

Business relationships in digital transformation

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Received 13 September 2024
Accepted 29 August 2025

Abstract

Purpose – This paper aims to clarify the relationship between typical Industry 4.0 technologies and the relationships between companies and their business networks to understand the relevance of this connection. The central point of this study is to verify the influence that existing digital technologies in the industrial segment exert on business relations.

Design/methodology/approach – The research opted for an exploratory study in nature and adopted a quantitative approach in a sample of companies in the Brazilian automation and robotics segment. A bibliographical research was also carried out with searches in the Scopus (Elsevier) database.

Findings – The paper provides empirical insights about digital technologies, typical of I4.0, can exert a significant influence on companies' relationships with their business network. It was observed that the increase in the use of technology in the company contributes to an increase in the intensity of its economic and social relationships, and that there is a certain prevalence of each type of relationship in technological maturity.

Research limitations/implications – The main limitation of the article was the sample size (18 companies in the automation and robotics segment). Despite being a small number, it should be considered that there are few industrial segments that intensively use digital technologies from Industry 4.0, notably in emerging countries. Another important limitation is the impossibility of generalizing its results to the entire industrial sector.

Practical implications – The subject is promising because it allows the administrator of a manufacturing company to conveniently deal with the technological level of the companies in their business network and allows the manager a strategic vision of the analysis of Relationship Marketing in the business network.

Originality/value – This article meets a need to study how modern technology influences relationships between companies. The article is original because it manages to associate three areas of management, that is, Social Capital, Relationship Marketing and Strategic Management, and point out the coherences between them.

Keywords Industry 4.0, Business relationships, Business links, Strategic management, Relationships marketing

Paper type Research paper

Relaciones empresariales en la transformación digital

Resumen

Objetivo – El artículo tiene como objetivo profundizar en la relación entre las tecnologías de la Industria 4.0 y las relaciones entre las empresas y sus redes de negocio, con el fin de comprender la relevancia de esta conexión. El punto central del estudio es verificar la influencia que las tecnologías digitales existentes en el segmento industrial ejercen sobre las relaciones empresariales.



Diseño/metodología/enfoque – La investigación optó por un estudio de carácter exploratorio y adoptó un enfoque cuantitativo en una muestra de empresas del segmento brasileño de automatización y robótica. También se realizó una investigación bibliográfica mediante búsquedas en la base de datos Scopus (Elsevier).

Resultados – El artículo ofrece evidencias empíricas de que las tecnologías digitales, típicas de la Industria 4.0, pueden ejercer una influencia significativa en las relaciones de las empresas con su red de negocios. Se observó que el aumento en el uso de tecnología dentro de la empresa contribuye a intensificar sus relaciones económicas y sociales, y que existe cierto predominio de cada tipo de relación según el nivel de madurez tecnológica.

Originalidad/valor – Este artículo responde a la necesidad de estudiar cómo la tecnología moderna influye en las relaciones entre empresas. Es original porque consigue integrar tres áreas de la gestión —capital social, marketing relacional y dirección estratégica— y señalar las coherencias entre ellas.

Implicaciones prácticas – El tema es prometedor porque permite a los directivos de empresas manufactureras gestionar de manera conveniente el nivel tecnológico de las compañías en su red de negocios y brinda al gestor una visión estratégica para analizar el marketing relacional dentro de dicha red.

Limitaciones de la investigación – La principal limitación del artículo fue el tamaño de la muestra (18 empresas del segmento de automatización y robótica). A pesar de ser un número reducido, debe considerarse que existen pocos segmentos industriales que utilicen intensivamente tecnologías digitales propias de la Industria 4.0, especialmente en países emergentes. Otra limitación importante es la imposibilidad de generalizar los resultados a todo el sector industrial.

Palabras clave Industria 4.0, Relaciones empresariales, Vínculos empresariales, Dirección estratégica, Marketing relacional

Tipo de artículo Trabajo de investigación

数字化转型中的商业关系研究

摘要

研究目的 – 本文旨在阐明典型的工业4.0 (Industry 4.0) 技术与企业及其商业网络关系之间的关联, 以理解这种联系的重要性。本研究的核心在于验证工业领域现有数字技术对企业商业关系所产生的影响。

研究设计/方法 – 本研究选择了探索性研究的性质, 并采用定量研究方法, 以巴西自动化与机器人领域的企业为样本。同时, 通过在Scopus (Elsevier) 数据库中进行文献检索, 进行了系统的文献综述

研究结果 – 研究结果提供了实证性见解, 表明典型的工业4.0数字技术对企业与其商业网络的关系具有显著影响。研究发现, 企业内部技术使用水平的提高, 有助于增强其经济与社会关系的强度; 同时, 不同类型的关系在技术成熟度的不同阶段表现出一定的主导性。

研究原创性 – 本研究回应了一个亟需探讨的主题——现代技术如何影响企业间关系。本文的原创性在于成功地整合了三大管理领域: 社会资本、关系营销与战略管理, 并揭示了它们之间的内在一致性与逻辑关联。

实践意义 – 该主题具有重要的实践潜力, 因为它使制造型企业的管理者能够更有效地评估其商业网络中企业的技术水平, 并为管理者提供了从战略视角分析商业网络中关系营销的思路。

研究局限性 – 本研究的主要局限性在于样本规模较小 (巴西自动化与机器人领域的18家企业)。尽管样本数量有限, 但应考虑到在新兴国家中, 密集使用工业4.0数字技术的工业部门相对较少。另一重要局限性是研究结果无法推广至整个工业部门。

关键词 工业4.0, 商业关系, 商业联系, 战略管理, 关系营销

文章类型 研究型论文

1. Introduction

The 21st century has arrived bringing with it an unprecedented technological evolution in the history of mankind. The digitalization provided by the scientific advances of Telematics with the support of the World Wide Web – Internet, have had a marked influence on society and the various sectors of the world economy through the establishment of new paradigms that are converting modern civilization.

