Shared IT infrastructure: an intercooperation model for agricultural cooperatives

Infraestrutura de TI compartilhada: um modelo de intercooperação para cooperativas agrícolas

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ABSTRACT

The aim of this study is to propose a shared information technology infrastructure model for cooperatives. The methodology followed a qualitative approach and was descriptive and exploratory. The technical feasibility was analyzed using benchmarking, technical documents, the 95th percentile method and calculations of the sizing of resources. The analysis of the economic feasibility was based on price quotes for all the individual IT infrastructure components, as well as the development of cash flow, income statements and indicators of return and risk. The study demonstrated that a shared IT model is feasible from a technical, economic, and financial standpoint, considering a strategic intercooperation alliance in the form of a central cooperative.

Keywords: Information Technology infrastructure. Information Technology management. Strategic alliances. Intercooperation. Cooperatives.

RESUMO

O objetivo deste estudo é propor um modelo compartilhado de infraestrutura de tecnologia da informação para cooperativas. A metodologia adotou um enfoque qualitativo e foi descritiva e exploratória. A viabilidade técnica foi analisada por meio de benchmarking, documentos técnicos, método do percentil 95 e cálculos de dimensionamento e recursos. A análise da viabilidade econômica foi baseada em cotações de preços para todos os componentes individuais de infraestrutura de TI, desenvolvimento de fluxo de caixa, demonstrativos de resultados e indicadores de retorno e risco. O estudo demonstrou que um modelo de TI compartilhado é viável do ponto de vista técnico, econômico e financeiro, considerando um modelo de aliança estratégica de intercooperação na forma de uma cooperativa central.

Palavras-chave: Infraestrutura de tecnologia da informação. Gestão de tecnologia da informação. Alianças estratégicas. Intercooperação. Cooperativas.

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1 INTRODUCTION

One of the principles of cooperatives is intercooperation. The International Cooperative Alliance (ICA) understands that the purpose of intercooperation is to strengthen the cooperative movement through the joint work of local, regional, national and international structures. Thus, cooperatives can serve their members more effectively since intercooperation stands out in the contemporary cooperative movement as a trend in strategic action for future business (Valadares, 2002).

The need for cooperatives to remain competitive leads them to form intercooperative relationships as a way of lowering the costs of technology, products, and services. Although very difficult to apply in practice, the development of strategic alliances and partnerships in the form of intercooperation is directly linked to a cooperative's strategy of building lasting relationships that can influence results and reduce costs (Lago, 2009). Studies have shown that intercoooperation occurs in several forms: networks/associations between single cooperatives, central cooperatives, agreements or alliances between cooperatives or even through relationships with non-cooperative companies (Braga, 2010; Carvalho, 2016; Konzen & Oliveira, 2015; Lago, 2009). It has also been observed that the formats of intercooperation that exist today include activities involving industrialization, storage and distribution focusing on the cooperative's end business, in addition to occasional negotiations for joint purchases.

However, few studies in Brazil have addressed the sharing of IT infrastructure through strategic alliances such as intercooperation between cooperatives. IT infrastructure is understood as the set of hardware and software, in addition to other components, necessary to support computer programs, including the physical installations of a data center. To bridge this gap, the aim of the present study is to propose a model for a shared IT structure through intercooperation between agricultural cooperatives. The study evaluated the willingness of cooperatives in Paraná State to share their IT structures, the preferred legal form of strategic alliances through intercooperation and the technical, economic, and financial feasibility of the proposed model. It should be highlighted that business application software (business and management systems, support systems and others) was not the object of this study on sharing, in other words, the study focused only on infrastructure software.

The theoretical relevance of this work lies in exploring the theme of strategic alliances and intercooperation between cooperatives. The practical contribution of the study is that it identifies the requirements and technical, economic, and financial feasibility for a shared IT infrastructure between cooperatives based on the principle of intercooperation. Studies have shown that intercooperation, among other advantages, reduces costs, creates new business opportunities, and helps to form an environment for forming bonds and building trust (Braga, 2010; De-Carli, Segatto, & Alves, 2016; Carvalho, 2016; Konzen & Oliveira, 2015). In this context, intercooperation in the sharing of IT infrastructure, in addition to the aforementioned advantages, can mean greater information security, compliance with legal norms, and access to state-of-the-art technology through partnerships at the global level. In Paraná State, intercooperation is consolidated in a number of partnerships and alliances between cooperatives. The Paraná Cooperative Organization (OCEPAR) has encouraged intercooperation through the Paraná Cooperative Plan 100 (PRC 100), which establishes the strategic planning of cooperatives until the year 2020, with the Partnership and Strategic Alliance Committee bringing together representatives from cooperatives involved in several lines of business who seek to expand opportunities for intercooperation (OCEPAR, 2016).

2 THEORETICAL FRAMEWORK

2.1 Cooperatives and intercooperation

In 1895, the first International Cooperative Congress was held in London and resulted in the founding of the International Cooperative Alliance (ICA), an independent and non-governmental association that represents cooperatives from all over the world. According to the definition of the ICA, in cooperatives people operate through a business of which they are joint owners and control it democratically based on principles. These principles, which evolved in the social and historical context, have been reformulated and remain valid: voluntary and open membership; democratic member control; member economic participation; autonomy and independence; education, training, and information; cooperation among cooperatives; and concern for the community.

In Brazil, the Brazilian Cooperative Organization defines cooperatives as a socio-economic movement capable of combining economic development and welfare, with the principles of democratic membership, solidarity, independence, and autonomy, with collective decision-making and fair and equal distribution of profits. This movement is operationalized through the cooperatives.

A cooperative is an autonomous association of people with spontaneous membership, in which individuals seek an economic activity that also achieves social benefits (Barros, Silva, Amaral, & Melo, 2005; Rech, 2000). According to OCEPAR, it is a kind of society of people, with members being both users and owners of the “venture”.

