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An integrative framework to driver innovation among dairy actors

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Abstract

Objective of the study: We aim to propose, and test an integrative framework for actors' orchestration in the dairy sector based on a data science perspective to drive innovation.

Methodology/Approach: To achieve this aim, a systematic literature review and content analysis were conducted, then, an integrative framework was developed and empirically tested. Subsequently, incremental adjustments in the framework's data structure were performed based on the interviews conducted through the focus group were taken into consideration. Increasing the framework assertiveness and adaptability in different contexts.

Originality/Relevance: The article delves into the world of dairy production, focusing on the key players in the milk and its derivatives sector. It emphasizes the crucial role of data in driving innovation and value co-creation among these actors. By collecting and displaying the relevant data, each player can unlock new opportunities for growth and collaboration within the value chain. The data science principle forms the bedrock of this process, as it enables a deeper understanding of the data flow and facilitates effective information-sharing across the right value chain actors.

Main results: A framework that encompasses key data that can be shared among actors, to foster information exchange and long-term relationships, promoting transparency in the process, which raises a sense of trustworthiness, responsibility, and innovation.

Theoretical/Methodological contributions: The study involves the development of an integrative framework that is constructed based on insights gathered from the systematic literature review and content analysis. This framework serves as a comprehensive and cohesive structure for understanding the utilization of data flow to connect stakeholders in the dairy sector. It highlights the key elements necessary for successful actors' relationships and outlines the potential impact on value co-creation and the generation of valuable information. Empirical contributions are made through the testing and validation of this framework with a diverse range of stakeholders in the dairy sector. Through focus groups involving multiple players within the industry, valuable insights are gathered, and the framework is tested. The empirical findings validate the applicability and effectiveness of the framework, ensuring its practicality and relevance.

Social/management contributions: The framework elevates the knowledge level about the dairy sector and its practices among stakeholders. It amplifies the potential for innovation within the sector, serves as a guiding tool that encourages stakeholders to explore new avenues for enhancing the customer experience. The social and management contributions are evident in its ability to empower stakeholders with knowledge, inspire innovation, and elevate the overall customer experience in the dairy sector.

Keywords: value co-creation, business-to-business, dairy production, data science, innovation

UM FRAMEWORK INTEGRATIVO PARA IMPULSIONAR A INOVAÇÃO ENTRE OS PRODUTORES LÁCTEOS

Resumo

Objetivo do estudo: Nosso objetivo é propor e testar um *Framework* integrativo para a orquestração de atores no setor lácteo para a inovação no setor com base na perspectiva da ciência de dados.

Metodologia/Aproximação: Para atingir esse objetivo, foram realizadas uma revisão sistemática da literatura e uma análise de conteúdo. Em seguida, uma estrutura integrativa foi desenvolvida e testada empiricamente. Posteriormente, foram realizados ajustes incrementais na estrutura de dados da estrutura com base nas entrevistas realizadas por meio do grupo de foco. Aumentar a assertividade e a adaptabilidade da estrutura em diferentes contextos.

Originalidade/Relevância: O artigo se aprofunda no mundo da produção de laticínios, com foco nos principais participantes do setor de leite e seus derivados. Ele enfatiza o papel crucial dos dados na promoção da inovação e da co-criação de valor entre esses atores. Ao coletar e exibir os dados relevantes, cada participante pode desbloquear novas oportunidades de crescimento e colaboração na cadeia de valor. O princípio da ciência de dados forma a base desse processo, pois permite uma compreensão mais profunda do fluxo de dados e facilita o compartilhamento eficaz de informações entre os atores certos da cadeia de valor.

Principais resultados: Uma estrutura que engloba os principais dados que podem ser compartilhados entre os atores, para fomentar a troca de informações e relacionamentos de longo prazo, promovendo a transparência no processo, o que gera um senso de confiabilidade, responsabilidade e inovação.

Contribuições teóricas/metodológicas: O estudo envolve o desenvolvimento de uma estrutura integrativa que é construída com base em percepções obtidas a partir da revisão sistemática da literatura e da análise de conteúdo. Essa estrutura serve como uma estrutura abrangente e coesa para compreender a utilização do fluxo de dados para conectar as partes interessadas no setor de laticínios. Ela destaca os principais elementos necessários para o sucesso das relações entre os atores e descreve o impacto potencial sobre a co-criação de valor e a geração de informações valiosas. As contribuições empíricas são feitas por meio do teste e da validação dessa estrutura com uma gama diversificada de participantes do setor de laticínios. Por meio de grupos focais que envolvem vários participantes do setor, são reunidas percepções valiosas e a estrutura é testada. Os resultados empíricos validam a aplicabilidade e a eficácia da estrutura, garantindo sua praticidade e relevância.

Contribuições sociais/gerenciais: A estrutura eleva o nível de conhecimento sobre o setor de laticínios e suas práticas entre as partes interessadas. Ela amplia o potencial de inovação dentro do setor e serve como uma ferramenta de orientação que incentiva as partes interessadas a explorar novos caminhos para melhorar a experiência do cliente. As contribuições sociais e gerenciais são evidentes em sua capacidade de capacitar as partes interessadas com conhecimento, inspirar inovação e elevar a experiência geral do cliente no setor de laticínios.

Palavras-chave: co-criação de valor, business-to-business, produção de laticínios, ciência de dados, inovação

UN FRAMEWORK INTEGRADOR PARA IMPULSAR LA INNOVACIÓN ENTRE LOS ACTORES LÁCTEOS

Resumén

Objetivo del estudio: nuestro objetivo es proponer y probar un *framework* integrativo para la orquestación de actores en el sector lácteo basado en una perspectiva de ciencia de datos para impulsar la innovación.

Metodología/Enfoque: Para alcanzar este objetivo, se llevó a cabo una revisión sistemática de la literatura y un análisis de contenido, a continuación, se desarrolló un marco integrador y se probó empíricamente. Posteriormente, se realizaron ajustes incrementales en la estructura de datos del marco basándose en las entrevistas realizadas a través del grupo de discusión. Aumento de la asertividad y adaptabilidad del marco en diferentes contextos.

Originalidad/Relevancia: El artículo se adentra en el mundo de la producción láctea, centrándose en los actores clave del sector de la leche y sus derivados. Destaca el papel crucial de los datos para impulsar la innovación y la cocreación de valor entre estos actores. Recopilando y mostrando los datos pertinentes, cada agente puede desbloquear nuevas oportunidades de crecimiento y colaboración dentro de la cadena de valor. El principio de la ciencia de los datos constituye la base de este proceso, ya que permite una comprensión más profunda del flujo de datos y facilita el intercambio eficaz de información entre los agentes adecuados de la cadena de valor.

Principales resultados: Un marco que englobe datos clave que puedan compartirse entre los agentes, para fomentar el intercambio de información y las relaciones a largo plazo, promoviendo la transparencia en el proceso, lo que aumenta el sentido de la confianza, la responsabilidad y la innovación.

Aportaciones teóricas/metodológicas: El estudio implica el desarrollo de un marco integrador que se construye a partir de las ideas recogidas en la revisión sistemática de la literatura y el análisis de contenido. Este marco sirve de estructura global y cohesiva para comprender la utilización del flujo de datos para conectar a las partes interesadas del sector lácteo. Destaca los elementos clave necesarios para el éxito de las relaciones entre los actores y esboza el impacto potencial en la co-creación de valor y la generación de información valiosa. Las contribuciones empíricas se hacen a través de la prueba y validación de este marco con una amplia gama de partes interesadas en el sector lácteo. A través de grupos de discusión en los que participan múltiples agentes del sector, se recogen valiosas percepciones y se pone a prueba el marco. Los resultados empíricos validan la aplicabilidad y eficacia del marco, garantizando su practicidad y pertinencia.

Contribuciones sociales y de gestión: El marco eleva el nivel de conocimiento sobre el sector lácteo y sus prácticas entre las partes interesadas. Amplía el potencial de innovación del sector y sirve como herramienta de orientación que anima a las partes interesadas a explorar nuevas vías para mejorar la experiencia del cliente. Las contribuciones sociales y de gestión son evidentes en su capacidad para dotar de conocimientos a las partes interesadas, inspirar la innovación y elevar la experiencia general del cliente en el sector lácteo.

Palabras clave: ~~cocreación de valorm, business-to-business, producción láctea, ciencia de datos, innovación~~

Introduction

The term "industrial services" typically refers to services that are directly associated with products or processes and are exchanged between different organizations within an ecosystem. The main objective of such services is to create a mutual perceived value among the participating businesses, while fostering collaboration among the various actors involved in the ecosystem (Boyt & Harvey, 1997; Bonamigo et al., 2022). This collaboration is aimed at driving growth, innovation, and overall success in the industrial sector.

According to Simão et al., (2022), the power of collaboration among actors in emerging countries is a game-changer in the realm of agricultural economics. It not only fuels the aggregation of value in products and services but also drives down production costs and sparks innovation. The literature has revealed a critical obstacle hindering the development of the dairy sector: the inadequate management of actors. The absence of effective management among key players has been identified as a significant barrier preventing progress in the sector (Bonamigo, 2017; Ferenhof et al., 2019). In order to unlock greater opportunities for innovation and foster valuable networking connections, the integration of collaborative and participatory processes becomes an integral component of industrial services (Dhanaraj & Parkhe, 2006; dos Santos & Zen, 2022; Ferenhof, Bonamigo, Rosa, Vieira, & Systems, 2022; Kumar, Tyagi, & Sachdeva, 2021; Maaz & Ahmad, 2022).

