi dos Reis Terra[1], Enzo Morosini Frazzon[12][0000-0001-8497-1493] and Maurício Randolfo Flores da Silva[12][0000-0002-9334-0172]

[1]Federal University of Santa Catarina, Brazil
[2]Graduate Program in Production Engineering
nicollas_schweitzer@hotmail.com

Abstract. This research sought to build a digital maturity model applied to e-commerce courier companies, defining current tendencies and necessities in the market. The model is constituted of 6 domains based on the e-commerce consumer journey, utilizing a 1 to 5 scale to evaluate qualitative concepts to quantitative measures, in 35 indicators, observing criteria from every phase of the on-line buy where logistics fulfills a major role, such as freight bidding, package tracking and sending order data to the courier. A digital maturity matrix of the carriers of the Brazilian e-commerce segment was obtained, highlighting in the evaluations of each component the characteristics of this logistics segment, with potential pains and more consolidated phases of the market. The sample of carriers evaluated (11) concentrates a large portion of the most relevant carriers in the Brazilian e-commerce transportation market, but still does not have the largest share of the market.

Keywords: E-commerce, Logistics, Digital maturity.

1 Introduction

The COVID-19 while pandemic has been one of the most impactful events in the world in the 21st century, affecting consumer behavior [1]–[3]. One of the main movements ended up being the adoption of e-commerce as an investment focus, a factor that tends to endure in the market, with studies indicating that online retail should represent up to 25% of all retail sales, given that in 2019 was 16% [4]–[6].

Large retailers often face difficulties in choosing carriers to serve their e-commerce [7]–[9]. Also, according to the authors, these difficulties are due to the homogeneity of the transportation market in traditional value deliveries, such as: scope, price and deadline. Nowadays, these have become a minimum requirement and are no longer a differential factor between carriers [10].

The competitiveness in the transportation market, driven by e-commerce demand, brings pressure for better lead times, costs, and consequently scope and success rate

of delivery[11], [12]. The standard presented by NMFTA (National Motor Freight Traffic Association), applied in the USA, known as NMFC (National Motor Freight Classification) is a worldwide reference in the standardization of freight practices, contributing to the competitiveness in service level and simplifying the implementation of improvements in logistics processes [13].

Using a digital maturity assessment model, a comparison of best practices can be made and the present and future of the development of integrations between carriers and retailers can be defined, thus adding to the choice of a carrier by a retailer [14], [15]. In order to provide a quantitative alternative in the retailer's decision-making process when choosing a freight carrier, inserting the technology variable, which has been increasingly strategic in competitive markets such as retail and logistics, this paper proposes a digital maturity model of carriers with a use case in Brazilian e-commerce.

2 Research methodology

This research has been developed following the step-by-step approach showed in figures 1. The work starts by studying several literature references previously mentioned, looking for references to base the final maturity model. After that, the logistic and technology scope of the evaluation is determined, generating with it the model's domains.

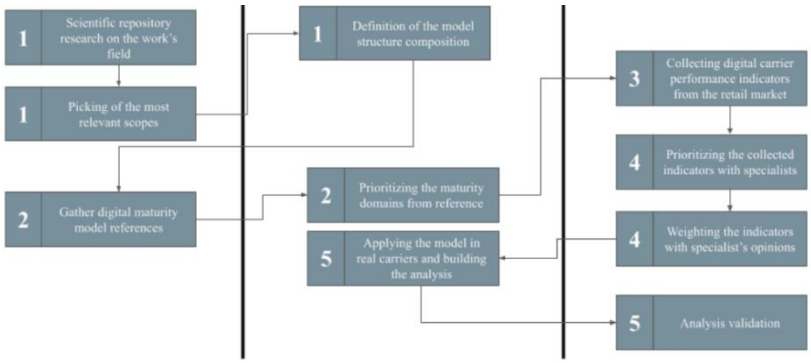


Fig. 1. Macro steps of this study.