Cooperating means working together to achieve a common goal. Cooperation is essential for the development of relationships and, consequently, the evolution of humanity. According to Wilke, Costa and Freire (2016, p. 02): “Inter-organizational cooperation means joint actions in which the autonomous interested parties become involved in an interactive process, using shared rules, norms and structures to act and decide on issues related to development”. The formation of cooperation networks stems from the perception that organizations, when they operate in isolation, have fewer chances of competing, while working together with other organizations means complementarity and interdependence, enabling the diversification of competencies and resources. According to De-Carli, Segatto and Alves (2016), developing joint relationships in organizations has been very productive as it results in numerous benefits for institutions, mainly with regard to broadening relational capability and inter-organizational cooperation processes.

Cooperation in cooperatives advocates relationships that involve mutual actions such as sharing equipment, installations, research, new product development, joint advertising or participation in events, as well as other diverse actions that stem from or can be developed through cooperation between people or groups (Lago, 2009). Rossetto and Segatto (2014), in their study, found that relational capabilities developed in inter-organizational cooperation/alliances transform internal and external features of an organization because they provide access to knowledge and greater learning through relationships.

In a strategic alliance, participating organizations remain independent after the formation of the alliance, share the benefits of the alliance and control the performance of specific tasks, in addition to contributing continuously to one or more fundamental strategic areas (Yoshino & Rangan, 1996). According to Oliveira (2006), when a strategic alliance is optimized, it can lead to a series of results for the partner cooperatives, such as: a) greater competitive strength for each cooperative or any new cooperative that might be formed; b) better and faster access to technological, financial, commercial and human resources; c) structuring and optimization of the monitoring and evaluation process; d) sharing the risks of the business; e) adding value and strengthening products or services, reducing costs, creating new utilities in products; f) better access to markets; g) improved production processes, optimizing installations and developing operational patterns; h) greater technological capacity through creativity in research and development; i) identification and exploration of new opportunities; j) joint learning and organizational evolution; k) better financial conditions due to higher surpluses and lower administrative costs and investments.

In this context, within the cooperative principles mentioned above, intercooperation is intended to strengthen the cooperative movement with joint work, serving members more effectively (Valadares, 2002). Intercooperation is a form of strategic alliance, as alliances are unions between autonomous firms that seek a common goal and thus share elements of their value chains (Porter, 1989).

Intercooperation can and must be in the relationships of cooperatives, especially because they represent the essence of cooperatives and not only because they result in market expansion, adding to the product portfolio, reducing costs and increasing investment capacity, technology sharing with gains in productive scale and improving the cooperatives’ competitive strength.

2.2 IT Infrastructure

IT infrastructure, also known as computational infrastructure, consists of a set of concepts, components, processes and metrics that can be combined and organized according to the requirements of availability and security of data demanded by the business. According to João (2012), it is made up of five main elements: hardware, software, data management technologies, network and telecommunications technologies, and technology services. Depending on the requirements, it is possible to construct IT infrastructures ranging from the most basic, which support systems for non-critical businesses, to extremely complex ones with high fault tolerance for organizations whose operations cannot stop.

Infrastructure components require integration with one another to constitute a technological architecture that meets the requirements of the business, with critical businesses demanding high levels of reliability and availability of systems, which are inherent characteristics of environments known as data centers.

A data center is an environment with a critical mission that houses equipment and systems responsible for storing information that is vital for the operations of a wide range of businesses to continue (Faccioni Filho, 2016; Marin, 2011) and must have characteristics of resilience, fault tolerance and availability (Marin, 2011). Resilience and fault tolerance in the sense of having the capacity to return the site to its original state in the case of eventual faults and can be obtained with the implementation of redundancy of parts and complete systems. Availability is defined as the time during which a system is operational in relation to the time in which it should be operational.

According to Marin (2011), a data center can be constructed to meet the needs of a single company. In other words, a company can build its own data center, assembled and operated by its owner, known as an Enterprise Data center (EDC). It is also possible to build a data center shared by several companies that are normally clients, and to them the entire infrastructure necessary to operate their systems is offered, meaning physical structure, critical IT equipment (servers, storage facilities and networks), physical and logistical security, and support and management services to maintain the environments in operation, known as an Internet Data center (IDC). Finally, there is a kind of data center that concentrates on delivering ready-made infrastructure (space, electric installations, air conditioning, security, etc.) for the customer to install and operate his own equipment necessary for IT. In this case, the customer is responsible for managing and maintaining his equipment and systems. This is known as a Colocation Data center (CDC).

To prepare project professionals, data center operators and IT managers with the effective means for identifying the performance of the availability of different topologies for the distribution of electricity and air conditioning for data centers, the Uptime Institute (USA), through norm ANSI/TIA-942, developed a classification model for these environments at four levels, known as tiers (Marin, 2011). According to the norm, the availability of data centers is given as probabilities of availability, which can vary from 99.67% to 99.99%, between Tier I and Tier IV sites. However, a data center project that meets the requirements of a certain tier does not necessarily guarantee a determined availability rate. What the model allows is an assumption of an expected probable availability corresponding to the tier for which a given data center was projected. Therefore, the classification of data centers in tiers determines the characteristics of architecture, telecommunications, and electrical and mechanical features to define the level of availability, redundancy and fault tolerance of a data center.

3 METHODOLOGICAL PROCEDURES

Initially, a questionnaire was sent to the strategic managers of agricultural cooperatives in Paraná State that were members of OCEPAR in January and February 2019. This first survey was intended to gauge the managers' perception of regarding IT, the willingness of cooperatives to take part in a pilot study to develop a structure for sharing and to determine the most appropriate legal framework for this structure. The questionnaire was made up of three parts: (i) profile/characterization of the cooperative; (ii) on a Likert scale (1 – totally disagree; 2 – partly disagree; 3 – indifferent; 4 – partly agree; 5 – fully agree), to determine the level of agreement with statement that focused on IT, specifically regarding the strategy for investment in cutting-edge technology and upgrading technology, the impact of the unavailability of IT and willingness to increase investments in performance and information security; (iii) focused on information infrastructure sharing with regard to interest in practicing intercooperation, intention to participate in a pilot study for sharing and the most appropriate legal framework for a shared IT structure.