According to Berente et al. (2009), information serves as the foundation that supports the integration of groups, organizations, and systems within a business process context. In alignment with this, Mignoni et al., (2021) state that value co-creation is the key approach for collaborative innovation. This approach has profound implications for actor management, as it strives to enhance information transparency in the inter-organizational environment (Bonamigo et al., 2016; Ferenhof et al., 2019). By facilitating the sharing of information among actors, new experiences and services can be delivered to clients and consumers, ultimately driving growth and satisfaction in the business ecosystem.Bonamigo et al. (2018) highlight heterogeneity in technology adoption as a key barrier in the agro-industrial service context. This manifests as a lack of knowledge sharing, tools, models, procedures, and techniques, which weakens integration among the business actors. As a result, it generates fragility in the actors' potential to collaborate and creates an imbalance of power (Aarikka-Stenroos et al., 2014; Ghosh & Maharjan, 2004). Consequently, this heterogeneity further hampers transparency, communication, network potential, value co-creation, and innovation among actors in the agro-industrial settings (Gorton et al., 2015; Shams, 2015; Bonamigo et al., 2021; Marthur et al., 2018; Kashyap & Agrawal, 2019).

In the midst of these challenges, data science emerges as a formidable force, acting as the bedrock that brings together an abundance of information scattered throughout the agro-industrial landscape. In accordance with Provost (2013), Data Science can be defined as a set of fundamental principles that support and guide the principled extraction of information and knowledge from data. It possesses the remarkable ability to delve deep into this wealth of data, meticulously extracting insights (Rahm, 2000) and empowering informed decision-making. Which has a direct impact on value co-creation by actors' interactions.

In line with Ramaswamy (2011) and Bonamigo (2017), value co-creation involves configuring economic and social aspects within a network that interacts and exchanges values, to create and share value (benefit) collaboratively. However, actors within the dairy ecosystem often fail to consider their partners for long-term relationships, which poses challenges to value co-creation and hinders sector development. Limited access to resources and information, coupled with a lack of interaction and non-communication among actors, further exacerbate these challenges.

Consequently, this situation detrimentally affects the service potential within agro-industrial settings (Bonamigo et al., 2016; Bonamigo et al., 2017; Ferenhof et al., 2019; Luning & Marcelis, 2007; Manzini & Accorsi, 2013; Mazzarol et al., 2013).

Drawing from previous studies, a framework that effectively manages the dairy network emerges as a valuable guide. This framework not only ensures stability within the network but also promotes the alignment of knowledge and fosters value co-creation among actors (de Freitas Nascimento, Lima, & Gondim, 2022; Dhanaraj & Park,2006 Kashyap & Agrawal, 2019). To connect multiple actors within the network, Mariotti et al. (2018) and Dhanaraj and Parkhe (2006) propose the concept of orchestration, whereby purposeful and deliberate actions by the various links seek to generate value. By implementing these practices, the dairy supply chain can be stimulated to adopt and promote the best practices that contribute to overall improvement (Nishat Faisal, 2010).

According to Trienekens et al. (2012), the establishment of production standards plays a crucial role in fostering transparency among dairy actors. These standards serve as a foundational guide for co-creating value and promoting innovation within the industry. By clearly understanding the strengths and weaknesses of their partners, dairy actors can cultivate an environment of trustworthiness and transparency. Bonamigo et al. (2021) emphasize that trust is not only essential in contractual relationships but also facilitates effective communication and collaboration among stakeholders. O'Neill and Bardrick (2015) highlight the importance of considering diverse perspectives and open communication channels to enhance trustworthiness. Utilizing information systems is a primary means through which transparency is achieved, ensuring adherence to quality and safety standards (Trienekens et al., 2012). Furthermore, transparency is required not only within the industry but also extends to the information and knowledge shared with suppliers (Ferenhof et al., 2022).

Moreover, Pant et al. (2015) assert that transparency among stakeholders is valuable for all participants in a business ecosystem. It strengthens relationships, facilitates knowledge sharing, and provides access to essential product-related information without any loss, noise, or delays. Therefore, transparency becomes a powerful asset in industrial services, allowing partners to gain access to relevant actions and properties of their collaborators (Eggert and Helm, 2003; Bonamigo et al., 2022).

Given the increasing quantity and quality of data generated by livestock systems in recent years (Wolfert et al., 2017), the effective use of data management becomes a crucial ally for decision-making (Chaudhuri et al., 2018). With the help of proper data management techniques, the vast amount of data can be efficiently processed, leading to valuable insights and information that can inform decision-making processes.

However, despite the potential benefits, the complexity of data management has prevented the utilization of advanced equipment and machinery to transform data into information and subsequently into knowledge within the dairy sector (Sefeedpari et al., 2020). This complexity has created barriers in effectively harnessing the data generated by these systems for activities on dairy supply chain actors. As a result, valuable data that could potentially drive improvements in livestock operations and overall dairy productivity goes untapped.

Based on the exposure, this study aims to propose and test an integrative framework for actors' orchestration in the dairy sector based on data science perspective to guide the data management activities and accountability of each dairy supply chain actor. The framework offers support and guidance, addressing the information transparency gaps among the key actors within the dairy sector while nurturing a culture of innovation. Thus, we name those actors as: farmers, dairy processors, transporters and cooperatives (Al-Fuqaha et al., 2015); Bonamigo, 2017;

Galstyan & Harutyunyan, 2016; Minh & Hjortsø, 2015; Pant et al., 2015; Poláková et al., 2015; Ramaswamy & Ozcan, 2018; Winck, 2013).

According to Verhoosel et al. (2015), rural farmers are migrating to precision livestock, in which the information available for decision-making is becoming crucial for gaining competitive advantages. Some of the reasons that prevent this information sharing can be fear of information leakage, lack of clear performance indicators, differences in educational levels, lack of entire ecosystem knowledge, and lack of clarity on mutual benefits and actors' management (Bonamigo et al., 2020; Bonamigo et al., 2017; Dantas et al., 2016; Okano et al., 2014).

The absence of information sharing within the supply chain leads to transactional relationships among the parties involved, resulting in adverse consequences. These transactional interactions give rise to a dearth of long-term vision in the procurement process, a lack of comprehension regarding the values each actor demands, and a deficiency in product and service standards across the supply chain network. Additionally, the absence of innovation hinders the co-creation of value (Manzini & Accorsi, 2013).

According to Nurmaganbetova et al. (2019), the agro-industrial service is created by the actors' partnership to improve quality, supply chain efficiency, innovation and consequently, social development. In this way, the customers acquire better product quality, better cost-benefit and services linked to the product. Moreover, customer desire is mentioned by Troccoli and Altaf (2012), as a decision-making process that considers the involvement of social, psychological, environmental, political and technological elements in the purchase and consumption.

Our paper contributes to gathering the main actors presented in the dairy sector, and how each of them can support specific information sharing about their role in the value chain in agro-industrial service (Achchuthan et al., 2012; Bonamigo, 2017; Ferenhof et al., 2019). Some of them are Milk quality by farmers, logistics by transporters, demand by dairy processors, and best practices by cooperatives. In this way, the findings contribute to the actors' management, since this framework seeks to increase the relationship among them, improving the process overview so that they can have competitiveness (Bonamigo, 2017; Bonamigo et al., 2022).

In this way, the value co-creation becomes a strategy to bring together the players of the agro-industrial ecosystem for joint collaboration to overcome the barriers presented, as well as to develop services that generate value for the agro-industrial supply chain and open opportunities for innovation (Asmara et al., 2017; Junior et al., 2022; Newton et al., 2020; Rong-Da Liang, 2017; Tardivo et al., 2017).

For performing this research, our study was guided by the following research questions:

a) Who are the essential actors to co-create value and innovate in the dairy sector?

b) What kind of data are drivers to innovate the transparency among the actors in the dairy ecosystem?

Methodology

This study aims to propose and test an integrative framework for actors' orchestration in the dairy sector based on data science perspective. To achieve the proposed objective, five steps were conducted, which are: 1. Systematic literature review; 2. Content analysis; 3. Integrative framework construction; 4. Empirical testing of the framework and 5. Incremental post-test adjustments. The aforementioned methodological strategy was based on Bonamigo (2017).

The first stage comprised the Systematic Literature Review (SLR), to enable the survey of a portfolio of works that met the research scope. This stage of the research was based on the Systematic Search Flow Method (SSF), proposed by Ferenhof and Fernandes (2016), whose objective was to systematize in a didactic way all the steps of the search process for scientific data.

In dealing with the stages presented by the SSF method, first to conduct the literature mapping, the research question of interest, the keywords, and the inclusion and exclusion criteria to be adopted were defined. The research question used was, "How has Industry 4.0 technology been used in dairy production relationships?" and "How can it impact the transparency management among the dairy ecosystem?"

