Intellectual Property and Innovation as a Way to Enable Technological Development in the Agribusiness Sector: a meta-analysis

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Abstract

This article deals with intellectual property, the process of innovation and technological development in the agribusiness sector, and aims to identify and understand the relationship between these themes, in order to know whether intellectual property and innovation are able to foster technological development in this sector. The methodology is meta-analysis, of quantitative approach, preceded by bibliometry and systematic review. The overall result shows that there is a positively high correlation between intellectual property, innovation and technological development in the agribusiness sector, as the result of the meta-analysis was a Pearson's r value of 0.55.

Keywords: Intellectual Property; Innovation; Technological Development; Agribusiness;

1. Introduction

Intellectual Property (IP) represents a stimulus to innovation, to the extent that it rewards the innovator, but can also mean a barrier to the dissemination of knowledge, to reconcile them is a challenge imposed on society (TIGRE; MARQUES, 2009), besides acting as a driving force of the innovation and development process (CARVALHO; SALLES-FILHO; PAULINO, 2007). The protections offered by IP, such as cultivars, have important significance for agribusiness (BUSCH, 2010)

The countries innovation index is measured by the World Intellectual Property Organization (WIPO), which places Brazil in has a great innovative potential, although it still does not have a good level of innovation (MATIAS-PEREIRA, 2013). The WIPO points out a growth of investment in innovation on the planet and, at the same.

Given the objective of identifying and understanding the relationship between IP, the innovation process and technological development in the agribusiness sector, it is sought to know if there is a direct relationship between IP and innovation in technological development in the agribusiness sector, so that IP and innovation foster technological development. To this end, the triangulation method (PARANHOS et. al., 2016) was used, which consists of the quantitative and qualitative approach in the same study, which is possible when using meta-analysis. To carry out the meta-analysis, which has a quantitative approach, it is first necessary to perform a bibliometry, also quantitative, and a systematic review, which is qualitative.

2. Theoretical Referential

2.1 Intellectual Property

IP covers applications in diverse areas of society, from map of ancient Rome to modern day computerized applications (KAMP; HUNTER, 2019). It is regulated internationally through international treaties and conventions, such as the 1883 Paris Convention, the 1886 Berne Convention, the 1970 Patent Cooperation Treaty (PCT), the TRIPS Agreement (1994), and the Madrid Agreement (1989). The Brazilian constitution of 1988 elevated IP to the level of fundamental rights (BASSO, 2008). Brazil also has a vast legislation on IP, highlighting the Industrial Property Law, (nº. 9.279/1996[1]), the Computer Program Law (law nº. 9.609/98[2]), the Copyright Law (nº. 9. 610/98[3]), the Integrated Circuit Topographies Law (nº. 11.848/2007[4]), the Plant Variety Protection Law (nº. 9.456/97[5]), and the Genetic Heritage and Biodiversity Law (nº. 13.123/2015[6]) (CARVALHO; SALLES-FILHO; PAULINO, 2007; VARELLA, 1997).

An integrated set of means of protection is then formed called the Intellectual Property System (SPI) (RUSSO; SILVA, 2018) (Table 1).

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[1]Available at: http://www.planalto.gov.br/ccivil_03/leis/l9279.htm. Accessed on: 07 Jul. 2020.

[2]Available at: http://www.planalto.gov.br/ccivil_03/leis/L9609.htm. Accessed on: 10 Jun. 2020.

[3]Available at: http://www.planalto.gov.br/ccivil_03/leis/l9610.htm. Accessed on: 10 Jun. 2020.

[4]Available at: http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2007/Lei/L11484.htm. Accessed on: 14 Set. 2020.

[5]Available at: http://www.planalto.gov.br/ccivil_03/LEIS/L9456.htm. Accessed on: 22 Jun. 2020.

[6]Available at: http://www.planalto.gov.br/ccivil_03/_Ato2015-2018/2015/Lei/L13123.htm. Accessed on: 14 Set. 2020.

Table 1. Intellectual Property System (IPS)

<table>
<tr><td colspan="4">Intellectual Property</td></tr>
<tr><td colspan="2">Industrial Property</td><td>Copyright</td><td>Sui Generis Protection</td></tr>
<tr><td rowspan="2">Patent</td><td>Invention</td><td rowspan="2">Right Author</td><td rowspan="2">Integrated Circuit Topography</td></tr>
<tr><td>Utility model</td></tr>
<tr><td rowspan="2">Register</td><td>Brands</td><td>Related Rights</td><td>Cultivars</td></tr>
<tr><td>Industrial design</td><td rowspan="4">Computer programs</td><td rowspan="4">Traditional knowledge</td></tr>
<tr><td rowspan="2">Geographical Indication</td><td>Indication of source</td></tr>
<tr><td>Designation of origin</td></tr>
<tr><td colspan="2">Industrial secrets and reprehension of unfair competition</td></tr>
</table>

Source: The SPI with its modalities each of these divided and submodality, according to Russo and Silva (2018) and Araújo et. al. (2010)

2.2 Innovation

Schumpeter (1934) proposes a list of five types of innovation, the introduction of new products, introduction of new production methods, opening of new markets, development of new sources providing raw materials and other inputs, and creation of new market structures in an industry. This concept is in line with that established by the Organization for Economic Cooperation and Development or Economic (OECD, 2005). Innovation, then, represents a possibility to raise the capacity of organizations to compete, to create new ventures, products and services, to make the management of intellectual property in a way that can be an instrument for economic growth (MATIAS-PEREIRA, 2011). Brazil has an innovation model along the lines of triple helix (ETZKOWITZ, 2008), in which the three elements are represented by the State, Society and Universities (ARAÚJO et. al., 2010).