In the second data collection phase, a non-probabilistic convenience sampling technique was used, with the eight agricultural cooperatives in the west of Paraná State that participated in the first phase and agreed to continue with the study on shared infrastructure. This region was chosen for the study because it is home to the cooperatives with the highest levels of industrialization in the state and because they have their own large IT structures, and these conditions are considered suitable for the purposes of the study. The managers of the technological areas of the cooperatives were surveyed between March and April 2019. The purpose of the questionnaire in the second phase was to identify the cooperatives' sharable IT infrastructure components and their respective quantities. The components were classified in terms of data processing, data storage, internet link traffic, software licensing, and exclusive use components.

After surveying the cooperatives' IT requirements, analyses were conducted to determine the technical, economic, and financial feasibility of the proposed shared infrastructure. According to Silva, Jacovine and Valverde (2002), prior to implementation, the entire project must be submitted to feasibility tests. The authors claim that the purpose of a technical feasibility analysis is to gauge the capacity to execute the project. This is where the existence of technical resources and/or technology to enable delivery (product, service or idea) and meet the required specifications is determined. To analyze the economic feasibility, the aim is to evaluate whether revenues will surpass costs throughout the lifespan of the venture, and the financial feasibility analysis gauges whether the resources required to implement the project are available. To Souza and Clemente (2009), decisions to invest capital primarily involve analyzing the technically viable alternatives, in a decision-making process that includes generating and evaluating different alternatives that satisfy the technical specifications of investments.

The technical feasibility was analyzed using benchmarking with a data center company, technical document analyses of the IT infrastructure technologies considered in the study, applying the 95th percentile method to estimate the data processing capacity and resource sizing calculations for a shared infrastructure. To analyze the economic and financial feasibility, it was necessary to obtain price quotes for all the components in the cooperatives' individual IT infrastructures to determine the monthly expenditure on this infrastructure with third-party suppliers. The estimates were prepared in April and May 2019 with prominent providers in the market, such as Microsoft, Amazon, Google, CDZNet, Odata, and Maxihost. Estimates for the components were sought from three different suppliers, and the average price was used for the purpose of the study.

Regarding the budget for the components needed to build a shared IT infrastructure, the sizing was based on the sum of the demands for use collected from the cooperatives and weighted using benchmarking with a technology company based in Cascavel, Paraná, which has provided data center and IT infrastructure services for twenty years.

All of the sizing of investments, costs, and expenses necessary for a shared infrastructure were followed by estimates of values from specific suppliers. These estimates were made in person, by e-mail and on the suppliers' websites, and all the documents were kept on file.

Finally, cash flows were constructed and economic and financial feasibility calculations were made using the multi-index methodology. The multi-index methodology for investment analysis proposes an alternative to evaluate projects considering the dimensions of return and risk. It makes use of several indicators, resulting in consistent information to support the decision to accept or reject an investment project. The indicators associated with the project's return dimension are: Net Present Value (NPV); Net Present Value annualized (NPVa); Internal Rate of Return (IRR); Benefit/Cost Index (BCI) and Return on Investment Added (ROIA). The indicators that form the risk dimension of the project are: Internal Rate of Return (IRR); Payback; Payback/N Index, MAT/IRR (Minimum Attractiveness Rate/Internal Rate of Return) Index, Degree of Revenue Commitment (DRC), Management Risk and Business Risk. Full details of the methodology for calculating and interpreting the indicators can be found in Souza and Clemente (2009).

4 FINDINGS AND DISCUSSION

In the first phase of the research, 22 agricultural cooperatives in Paraná State completed the questionnaire. Of these, 18 are single cooperatives and 04 are central cooperatives. Regarding turnover, 36.4% of the cooperatives have a turnover higher than three billion reais, 13.6% have a turnover of 2 to 3 billion reais, 13.6% is also the number of cooperatives that have a turnover of one to two billion reais, while 36.31% have a turnover of under one billion reais. Concerning the number of employees, 4.5% of the cooperatives employ over 10,000 people, 22.7% have between 5,000 and 10,000 employees, and 72.7% employ under 5,000 workers. As for the number of cooperative members, 22.7% have a membership of over 10,000, 27.3% have from 5,000 to 10,000 members, and 50% have fewer than 5,000 members. Regarding the position of the respondents, 01 was a director, 04 were superintendents, 13 were mangers, 01 was a supervisor and 03 were coordinators.

The representatives' replies with regard to how the cooperatives perceive IT are presented in Table 1. In 77.3% of the cooperatives, there is partial or full agreement with the statement that the cooperative has an effective strategy for investments in state-of-the-art IT and upgraded technology. All of the cooperatives (100%) agree (fully or partly) that the unscheduled unavailability of IT has a very high impact on their operations. The same number is in agreement with the perception that the cooperatives are willing to intensify their investments with a view to gaining better performing IT infrastructures and are also willing to make more investments available to achieve greater information security.

Table 1

Cooperatives' perception of information technology

Questions	**1**	**2**	**3**	**4**	**5**
Considering the cost-benefit relationship, my cooperative has an effective strategy for investing in cutting-edge information technology and technological upgrades	4.5%	18.2%	0%	27.3%	50%
The unscheduled unavailability of information technology in my cooperative has a very high impact on operations	0%	0%	0%	18.2%	81.8%
Considering the cost-benefit relationship, my cooperative is willing to invest more intensely to achieve greater performance of our information technology infrastructure	0%	0%	0%	27.3%	72.7%
Considering the cost-benefit relationship, my cooperative is willing to increase its investments to achieve greater security of our information	0%	0%	0%	31.8%	68.2%

Note: 1 – totally disagree; 2 – partly disagree; 3 – indifferent; 4 – partly agree; 5 – fully agree.