The search strings were tested on the databases and adjusted to calibrate the search query: ((“dairy production” OR “dairy farming” OR “dairy products” OR “dairy ecosystem” OR “milk supply chain” AND (“data analytics” OR “data analysis” OR “data science”) AND (innovation) AND (management OR business OR administration OR governance)).

The search bases that were used are Ebsco, Emerald, Science Direct, Scopus, Village and Web of Science. Regarding the inclusion or exclusion criteria, only peer-reviewed academic articles in English were analyzed. In addition, the portfolio of works considered were those that presented a relationship between Data management and the agro-industrial system. On the other hand, non-academic reports and research papers, languages other than English, works that did not adhere to the scope of the search, and works unrelated to the research objective were excluded. Furthermore, the portfolio resulting from the search was consolidated in an electronic spreadsheet and found organized.

In the second stage, the database collection was performed. This search stage was performed on December 18, 2022, and a total of 953 works were obtained, 359 of which were duplicates, which were later removed. This resulted in 594 works presented in Table 1.

Table 1

Resulting bibliographic portfolio

Data Base	Number of works found
Science Direct	761
Scopus	57
Emerald	49
Ebsco	47
Web of Science	23
Village	16
Total	**953**
Duplicates	**- 359**
Total RBS results	**594**

Source: The authors

The third stage is defined by the evaluation of the works that adhere to the search scope and that will be selected for the integrative framework construction. During this stage, the evaluation of relevance was conducted by reading the titles, abstracts, and keywords to verify the alignment of the works with the research scope. Based on the portfolio resulting from this stage, the authors read all the works.

For the fourth stage referring to the second step, it was conducted content analysis with the data extracted from the portfolio consisting of three phases mentioned by Bardin (2011), being defined as 1. Pre-analysis, in which should be chosen the material (corpus) that will be analyzed; 2. Exploration of the material or coding, according to previously formulated rules (e.g., presence, absence, frequency, or intensity) and; 3. Treatment of the results obtained and interpreted, consists of the preparation of diagrams, figures, and models as mentioned in the fifth stage of the SSF method.

Based on the analysis described in the third step of the method, it was possible to obtain a portfolio of 50 articles, which was read completely by the authors. In addition, a complementary exploratory search was subsequently conducted, ready completely and mentioned on the paper. Appendix 1. The 50 resulting articles found during the SSF method are described in Table 2.

Table 2

Portfolio of papers adhering to the scope of the search

Code	Authors (Year)	Title	Journal
A1	Sefeedpari, Shokoohi, and Pishgar-Komleh (2020b)	Dynamic energy efficiency assessment of dairy farming system in Iran: application of Window Data Envelopment Analysis	Journal of Cleaner Production
A2	Østergaard, Lastein, Emanuelson, Rustas, Krogh, Kudahl, Munksgaard, and Kristensen (2020)	Feasibility of Evolutionary Operation (EVOP) as a concept for herd-specific management in commercial dairy herds	Livestock Science
A3	Kolipaka (2020)	Predictive analytics using cross media features in precision farming	International Journal of Speech Technology
A4	Susanty, Puspitasari, Prastawa, and Renaldi (2020)	Exploring the best policy scenario plan for the dairy supply chain: a DEMATEL approach	Journal of Modelling in Management
A5	Higaki, Koyama, Sasaki, Abe, Honkawa, Horii, Minamino, Mikurino, Okada, Miwakeichi, Darhan, and Yoshioka (2020)	Technical note: Calving prediction in dairy cattle based on continuous measurements of ventral tail base skin temperature using supervised machine learning	Journal of Dairy Science
A6	Ferris, Christensen, and Wangen (2020)	Symposium review: Dairy Brain—Informing decisions on dairy farms using data analytics	Journal of Dairy Science
A7	Cabrera, Barrientos-Blanco, Delgado, and Fadul-Pacheco (2020)	Symposium review: Real-time continuous decision making using big data on dairy farms	Journal of Dairy Science

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A8	Yang, Huisman, Hettinga, Liu, Heck, Schrijver, Gaiardoni, and van Ruth (2019)	Fraud vulnerability in the Dutch milk supply chain: Assessment Of farmers, processors and retailers	Food Control
A9	Taneja, Jalodia, Malone, Byabazaire, Davy, and Olariu (2019)	Connected Cows: Utilizing Fog and Cloud Analytics toward Data-Driven Decisions for Smart Dairy Farming	IEEE Internet of Things Magazine
A10	Taneja, Jalodia, Byabazaire, Davy, and Olariu (2019)	SmartHerd management: A microservices-based fog computing assisted IoT platform towards data-driven smart dairy farming	Software - Practice And Experience
A11	Michels, Bonke, and Musshoff (2019)	Understanding the adoption of smartphone apps in dairy herd management	Journal of Dairy Science
A12	Mancini Maria, Arfini, and Guareschi (2019)	Innovation and typicality in localized agri-food systems: the case of PDO Parmigiano Reggiano	British Food Journal
A13	Ferenhof Helio, Bonamigo, Cunha Andre, Tezza, and Forcellini Fernando (2019)	Relationship between barriers and key factors of dairy production in Santa Catarina, Brazil	British Food Journal
A14	Zhang, Zhou, Zuo, Zhang, Bi, Jin, and Xu (2018)	Prediction of Dairy Product Quality Risk Based on Extreme Learning Machine	2018 2nd International Conference on Data Science and Business Analytics (ICDSBA)
A15	Schuetz, Schausberger, and Schrefl (2018)	Building an active semantic data warehouse for precision dairy farming	Journal of Organizational Computing and Electronic Commerce
A16	Nielsen, Fontana, Sloth, Guarino, and Blokhuis (2018)	Technical note: Validation and comparison of 2 commercially available activity loggers	Journal of Dairy Science
A17	Dórea, Rosa, Weld, and Armentano (2018)	Mining data from milk infrared spectroscopy to improve feed intake predictions in lactating dairy cows	Journal of Dairy Science
A18	Chaudhuri, Dukovska-Popovska, Subramanian, Chan, and Bai (2018b)	Decision-making in cold chain logistics using data analytics: a literature review	International Journal of Logistics Management

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A19	Bonamigo, Ferenhof Helio, Tezza, and Forcellini Fernando (2018)	Dairy production barriers diagnosis in Southern Brazil	British Food Journal
A20	Zhong, Xu, and Wang (2017)	Food supply chain management: systems, implementations, and future research	Industrial Management & Data Systems
A21	Zehner, Umstatter, Niederhauser, and Schick (2017)	System specification and validation of a noseband pressure sensor for measurement of ruminating and eating behavior in stable-fed cows	Computers and Electronics in Agriculture
A22	Wang, and Yue (2017)	Food safety pre-warning system based on data mining for a sustainable food supply chain	Food Control
A23	Van De Gucht, Saeys, Van Nuffel, Pluym, Piccart, Lauwers, Vangeyte, and Van Weyenberg (2017)	Farmers' preferences for automatic lameness-detection systems in dairy cattle	Journal of Dairy Science
A24	Tse, Barkema, DeVries, Rushen, and Pajor (2017)	Effect of transitioning to automatic milking systems on producers' perceptions of farm management and cow health in the Canadian dairy industry	Journal of Dairy Science
A25	Kulatunga, Shalloo, Donnelly, Robson, and Ivanov (2017)	Opportunistic Wireless Networking for Smart Dairy Farming	It Professional
A26	Chudasama, Dobariya, Patel, and Lopes (2017)	DAPS: Dairy analysis and prediction system using technical indicators	2017 Third International Conference on Sensing, Signal Processing and Security (ICSSS)
A27	Tremblay, Hess, Christenson, McIntyre, Smink, van der Kamp, de Jong, and Döpfer (2016)	Customized recommendations for production management clusters of North American automatic milking systems	Journal of Dairy Science
A28	Minegishi (2016)	Comparison of production risks in the state-contingent framework: application to balanced panel data	Journal of Productivity Analysis
A29	Verhoosel, Van Bekkum, and Van Evert (2015a)	Ontology matching for big data applications in the smart dairy farming domain	10th International Workshop on Ontology Matching, OM

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A30	Trafialek, Laskowski, and Kolanowski (2015)	The use of Kohonen's artificial neural networks for analyzing the results of HACCP system declarative survey	Food Control
A31	Krug, Haskell, Nunes, and Stilwell (2015)	Creating a model to detect dairy cattle farms with poor welfare using a national database	PreventiveVeterinary Medicine
A32	Kamal, and Karoui (2015)	Analytical methods coupled with chemometric tools for determining the authenticity and detecting the adulteration of dairy products: A review	Trends in Food Science and Technology
A33	Busse, Schwerdtner, Siebert, Doernberg, Kuntosch, König, and Bokelmann (2015)	Analysis of animal monitoring technologies in Germany from an innovation system perspective	Agricultural Systems
A34	Borchers, and Bewley (2015)	An assessment of producer precision dairy farming technology use, pre purchase considerations, and usefulness	Journal of Dairy Science
A35	Alsaaod, Niederhauser, Beer, Zehner, Schuepbach-Regula, and Steiner (2015)	Development and validation of a novel pedometer algorithm to quantify extended characteristics of the locomotor behavior of dairy cows	Journal of Dairy Science
A36	White, and Capper (2014)	Precision diet formulation to improve performance and profitability across various climates: Modeling the implications of increasing the formulation frequency of dairy cattle diets	Journal of Dairy Science
A37	Espetvedt, Reksen, Rintakoski, and Østerås (2013)	Data quality in the Norwegian dairy herd recording system: Agreement between the national database and disease recording on farm	Journal of Dairy Science
A38	Pinedo (2011)	Applied Statistical Analyses for Dairy Production	Dairy production medicine
A39	Demeter, Kristensen, Dijkstra, Oude Lansink, Meuwissen, and van Arendonk (2011)	A multi-level hierarchic Markov process with Bayesian updating for herd optimization and simulation in dairy cattle	Journal of Dairy Science