In the industrial sector, this movement has caused significant changes in the production system of manufacturing companies. Known as Digital Transformation (DT) (Ferraris *et al.*, 2019; Broekhuizen *et al.*, 2021), or merely industry 4.0 (I4.0), this strategic operational process guided by digital technologies (Vial, 2019) proposes to make the sector more competitive in the face of ongoing economic globalization and enhancing service quality (Singh *et al.*, 2023). These technological changes are gaining strategic importance in business and in the way of adding value throughout the production chain, generating connection mechanisms in networks and changing the way consumer needs are satisfied (Grabowska, 2020). In this scenario, even companies' relationships with their stakeholders need to be better understood (Pilny and Siems, 2019).

The DT concept considers the meeting of several digital technologies in the factory and has a characteristic of a multidisciplinary approach including topics related to processes, efficiency, competitiveness, data management and relationships (Piccarozzi *et al.*, 2018). Other authors go further and claim that this idea proposes bringing companies together in a telematic network (Preuveneers *et al.*, 2018) generating more information about the manufacturing process itself (Preuveneers *et al.*, 2018) which will also influence the relationship between industrial companies. Due to its highly dynamic nature, new strategic business models are emerging with the aim of integrating digital transformation into the organizational scope, favoring changes (Fonseca, 2022).

Although it is a subject of interest to academia, it is still very difficult to find a research article on the subject of I4.0 dedicated exclusively to the management area (Piccarozzi *et al.*, 2018) and its aspects, role of senior management, leadership style, human resource management, skills and abilities (Piccarozzi *et al.*, 2018). This difficulty can be explained in part by the complexity of the DT phenomenon (Broekhuizen *et al.*, 2021). This article proposes to discuss the gap related to the competencies and skills needed by administrators in the development of business relationships (Jiang *et al.*, 2020) in the modern industrial sector. This subject is relevant from a practical point of view as relational capacity is a mediating variable between digital orientation and company performance (Silva *et al.*, 2023), and many authors understand that these relationships have the potential to generate competitive advantage (Teece *et al.*, 1997; Dyer and Singh, 1998; Eisenhardt and Martin, 2000; Barney, 2001; Dyer *et al.*, 2018; Contador *et al.*, 2023). In this way, the study can contribute to improving this understanding.

The mechanisms that provide quality in the collaborative relationship between industrial manufacturing companies are not evident (Frank *et al.*, 2019). It is also unclear the influence that digital transformation exerts on the ability to collaborate and cooperate between companies (Scuotto *et al.*, 2017) that certain authors consider trust and commitment (Morgan and Hunt, 1994) essential pillars of this ability. Empirical studies also indicate that relationships considered successful are based on trust and commitment (Jap and Anderson, 2007). The creation of smart factories arranged in cooperation networks (Grabowska, 2020) suggests the need for managers to have advanced knowledge about the relational process. It is no longer just the usual and everyday relationship between companies, but new processes based on real-time data processing systems that require new skills and capabilities from managers (Verhoef *et al.*, 2021). Some authors also suggest that the interaction of resources and capabilities contribute to technology transfer processes between companies, which facilitates the exchange of knowledge, collaboration and adoption of new Technologies (Adomako and Nguyen, 2024) a thought that has not yet been fully pacified.

In this sense, the article intends to answer the following research question:

RQ1. What is the influence that digital technologies have on business relationships?

By protocol, the Brazilian Automation and Robotics Industry-IBAR was chosen as the research subject for its characteristic of employing various digital technologies, typical of I4.0, and structuring itself in the form of business networks. The option for the business networks perspective is due to the fact that in this typology the interorganizational relationships are evident (Rosińska-Bukowska, 2020). The following objectives were defined:

- identify and estimate the intensity of the digital technologies used by the companies studied;
- identify and measure the intensity of the relationships of these companies with their business network; and
- relate the two variables to understand the phenomenon.

The work is organized with a brief introduction to place the reader in the proposed theme. Section 2 intends to substantiate the main theoretical titles, inter-company relationships and links. Then section 3 presents the methodology applied in the research and section 4 the results found with their respective discussion. Closing the work, section 5 presents the conclusion.

2. Theoretical foundation

2.1 Business relationships

Industrial relations in general have two main paradigms: transactional (Williamson, 2008) and relational (Dyer and Singh, 1998; Dyer *et al.*, 2018). In this sense, some authors understand that in environments where digital technologies are used, the transactional, or merely economic, approach is replaced by the relational approach with greater social influence, provided that both companies accumulate benefits (Grandinetti *et al.*, 2020). However, organizations have two motivations: to maintain or gain their resources in social actions (Lin, 2002). This is how (Lin, 2002) classified it: expressive and instrumental action, respectively, maintaining or gaining resources.