In addition to perceptions regarding IT, the questionnaire also asked about the cooperatives' interest in practicing intercooperation as a strategic alliance by sharing IT infrastructure with other cooperatives. Of the respondents, 95.5% said they were interested in practicing intercooperation.

The cooperatives that voiced interest in intercooperation were asked whether they would be willing to participate in a pilot study to identify the requirements and feasibility of building a shared IT infrastructure. Around 91% agreed to take part in the study (20 cooperatives).

Thus, the cooperatives showed that they were willing to strategically and politically make this sharing model feasible, demonstrating the managers' interest in practicing intercooperation. Therefore, an effort was also made to discover the most appropriate legal framework for a shared IT structure in the opinion of the cooperatives in question. For 22.7%, the preferred option was to open a limited company (LTDA or S/A in Brazil), 36.4% suggested other options and 40.9% opted for a central cooperative. Consequently, in the research, a decision was made to analyze the feasibility of opening a central cooperative for the sharing model. A central cooperative, considered second-degree, seeks to organize in common and on a larger scale the services of its members (single, first-degree cooperatives), thereby facilitating the reciprocal use of services. It is constituted by at least three single cooperatives. In exceptional circumstances, it can also allow private individuals to join.

Considering that its activity and goals define how a cooperative is classified, the line of business of this cooperative, according to OCEPAR (n. d.), is infrastructure for the purpose of directly satisfying the priorities and needs of the members by providing infrastructure services. This will allow it to focus on the end activities of the business.

To constitute a central cooperative, it is necessary to define a set of rules governing how the cooperative will be organized and how it will function. This is known as the company bylaws. This was achieved through benchmarking with a central cooperative that has been operating in the west of Paraná for 44 years. The outline of the company bylaws included defining the: a) name, headquarters, and line of business; b) social goals; c) relationship between the central cooperative and its members; d) social capital; e) organizational structure; f) fiscal year, balance sheet, surplus, losses, and funds; and g) dissolution and liquidation.

The organizational structure of the proposed central cooperative is shown in Figure 1.

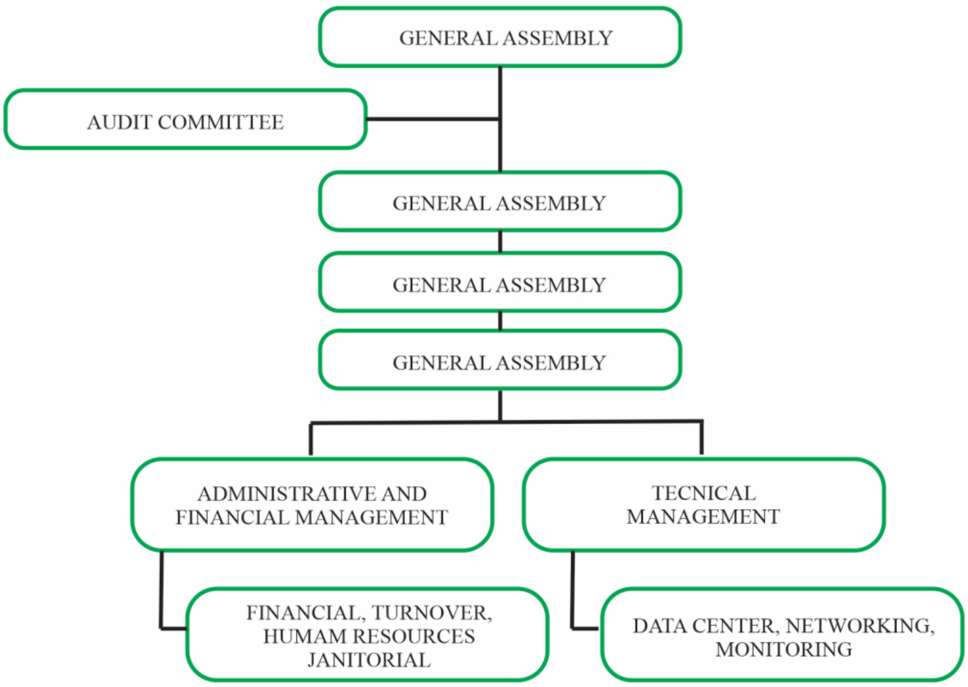

Figure 1. Organizational structure of the Central Cooperative

The General Assembly, which can be Ordinary or Extraordinary, is the supreme body of the central cooperative. Formed by the delegates from the affiliated cooperatives, it has powers within the limits of the Law and Bylaws to make any decisions of social interest, and its resolutions are binding on all affiliated cooperatives, including those not in attendance or who disagree. The Audit Committee consists of three full members and three alternates, delegates from affiliated cooperatives, elected annually by the Ordinary General Assembly, with the task of supervising and monitoring the management of the central cooperative. The Board of Directors is composed of the Presidents of the affiliates, as full members, with an equal number of alternates, elected at the General Assembly, for a term of four years. The Board of Directors is responsible for indirectly participating in the management by monitoring the executive management and deliberating on the organization's strategies. The Chief

Executive Officer is elected from among the members of the Board of Directors for a four-year term. The Chief Executive Officer is responsible for planning, organizing, executing and directing all activities of interest to the central cooperative, respecting the private attributions of the Board of Directors as defined in the Bylaws. The organization chart also includes the positions of employees hired for command and execution functions, at the hierarchical level of superintendence, answering to the Chief Executive Officer, and technical, administrative, and financial management.