With the base structure made, the research takes a field approach, through interviewing and following the daily routine of a logistics department on a major Brazilian retailer, looking for performance indicator references on carrier technologic maturity. Pondered by specialists' opinion, the model is applied through experimentation and questioning, giving us the results and analysis shown at the end of this research.

2.1 Building the model structure

The structure of the evaluation model was carried out through research in academic works and critical analysis of the application of various maturity models. Through research in the Scopus database, several articles on the subject were found, according to the theoretical reference. In the end, three main works were highlighted. [16] who contributed to this study with maturity model structure, evaluation dimensions, work structure, theoretical references. [15] who contributed to this study with work structure, theoretical references, evaluation dimensions, result analysis, scope limitations and ideas to expand this model. [17] who contributed to this study with work structure, theoretical references, evaluation domains definition.

[17] brings us a reference on digital maturity domains. These can be described as groups of indicators, mapping the knowledge fields treated on the research, in this case, logistics and technology. The general model by [17], was adapted on the composition of this research's model, converging the proposed definitions, noting that there is already a common means of structure among the maturity models, but there is not one applied to the context that one wishes to address (digital maturity of carriers in electronic retail). The greatest contribution of this study will be in the construction of indicators and categories respecting the analyzed context.

The maturity model built in this study must contain a quantitative evaluation of domains that must have components whose performance will be measured by indicators generated by quantitative and qualitative information. The mode of evaluation of the practices will be by analysis of collected information, experimentation, and collection of perception with experts.

2.2 Defining the evaluation's scope

According to [18], the logistics value chain has been fueled by a strong digital component in recent years. This paper will propose a model to evaluate how well a carrier uses technology adding value in the stages where it is involved.

Using as a basis the consumer journey of [19], the domains were determined as being the points of the journey where the carrier has the potential to add value to the digital consumer. The domains and components are respectively, Delivery method choice (Bidding and Customizing), Order placing (Contracting and Dispatch), Wait (Tracking and Exception flow), Receiving and checking (Last mile and Proofing), Returns (Reverse) and Technological base (Information security and Common resources). Just like the domains, the components are proposed to be derived from the topics most addressed in practice by carriers, related to the domain where it generates the most impact.

2.3 Indicator construction and grouping

In the maturity models, the previously defined dimensions act as guidelines, however, the indicators are the ones that indicate the best or worst performance of the evaluated carrier.

Indicators that are used to measure the performance of each of the defined dimensions were identified, based on the management strategy of the carriers of the retail company studied. These indicators are elaborated based on the unfolding of strategic and tactical goals of the company, omitted from the study due to their secrecy.

In the creation of the ruler, following the reference used by [15], [16] 5 levels of evaluation were determined, with reference to a high, medium, or low score according to each indicator to be evaluated, with quantitative or qualitative reference.

The final purpose of the evaluation is to understand which technologies are most used in adding value to the e-commerce consumer through the technology used in transportation logistics. Therefore, the scope of the 7Rs methodology [20] was considered to verify the initial validity of the indicators, observing to which of the "Rs" each one has the greatest impact, for subsequent prioritization. All the indicators will be considered for the next step, validation with experts. The objective is to raise options that contemplate the dimensions previously determined and that the experts' opinion order the relevant ones from highest to lowest importance.

2.4 Model's pondering

In this step, to make tangible the perception of value for each indicator measured in the model, the opinion of specialists in the areas of logistics and technology was collected. The survey was composed of 35 questions, one for each indicator, asking the respondent to classify the indicators from greatest to least importance, within each component of the maturity model.

Observing the total of 13 responses obtained, valuing the views of experts with greater impact, in the indicators most related to logistics, logistics professionals had a weight greater than 1, idem for the indicators related to technology. Considering the time of experience as a factor to determine the importance of each respondent's opinion, the opinion of professionals with up to 5 years of experience have, in the model, 25% more importance than someone with no experience. Professionals between 6 and 10 years have 50% more importance, between 11 and 20 years 75% more importance, and when the experience is longer than 20 years, 100% more importance.