In the operations of industry 4.0 Piccarozzi *et al.* (2018) observes the existence of a trend of changes in the company's relationship with its environment. The use of Physical Cyber Systems (CPS) allows the integration of suppliers, manufacturers and customers through the use of digital technologies (Saniuk *et al.*, 2019). This new propensity generates the need for interorganizational relationships to be led by people considered key in the company. That is why the high turnover of employees is considered harmful to the development of digitalization (Salo, *et al.*, 2020). Grandinetti *et al.* (2020) also emphasizes that the improvement in the company's relationship with all its partners can generate profound changes in the management of companies. In this integrative scenario through e-business platforms, information exchanges take place, safely and in real time, favoring the development of cooperation between companies (Saniuk *et al.*, 2019). The Internet of Things (IoT) technology, for example, allows the collection of data from smart devices for the composition of strategic information for companies (Santos *et al.*, 2017). This feature enables the sharing of information in real time, makes available the exploration of new business opportunities (Saniuk *et al.*, 2019) and emphasizing the main concepts of relationship quality such as trust and commitment between supplier and customer (Saniuk *et al.*, 2019; Grandinetti *et al.*, 2020).

Some authors argue that digital technologies can also be used in a relational way and that the use of relationship-specific technologies (Salo, *et al.*, 2020) reinforce inter-organizational relationships, enriching social relationships and replacing traditional social interactions such

as face-to-face interviews or even evolving with the sending of correspondence via the internet (Salo, *et al.*, 2020). High-quality relationships between suppliers and customers influence the competitiveness of companies (Dyer *et al.*, 2018; Grandinetti *et al.*, 2020) and can be enhanced by digital technologies (Gaiardelli *et al.*, 2014; Grandinetti *et al.*, 2020). In this case, collaborative mechanisms between the production and logistics systems of the companies involved must be flexible enough to meet the customer's personal preferences quickly and without delays in the production process (Preuveneers, *et al.*, 2018).

High-capacity computing and data storage characterize cloud computing systems, allowing fast access from any location (Schuh *et al.*, 2014). Some authors believe that companies, especially small and medium-sized ones (Nah *et al.*, 2001) need to develop collaborative networks with organizations that are part of the value chain, allowing favorable conditions of access to the existing technological infrastructure with the expenditure of shared resources or even without any investment in IT (Beheshti, 2006).

In general, the use of digital technologies in companies considerably increases transparency in intercompany relationships (Salo, *et al.*, 2020) and allows the development and improvement of the environment of trust between companies (Mubarak and Petraite, 2020), favoring the establishment of innovation processes, particularly among customers and suppliers (Barrane, *et al.*, 2020). In the case of integrated systems of organizations where interoperability is fundamental, issues related to trust and commitment are highlighted and access control authorization policies must consider the dynamic nature of commercial relationships (Preuveneers, *et al.*, 2018). In this case, cybersecurity gains importance by mitigating platform vulnerabilities and protecting technologies, systems and data against malicious attacks, requiring high levels of trust between companies (Preuveneers, *et al.*, 2017).

2.2 Inter-company ties

When intercompany relationships become special, the ties occurs. Organizations have ties when they serve a particular market (Ebers and Jarillo, 1998). Contador (2008) considers the existence of three types of links between organizations: economic, referring to commercial transactions, social, referring to interpersonal relationships and locational, linked to the physical territory. This is the study of relational capital, which refers to the qualities of the relationship between companies that allow collaboration and sharing of resources between them (Moshtari and Vanpoucke, 2021).

Business networks can be understood as inter-organizational arrangements based on systematic, often collaborative, links between companies (Brito, 2002, p. 347) that operate in a given business within the scope of an economic activity. They are made up of companies that operate in the business microenvironment: customers, competitors, suppliers, (Lu *et al.*, 2020) among others, have a complex relationship system and require a specific model of business cooperation (Saniuk *et al.*, 2019).

Economic links refer to commercial transactions and can be identified in Williamson's (1985) studies on the costs of these transactions established in contracts. Some authors also suggest the existence of a type of inter-company relationship, in addition to social interaction, which can be found in business processes and eventually in the routinization of work produced by a digital infrastructure, which makes transactions efficient with economic gains (Salo *et al.*, 2020). These digital ties make it possible to integrate inter-company processes (Salo and Wendelin, 2013) into e-business platforms (Saniuk *et al.*, 2019).

The very construction of the digital infrastructure between two companies produces relations of economic dependence (Dyer, 1997). This link of economic dependence serves as

a barrier against new entrants (Salo *et al.*, 2020) and this level of interdependence of resources can determine the value creation potential of the business (Dyer *et al.*, 2018).

Technology transfer must be understood as a process of transferring technology and knowledge from one organization to another (Bozeman, 2000) and this link of an economic nature must be governed by a contract between the actors.

Certain authors point to the existence of multiple forms of collaboration (Moshtari and Vanpoucke, 2021) that can occur from both economic and social aspects. Paiola and Gebauer (2020) highlight that advanced services with the application of digital technologies print greater sophistication in business relationships between suppliers and customers. Cooperation, with an economic focus, allows companies to exchange resources (Ndubisi *et al.*, 2020) contractually to complement each other and can have two distinct natures, among others: cooperation for conducting business and technological cooperation.

Social capital, considered a resource (Kriesi, 2007), is found in relationships (Häuberer, 2011) – intercompany ties, and includes trust as one of its aspects that comes from networks (Häuberer, 2011). Business bonds with social characteristics involve three affective assumptions, among others: trust, commitment and cooperation considered essential in interorganizational digitization (Salo, *et al.*, 2020). Social relationships have value due to the potential information that the parties can benefit from (Häuberer, 2011). Fisher (1997) guides that sharing information between companies can reduce supply chain costs, Dyer (1997) clarifies that information sharing between companies can be seen as a sign of the trustworthiness of the supplier. Many trust relationships are grounded in repeated interaction (Reiersen, 2018). Thus, trust is expectation of goodwill and benign intent (Yamagishi and Yamagishi, 1994), a psychological mechanism based on information sharing between companies to reduce asymmetric information (Dyer, 1997) and is rooted in maximization of long-term self-interest. Commitment and cooperation are plural phenomena that involve some reciprocity. The commitment represents both the development of a collective action, (Fisher, 1997), as well as the sharing opportunities, risks, costs and/or investments (Dyer, 1997) and relationship-specific assets (Yamagishi and Yamagishi, 1994).