Continues on the next page

A40	Samad, Murdeshwar, and Hameed (2010)	High-credibility RFID-based animal data recording system suitable for small-holding rural dairy farmers	Computers and Electronics in Agriculture
A41	Tempelman (2009)	Invited review: Assessing experimental designs for research conducted on commercial dairies	Journal of Dairy Science
A42	Hruškar, Major, Krpan, Krbavčić, Šarić, Marković, and Vahčić (2009)	Evaluation of milk and dairy products by electronic tongue	Ocjenamlijekaimliječnih proizvodaelektronskimje zikom.
A43	Cannon Alan, Reyes Pedro, Frazier Gregory, and Prater Edmund (2008)	RFID in the contemporary supply chain: multiple perspectives on its benefits and risks	International Journal of Operations & Production Management
A44	Herrero, González-Estrada, Thornton, Quirós, Waithaka, Ruiz, and Hoogenboom (2007)	IMPACT: Generic household-level databases and diagnostics tools for integrated crop-livestock systems analysis	Agricultural Systems
A45	Mottram, Velasco-Garcia, Berry, Richards, Ghesquiere, and Masson (2002a)	Automatic on-line analysis of milk constituents (urea, ketones, enzymes and hormones) using biosensors	Comparative Clinical Pathology
A46	Tomaszewski, Van Asseldonk, Dijkhuizen, and Huirne (2000)	Determining farm effects attributable to the introduction and use of a dairy management information system in the Netherlands	Agricultural Economics
A47	Solano, Bernués, Rojas, Joaquín, Fernandez, and Herrero (2000)	Relationships between management intensity and structural and social variables in dairy and dual-purpose systems in Santa Cruz, Bolivia	Agricultural Systems
A48	van Tassell, Wiggans, and Norman (1999)	Method R Estimates of Heritability for Milk, Fat, and Protein Yields of United States Dairy Cattle	Journal of Dairy Science
A49	Pellerin, Levallois, St-Laurent, and Perrier (1994)	LAIT-XPERT VACHES: An Expert System for Dairy Herd Management	Journal of Dairy Science
A50	Tomaszewski (1993)	Record-Keeping Systems and Control of Data Flow and Information Retrieval to Manage Large High Producing Herds	Journal of Dairy Science

Source: The authors

Integrative framework construction

The third step contemplated the integrative framework construction, based on the model presented by Saeed et al. (2003), which enables an easier understanding of the key actors and their respective subgroups. Initially, using the findings of the research portfolio, it was possible to define the four main actors that are part of the dairy ecosystem, these being: Farmers; Dairy processors; Transporters, and Cooperatives. Thus, we analyzed the types of relationships that each actor has with the variables that define data collection, such as Milk Quality; Logistics; Livestock information, and Demand. Besides the portfolio analyzed with the SSF, we had to further search for articles that could give more in depth understanding about each of the actors present in the dairy ecosystem. In the study of the relationship among the actors and data collection, it was taken into consideration the types of data that each key actor individually could be generating within this framework, based on the organization's network and individuals who compete and cooperate (Moore, 1996; Moore, 1993; Peltoniemi, 2006).

By obtaining the data provided by the actors of the dairy ecosystem, it is possible to perform relational analyses with them. During this step, we use the following steps: Processing, Cleaning, and Analysis. For Wolfert et al. (2017), the decision-making process becomes increasingly complex, and the use of the mixture of data coming from humans and machines, provide decision and data accuracy for dairy processors.

Empirical test of the integrative framework

Once the integrative framework was developed, then the empirical tests began. For this, we used the Focus Group method with professionals, and academics directly linked to the dairy sector, such as farmers, dairy processors, cooperatives, and transporters. The focus group method is defined by Sim et al. (2019) and Barbour (2008), as the ability to interact among participants who share their points of view on a problem, theme, or situation.

Additionally, the method emphasizes the use of a moderator, whose responsibility is to conduct the group interviews and obtain the data necessary to support the study (Kitzinger and illness, 1994).

Following Morgan (1996) and Sim et al. (2019), Kamberelis & Dimitriadis (2013), the moderator's level of involvement can be considered as more or less structured. In the first type, it is emphasized by the authors that there is the use of questions focused on specific points that help to drive the focus group and benefit the removal of attention from issues that are unimportant to the study.

In the second type mentioned, Sim et al. (2019) state that this type of structured involvement seeks to control the interaction of the people in the focus group. Ensuring that all participants are participating equally in the focus group. We conducted the focus group in a semi-structured way, using a questionnaire with open questions in which each of the participants could expose their ideals and perceptions concerning the questions. The research protocol is described in Appendix 2, which presents the sequence of questions asked according to the order of the integrative framework presentation.

The focus group was conducted to test the proposed framework. In this step, we conducted interviews with 9 experts in a group (Morgan, 1996). The respondents have different positions (decision-makers) in the agro-industrial sector and with some experience with data science. In addition, we recorded the interviews with all the people who authorized it, which later served as a source of data to be analyzed for the improvement of the integrative framework. Considering the duration of the interviews, based on Fernqvist et al. (2015), we managed the time within five hours and five minutes.

Conducting the focus group

To Shetty et al. (2017), the complete visualization of the dairy ecosystem is not yet fully explored by the literature, and thus, to test the framework developed, a focus group was conducted where the participants were professionals in the industry, such as Farmers, Dairy Processors, Data scientists, Dairy Industry Academics, Cooperative and Milk Transportation Specialists. Initially, we limited our focus group only to the dairy sector professionals. With the result of these contacts made through e-mails, a total of 9 participants were selected for the focus group, which lasted 5 hours and 5 minutes.

To conduct the focus group, we developed a protocol to be followed, as presented in Appendix 2. To conduct the focus group, it was necessary to create a questionnaire. Thus, semi-structured questions were used so that the participants could openly discuss their criticisms and opinions about the integrative framework. The questions aimed to assess whether the elements presented in the integrative framework were sufficient to provide information transparency in the dairy industry. The interview questions were written in Portuguese and later translated into English. Appe

Incremental adjustments in the integrative framework

With all the feedback received by the interviewees, the authors organized them in an electronic spreadsheet for critical analysis of the points mentioned by the experts. As criteria for adopting the indicated improvements, the following criteria were analyzed:

"Did these changes seek to further adapt the reality of the dairy ecosystem?", "Does the suggestion have a direct or indirect impact on data transparency among the parties?", "Does it contribute to the integration of the parties?", once the mentioned increment was evidenced as convenient, it was added to the mentioned developed framework.

Results and discussions

The following results were divided into 2 subtopics. The integrative framework construction and the second is the testing of the framework conducted through the focus group.

Integrative framework construction

To create the framework, the perspective of a user entering data into a system was used to generate valuable information for the actors in the dairy ecosystem process (Ramtahalsing et al., 2020). According to Bonamigo et al. (2017), a service system represents any configuration of value co-creation composed of people, technology, and information sharing. In this case, the goal is to generate the sharing of beneficial information for the actors involved transparently in this kind of industrial services. With this, after obtaining the theoretical foundations of content analysis and its respective constructs, it was possible to structure the integrative framework. Thus, it was composed of four columns: Actors, Data Collection, Data Science, and Output.

Actors

For the framework construction, it was observed a gap in the connection among the actors of the dairy ecosystem process, which impacts the mutual decision making and the potential to innovate solutions among them (Mazzarol et al., 2013). Following Li (2021), the partnership quality is intrinsically related to the knowledge shared by the members present in an industrial service environment.

Once the knowledge transference increases, the partnership between buyer and supplier positively affects the knowledge shared among them. Following the supply chain collaboration literature, the close relationship among the actors can effectively affect the quality of decision-making, performance beyond the actor's expectations (Kumar et al., 2016), and efficiency among the businesses (Silva et al., 2021).

To Bonamigo et al. (2017), a factor that limits the development of the dairy sector is the excessive use of transactional relationships, in which a relationship bond is broken the moment one of the parties does not fulfill its responsibilities. Since it prevents the development of the links in the production chain and the building of a long-term relationship. In addition, the lack of trust among the actors in the dairy sector increases the lack of loyalty among them (Boniface et al., 2012; Morgan & Hunt, 1994).

The principal actors in the dairy chain are producers, transporters, cooperatives, and dairy processors. Each actor has an indispensable role in the value chain, and from the moment each one submits its data to the system, the data management occurs and it improves the industrial service relationship among the actors (Annanperä et al., 2015; Moore, 1993; Valkokari, 2015). Producers, according to Berge et al. (2020), are responsible for the maintenance of cattle and their respective controls to maintain and improve the quality of raw milk, within sanitary regulations.