In components with 4 indicators, the weight of placing an indicator in the 1st, 2nd, 3rd, and 4th position, respectively, was 0.40, 0.30, 0.20 and 0.10. For components with 3 indicators, the weights were 0.43, 0.33 and 0.23, while for components with 2 indicators, the weights were 0.67 and 0.33. Multiplying the chosen weight by the experience factor.

2.5 Application and validation

Finally, the evaluation will be performed within a sample, to be determined by data availability, starting from an initial sample of 34 carriers within the database, filtering which ones will have information and sources available to apply the proposed evaluation model. The collection of information to assign a score to one of the criteria

will be done, in a different way for each criterion. These criteria are presented as follows.

Inspection (study of documentation): Valid for criteria that require observing an aspect, whether technological or logistical, that is present or not in the integration. Test: In cases where the criterion requires measuring a value in the API performance (such as response time, for example). Responsible party evaluation: For qualitative criteria, where one seeks to understand how much indirect value is being added to the process.

Once the evaluation is complete, an analysis will be performed to achieve the specific objectives of the work, understanding what the biggest challenges and advances in the e-commerce carrier business, exceptions and fashions are, as well as identifying potential for systemic improvement, bringing business opportunities.

3 Results

3.1 Descriptive analysis of the carriers

This step aims to present the results obtained, following the methodology adopted to achieve the proposed objectives. The evaluation was applied to a sample of 11 carriers, following the model application procedures described in the previous step. From the complete database of carriers available (32) for the sample analyzed (11), those for which data was not available for the evaluation were filtered. Most of them (7) have their headquarters in the state of São Paulo, with each of the others located only in the Federal District and states of Rio Grande do Sul, Paraná, and Santa Catarina.

Observing the sample by the fleet model used for cargo transportation, we have the largest slice using the divided model of own fleet and outsourced fleet, outsourcing the transportation to partners in the industry when necessary. Two of the carriers use the franchise model, standardizing the transportation process, and two use a totally autonomous fleet, either with independent drivers and vehicles or in the cooperative model.

3.2 Variable analysis

In table 1, there is a list of the average, standard deviation, mode, median, maximum, and minimum for each component, considering the individual evaluation per carrier, already weighted by the weights established in the consultation with specialists.

Table 1. Analysis of variables per component

Component	Average	Standard deviation	Mode	Median	Maximum	Minium
Tracking	4,19	0,55	4,19	4,19	5,00	3,28
Information security	4,15	0,58	4,85	4,28	4,85	3,24

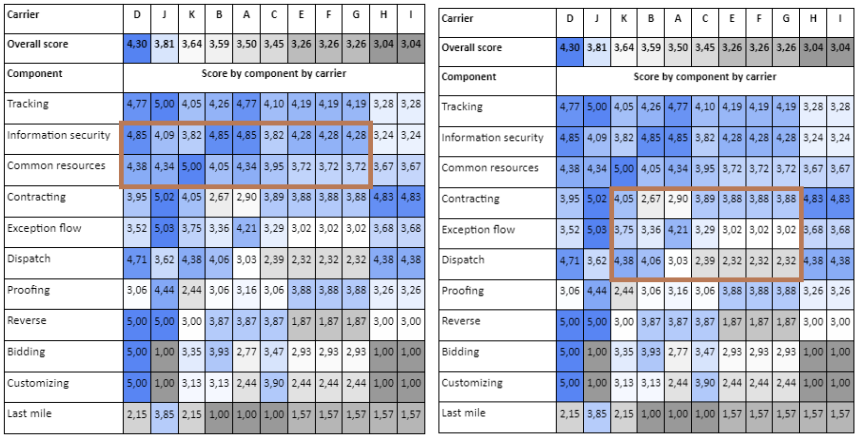
Common resources	4,05	0,42	3,72	3,95	5,00	3,67
Contracting	3,98	0,74	3,88	3,89	5,02	2,67
Exception flow	3,60	0,60	3,02	3,52	5,03	3,02
Dispatch	3,44	0,99	4,38	3,62	4,71	2,32
Proofing	3,40	0,56	3,06	3,26	4,44	2,44
Revers	3,29	1,15	3,00	3,00	5,00	1,87
Bidding	2,76	1,29	1,00	2,93	5,00	1,00
Customizing	2,54	1,26	2,44	2,44	5,00	1,00
Last mile	1,73	0,81	1,57	1,57	3,85	1,00