3. Methodology

A bibliographic search was also carried out on January 22 and 23, 2021, to verify the existence of articles similar to the present research. Thus, two searches were carried out in the Scopus database with the following filter: documents searched only for academic articles; limits ranging from 2011 to the present and scanning in the title, abstract and keyword fields.

The first search used the terms “business relationship” AND “Industry 4.0” resulting in 2 documents. The words “business relationship” AND “digital technology” were also related, providing 4 articles, 1 of which was unavailable for access. When the terms “relationship” AND “Industry 4.0” AND “digital technology” were combined, the result was zero.

The second search for more generic characteristics adopted the words “relationship” AND “industry 4.0” resulting in 627 documents. When filtering by knowledge area Business, Management and Accounting and Social, 269 remained whose abstracts were read carefully, being selected 13 articles that deal with the topic of interest of this research. These 13 articles were studied in full, allowing the theoretical support of this investigation developed in Section 2.

The research had an exploratory character and adopted a quantitative approach in a sample of 18 companies in the Brazilian automation and robotics segment, 15 from the Southeast region and 3 from the South region. Two companies (G and L) that did not fully comply with the research protocol were discarded. Therefore, in the robot segment (IBAR), which has 31 companies cataloged in the Brazilian Association of Machinery and Equipment – ABIMAQ, the return rate was significant, around 51%. The exploratory nature of this investigation seeks

new evidence in the context of the subject and is in line with [Piccarozzi et al. \(2018\)](#)'s thinking that empirical research on industry 4.0 has outnumbered conceptual and theoretical articles, which may indicate a new phase of scientific discoveries in this area.

The following digital technologies typical of Industry 4.0 were considered: internet of things, cloud computing, big data analytics, simulation, augmented reality, additive manufacturing, system integration, autonomous robots and cybersecurity ([Saucedo-Martínez et al., 2018](#)), artificial intelligence ([Tao et al., 2018](#)), sensors, radio frequency identification – RFID and quick response code – QR ([Fusko et al., 2018](#)) that had their respective intensities collected in the initial survey.

Recognizing that technology (t) impacts company performance and relies on its technological development degree, the quantitative construct technological intensity (TIt) was conceived. TIt is the technological development degree of technology t, which is evaluated at five levels: TIt = 5 expresses the highest degree of development; TIt = 1, the initial degree of development; and TIt = 0 means that technology (t) is not used by the company.

For our sample, certain technology was denoted by $t = 1, \dots, 14$; certain companies by $c = 1, \dots, 16$; and the intensity of technology t in company c by (TItc). From TItc, two metrics were conceived:

$ATIt = \sum (TItc)/16$ = Average technological intensity of the technology t at the 16 sample companies;

$ATItc = \sum (TItc)/14$ = Average technological intensity of the company c based on 14 technologies.

A literature-based questionnaire was also developed to establish the main economic and social link of a company with its I4.0 business network. It should be mentioned that the aforementioned questionnaire was built by academics and validated in a pilot company and is available in [Table 1](#) below.

The quantitative part sought to empirically measure the relationship between companies in their respective business networks in terms of the firm's dyadic relationship with its three main competitors, three main suppliers and three main customers. Respondents were instructed to choose companies in the business network that were of vital importance for the operation of the researched company. This choice was inspired by the Pareto Principle, which states that in many areas of the social sciences 80% of the effects come from 20% of the causes ([Trček, 2022](#)). In this case, it was considered that as the research adopted 16 companies that competed with IBAR, the number 3 would be adequate, about 20% of the universe that would represent the main competing companies. The quantity was preserved for suppliers and customers, believing it to be an approximate and logical number for this type of estimate.

The construct intensity of the company's links with its main competitors, providers and customers in its business network was created, which is expressed by an estimate that varies from 0 to 5, with 5 being the optimal value of this relationship. From this construct, the following were developed:

Average links per company $\sum (\text{links})/30$ – considers the average of all economic and social links for each company in the sample.

Average of the social bonds of the companies $\sum (\text{social links})/18$ – covers all social bonds.

Average of the economic ties of the companies $\sum (\text{economic links})/12$ – comprises all economic ties.

As criteria for selecting companies for the research were:

- Industrial companies with B2B characteristics in the automation and robotics segment based in Brazil; and
- Companies dedicated to the use of digital technologies, typical of Industry 4.0.