4.1 Technical feasibility analysis

With the cooperatives willing to participate in the pilot study, the next step was to analyze the technical feasibility, and later the economic and financial feasibility, of the proposal to establish the central cooperative for a shared IT infrastructure. Thus, the aim of the second phase of the research was to conduct at each selected cooperative a survey of the sharable IT infrastructure components. With these components, it is possible to determine the requirements, sizing of infrastructure, and the necessary investments for the feasibility analyses.

Of the 22 cooperatives that participated in the first phase of the research, 8 agricultural cooperatives from western Paraná were selected to continue the study. Made up of six single cooperatives and two central cooperatives, the cooperatives are referred to in the study as Cooperative A, B, C, D, E, F, G, and H. The 8 cooperatives are represented by people who work as managers, supervisors, coordinators, analysts, and other positions of responsibility. In this profile, professionals who have worked in the information technology area for between 4 and 25 years stand out.

To survey the infrastructure of each cooperative, it was necessary to study and cluster the components, classifying them into five groups: data processing; data storage; internet link traffic; software licensing; and exclusive use components. The number of components required in each group and at each cooperative is listed in Table 2.

Table 2

Number of sharable IT infrastructure components

Groups	Components	Cooperatives							
		A	B	C	D	E	F	G	H
Data processing	VMs	106	61	18	37	270	113	112	23
	Average number of vCPUs per VM	4	4	9	4	10	6	5	6
	Average RAM memory per VM	8	10	35	24	20	25	7	17
Data storage	Space used (TB)	20	15	3	16	164	47	146	9
	Backup (TB)	12	105	10	5	1049	180	61	10
Internet link traffic	Access to VMs (GB)	210000	9428	2375	21600	43000	4320	55000	436
Software licensing	Remote terminal service	0	289	500	150	3947	15	110	150
	Database	13	6		12	20	15	9	2
	E-mail	0	1590	1000	260	3500	1500	1500	200
	Application suite	0	7	0	0	200	0	120	150
Exclusive use components	No. of exclusive use components	Cage	Cage	¼ Rack	¼ Rack	Double Cage	½ Rack	Double Cage	None

The Data Processing group includes the number of existing virtual machines, the average number of Virtual CPUs (vCPUs) per Virtual Machine (VM) and the average amount of RAM memory per Virtual Machine (VM). There is a total of 740 VMs at the 8 cooperatives in question.

For the Data Storage group, the total amount of data storage space used was identified, considering the production, test, and development environments and the total amount of storage space used specifically for the maintenance of backups.

The Internet Link Traffic group is related to the monthly volume of traffic generated by user access to systems hosted on Virtual Machines (VMs).

For the Software Licensing group, the number of licenses for remote terminal service software, database manager software, and e-mail software, as well as the number of office suite licenses in VMs, necessary for the functioning of the IT infrastructure, were identified.

The Exclusive Use Components group has to do with machines that, due to a characteristic of the business or the technology used, do not allow the sharing of equipment, although it is possible to use all the infrastructure for air conditioning, security, energy, and other resources that a data center can offer in the form of colocation. Thus, the amount of rack space used (RU - rack unit, metallic cabinet where equipment is allocated) was identified considering these exclusive use components. Cooperative H has no exclusive use components, cooperative F needs half a rack to store its components, cooperatives C and D need a quarter of a rack, cooperatives A and B require a cage (two racks) and cooperatives E and G need a double cage (four racks) each.

The next stage involved identifying the estimated expenses with the individual IT infrastructure components of each cooperative. To determine the values, price quotes were made considering the average market prices for the use of the same services by outsourced infrastructure suppliers. For the Data processing, Data storage, and Internet link traffic groups, estimates were obtained from the main cloud service providers in the world market: Microsoft, Amazon, and Google. For the Software Licensing group, the supplier was Microsoft. For the Exclusive Use Components group, estimates were obtained from CDZnet, Odata and Maxihost. The individual total monthly expenditure of the cooperatives is shown in Table 3. In the estimates from three providers for each component, the average value of the price quotes was considered.

Table 3

Individual infrastructure expenses per cooperative

	Monthly Expenditure in R$								
IT Components	Coop A	Coop B	Coop C	Coop D	Coop E	Coop F	Coop G	Coop H	Total
Data processing	114,257	66,586	60,162	68,282	481,145	175,819	116,644	68,979	1,151,874
Data storage	30,775	36,944	11,422	15,807	387,197	95,172	109,323	19,046	705,685
Internet link traffic	145,625	9,976	3,660	22,988	30,020	3,782	41,775	531	258,357
Software licensing	9,791	39,447	29,090	17,073	186,005	37,601	45,714	21,493	386,214
Exclusive use components	10,988	10,988	1,900	1,900	21,976	3,300	21,976	-	73,028
Total by Coop	311,435	163,941	106,233	126,049	1,106,343	315,673	335,433	110,049	2,575,158
Share	12.1%	6.4%	4.1%	4.9%	43.0%	12.3%	13.0%	4.3%	100%

After calculating the expenses for the individual infrastructure of each cooperative, the next step was to determine the requirements and components, the values of investments, costs, and expenses for the shared IT infrastructure. Therefore, to define the necessary and adequate IT infrastructure for sharing, it was necessary to establish some requirements that guided the conception, sizing, design, and construction of this infrastructure.

Regarding sizing, it is necessary to consider the size and number of cooperatives. Thus, an infrastructure was defined that meets the capacity demand of the eight (8) cooperatives considered in the survey of sharable infrastructure components.

Concerning the kind of data center, it should be noted that the scope of this work is in keeping with the concept of Internet Data centers, due to the aim of sharing IT infrastructure with more than one organization.

As for the service modality, the hosting option was adopted as a standard service for providing the systems of each cooperative, where the data center will be responsible for the delivery, management, and support of the entire energy, air conditioning, and secure access infrastructure, as well as critical IT equipment and operating systems.