In the components of the domain "Choice of delivery method" (quotation and customization) there is a high ratio of standard deviation to the average, showing an average variation of 46.77% and 49.42% in relation to the average. In other words, in this domain there are representatives in the extreme positive and extreme negative of the evaluation, keeping the average low, in relation to the others, because they are two of the three lowest averages.

The indicators in the Last mile component have a low performance, with the worst mean, mode, median, lowest maximum, and lowest minimum. On the other hand, the components of the "Technology base" domain (common resources and safety) are among the three best (second and third) in average, with low deviations (two of the five smallest deviations), clarifying a consistency in the fundamental technology base among the carriers.

4 Discussion of results

Following the model of [21] for analysis, the following figure 2 was developed, with the blue color representing the highest scores and gray representing the lowest. It is noteworthy that carriers E, F and G use the same system and same digital integration, so they have the same score in the evaluation, as well as carriers H and I, which have the system (other) in common.



Carrier	D	J	K	B	A	C	E	F	G	H	I
Overall score	4,30	3,81	3,64	3,59	3,50	3,45	3,26	3,26	3,26	3,04	3,04
Component	Score by component by carrier										
Tracking	4,77	5,00	4,05	4,26	4,77	4,10	4,19	4,19	4,19	3,28	3,28
Information security	4,85	4,09	3,82	4,85	4,85	3,82	4,28	4,28	4,28	3,24	3,24
Common resources	4,38	4,34	5,00	4,05	4,34	3,95	3,72	3,72	3,72	3,67	3,67
Contracting	3,95	5,02	4,05	2,67	2,90	3,89	3,88	3,88	3,88	4,83	4,83
Exception flow	3,52	5,03	3,75	3,36	4,21	3,29	3,02	3,02	3,02	3,68	3,68
Dispatch	4,71	3,62	4,38	4,06	3,03	2,39	2,32	2,32	2,32	4,38	4,38
Proofing	3,06	4,44	2,44	3,06	3,16	3,06	3,88	3,88	3,88	3,26	3,26
Reverse	5,00	5,00	3,00	3,87	3,87	3,87	1,87	1,87	1,87	3,00	3,00
Bidding	5,00	1,00	3,35	3,93	2,77	3,47	2,93	2,93	2,93	1,00	1,00
Customizing	5,00	1,00	3,13	3,13	2,44	3,90	2,44	2,44	2,44	1,00	1,00
Last mile	2,15	3,85	2,15	1,00	1,00	1,00	1,57	1,57	1,57	1,57	1,57

Carrier	D	J	K	B	A	C	E	F	G	H	I
Overall score	4,30	3,81	3,64	3,59	3,50	3,45	3,26	3,26	3,26	3,04	3,04
Component	Score by component by carrier										
Tracking	4,77	5,00	4,05	4,26	4,77	4,10	4,19	4,19	4,19	3,28	3,28
Information security	4,85	4,09	3,82	4,85	4,85	3,82	4,28	4,28	4,28	3,24	3,24
Common resources	4,38	4,34	5,00	4,05	4,34	3,95	3,72	3,72	3,72	3,67	3,67
Contracting	3,95	5,02	4,05	2,67	2,90	3,89	3,88	3,88	3,88	4,83	4,83
Exception flow	3,52	5,03	3,75	3,36	4,21	3,29	3,02	3,02	3,02	3,68	3,68
Dispatch	4,71	3,62	4,38	4,06	3,03	2,39	2,32	2,32	2,32	4,38	4,38
Proofing	3,06	4,44	2,44	3,06	3,16	3,06	3,88	3,88	3,88	3,26	3,26
Reverse	5,00	5,00	3,00	3,87	3,87	3,87	1,87	1,87	1,87	3,00	3,00
Bidding	5,00	1,00	3,35	3,93	2,77	3,47	2,93	2,93	2,93	1,00	1,00
Customizing	5,00	1,00	3,13	3,13	2,44	3,90	2,44	2,44	2,44	1,00	1,00
Last mile	2,15	3,85	2,15	1,00	1,00	1,00	1,57	1,57	1,57	1,57	1,57