Table 1. Questionnaire about the company's relationships with its business network

Links: concept, content and attributes	Typology (expression)
<i>Question 1 – Open or transparent exchange of information and knowledge.</i> It consists of the degree of openness of communication between your company and its main competitors, suppliers and customers The greater the intensity of openness, the greater your company's confidence that in these companies there are no people who take advantage of your company's problems, difficulties and weaknesses to benefit their own company or obtain private advantages	Social (trust)
<i>Question 2. Different types of exchange.</i> It consists of the variety of types of reciprocal exchange between your company and competitors, suppliers and customers (such as exchanging experiences, knowledge, information, favors, resources, materials, ideas and equipment loans)	Social (cooperation)
<i>Question 3. Your company's existing propensity to ask for and provide help.</i> It consists of requesting help and teachings from competitors, suppliers or customers, respectively, who have more knowledge, information and experience, and providing assistance	Social (trust)
<i>Question 4. Presence of collective actions.</i> It consists of the quantity and diversity of joint actions (events, training, initiatives with government agencies, research, technological development)	Social (commitment)
<i>Question 5. Sharing opportunities, risks, costs and/or investments</i> between your company and your main competitors, suppliers or customers (remember that one's risks represent opportunities for others)	Social (commitment)
<i>Question 6. Transfer of information, technology, innovation or novelty</i> between your company and your competitors, suppliers and customers, respectively	Economic
<i>Question 7. Your company's dependence</i> on its competitors, suppliers and customers. It consists of any type of dependence, such as joint actions, products, technology	Economic
<i>Question 8. Specifically technological cooperation</i> to generate knowledge and develop a product and/or process	Economic
<i>Question 9. Cooperation specifically to facilitate the conduct of business of any kind</i>	Economic
<i>Question 10. Cooperation for any purpose</i> other than the two previous questions. Consider cooperation to develop collective resources, solve common or specific problems of partners, including making inputs, products, equipment available without needing a contract, trusting the other party and reciprocity	Social (cooperation)

The questionnaires were applied between December 2019 and March 2020 and were intended for key elements of the organization, directors and managers with a holistic view of administration. Respondents gave their opinion on the strengths of industry 4.0 technologies existing in the company and the relationships it maintains with competitors, suppliers and customers, ranging on a scale from 0 to 5 points, with 5 being considered the best assessment in the item for the company.

Table 1 below presents the questionnaire used, which contains six questions referring to social ties and four questions referring to economic bonds. This distinction, which is initially difficult to verify, is revealed through empirical research that compares organizations (NGO and companies) that operate under different work logics (Moshtari and Vanpoucke, 2021) making it evident and enabling its application in industrial firms. Economic relations aim at decisions based on numbers and rational arguments, social relations in turn have a "soft" nature (Moshtari and Vanpoucke, 2021). As can be seen in the questions of social typology, two (02) estimate trust, two (02) commitment and two (02) cooperation. Issues related to

trust can be understood as measures of a certain degree of risk that a company confers on another company, seeking to estimate states of convergence of interests (Powell, 1987) and considered vital to relationship success (Singh *et al.*, 2023). It is a feeling of value originating from the focal company that follows an expectation of reciprocity (Häuberer, 2011). Questions 1 and 3 deal with capturing perceptions in the processing of imperfect information about the partner's interest because, according to Powell (1987), you trust the best information that comes from someone you know well and the exchange of help confirms this trust expectation (Häuberer, 2011). Commitment and cooperation differently have a certain degree of reciprocity in the relationship, with commitment referring to unilateral action in the other company, and social cooperation requiring interaction between companies as a single objective. In the four (04) questions of economic typology, all are transactional in nature and require the signing of contracts between firms (Williamson, 2008). The table below presents the questionnaire used with questions related to affective assumptions and economic ties.

The research also adopted the use of the PSPP Statistics software to perform the Kolmogorov-Smirnov (K-S) normality tests and used Pearson's linear correlation in normal samples.

4. Results and discussion

Table 2 above shows the estimates of companies in the automation and robotics segment regarding the intensity of business relationships with their competitors, suppliers and customers. The column type of relationship (links) can be highlighted with the options: Economic and Social, identifying the link according to its respective dimension.

As evidenced in Table 2, the link between the transfer of information, technology, innovation and novelty with customers (3.63) had the highest average in the automation and robotics segment. As it is a link of an economic nature, it may indicate that automation and robotics companies seem to need their customers to actively participate in the processes related to what is established in the contracts. Secondly, there is the link of open exchange between the company and its customers (3.38) and thirdly, the same link now with suppliers (3.31), both of social expression indicating the importance of trust in the business relationship. These three results corroborate, with respect to the business network, a preference of the companies of the segment in the relationship with their customers, since the average of the 10 links with the customers (2.94) is significantly higher than the average of the 10 links with the suppliers (2.81), approximately 5%.

Also observing questions 3 – existing propensity in the company to request and provide help from suppliers, with an average of 3.25, and 2 – different types of exchange with customers, average of 3.13, both of a social nature, evidence the importance of trust and cooperation in establishing business relationships. Then, with an average of 3.06, the bonds of dependence, which is economic, and of general cooperation, both related to customers, are highlighted. With an average of 3.00, the links, different types of exchanges with suppliers and business cooperation with customers and finally the link of propensity to request and provide help from customers (2.94).

It can be inferred that of the ten bonds with the highest averages in the survey: seven are of the social typology and three of the economic type. Although economic issues account for four of the six of the questions of a social nature, this finding may indicate that companies in the industry 4.0 of the IBAR segment seem to be inclined to establish inter-company relationships with greater social rather than economic or contractual appeal. Also, considering the business network, of these ten links highlighted above, seven are referred to customers and three to suppliers in the same ratio of 3/7 with the difference that the issues are

Table 2. Intensity of the company's economic and social links with its business network