For the exclusive use components of each cooperative, the Colocation modality was proposed, in which the cooperative hires only the physical space of the racks from the IDC, as well as its distribution of electricity, air conditioning, and telecommunications infrastructure. All critical IT equipment used, as well as support and management for hardware and software, are all the responsibility of the affiliated member.

Regarding the classification of the data center, it was considered a Tier 3 Internet Data center, predicting an availability rate of 99.982% and a maximum downtime of 1.6 hours per year. This kind of data center was chosen because most of the large cooperatives are currently involved in some form of industrial activity, requiring production or logistic operations for more than one shift and, consequently, need their IT systems to be operational 24x7x365 (24 hours a day, 7 days a week, 365 days a year). Therefore, an IT infrastructure must be able to depend on a self-sustaining system served by redundant subsystems so that unforeseen flaws and scheduled maintenance do not interrupt services.

Concerning the redundancy of the data center, additional infrastructure was proposed for a disaster recovery site. In other words, as well as the main Tier 3 Internet Data center, we must also consider the construction of a second redundant data center in the same category as the main one. This solution is intended to mitigate risks associated with catastrophic situations like natural disasters (earthquakes and storms) or accidental disasters (fires or airplane crashes).

With regard to the availability of the data center, there are variables that must be considered, such as the distance from the main data center to the redundant data center. The standards that govern the construction of data centers set requirements for the location of the building site, based on the distance from airports, rivers and lakes, and power stations. However, these standards do not address the minimum distance between a data center used for disaster recovery and its main data center. There are some minimum distance recommendations according to the type of disaster to be avoided (gales and earthquakes require much greater distances between the two data centers than a fire disaster, for example), but there is no defined consensus or standard.

The distance between sites must be considered in accordance with RPO (Recovery Point Objective) and RTO (Recovery Time Objective) parameters. According to Veras (2012), the RPO defines the quantity of data that it is tolerable to lose should a disaster occur, while the RTO defines the time required for operations to return to normal following a disaster.

Based on these concepts, the ideal scenario is to have a zero RPO, when no data are lost after recovery from a disaster, and a minimum RTO, no longer than a few hours. Starting only from the premise of zero RPO, we should already consider a synchronous data replication solution between the main data center and the redundant data center.

Synchronous replication requires that any data recorded at the main data center should be simultaneously recorded at the redundant data center. For this to happen, the network delay (the time it takes data to travel from one point to another in the network) between both data centers cannot be very long and must be close to the network delay in a local network scenario.

As already mentioned, although there is neither a norm nor a consensus on the minimum distance between two data centers for disaster recovery, synchronous replication solution providers recommend considering a maximum network delay of 5 ms (milliseconds) to enable the replication process at the technical level.

Since network delay is directly affected by the distance that light must travel through fiber optic cables and the amount and types of network equipment that exist between the two points where the main and redundant data centers are located, determining this distance is a relative task and should be the maximum permitted by the access providers in the potential regions, without the delay exceeding 5 ms between the two points. For the purposes of this study, the Main Data Center and the Redundant Data Center will be located in Cascavel, a city in the west of Paraná State, the hub of the region of the eight cooperatives. The configuration of the proposed data center is shown in Figure 2.

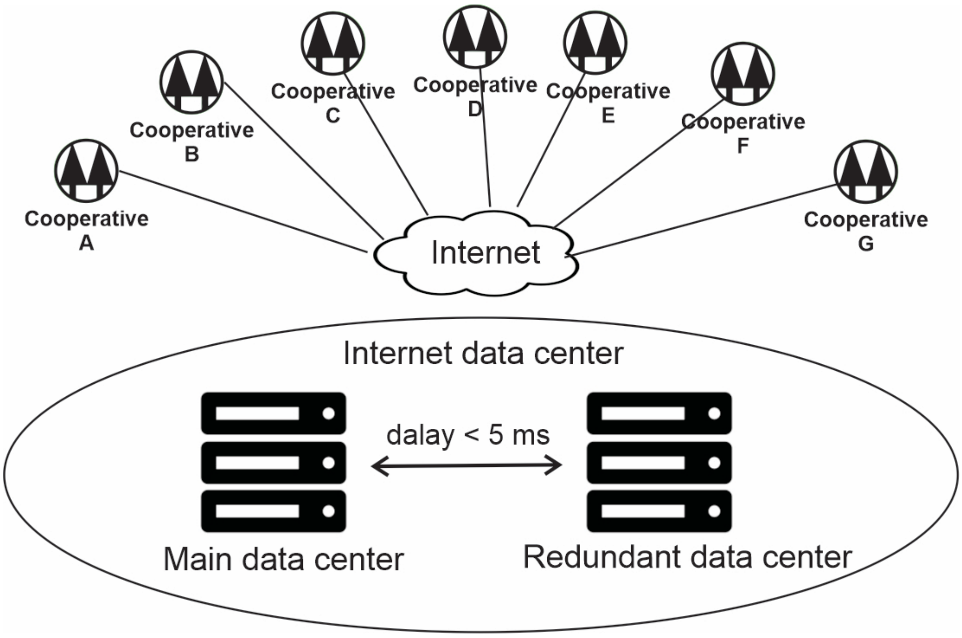

Figure 1. Configuration of the data center for a shared IT infrastructure

In short, it is concluded that the most adequate IT infrastructure for sharing between cooperatives is a Tier 3 Internet Data Center, providing application hosting and colocation services, supported by a Tier 3 Redundant Data Center to allow operations to continue in the case of disasters through synchronous data replication between the two data centers. This will guarantee zero RPO and minimum RTO.

4.2 Economic and financial feasibility analysis

Defining and constructing a shared IT infrastructure that meets the identified requirements results in a resilient, failure tolerant, and available data center environment. It also mitigates risks related to information security, data availability, performance of information assets, and compliance with legal or regulatory requirements.