Fig. 2. Highlighted in the matrix showing aggregation of improvement opportunities in contracting (left) and consistency in the technology base (right)

Initially, it is important to observe that the sample of carriers analyzed is already the one available at the retail company studied, where the data used were obtained, therefore they undergo a process with minimum technology criteria, limiting the view of lower maturity levels, since companies with inferior technology would not be hired as carriers by the company studied. Analyzing the groupings in the full digital maturity matrix showed in table 2 built based on the evaluation model prepared, the following observations can be made based on data observations and interviews with experts.

Table 2. Full digital maturity matrix

Compone.	Indicat.	Scale			Score by carrier										
		1	3	5	A	B	D	C	E	F	G	H	I	J	K
Informa. security	Cripto.	HTTP protocol	HTTPS protocol	TLS 1.2 or superior	5	5	5	5	5	5	5	5	5	5	5
Common resources	API type	FTP	SOAP	REST	5	5	4	5	4	4	4	5	5	5	5
Tracking	Delivery process	FTP	Webhook or polling	Polling and Webhook	5	5	5	5	4	4	4	3	3	5	5
Proofing	Receiver data	N/A	Collects proof	Collects proof, with integration	4	5	5	5	5	5	5	3	3	5	3
Contracti.	Involved subjects	Only physical doc.	Integrates only basic data	Receives complete data	3	3	5	3	5	5	5	5	5	5	3
Tracking	Delivery or	N/A	Available virtually, but	Dedicated field available via	5	5	5	3	5	5	5	3	3	5	3

	scheduled updating		not trough integration	integration										
Proofing	Proof of delivery	N/A	Just image or signature	Image, signature, date/time and latitude/longitude	4	3	3	3	5	5	5	5	5	3
Informa. security	Sensitive data	Sensiti. data unnece. Transfe.	No sensitive data unnecessarily transfered	No sensitive data transfer	5	5	5	4	4	4	4	3	3	5	4
Tracking	Ocurrence date	N/A	Reality not coherent between APIs or platform	Coherent with reality in all systems	5	3	5	5	3	3	3	5	5	5	3
Contracti.	Identifier	Only own identify.	Not adaptable	Adaptable identifiers for integration	3	5	1	3	4	4	4	5	5	5	5
Tracking	Delay	delays of several minutes	seconds os minutes delay	Event-oriented flow, without considerable delay	4	4	4	3	5	5	5	2	2	5	5
Reverse	Flexibility	Reverse logistics routing	Adapted or manual, trough digital system	Automatic routing adapted to reverse logistics	5	5	5	5	3	3	3	3	3	5	3
Exception flow	Status list	Small, not compat. with the operat.	Average, still needs clarifying in specific situations	Clear, completely fulfills the operation	5	3	5	3	3	3	3	4	4	5	4
Informat. security	Access	Open APIs	Encrypted token only	Two-step authentication (OAUTH)	5	5	5	3	4	4	4	2	2	3	3
Exception flow	Operational support	No support channel	Does have an operational support channel	Agile operational support channel	5	4	3	3	3	3	3	3	3	5	4
Common resources	Simplicity	Unnecessary data transfe.	Unnecessary data transfered, not mandatory	Only necessary data transfered	4	3	4	4	3	3	3	3	3	4	5
Informat. security	Access revision	N/A	Can be changed	Periodic, by carrier's initiative	4	4	4	3	4	4	4	3	3	3	3