Question, bonds	Type	A	B	C	D	E	F	H	I	J	K	M	N	O	P	Q	R	Mean
1. Open exchange comp	S	3	1	0	0	0	0	1	2	1	0	0	0	2	0	1	0	0.69
1. Open exchange p	S	4	4	4	4	2	3	3	4	4	3	5	3	3	4	1	2	3.31
1. Open exchange cust.	S	3	4	3	2	3	4	4	4	4	4	3	4	3	5	1	3	3.38
2. Different exchanges comp	S	0	0	0	0	0	0	2	1	1	0	0	1	3	1	1	0	0.63
2. Different exchanges p	S	3	4	2	4	2	3	3	4	5	3	0	3	3	4	3	2	3.00
2. Different exchanges cust	S	3	4	2	2	3	3	4	5	5	4	0	4	2	4	2	3	3.13
3. Propensity help comp	S	0	0	0	0	0	0	3	1	0	0	0	2	3	1	1	0	0.69
3. Propensity help p	S	4	3	2	3	2	4	4	5	5	3	0	3	4	4	4	2	3.25
3. Propensity help cust	S	4	0	0	3	3	4	5	5	4	3	3	3	2	4	2	2	2.94
4. Collective actions comp	S	0	0	0	1	0	0	1	2	0	0	0	3	0	0	1	0	0.50
4. Collective actions p	S	3	1	0	3	3	4	3	5	4	1	0	4	2	4	4	1	2.63
4. Collective actions cust	S	3	2	0	3	3	3	4	3	4	0	0	4	1	4	2	0	2.25
5. Risks and costs comp	S	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0.13
5. Risks and costs p	S	1	0	0	2	3	3	3	3	4	1	0	2	2	4	4	2	2.13
5. Risks and costs cust	S	4	0	0	4	3	2	4	4	3	1	0	2	0	4	3	2	2.25
6. Transfer info Tech comp	E	0	0	0	0	0	0	1	0	0	0	0	1	2	0	1	0	0.31
6. Transfer info Tech p	E	2	4	3	3	0	0	4	4	4	3	0	3	3	4	4	3	2.75
6. Transf. Info. Tec. cust	E	4	4	2	4	3	3	4	5	4	3	5	3	4	4	3	3	3.63
7. Dependency comp	E	1	0	0	0	0	0	0	0	0	3	3	0	0	0	1	0	0.50
7. Dependency p	E	4	3	3	4	3	4	4	4	4	1	0	2	2	0	3	3	2.75
7. Dependency cust	E	4	3	3	3	5	3	5	2	3	3	3	2	3	3	2	2	3.06
8. Tech Cooperation comp	E	0	0	0	0	0	0	2	1	0	0	0	0	1	0	1	0	0.31
8. Tech Cooperation p	E	3	4	2	3	2	0	3	5	4	3	0	3	3	4	3	2	2.75
8. Tech Cooperation cust	E	4	4	2	1	3	1	4	2	4	3	0	3	4	4	2	2	2.69
9. Bus Cooperation comp	E	1	0	0	0	0	0	3	1	0	3	0	0	0	0	1	0	0.56
9. Bus Cooperation p	E	4	0	3	2	3	4	4	4	3	3	0	3	3	4	2	3	2.81
9. Bus Cooperation cust	E	5	0	3	3	3	4	5	2	3	3	0	3	4	4	3	3	3.00
10. Cooperation comp	S	1	0	0	1	2	0	1	1	2	0	0	0	0	0	1	1	0.63
10. Cooperation p	S	3	0	2	3	3	3	3	4	4	3	0	3	2	4	3	3	2.69
10. Cooperation cust	S	4	3	2	3	4	4	4	2	4	3	0	3	4	4	2	3	3.06
Average links per company		2.50	1.60	1.27	2.03	1.93	1.97	3.03	2.83	2.77	1.90	0.73	2.27	2.17	2.60	2.10	1.57	

Note(s): E = economic bond; competitors = comp/customers cust/; S = social bond; providers = p

the same for both typologies, reinforcing the argument that there is a preference for a closer approach with customers in the environment of Industry 4.0.

Focusing on social expression, it was clear that trust, represented by questions 1 and 3, is the attribute most valued by automation and robotics companies in their relationships with organizations in the business network, reaching an average of 2.38. This result can be explained by the companies' need for counterparts to open up their critical information to the use of digital technologies. The average obtained by questions 2 and 10 and which represent the attribute of cooperation had the result of 2.19, indicating its importance in industry 4.0. On the other hand, the commitment evidenced by questions 4 and 5 obtained an average of 1.65, indicating that trust and cooperation can be considered bases to support this powerful marketing tool (Ampornklinaew, 2023).

As expected, the lowest average values of economic and social bonds occur with competing companies. The social bond of sharing opportunities and risks (0.13), and the economic bonds of information and technology transfer (0.31) and technological cooperation (0.31) were the lowest averages, indicating practically no commitment relationships of companies with their competitors and that contracts with technological appeals are rare in these circumstances. The highest averages obtained in this group were the bonds related to

the attribute of trust, questions 1, open exchange of information (0.69), and 3, propensity to request and provide help (0.69), evidencing that in the segment studied, companies seek to develop some relationship of trust with competitors, probably due to the constant concern of managers with technical particularities existing in digital technologies.

Table 3 below presents the declared intensities of the companies' use of digital technologies, varying on a scale from 0 to 5 and considering their most advanced competitor as TI (Technological Intensity)=5. In this way, companies indicate the level of the 14 typical industry 4.0 digital technologies used for this investigation. The table is arranged in descending order of the Average Technological Intensity of Technology (ATIt), with the values in the last column, and of the Average Technological Intensity of the Company (ATIC), in the last row.