For the sizing of the shared infrastructure, the sum of the cooperatives' individual components was considered, in other words, the entire demand for a technology infrastructure necessary for cooperative business to run smoothly. In this calculation, the possible idleness of individual infrastructures was not considered in order to optimize the shared infrastructure.

Thus, for the shared infrastructure, the construction of two buildings is proposed:

I. Building of the main data center (MDC): Physical structure that meets the technical requirements necessary for a high availability data center, in addition to appropriate installations for managerial, technical, and administrative teams.

II. Building of the redundant data center (RDC): Physical structure that meets the technical requirements for a high availability redundant data center, but not including installations for work teams.

In addition to the necessary investment to build the infrastructure, the operation costs and expenditures were taken into account. The sums involved in the price quotes for a shared infrastructure were categorized into 5 blocks:

a) Block 1 – Building of the data center: real estate, projects (structural, architectural, electric, and others), civil works, specific electric installations for a data center, air conditioning, furnishings, utensils, computers, and office equipment. A total of R$3,269,874.82 for the MDC and R$1,271,449.00 for the RDC.
b) Block 2 – Data center components: racks, structured cabling, precision air conditioning, video surveillance, access security, fire detection and fighting, generator set, UPS (Uninterrupted

Power Supply), PDU (Power Distribution Units), and ATS (Automatic Transfer Switches). Total: R$1,447,872.26 for the MDC and R$1,447,872.26 for the RDC.

c) Block 3 – IT components: servers, storage, and networks. Total: R$11,458,976.64 for the MDC and R$11,245,878.34 for the RDC.
d) Block 4 – Costs: Licensing and communication. Total: R$655,309.39 per month for the whole infrastructure.
e) Block 5 – Expenses: Electricity, machine maintenance contracts, personnel expenses, property insurance, and general expenses (water, telephone, conservation, and maintenance). Total: R$471,723.03 per month for the entire infrastructure.

The total fixed assets necessary for the initial investment in the project correspond to R$30,141,923.32. For this study, any pre-operational expenses will be paid by the affiliated cooperatives, proportionally according to each one's share in the central cooperative, estimated at approximately 1% of the total investment in the shared infrastructure.

For the economic and financial analysis of the project, a period of five years was considered. This is justified by the fact that 79% of the sum invested in the project are for computers and peripheral equipment and communication equipment. For all of these items, the tax legislation provides for a depreciation of 20% a year. In other words, these goods have an economic lifespan of 5 years (Normative Instruction RFB Nº 1700, of 14 March 2017). At the end of this period, it will be necessary to reinvest in technological upgrades.

It should be highlighted that after the project has begun, there are no provisions for raising funds for working capital, given that the business operates with a negative financial cycle. In other words, expenses will always be paid after monthly revenue has been received.

In this analysis period, it should be emphasized that there will be a monthly surplus of 33% to 36% regarding the project's revenue. Concerning cash flow, the study presents a surplus of R$ 84,089,380.94 over 5 years, as shown in Table 4.

Table 4
List of the project's results and cash flow

	Year 1	Year 2	Year 3	Year 4	Year 5
1. Gross revenues	30,901,895	32,470,074	34,117,833	35,849,210	37,668,450
Infrastructure Location	23,167,039	24,342,697	25,578,016	26,876,023	28,239,901
Communication Service	3,100,287	3,257,617	3,422,931	3,596,635	3,779,153
SW Licensing	4,634,570	4,869,760	5,116,886	5,376,553	5,649,396
Taxes	2,182,139	2,292,876	2,409,232	2,531,494	2,659,959
PIS/COFINS[a]	1,127,919	1,185,158	1,245,301	1,308,496	1,374,898
ICMS[b]	899,083	944,709	992,650	1,043,024	1,095,954
ISSQN[c]	139,037	146,093	153,507	161,297	169,482
FUST/FUNTTEL[d]	16,099	16,916	17,775	18,677	19,625
Net Revenues	28,719,757	30,177,198	31,708,600	33,317,717	35,008,491
Licensing Cost	7,300,517	7,670,996	8,060,276	8,469,311	8,899,103
Communication Cost	563,196	591,777	621,807	653,362	686,518
2. Gross Margin	20,856,044	21,914,426	23,026,517	24,195,044	25,422,869
Personnel Expenses	3,265,920	3,431,656	3,605,802	3,788,785	3,981,055
Electricity	1,675,705	1,760,742	1,850,094	1,943,981	2,042,632
Maintenance and Loc,	570,059	598,988	629,385	661,324	694,885
Insurance	28,992	30,463	32,009	33,634	35,340
Other Expenses	120,000	126,090	132,488	139,212	146,276
Depreciation	5,129,965	5,129,965	5,129,965	5,129,965	5,129,965
3. Surplus and Losses	10,065,402	10,836,522	11,646,773	12,498,142	13,392,716
% Surplus and Losses	33%	33%	34%	35%	36%
Depreciation	5,129,965	5,129,965	5,129,965	5,129,965	5,129,965
Cash Flow	15,195,368	15,966,487	16,776,738	17,628,107	18,522,681

Note: a = Social Integration Program, b = Social Security Contribution, c = Tax On The Circulation of Goods,
d = Tax On Services of Any Nature, e = Universal Telecom e Service Fund/Telecom Technology Development Fund.

The result of the economic analysis of the project for a five-year investment horizon is presented in Table 5.