On the other hand, transporters are the link between the producer and the dairy company Kumar et al. (2011), so they are essential for the successful operation of the supply chain. Their function in Brazil is to perform the hygienic and proper collection of milk, which should occur only if the milk presents the normal or minimum conditions according to the guidelines of its buyer (dairy processor). In some regions of Brazil, the transporter performs some quality tests before collection, such as the Alizarol® solution test, which tests the acidity and measures the milk temperature before it is collected into the storage tank.

Dairy processors are considered the largest purchasers of raw milk once they need it to produce derivatives and supply quality milk to their consumers within very restricted standards (Winck, 2012). Thus, the co-creation among the producers, dairy processors and transporters may bring innovative operations' solutions to streamline processes, reduce the customer lead-time, achieve higher quality standards among others. Besides the business side related to a faster Source to Pay process, and predictability of cash flow for the actors involved.

Cooperatives are formed by producers and aim to promote welfare among the dairy actors (Sebayang, 2013), besides being a support link for the actor's management. In the present framework, we emphasized it, because they play the role of linking producers and dairy processors (Byrne, 2022).

For Susanty et al. (2018), cooperatives have a role in providing producers with services and inputs for their development. Examples are the facility to sell milk directly to dairy processors, credits to buy feed and medicines for the herds, and also, services such as animal insemination. Therefore, they serve as a support link for producers and help them become more competitive in the market and promote innovative benchmarks among the producers (Botaro et al., 2013; Ferenhof et al., 2019; Mazzarol et al., 2013; Rice et al., 2012).

Data collection

To have transparency in the actors' relationship in the dairy chain, relevant data needs to be shared by each of the actors. Thus, they can collaborate without any waste of information and, consequently, they can create collective knowledge (Hecker, 2012). This data makes up the data collection column in the framework, where it has been divided into 4 topics: Milk quality, Logistics, Animal information, and Demand. To obtain the links among the subtopics of Data Collection, it was necessary to consider the links among the data availability that each actor holds for individualized insertion in the system.

The literature presents several essential notes for data collection regarding milk quality, such as temperature, environment and equipment surveillance certification, SCC, TBC, fat percentage, protein percentage, and production automation level. To Winck (2012), quality occurs through cleanliness, hygiene, sanitary standards, and animal feed, among others. Somatic Cell Count (SCC) and Total Bacterial Count (TBC) are prerequisites for dairy processors (Botaro et al., 2013; Winck, 2012).

Furthermore, to achieve the quality prerequisites demanded by the dairy processors, it is required a high level of milk protein and fat, so the dairy producer can benefit from a bonus or an additional payment to produce within the quality standards. Winck (2012) mentions that the temperature measured when milk is collected by transporters must be within the purchasing guidelines established by the buyer. According to the Brazilian normative instruction of November 26, 2018, the temperature of the milk until it reaches the dairy cannot exceed 7 degrees Celsius. This reduces the damage that can occur to the health of the final consumers in the dairy chain. Thus, the precision farming concept is a facilitator to achieving the growing market demand, with the use of equipment and sensors to assist in the dairy production process automation. In this sense, Verhoosel et al. (2015) exposes that the data generated by the equipment systems used in the automation are indispensable to support decision making and are crucial to maintaining competitive advantages in the process management.

Variables are a level of requirements to be evaluated by the actors (Farmers, Transporters and Dairy Processors) involved in the agro-industrial sector. All these variables are to verify the quality level within pre-defined terms signed in contracts between the organizations. Thus, it involves a collaborative process once all of the actors are responsible for the product quality. In accordance with Boyt and Harvey (1997) and Bonamigo et al. (2022), they seek to enhance the value perceived among them as it is cited in the definition of industrial services.

Regarding the subtopic Logistics, we can consider essential data for decision making: distance among partners, certification of vehicle conditions for milk transportation, location update, and road conditions. The distance among partners is directly linked to the purchase decision. To Bánkuti and Caldas (2018), large distances from the milk distribution route to the processing companies can make the product unviable. However, if the actors have developed relationships and trust through the value co-creation, innovations in the distribution process can be beneficial for all actors involved. According to Urquhart and Viera (2002), data related to the quantity demanded by the buying dairy processors enables analysis with the purpose of making consistent decisions to reduce the transportation cost and valuing producers which are located in regions near the buyer.

According to dos Santos et al. (1999), until 1999 most of the milk was stored in cans, which increased the number of undesirable microorganisms. To solve this problem, some authors in the literature mention the use of trucks with tanks for milk storage and transport to the dairy processors and emphasize the importance of the tanks being within the conformities required by the food safety standards and the importance of innovation to foster product quality (Chokanat et al., 2019).

The route of the transporter is an important point to be taken into account in decision making, where the condition of the road can be classified as asphalt, dirt, narrow, bumpy, among others (Urquhart & Viera, 2002). To Bánkuti & Caldas (2018), such conditions affect the transportation time, thus it is essential to have an update on the vehicle location, for product quality control and to minimize the fraud risks on the route.

About Livestock Information, it was possible to identify the following data for decision making in the dairy processor: health, feed type, a production average, herd size, species history, and animal tracking devices.

According to Taneja et al. (2019), there are two main ways to control productivity and increase profitability in dairy farms. The first is monitoring livestock welfare to treat and prevent abnormalities and diseases. The second is to improve cattle reproduction and milk yields through data accuracy and increased farms. It is also mentioned that the use of wearable devices on animals, enables better animal monitoring and becomes fundamental to overcoming common producers' problems, such as cattle reproduction, health monitoring, and animal welfare. Another factor is transparency about the food type provided to the animals.

To Mottram et al. (2002), nutritional monitoring is essential for good metabolic functioning and to obtain parameters that serve for decision-making about quality and genetic selection. In this sense, the Logistics aligned with Livestock Information may create better value perceived by the partners promoting efficiency in the industrial service. For the average production sold in the market, it is important to know the potential of the herd, so there is transparency in the negotiation regarding the amount that will be marketed and not generate conflicts or lack of trust among partners (Schuetz et al., 2018).

With Milk quality, Logistics, and Animal information data shared, it is possible to have greater precision about the product quality, and such information is valuable to make the best deals among the partners (Shingh et al., 2020). With the data visible to the entire chain, the chances of product fraud concerning quality are reduced. In addition, it provides traceability in all process stages, as the data entry is done jointly with the main members of the chain. It also opens up new business opportunities among the partners, being able to simulate routes and find the shortest distance to the producer, or even source a supplier with higher quality in distant locations fostering business innovations (Bonamigo, 2017).

Another factor that shows to be essential in the literature for decision making is the subtopic of Demand. Thus, it was sought to detail it in the framework as follows: Quantity per collection, Buyer guidelines, and Purchase price. According to Winck (2012), consumer demands are the starting point for improvements in the milk production chain. And all actors involved should work towards quality and food safety seeking the industrial services improvement within the data created among the organizations, and consequently enhancing the traceability potential (Pant et al., 2015).

In addition, Urquhart and Viera (2002) present that the demand is considered one of the data for the chain management, as well as: the capacity of milk tanks, process capacity, service time, and production type. The framework aims to provide greater milk production management, improving the quality of products, and the actor's involvement in the data management, bringing innovative ideas and actions to the business excellence (Lopes et al., 2005).

Data science

The need for the basic data for decision-making among the four mentioned actors was found due to the papers selected as a bibliographic portfolio. Among them is the one presented by Pant et al. (2015) and Saeed et al. (2003), which demonstrate the arrangement of the connections among the basic elements, and which was later used to emphasize the elementary data for the actors of the dairy ecosystem. Data is a basis for innovation between actors, for example Big Data can be an enabler of knowledge creation in co-innovation, acting as a driver for co-innovation processes based on customer engagement, impacting on service ecosystems (Bresciani et al., 2021). By the data mentioned in the Data Collection, data processing and cleaning are needed, so that only after all this process a reliable analysis can be generated (Mishra & Eich, 1992; Rahm & Do, 2000).

To Kraleva et al. (2018)**,** the main problems faced with the data coming from this sector are storage, data access, sharing, processing, and analysis. In addition, it is required that formats be predefined in which the objective is to make the processing and its relational analysis. With this, due to the high amount of data in the ecosystem, its processing becomes essential. Data collection can generate a lot of important information for the business, but to find it, it is necessary to process and treat the data, so that it can be polished into valuable information (Faria et al., 2020). After that, another step is data cleaning, which consists in detecting errors and data inconsistencies. These problems are derived from data collection, where spelling errors, missing information, and other invalid data can occur.

Rahm and Do (2000), mention that data cleaning is especially important when aiming to integrate heterogeneous data from different sources. Thus, it is possible to use statistical models to help visualize outliers and forecasts. Once collaboration with supply chain stakeholders is possible based on indicators shared (Maaz and Ahmad, 2022). Knowledge management is an important pillar within industrial services, and for it to occur, data needs to be treated so that it becomes information, and this information returns knowledge about the dairy chain to the actors.