From Tables 2 and 3, it is possible to compare the averages of the bonds and the Average Technological Intensity (ATIC) of each company in the sample and calculate the Pearson dispersion coefficient as provided in Table 4 below. The sequence shown in Table 3 was preserved, which indicates the companies with the highest ATIC on the left, with those that use less digital technologies typical of industry 4.0 on the right.

The Kolmogorov-Smirnov (K-S) normality test was performed, using the PSPP Statistics software, on the variables and all *p*-values found were greater than 0.05, conferring a degree of normality for the samples. The *p* values found were: 0.352 (ATIC); 0.939 (Average Links); 0.866 (Average Social Bonds) and 0.940 (Average Economic Ties). As can be seen from the result of Pearson's correlation, *r* = 0.74, which is a positive correlation between the two variables, suggesting the argument that the increase in the use of digital technologies by a company also leads to a increase in the intensity of intercompany relationships and in the establishment of links with the business network. On the other hand, companies that use less technologies typical of Industry 4.0 tend to develop less economic and social links with the companies in their business network. The coefficient of determination *R*², with a value of 0.55, is proposed to explain the occurrence of approximately half of this phenomenon.

When calculating Pearson's correlation for the halves of the sample composed of eight companies each, a strong correlation, *r* = 0.82, for the half that uses less digital technologies, reinforcing the initial argument. The little use of digital technologies contributes to the reduction of economic and social ties between companies and their business networks. On the other hand, Pearson's *r* (0.04) in half of the eight companies with higher ATIC averages

Table 3. Average technological intensity of the company (ATIC)

Digital technologies	Companies																
	P	N	B	H	I	J	K	A	E	D	F	O	Q	R	C	M	ATIt
Automation and robotics	5	5	3	3	4	5	3	4	4	3	4	3	2	3	5	3	3.69
M2M Communication	4	4	4	3	3	4	3	4	4	3	2	3	1	3	0	0	2.81
Advanced manufacturing	4	4	4	4	4	0	3	3	4	3	2	3	1	3	4	0	2.88
Systems integration	4	4	4	2	4	4	3	2	5	3	2	2	3	0	0	0	2.63
Sensors	4	4	3	3	2	3	3	0	4	3	2	4	3	0	0	0	2.38
Internet of things	4	4	2	3	4	3	3	3	3	2	2	3	1	3	0	0	2.50
Tags RFID/QR	3	5	3	2	1	3	3	0	4	2	3	3	2	0	0	0	2.13
Cloud computing	4	4	3	3	4	3	3	0	3	2	3	2	1	0	0	0	2.19
Cyber security	3	1	3	3	1	3	3	4	0	2	2	2	2	0	0	0	1.81
Microelectronics	4	2	3	3	3	3	3	4	0	3	2	0	0	0	0	0	1.88
Augmented reality	2	3	2	3	2	3	0	4	0	1	3	0	0	0	0	0	1.44
Big data analytics	3	0	3	2	2	3	3	0	0	2	2	2	0	0	0	0	1.38
Artificial intelligence	3	2	3	2	2	0	0	3	3	2	1	3	0	0	0	0	1.50
3D printing	2	1	0	2	1	0	3	3	0	2	2	0	0	0	0	0	1.00
ATIC	3.50	3.07	2.86	2.71	2.64	2.64	2.57	2.43	2.43	2.36	2.29	2.14	1.14	0.86	0.64	0.21	2.16

Table 4. Analysis of the correlation between ATIC with the average links, average of the social ties and average of economic of companies

Companies	P	N	B	H	I	J	K	A	E	D	F	O	Q	R	C	M	Stats
ATIC	3.50	3.07	2.86	2.71	2.64	2.64	2.57	2.43	2.43	2.36	2.29	2.14	1.14	0.86	0.64	0.21	$r = 0.74$
Average links	2.60	2.27	1.60	3.03	2.83	2.77	1.90	2.50	1.93	2.03	1.97	2.17	2.10	1.57	1.27	0.73	$\alpha = 0.05$
ATIC	3.50	3.07	2.86	2.71	2.64	2.64	2.57	2.43	2.43	2.36	2.29	2.14	1.14	0.86	0.64	0.21	$r = 0.75$
Average social ties	2.83	2.50	1.44	2.89	3.06	3.00	1.61	2.39	2.00	2.11	2.22	2.00	2.06	1.44	0.94	0.61	$\alpha = 0.05$
ATIC	3.50	3.07	2.86	2.71	2.64	2.64	2.57	2.43	2.43	2.36	2.29	2.14	1.14	0.86	0.64	0.21	$r = 0.55$
Average economic ties	2.25	1.92	1.83	3.25	2.50	2.42	2.33	2.67	1.83	1.92	1.58	2.42	2.17	1.75	1.75	0.92	$\alpha = 0.05$

indicate the inexistence of correlation with economic and social ties. These two results may suggest the existence of an optimal point between the two variables, where technology no longer exerts a significant influence on business relationships.

That way, in Table 4, we present the analysis of the correlation established between the independent variable average technological intensity of the company – ATIC, with the dependent variable, the average only of the social bonds of each company. The result of Pearson’s correlation coefficient, $r = 0.75$, indicates the existence of a moderate positive association between the two variables. Very much in agreement with the initial correlation of $r = 0.74$ which considers all links. This result seems to indicate the importance that the researched social relationships have in the technological development of Industry 4.0.

On the other hand, conducting the same experiment for the means of economic ties, the result is different, as Pearson’s r decreased to 0.55, a value significantly lower than that found in the relationship with social ties (0.75). Table 4 above presents all the values used in this dynamic. This result, therefore, characterizes the occurrence of a weak correlation between ATIC and economic ties, indicating that contractual issues do not seem to be significantly influenced by the use of technology in the company.