			manually											
Dispatch	Packing list	Only dispatch control,	Own physical proof of collection	Digital packlist available	3	3	4	3	3	3	3	3	5	3
Exception flow	IT support	No IT support channel	Unsatisfactor y delaying	Agile IT support channel	2	3	2	4	3	3	3	4	5	3
Bidding	Price auditing	Incomp. price is present.	Complete, but only full value	Complete price with detailed costs	3	3	5	3	5	5	5	1	1	3
Customi.	Complete price	System price does not always reflect reality	System price does not update during delivery process	System price reflects reality and updates during delivery process	3	5	5	4	3	3	3	1	1	5
Reverse	Delivery schedulin g	Only direct offline contact	Via carrier platform or incomplete integration	Reverse logistics process fully integrated	3	3	5	3	1	1	1	3	5	3
Customi.	Service personaliz ation	N/A	Only pre-established services available	Client is able to choose via integration the delivery service type	3	3	5	3	3	3	3	1	1	3
Last mile	Live package position	N/A	Only available at the carrier platform	Available via integration (latitutde/longitud e)	1	1	3	1	2	2	2	2	3	3
Customi.	PUDO	Only physical process	Off-line configuration is still necessary	All information is available to all users	1	1	5	5	1	1	1	1	1	1
Last mile	Delivery data	N/A	Insuficient for operational	All data necessary is available	1	1	1	1	1	1	1	1	5	1
Proofing	Proof of non delivery	N/A	Just image or signature	Image, signature, date/time and latitude/longitude	1	1	1	1	1	1	1	1	3	1

The technological base of the e-commerce carriers shows solidity. The "Security" and "Common Resources" components of the "Technology Base" domain were 2 of

the 3 with the highest average, present in the upper quadrant. Even for the lowest scoring carriers (H and I), the scores on these components are among their highest.

The contracting and screening stages are consolidated, while the quoting stage is, with large deviations, below market need. A low average is perceived for the pair components of quotation and customization, showing a low maturity when considering the practice of "live" quotation, with an e-commerce system connected to the carrier's system, reinforcing the market practice of using a fixed freight.

Reverse logistics is insufficient in general, with only one carrier standing out, as is the market trend today. The trend shows the need for a greater evolution in technology supporting reverse logistics to boost the market share.

The last mile component reflects the sample of analyzed carriers, with most of them (7) showing in their own CNAE that their main modal is the national transportation, paying little attention to the local model (last mile).

Even Last mile being the worst component on average, the worst indicator was "Proof of failure", with an average of 1.18. Meanwhile, its peer in the component, "Proof of delivery" had an average of 4.18, showing greater maturity in the success flow, but an often-non-existent proof of failure pulls the component average down.

Observing the quotation component, despite getting an average of 3.18 in the price audit (full price display), the average that pulled it down was the evaluation of the "Parameterization of restrictions", with 2.00, showing one of the big reasons for the weakness of the carriers in this domain - the susceptibility to errors, with less control by the retailer, which harms the customer experience and can lead, for example, to the need for complete reprocessing of the order, changing carriers, delaying a promised delivery.In the "Waiting" domain, all indicators of the "Tracking" component have an average greater than or equal to 4, while all indicators of the "Exception Flow" have an average lower than 4. Even though the focus of order management, and the reason for the existence of the information exchange, is the handling of exceptions, we have a weakness here, showing the importance of standardization exemplified above, as the NMFTA implies in the USA.

5 Conclusion and outlook

The digital maturity model for carriers had as its main objective the validation of its coherence before the theoretical analysis of concepts of value generation in digital retail, logistics 4.0 and in the traditional objectives of logistics, thus being formed by 6 domains that reflect the e-commerce consumer's journey, composed of 11 components that group 35 indicators that combine concepts of digital logistics with the search for efficiency in traditional logistics.