Output

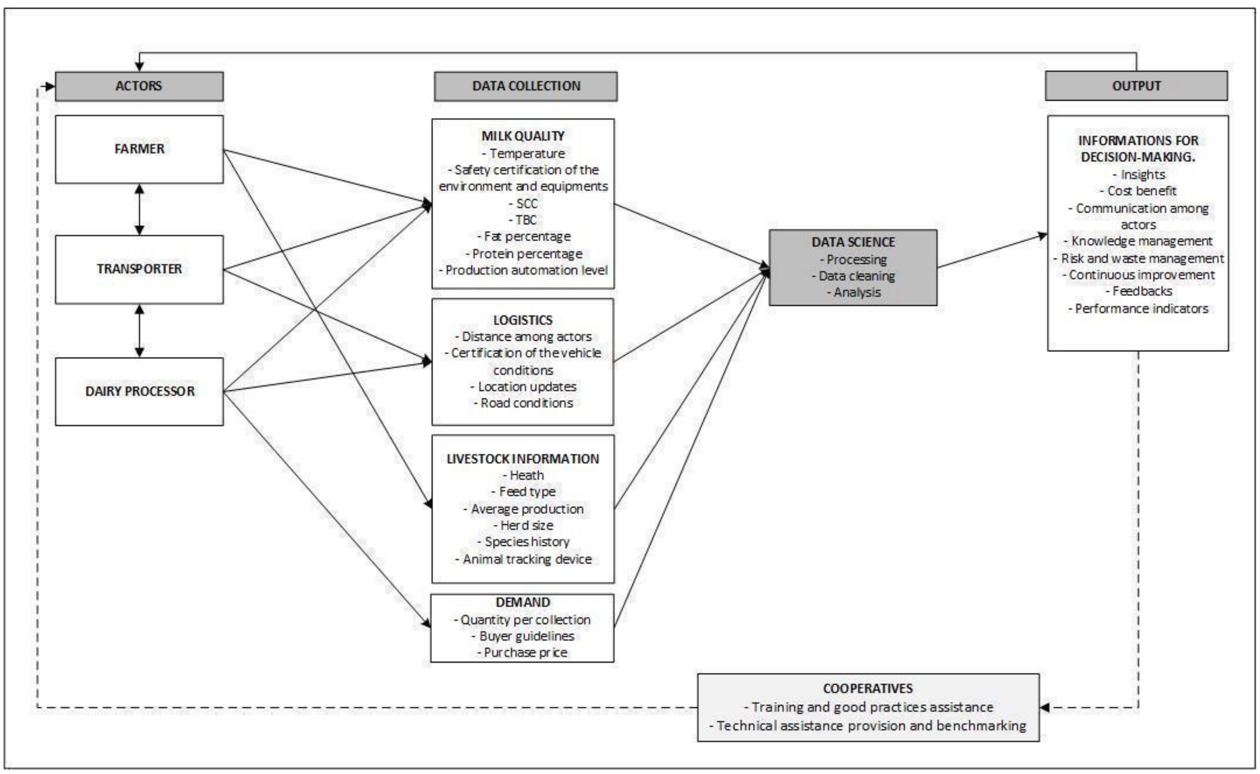
After the specific data for each actor is entered it will be processed and analyzed to deliver in column 4 of the framework, the Decision-Making Information Output. That will provide information of various types, some of which are: Quality Indicators, Improvement Opportunities, Risks, and Waste. An opportunity is developing an innovation-driven business model, delivering better or new products and services according to customer desires. Access to data provides information to re-design the business in an innovative way by changing processes. (Chesbrough, 2010).

With this information the actors will be able to make more assertive decisions and will have a systemic vision of the dairy chain, being able to observe the causes of the results and the consequences of the actions (Bonamigo et al, 2021). Through this, the players will be able to communicate in a clearer and more aligned way, strengthening B2B relationships, and consequently opening opportunities to develop industrial services in partnership and open space for innovation (Eggert & Helm, 2003; Pigola, da Costa, Mazzieri, & Scafuto, 2022). Furthermore, the information can provide measurements of the level of actors’ performance in the relationship they are involved in within the chain (Bonamigo et al., 2022).

The information can be delivered directly to the actors so that they can make decisions about their business, or be sent to the Cooperatives, which are responsible for providing support to the actor's needs, especially in understanding the market for new business opportunities through innovation (Botaro et al., 2013; Ferenhof et al., 2019; Mazzarol et al., 2013; Rice et al., 2012). Furthermore, this knowledge is responsible for creating new products, understanding the demand, and increasing competitiveness (Cavusgil et al., 2003; Schwetschke and Durugbo, 2018).

Figure 1

Proposed framework (before the empirical test)



Source: Authors

Focus Group Feedbacks

According to the people's profile interviewed in Table 3, it was possible to obtain the comments arranged in Table 4, through the content analysis proposed by Bardin (2011). Moreover, with the comments made by the interviewees, it was possible to make some adjustments to the proposed framework, which is presented in Figure 2.

Table 3

Participants' Profile

Respondent	Profile
A	Data Science Professional
B	Dairy Industry Scholar and Transportation Specialist
C	Dairy Industry
D	Dairy farmer
E	Veterinarian
F	Milk Quality Specialist
G	Cooperative Specialist
H	Dairy farmer
I	Dairy Production Management Consultant

Source: The authors

Table 4

Participants Comments

Players	Considerations/Comments
Dairy farmers	- " Technicians could be the respondents of the system from the farmer to the dairy processor." (B)
	- " Veterinarians and technicians are tied to the dairy processor or farmer. Insert labor, since production is increasing and the number of producers is decreasing. Search for family succession cases." (G)
	- " I can't imagine the farmer submitting the data alone, having autonomy, unless he is trained to use it." (A)
	- "I miss the laboratories. There are cases that can put dairy processors, transporters and farmers in the same box." (I)
Dairy processors	- " The technician who provides assistance on the farms (veterinarians and agricultural technicians) was missing in a box linked to the dairy processor." (D)
	- "It is interesting to make a subdivision into Dairy processors (uptake and production) and add the Laboratory representation." (C)
	- "Dairy processors have to connect with Animal Information, because they have breed criteria for specific products." (G)
	- "Insert Laboratory." (E)
Transporters	- "There is a milk transporter that plays the role of the dairy industry, doing the commercialization between the farmer and the dairy processor." (G)
	- " The transporter can be either the dairy processor or the farmer himself. There are cases where the dairy processors outsource the driver, the tank is its own and the outsourced company/person is responsible for the vehicle and the labor. The transporter is the most important link, because it influences the demand for collection, the purchase price, the quality, and the destination of the milk. The transporters are the ones who take information between dairy processors and farmers. Most of the information will be entered by the transporter." (B)
	- " The transporter is responsible for the collection, and sometimes the technician who goes to the farm" (F)
Cooperatives	- " Cooperatives and independent dairy processors train and assist farmers." (D)
	- " The dairy processor that I represent doesn't work with cooperatives, but there are dairy processors that are cooperatives (they do the bureaucracy of the process), and there are others that receive and sell the milk." (C)
	- " There are two types of Cooperatives, the cooperative and the commercial cooperatives. Private initiatives provide training, best practices, worksheets, to increase cooperativism." (E)
	- " The singular cooperative is responsible for milk collection, has a relationship with farmers and transporters."(F)

	- "According to the objective of providing training and networking, it is better to put Farmers' Associations so as not to confuse, because there are cooperatives with different profiles. After that, take the Cooperatives to the first column." (G)
	- " Cooperatives are the farmer's allies. Cooperatives that are separate from dairies help control production costs." (I)
Data Collection	
Milk quality	- " The quality of the milk is associated with the collection, and has a direct relationship with the transporter. Milk with antibiotics is discarded. Include hygienization of the equipment (every 15 days)." (B)
	- " Insert test for residues in milk.". (E)
	- " Remove the level of automation, because it does not guarantee quality."(G)
Logistics	- "The transporter himself decides the route. The transporter also does acidity tests, because if the milk is acid, he doesn't load. About the roads: More rutting gives a lower chance of spoilage, but these roads increase the maintenance cost of the truck. Location update is important." (B)
	- " Insert Alizarol® test and temperature." (E)
	- " Include assistance and inputs." (G)
	- " Insert collection frequency per month."(D)
Livestock Information	- " Tracking device exists, but it is not reality for everyone. Add the number of animals, breed, number of animals under treatment, type of milking (manual, mechanical...), type of cooler and cleaning of the same." (B)
	- " Insert Clinical mastitis, use of antibiotics, antiparasitic, breed, genetic origin. Devices are few animals in Brazil that have." (E)
	- " There is the detail of the level of farmers (not by size, but by technification)." (G)
	- " Include management type, age of animal and breed." (D)
	- " Having reference values for different types of farms. Identify what type of automation, because on-farm automation is very much tied to dairy milking, measuring acidity and temperature on the spot. Insert the periodicity of collection." (I)
Demand	- " Insert seasonality, because it influences the value of milk." (C)
	- " Indicate seasonality and insert the market." (G)
	- " Milk volume is very important for the price."(F)
Data Science	
- " Data Science begins when in addition to exploring the data, it can model it, in order to provide information to the user, making the process intelligent and autonomous." (A)	
- " There are internal Apps about catchment traceability, but the information is owned only by the dairies." (C)	
- " There are worksheets provided by consultants or cooperatives or printed material, for those who have difficulty with technology." (D)	
- " Data depends on the reality of the producers' profile. There are sensors that analyze the milk, and there could be an automatic insertion of this data." (H)	

- " There is an app that does livestock management using Data Intelligence, exporting spreadsheets and generating reports." (I)	
Output	
Information for Decision Making	- "It is interesting to professionalize milk transportation, training the transporters, because they can't improve the milk, but they can maintain it or make it worse. It would also be good to create a quality record, mainly because of the difference of milk for each type of derivative (fine cheese, non-fine cheese)." (B)
	- "Include profit, revenue (producer interest), costs, and economic indicators." (D)
	- " About 'cost benefit' it is better to change it to price and profit. Important indicators: production quantity, stock, profit, staying in business, export capacity, new products." (G)
	- " Remove "insights". Insert items as competitiveness, advantages for the 4 players, commercialization, risk management (such as the use of medicines)." (H)

Source: Authors

Once the focus group conducted with the nine people has been carried out, some changes suggested by them can be made, as is mentioned by (Onwuegbuzie et al., 2009). Respondent B cites that in Milk Quality, we should include the type of refrigerator and equipment sanitation, in addition, and suggests the insertion of the residue test in the milk and the Alizarol® test. For respondent G, the automation level is unnecessary as an item for data collection, because it does not guarantee product quality. Regarding Logistics, G suggests the inclusion of assistance and D presents the importance of data on frequency.