This situation could be explained to the extent that economic ties are basically developed by contracts between companies and their celebrations occur at different times. Looking at Table 4, if we compare the averages of social and economic ties and select the highest average results of each company, a certain pattern can be seen. Initially, the five companies that least use technologies (O, Q, R, C and M) have higher averages of economic ties, and then three companies (E, D and F) have their averages of higher social ties. In persisting in the comparative observation, companies K and A repeat the highest averages for economic ties and companies I and J again point to social ties and so on. This finding could indicate a complementarity between social and economic links: in the initial acquisitions of digital technologies by companies, economic links are more valued; after the acquisitions are carried out, social bonds become preponderant in the business relationship, and so on.

Corroborating the previous evidence of the existence of complementarity between social and economic bonds, one cannot forget that the technology is being implemented successively in stages, as can be seen in the decreasing order of the values of each Average Technology Intensity (ATIC). In this context, it can be suggested the predominance of the typology of bonds in different moments of technological maturity of the companies. This perspective can be based on studies by (Lin, 2002) who postulated the existence of motivations for social actions. The result found can be interpreted as moments of maintenance (expressive action) or gain of resources (instrumental action) (Lin, 2002) according to each case, or even the maintenance strategy motivated by the recurring gaps in interaction found in Relationship Marketing (Pilny and Siems, 2019).

Since Taylor, at the beginning of the 20th century, or even before, technology has been considered as a driver of an organization's business efficiency and effectiveness. On the other hand, more recently researchers have identified gains in competitiveness due to the relational view (Dyer and Singh, 1998; Dyer *et al.*, 2018). From 2017, six studies developed using the Fields and Weapons of Competition model in business networks (CAC – Networks) have highlighted the importance of business links/ties in achieving competitive advantage in companies from different sectors of the economy (Contador *et al.*, 2023; Fragomeni *et al.*, 2024). In this sense, this research gains relevance by associating the two dimensions - relationships and technology, in the same industrial segment, which gives robustness to its results.

5. Conclusion

The present investigation pursued the purpose of answering the research question: What is the influence that digital technologies have on business relationships? For this, it opted for the development of an exploratory methodology using the questionnaire to identify the business network of each company in the automation and robotics segment in Brazil that is part of the sample. The objectives set out in the research were then achieved:

- the most significant economic and social ties between companies in the industrial segment and their main suppliers, customers and competitors were identified and estimated;
- identified and estimated the digital technologies, typical of industry 4.0, in use by those companies; and
- related the two variables, ties and technologies, to understand the phenomenon.

Considering the business network, companies in the automation and robotics segment have intensive relationships with both customers and suppliers. Although customer preference was significantly higher, around 5%, it cannot be denied that companies consider suppliers to be decisive in negotiations regarding digital technologies.

It is also noted that digital technologies, typical of I4.0, can exert a significant influence on the business relationships of a business network. The positive and strong correlation between the technology variables (ATIt) and the average of the ties of each company in the researched segment could partially explain the phenomenon, with the correlation being even higher with social bonds, indicating the existence of an overlap between the two constructs.

Due to its complexity, the topic is multidisciplinary and covers different areas of knowledge from Strategic Management to Relationship Marketing. As a relevant finding, the existence of complementarity between social and economic ties may indicate that the technology is being implemented successively in stages, as observed in the decreasing order of the values of each Average Technology Intensity (ATIt). In this context, one can suggest the predominance of a certain typology of bonds at different moments of technological maturity of the companies.

The research is useful because it clarifies to administrators that the adoption of digital technologies corresponds to the need to develop social relationships with companies in the business network in its aspects related to the attributes of trust, commitment and cooperation (see Table 5). It also guides that the conclusion of contracts, considered as an essential activity of a company's business, for the acquisition of digital technologies must be complemented by more intense inter-company social relationships. As a theoretical implication, the study points to the existence of relationships with the business network that can effectively favor the generation of competitive advantage for a company.

Table 5. Conclusion and theoretical and managerial implications

Conclusions	Theoretical and managerial implications
Companies undergoing digital transformation maintain strong ties with both customers and suppliers The strong correlation between technology adoption and social ties suggests that technology and interpersonal relationships are interdependent domains	Strengthen supplier partnerships during digital transformation This conceptual overlap between technology and social relationships, contributing to theoretical advancements in network management and innovation Technology adoption should be accompanied by efforts to strengthen trust, cooperation and commitment within business network partnerships Can effectively favor the generation of competitive advantage
Complementarity between social and economic ties suggests that technology adoption occurs in progressive stages	It points to a theoretical model that links technological maturity with the nature of the ties in the business network Managers can use this insight to strategically plan the firm's technological evolution based on relational maturity The purchase of digital technologies should be supported by collaborative networks, and not only by formal contractual agreements

As a suggestion for future research, an exploratory investigation of the evidence found of complementarity between social and economic relationships in the development of technological maturity of an industry 4.0 company is proposed. Confirmation of the evidence could be useful to managers suggesting guidelines for the company's conduct their relationships with business network during the phases of implementation of I4.0. A second suggestion could be to explore the influence that each digital technology has on business relationships.

The main limitation of this scientific investigation is the impossibility of generalizing its results to the entire industrial sector. Its results can be generalized to those segments that make intensive use of digital technologies, typical of I4.0, particularly in emerging countries. Another important limitation refers to the research topic, which is current and, consequently, the literature on the subject is scarce and requires an exploratory approach.

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