Table 5
Economic analysis of the project

MAR = Minimum Attractiveness Rate	6.5%
NVP = Net Present Value	39,313,721
NPVa = Net Present Value annualized	9,460,239
BCI = Benefit/Cost Index	2.30
ROIA = Return on Investment Added	18.17%
PBD (Payback Discounted)	2.13
IRR = Internal Rate of Return	46%
MAR/IRR Index	0.14
Payback/N Index	0.43
Degree of Revenue Commitment (DRC)	0.27
Business Risk	0.28

From the perspective of return, we have the following indicators: Net Present Value (NPV), Net Present Value annualized (NPVa), Internal Rate of Return (IRR), Benefit/Cost Index (BCI), and Return on Investment Added (ROIA). The Minimum Attractiveness Rate (MAR), a recommended rate for calculating discounts, was determined according to the basic interest rate of the domestic economy (SELIC), which at the time of analysis was 6.5% p.a.

The NPV represents the net surplus at the project's zero time of the difference between receipts and payments (discounted at the MAR). With a positive result, there is an indication that the project is attractive in economic terms. In other words, the initial investment in the project presents a higher financial return than if this sum were invested in a risk-free application, with the MAR as the yield rate. The NPVa is interpreted like the NPV, but the sums are annual and facilitate interpretation. The outcome of the IRR (in the analysis of the return) being higher than the MAR also indicates the attractiveness of the project. These indicators attest to the economic feasibility of the project in terms of financial return. However, the indices that evidence the real return, after the exclusion of the effect of the MAR, are the BCI and the ROIA. The project's BCI was 2.30, meaning that for every R$ 1.00 invested in the project, there is a return of R$2.30 over the 5 years analyzed. The ROIA indicates 18.17% of the additional return on the investment, which is a return higher than the MAR.

From the risk perspective, there is Payback Discounted, the IRR in the risk dimension, the MAR/IRR Index, the PayBack/N index, Degree of Revenue Commitment (DRC), and Business Risk. A radar chart that aids analysis of the project's risk is shown in Figure 3. The smaller the highlighted internal area, the lower the general risk of the project.

Figure 3. Project's risk

The result of the Discounted Payback represents the period of return on the investment. The project presents a payback of 2.13 years. This means that in little more than two years and one month, the benefits of the project totally recoup the initial investment. The IRR from a risk perspective represents the upper limit of the variability of the MAR. The risk of the project increases according to the proximity of these rates. Comparing the project's IRR of 46% with the MAR of 6.5%, there is a degree of low risk, also evidenced by the MAR/IRR Index (MAR divided by IRR). The lower the MAR/IRR index, the lower the risk of the project. In this study, this index represents 14%, meaning that the project is one of low risk. The Payback/N index (payback divided by the time horizon of the project analysis) also shows a low degree of risk and without dependence on the last periods for its feasibility.

The DRC, which analyzes the proximity between the operational breakeven point and the maximum capacity, is calculated based on the operational breakeven point, which corresponds to the minimum revenue volume to be produced and sold to cover operating costs. This breakeven in the study is R$ 43,136,717.33. The project presented 0.27 DRC, which means that the project sees profits at 27% of its maximum capacity and is thus one of low risk.

The Business Risk, an index linked to cyclical and non-controllable factors that affect the project environment, showed a result of 28%, a further indicator of low risk investment. In this study, the business risk was analyzed using the SWOT (Strengths, Weaknesses, Opportunities and Threats) tool. This SWOT tool was developed based on the perceptions of managers and specialists of the IT infrastructure company, a form of benchmarking employed in the study.

5 CONCLUSIONS

Sharing IT infrastructure seems logical and feasible, as it is well known that every operation conducted collectively produces better results than those done individually. However, in practice there are few initiatives to build models that operationalize the principle of intercooperation.

Initially, the study produced evidence of the managers' perceptions regarding IT infrastructure. All of them are interested in investing more in technology to achieve greater availability, performance and security and promote technological upgrades. The managers demonstrated the importance of technology and understand its impact on business. Furthermore, they also showed their willingness to practice intercooperation as a strategic alliance model for shared IT infrastructure. This willingness is in keeping with the Paraná Cooperative Plan 100, in which OCEPAR has encouraged the development of intercooperation in Paraná through the Partnership and Strategic Alliance Committee.

Most of the cooperatives in the first phase of the study showed their willingness to participate in a pilot study to build a shared model through intercooperation. This willingness represents the cooperatives' intention to put a challenging project into practice, even though it is difficult to do so because it is unprecedented and complex. Thus, another important stage in building a shared infrastructure is analyzing the project's technical feasibility.

The use of various techniques like benchmarking, technical document analysis, calculating capacity sizing, defining the volume and features of products and services, confirmed the project's technical feasibility. In other words, it was possible to specify consolidated technological outcomes using hardware and software from large worldwide suppliers to build this shared infrastructure.

It was then possible to demonstrate the economic and financial feasibility of the project. The set of various investment analysis indicators ensure its feasibility from the viewpoint of return and through the perspective of risk, where all the indicators showed that it was a low risk investment. For this analysis, the multi-index method was used, with the composition of perceived risk analysis versus maximum risk considering the use of five indicators: the MAR/IRR index, Payback/N index, DRC, Management Risk and Business Risk. The absence of a Management Risk indicator is considered a limitation of the study, given that the proposal to create a central cooperative does not define who the professional managers of the business might be, thus making it impossible to achieve the degree of knowledge and competence of the managerial group in similar ventures.

The proposal for the sharing model was based on the format of strategic alliances in cooperatives through intercooperation. In this respect, the most appropriate legal framework for this model, in the opinion of 40.9% of the cooperatives in question, was the constitution of a central cooperative for IT infrastructure services.

Considering the cooperatives' willingness to share an IT infrastructure and the technical, economic and financial feasibility of the project, it was possible to propose a shared IT infrastructure model through intercooperation.

The model also has advantages that were not the focus of the present study but deserve to be mentioned, such as the opportunity to establish processes for joint purchases of technological resources that cannot be shared, like end-user devices, and offer the product and service portfolio of the central cooperative to non-member organizations. Suggestions for future studies include the development of a methodology to test the political feasibility of the project, and the development of a business plan to address other complementary factors for the analysis of a new venture.

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