As important data about the animals, B, D, E, G and I presented: addition of the breed, type of milking, and age of the herd. Moreover, B and E mention the irrelevance of adding the item about tracking devices, since despite being an interesting factor for the actors present in the dairy ecosystem, it still does not represent reality for everyone in the Brazilian scenario. To C and G, seasonality is primordial for Demand, since it directly influences the value of the product and opportunities for innovation within the ecosystem.

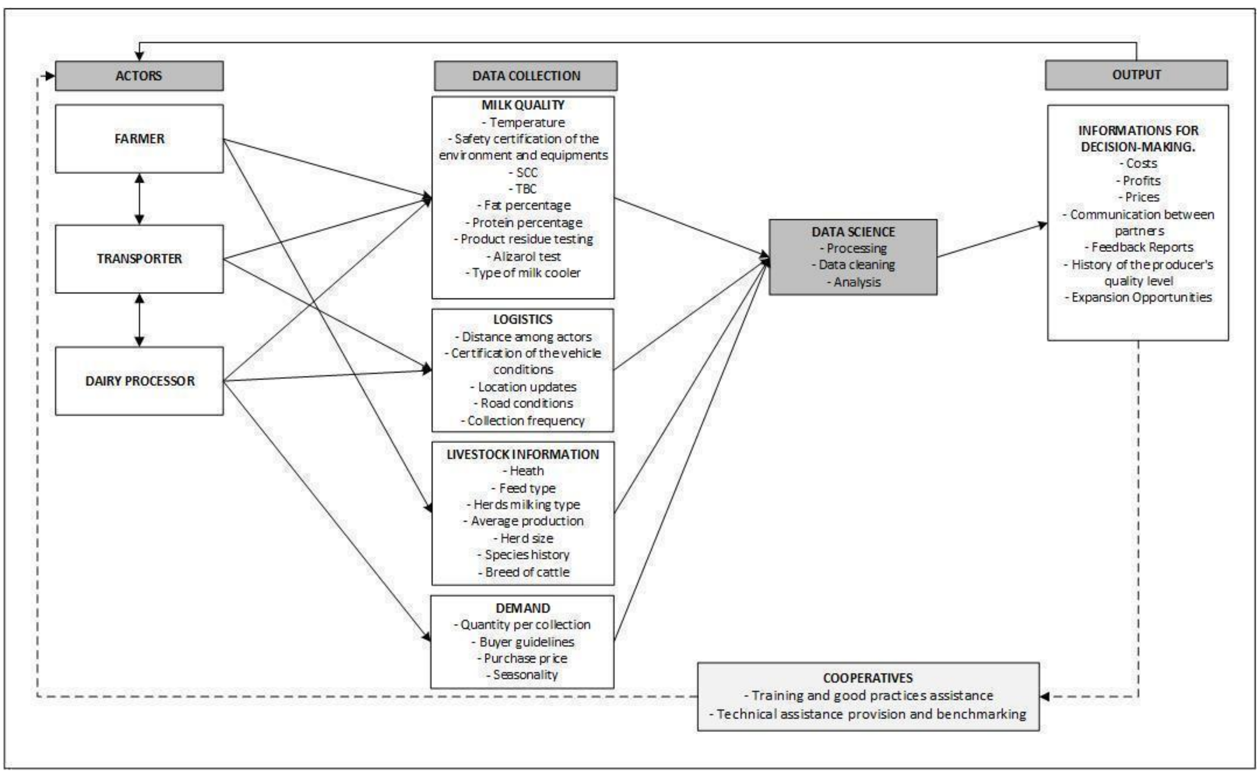
As an Output of the framework, H cites that the term "insights" makes understanding confusing, so he suggests it can be replaced by value information to the four actors. Participants B, D, and G indicate the following information: Profit, Price, Costs, Production Quantity, Permanence in the activity, Quality history of the farmer, and Potential innovation through new products and expansion.

The participants also commented that it would be interesting if technicians and veterinarians insert data of their knowledge, in order to provide greater accuracy in the output information.

As we chose to represent in the Framework only the four main actors, the participation of other actors in the first column is implicit, according to the needs of data to be inserted. Based on the suggestions from the focus group, the framework was improved with the proposed incremental adjustments. Figure 2.

Figure 2

Integrative Framework (after empirical evaluation by experts)



Source: *The* authors

Thus, the proposed and tested integrative framework allows for transposing the nature of the agro-industrial production system, centered only on a specific link or individual. It presents a systemic view of the process management, to make the agro-industrial segment competitive, and promote the advantages realized by the industrial services.

Conclusion and managerial implications

The present study aimed to propose and test an integrative framework for actors' orchestration in the dairy sector to stimulate innovation based on data science perspective. Once the framework was developed and tested, it served as a foundation for the construction of digital platforms using elements to facilitate the B2B relationship among the actors in the value co-creation in agro-industrial services.

In consonance, Jayashankar et al. (2018) mention that facilitating technology adoption as well as further understanding of how farmers' networks occur, it's an important factor for the research field development. Especially, to mitigate the communication weaknesses and knowledge shared within an information-sharing environment and stimulate the value co-creation among the actors in the process.

Based on the findings it became evident that the lack of trust and a holistic vision for the integrated management of the partners, is presented as a limiting factor, which the present integrative framework allows to provide guidelines to direct the actors for the value co-creation in an industrial services ecosystem. Additionally, it implies collaboration among the actors to co-create solutions and innovation. For example, dairy production is weak in management aspects related to information and knowledge sharing.

Therefore, the relationship among the actors is weak regarding the resource's complementarity. Thus, the study provides support in decision-making among the actors of the dairy agro-industrial system to generate mutual benefits via data sharing, as well as improve the services provided among the links in the dairy agro-industrial environment. Besides that, it promotes satisfactory relationships and orchestration among those involved in the dairy ecosystem. Once the data is shared among the actors, it is possible to output information, such as financial information (costs and profits), and performance indicators (quality and production level), among others. When this information is used in decision-making, it can lead to a process of continuous improvement using innovation, an important way to ensure competitive advantage in the value co-creation ecosystem (Junior et al., 2022).

So, this study has contributed to mitigating the gap presented in the literature regarding the use of Data Science to reduce the problems of actors' integration in the agro-industrial ecosystem. With this data being accessible to the entire dairy chain, it is possible to have transparency about it, and also to enable the opportunity identification for relationships, from a perspective to facilitate the industrial service value generation among multiple actors in the dairy sector context. Additionally, the actor's orchestration can be stimulated by sharing information (Bittencourt, et al., 2021; Borota et al., 2023). In this sense, the data science adoption is a potential way for transpose the lack confidence among the actors in dairy sector.

As future studies, a quantitative test is suggested to validate the developed framework, as well as the conduction of case studies based on the integrative framework proposed and tested in this study. In addition, it is valid to research with a technological focus, addressing the integration of data collection through sensors present in precision livestock farming and their respective correlations within an integrative system. However, we highlight that the framework is adaptable and can be applied in different contexts of agribusiness. Once tested in different contexts, comparative analyses can be performed to verify the proposal behavior.