Each indicator received a weighting derived from the experience of 13 professionals with experience ranging from less than 5 to almost 20 years, weighting its importance in generating value from digital logistics as a whole. The indicators, with their parameters regulating the evaluation on a scale from 1 to 5, received an evaluation from a sample of 11 carriers, built by tests, qualitative evaluation from experts, and documentation analysis.

Finally, a digital maturity matrix of the carriers of the Brazilian e-commerce segment was obtained, highlighting in the evaluations of each component the characteristics of this logistics segment, with potential pains and more consolidated phases of the market. The sample of carriers evaluated (11) concentrates a large portion of the most relevant carriers in the Brazilian e-commerce transportation market, but still does not have the largest share of the market. There was a limitation by the reach of the retail company with the source of the data, therefore, there is still a larger universe of analysis within the e-commerce carrier's industry. Following the established by [15] there is an opportunity to correlate the digital maturity with the financial and operational performance of the company, a scope not addressed in this work, but that, considering the distinct nature of the work cited, but present in this research, of practical indicators, the possibility of such an analysis becomes open.

In this model, the profile of the cargo transported (volume, weight, quantity) was not considered as a variable. Furthermore, the methods adopted are not exclusive in the application of the work, either for the evaluation ruler, validation of the research reliability, weighting of indicators and data analysis, and may bring different results through the application of other methods.

References

1. D. Grewal, D. K. Gauri, A. L. Roggeveen, and R. Sethuraman. Strategizing Retailing in the New Technology Era. Journal of Retailing 97(1), 6–12, (2021), doi: 10.1016/J.JRETAI.2021.02.004.
2. N. Luiz, S. De Souza, M. R. Flores, P. A. Cauchick-Miguel, and E. M. Frazzon, "Analysis of product-service system logistics strategies in e-commerce," Brazilian Journal of Operations & Production Management, vol. 20, no. 4, pp. 1693–1693, Oct. 2023, doi: 10.14488/BJOPM.1693.2023.
3. N. L. S. De Souza, E. M. Frazzon, L. F. Braghirolli, M. T. Arante, and M. M. P. Mafia, "Orchestrating a ship-from-store omnichannel operation using 4pl digital platform," International Journal of Business Forecasting and Marketing Intelligence, vol. 1, no. 1, p. 1, 2022, doi: 10.1504/IJBFMI.2022.10050550.
4. S. Escursell, P. Llorach-Massana, and M. B. Roncero, "Sustainability in e-commerce packaging: A review," J Clean Prod, vol. 280, p. 124314, Jan. 2021, doi: 10.1016/J.JCLEPRO.2020.124314.
5. N. L. S. de Souza, L. A. S. Neto, D. de C. Fettermann, and E. M. Frazzon, "Evaluation of the customer requirements for last mile delivery in Brazil," Brazilian Journal of Operations & Production Management, vol. 19, no. 3, pp. 1–12, Jun. 2022, doi: 10.14488/BJOPM.2022.1360.
6. L. A. Stradioto Neto, N. L. S. de Souza, I. D. F. Rossato, J. A. Henkes, and S. Keine, "avaliação dos metodos para aplicação da análise do inventário do ciclo de vida na indústria moveleira," Revista Gestão & Sustentabilidade Ambiental, vol. 9, no. 4, p. 126, Dec. 2020, doi: 10.19177/rgsa.v9e42020126-152.
7. A. Kawa and J. Światowiec-Szczepańska, "Logistics as a value in e-commerce and its influence on satisfaction in industries: a multilevel analysis," Journal of Business and Industrial Marketing, vol. 36, no. 13, pp. 220–235, Dec. 2021, doi: 10.1108/JBIM-09-2020-0429/FULL/PDF.