AUTHORS' CONTRIBUTIONS

Contribution	Bonamigo, A.	Lopes, A. C. C.	Mendes, L. F.	Andrade, H. S	Winck, C. A.
Contextualization	X	X	X	---	X
Methodology	X	X	X	---	---
Software	---	---	---	---	---
Validation	X	---	---	X	---
Formal analysis	---	---	---	---	---
Investigation	X	X	X	X	---
Resources	---	---	---	---	---
Data curation	---	---	---	---	---
Original	X	X	X	X	X
Revision and editing	X	---	---	---	X
Viewing		---	---	---	
Supervision	X	---	---	X	---
Project management	X	---	---	---	---
Obtaining funding	---	---	---	---	---

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Appendix 1 - Findings from the content analysis

Registration Units	Context Units	Freq
Data Science	A1- Machines and equipment for on-farm activities were neglected due to complexity, lack of statistical data in the dairy farming sector and the assumption of similarities between farms. A3- The study presents that some machine learning and deep learning models are delivering results at predictive levels for precision farming, still the levels of accuracy in system implementation can be more widespread if there is a holistic type of machine learning model developed. A4 - As microcomputers become more widely used in dairy operations, the amount of data collected will also increase. The challenge lies in managing the increase in data. A5 - The study aims to build a machine learning model with data collected from the tail temperature sensor. A6 - We describe a system that integrates farm data and facilitates a set of dairy applications that interface with this data and provide improvements using data, analytical tools and visualizations in specific dairy and domain recognizable formats. A7 - The Dairy Brain, applying precision agriculture, big data analytics, and the Internet of Things. A11 - The article shows that animal health observation, reproduction management and data collection function are considered very useful by German dairy farms. A15 - The agriProKnow project aimed to develop a data warehouse system that allows the integration of data from multiple sources, across multiple farms. A17 - DMI which is based on prediction based on cow variables is presented; to compare artificial neural network (ANN) and partial least squares (PLS). A18 - The challenges faced by cold chain participants in both decision making and technology adoption. This is done by analyzing the data captured, the technology infrastructure, and the use of data for decision making. A20 - The article provides some insights and lessons on supply chain network structure, data collection, decision-making models, and implementation. These 4 categories are discussed extensively about their technology used and how decision making is implementing these topics. A23 - A number of cows having lameness and false alarms, the cost of the system, and the ability to indicate which leg is lameness are important features of automatic detection systems.	14

	A27 - Production data and herd management information can be meaningfully clustered using cluster analysis and that this clustering approach would yield better groups of farm pairs than benchmarking methods based on criteria such as country, breed or region. A29 - An ontological method was used to combine different sensor data sources to enable big data analysis in the dairy farming domain.	
Livestock Information	A10 - Smart Herd, an end-to-end, cloud computing-assisted IoT platform for animal behavior analysis and health monitoring in a dairy farming scenario, is presented. A11 - The article shows that the animal health observation, reproduction management, and data collection function are considered very useful by German dairy farms. A15 - Data can be utilized to manage and improve operational business processes, for example, to effectively counteract disease outbreaks with detrimental effects on animal welfare and productivity. A16 - To validate the accuracy of 2 commercially available activity recorders in determining lying, standing, walking, and number of steps in dairy cows, 30 cows were fitted with the Cow Scout Leg. A21 - The researchers used a Rumi Watch muzzle sensor in order to provide a complete and detailed technical specification of the functionality of this device. A33 - In the development of technology and innovation, it is necessary to develop the capacity of the actors. Thus, "soft skill interventions" are proposed that could help actors to coordinate co-development processes and to improve communication. A34 - Technologies for monitoring milking performance, reproductive performance and udder health were the most widely used among the current parameters. The perceived usefulness of the parameter was highest for mastitis monitoring technologies, oestrus and milk production parameters. A35 - The study used RumiWatch and ITIN + HOCH GmbH software to conduct some experiments to understand the relationship between cow locomotor behavior and welfare. A36 - The goal of this study was to use a precision nutrition model to simulate the relationship between diet formulation frequency and performance of dairy cattle in various climates. A37 - Dairy cattle recording systems have become an essential part of the intensive dairy farm today, recording variable amounts of production and health data at both the individual and herd level. A45 – In this paper the main interests in dairy cows are ovulation prediction, detection of metabolic imbalance, and detection of pre-clinical mastitis in the inflammatory response. A46 - The adoption and use of a management information system has resulted in a significant annual increase in average herd milk production (carrier) and protein production of 62 and 2.36 kg per cow, respectively.	14

	A49 - It calculates goals in milk production, fat and protein production, feed cost, breeding and other areas. It also detects problems and high performance according to these goals; researches the causes of problems in herd management, feeding, genetics, health, housing, and other areas; and lists the findings by sector. A50 - As new technologies are introduced, they are integrated into total management programs that provide proactive management. The information age offers new technologies and opportunities for the dairy industry. As microcomputers become more widely used in dairy operations, the amount of data collected will also increase.	
Informations for decision making	A2 - The purpose of this study was to develop and evaluate the feasibility of implementing EVOP in commercial dairy herds as an integral part of herd management. A6 - Decision support tools can use data management and analysis services to explore data streams from farm and other economic, health, and agricultural sources. A7 - A conceptual framework with the flow of data conveyed from farms to the University where the study was conducted. A8 - 3 modes of fraud were discovered (Opportunities; Motivations and Controls). As a result, they were able to say that farmers have a lower probability of fraud than retailers and processing companies. A9 - The goal of the presented work is to enable data-driven decisions for dairy farming and extract timely insights from the data by designing suitable analytical models for such use case scenarios. A14 - If it can be predicted in advance how likely a food problem is, safety can be checked and supervised in advance, which can largely prevent unqualified food from entering the market. A19 -Aims to contribute to the development of dairy production, based on new insights that will help overcome the obstacles that hinder the development of the dairy industry A22 -The presented infrastructure has taken into consideration IoT technology and the association of data mining. A26 - The method clearly presents the access to information and feedback for convenient communication between all individuals in supply chain management, efficient combination and management of different data coming from different sources. A29 - Dairy farmers are currently in a precision farming era in which the provision of information for decision support is becoming crucial to maintain a competitive advantage. A34 - In addition, producers consider factors associated with return on investment, total investment, and technology performance as the most important pre-purchase considerations when deciding whether to implement a technology.	12

	A34 - Many farmers don't use technologies and they could provide potential areas for manufacturers, such as expanding their marketing and sales in the dairy production ecosystem.	
Quality	A13 - We also observed that the barriers linked to quality and productivity could be solved through a systemic interaction between the actors in this business environment. A17 - It is known that the use of RNA indicates that other unknown compounds may perform an important function in improving prediction quality, not just fat, protein and lactose. A24 - The study provides farmers, automatic milking system manufacturers, veterinarians, and dairy consultants with a more detailed understanding of what to expect when making the transition to automatic milking systems. A29 - These cows have been monitored during 2014, which has generated a huge amount of sensor data on grazing activities, feed intake, weight, temperature, and milk production of the individual cow stored in databases on each of the dairy farms. A40 - This paper presents an integrated system developed for small dairy farmers to enable the use of RFID technology to ensure the credibility of the data record and prevent illicit practices related to cattle insurance.	5
Logistics	A52 - Long distances in the milk transport route can make the product unviable. A53 - Until 1999, milk was packaged in cans. Nowadays, trucks with tanks are used to facilitate transportation and ensure greater food safety. A54 - To have food safety, the vehicle and the tank need to be up to the required standards. A55 - The importance of having a good milk transportation route.	4
Demand	A37 - Dairy cattle recording systems have become an essential part of the intensive dairy farm today, recording variable amounts of production and health data, both at the individual and herd level. A51 - A higher volume of milk collected does not guarantee that the product is of quality, but it allows for greater planning security for the industry and reductions in collection costs, which for companies can justify paying more attractive prices for larger volumes. A56 - Some of the important conditions for internal and external demand in Brazil: Integrated action for greater coordination, organization of the milk production chain, better quality dairy products and adoption of modern management techniques. A57 - Demand is considered one of the most important data for the management of the dairy chain.	4

Actors	A9 - Aims to provide a set of controls for the farmers and other players to increase productivity, thus leading to better agricultural practices for the overall benefit of the industry. A13 - We also observed that the barriers linked to quality and productivity could be solved through a systemic interaction between the actors in this business environment. A19 - It also serves as a basis for decisions for the actors that make up the dairy production ecosystem: producers, cooperatives, government, universities, research centers, and so on.	3

Source: Authors

Appendix 2

RESEARCH PROTOCOL
Objective: To test with different professionals who are part of the dairy and Industry 4.0 ecosystem the framework built from the literature findings.
Pre-Focus Group: Identify the possible participants, so that there would be a variety of profiles. Contact the possible participants to contribute to the focus group, so as to have at least one professional of each profile.
Focus Group: The focus group was conducted through a videoconference with all participants. We asked semi-structured questions about the framework after the presentation of the framework. The focus group was recorded with the permission of all present, which was used for future analysis.
Post Focus Group: After the end of the focus group, content analysis was performed using the recordings.

Source: Authors

Semi-structured questionnaire

Categories	Subcategories	Questions
Input	Actors	Do you believe that these are the main actors of the ecosystem?
Data Collection	Data	Do you think that the insertion data in the Framework are sufficient or are there still some missing?
Data Science	Technology	Do you have any experience with technology for product management, purchasing, negotiation, etc.?
		Do you use any app, software or worksheet to control and share information?
External	Cooperatives	What is the main impact of the Cooperative/Trade Union on your business?
		How do you see the role of the cooperative in the relationship between dairy industry and farmer?
		Is there any other activity that the cooperative could be developing within the flow presented?
Output	Informations for Decision-Making	Is there any decision-making information that would be important for your business that has not been presented?
		Does it meet expectations?
Others		What do you think limits this information sharing among the 4 actors of the dairy ecosystem?
		Is there anything that has not been exposed that you would like to talk about or have something to suggest?

Source: Authors