8. N. L. S. de Souza, L. A. Stradioto Neto, I. D. F. Rossato, B. S. da Silva, and J. A. Henkes, “aplicação de ferramenta da indústria 4.0 em um caso com alguns cenários nacionais e internacionais,” Revista Gestão & Sustentabilidade Ambiental, vol. 9, no. 2, p. 120, Jul. 2020, doi: 10.19177/rgsa.v9e22020120-140.
9. N. Luiz Schweitzer de Souza, I. D. F. Rossato, and J. A. Henkes, “uma análise das estratégias de produção mais limpa e eficiência energética em uma indústria de equipamentos odontológicos,” Revista Gestão & Sustentabilidade Ambiental, vol. 8, no. 3, p. 639, Oct. 2019, doi: 10.19177/rgsa.v8e32019639-659.
10. M. G. Cedillo-Campos, J. Piña-Barcenas, C. M. Pérez-González, and J. Mora-Vargas, “How to measure and monitor the transportation infrastructure contribution to logistics value of supply chains?,” Transp Policy (Oxf), vol. 120, pp. 120–129, May 2022, doi: 10.1016/J.TRANPOL.2022.03.001.
11. A. Melkonyan, T. Gruchmann, F. Lohmar, V. Kamath, and S. Spinler, “Sustainability assessment of last-mile logistics and distribution strategies: The case of local food networks,” Int J Prod Econ, vol. 228, p. 107746, Oct. 2020, doi: 10.1016/J.IJPE.2020.107746.
12. N. L. S. de Souza, L. G. Mendes, E. S. Rovaris, E. M. Frazzon, and L. F. Braghirolli, “Integrated Production and Maintenance Planning: A Systematic Literature Review,” Communications in Computer and Information Science, vol. 1407 CCIS, pp. 342–356, 2021, doi: 10.1007/978-3-030-76307-7_26/COVER.
13. P. Singh, J. Singh, J. Antle, E. Topper, and G. Grewal, “Load Securement and Packaging Methods to Reduce Risk of Damage and Personal Injury for Cargo Freight in Truck, Container and Intermodal Shipments,” Journal of Applied Packaging Research, vol. 6, no. 1, pp. 47–62, Jun. 2014, doi: 10.14448/JAPR.01.0005.
14. D. Kalaitzi and N. Tsolakis, “Supply chain analytics adoption: Determinants and impacts on organisational performance and competitive advantage,” Int J Prod Econ, vol. 248, Jun. 2022, doi: 10.1016/j.ijpe.2022.108466.
15. A. Q. Messina, “O impacto da maturidade digital no desempenho de transportadoras brasileiras,” Dec. 2018, Accessed: Jan. 16, 2023. [Online].
16. N. Follmann, “Modelo de maturidade logística para empresas industriais de grande porte,” Universidade Federal de Santa Catarina, 2012. Accessed: Jan. 16, 2023. [Online].
17. A. S. Barry, S. Assoul, and N. Souissi, “Benchmarking of digital maturity models according to the dimension component, IRASET 2022, 2022, doi: 10.1109/IRASET52964.2022.9737781.
18. I. Juliet Orji, F. Ojadi, and U. Kalu Okwara, “The nexus between e-commerce adoption in a health pandemic and firm performance: The role of pandemic response strategies,” J Bus Res, vol. 145, pp. 616–635, Jun. 2022, doi: 10.1016/J.JBUSRES.2022.03.034.
19. Y. Vakulenko, P. Shams, D. Hellström, and K. Hjort, “Service innovation in e-commerce last mile delivery: Mapping the e-customer journey,” J Bus Res, vol. 101, pp. 461–468, Aug. 2019, doi: 10.1016/J.JBUSRES.2019.01.016.
20. P. Trichai et al., “Developing Warehouse Employee Performance by Applying the Principles of 7R in Logistics,” Turkish Journal of Computer and Mathematics Education, vol. 12, no. 11, pp. 4121–4126, 2021.
21. R. Venkata Rao and O. P. Gandhi, “Failure cause analysis of machine tools using digraph and matrix methods,” Int J Mach Tools Manuf, vol. 42, no. 4, pp. 521–528, Mar. 2002, doi: 10.1016/S0890-6955(01)00135-3.