In this context, technological innovation stands out, which is the "production, application and distribution of new technologies in society, having as its main effect the penetration of technology-based products in economic, social, political, etc. sectors. (WOLFGANG, 2015, p. 13, *apud* LIMA, 2020, p. 121). This innovation modality interacts with open innovation (CHESBROUGH, 2003). Open Innovation explains how companies can rely on external technologies to enhance their internal innovation development or how they can leverage external partners to exploit internally developed technologies (HOLGERSSON; GRANSTRAND; BOGERS, 2018) and is a consolidated reality, being relevant not knowing if it will be used, but knowing the degree of openness and the appropriate timing (DAHLANDER; GANN; WALLIN, 2021).

2.3 Technology development

IP is associated with innovation and technology, for him the value of a new technology is directly associated with the possibility of the holder to exploit it in an exclusive way, because a technology that can easily be imitated reduces the organization's revenues to near zero (TIGRE, 2014). Some countries, especially those of emerging economies such as China, India and Russia, face the challenge of protecting IP and, at the same time, attracting foreign investment that can boost technological development and domestic innovation (YI; NAGHAVI, 2017), because the emergence of new companies with new products is fundamental for the technological and economic development of a country (DIAS et. al., 2020). Thus, long-term economic growth is directly influenced by technological innovation, and thus, many countries, especially emerging ones, produce innovation-friendly regulations, but that can ensure significant protection (WOO; JANG; KIM, 2015).

2.4 Agribusiness

In the agribusiness sector it is possible to identify the concepts of agroinnovation, when the traditional concept of innovation is transferred to the field (PIMENTA, 2010), and ecoinnovation, related to sustainable innovation (BARBIERI; SANTOS, 2020).

Brazilian agribusiness is responsible for a considerable portion of the Brazilian economy, generates industrial development in the field, creates jobs, provides development, and produces food (ZANANDREA et. al., 2018), and makes Brazil occupy a prominent role internationally (RODRIGUES; MARTA-COSTA, 2021). The Southern Common Market (MERCOSUR), of which Brazil is part, has a cooperation policy with the European Union to promote scientific research for agricultural development (VELO; PERROTTA, 2020).

Studies related to IP and agribusiness are present in several areas of knowledge, such as: the cultivation of microalgae in Brazil as an alternative for clean production associated with agribusiness in a study that took into account the patent bank (ANDRADE; TELLES; CASTRO, 2020); and the development of technological innovations aimed at sustainability, export expansion, and increased income in the field (MACEDO, 2009). These are examples of the diversity of studies in the agribusiness sector. The agribusiness sector comprises many subareas of the economy and is the largest economic sector in Brazil with relevant participation in the country's economy, a quarter of the national GDP is composed of products from agribusiness (KURESK; MOREIRA; VEIGA, 2020).

3. Methodology

The methodology adopted was meta-analysis, for which a bibliometry was carried out followed by a systematic review to find publications that provide enough statistical data for the meta-analysis. The bibliometry, of quantitative approach, is a search for articles in four databases (Table 2). The systematic review aims to qualitatively analyze bibliometric findings, is a planned study of publications with the aim of meeting the objective formulated for the research, and uses systematization to identify, select and evaluate studies. It was carried out in three steps (Table 3). From the result of the two previous phases, the meta-analysis was performed, which is the calculation of the correlation between different correlation indexes of each study, thus resulting in a final index capable of drawing a conclusion about a given study (VIEIRA, 2020).

Table 2. Search criteria with three parameters

Bases	Criterions					
Scopus and Web of	Indexers					Filters
	1st parameter	Conjunction	2nd parameter	Conjunction	3rd parameter	Open access scientific articles

Science	Property intellectual OR innovation	AND	Agribusiness OR Agroindustry OR Agriculture	AND	Quantitative	with the words in the Title, Abstract or Keywords
SPELL and Scielo	Indexers					Filters
	1st parameter	Conjunction	2nd parameter	Conjunction	3rd parameter	Open access scientific articles with the words in the Abstract
	Propriedade Intelectual OR inovação	AND	Agronegócio OR Agroindústria OR Agricultura	AND	Quantitativo	

Criterions, parameter and indexers used for searches in the four databases, prepared by the authors.

In the making of the meta-analysis itself, one seeks to obtain the primary data of the publications in order to obtain Pearson's r coefficient (PEARSON, 1901, 1904) or Cronbach's Alpha, or other data that can through calculations reach this coefficient and, if necessary (BOBKO; RIECKE, 1980; HUNTER; SCHMIDT; LE, 2006).

Table 3. Methodological steps

Steps	Criterion	Objective
1st	Reading of abstracts and keywords	Select publications that meet some of the study objectives and have some statistical data
2nd	Reading of the objective and theoretical framework	Identify the articles that relate the topics under study
3rd	Analysis of results and final considerations	To detail the results and identify in them which ones provide possible data to relate IP with innovation in agribusiness, such as quantitative method, sample, correlation coefficient, among others.

Details of the criteria and objectives of each step of the systematic review, elaborated by the authors.

From these data, we obtain the so-called effect size or ES, which is "a measure of the strength of the relationship between two variables in a statistical population" (BREI; VIEIRA; MATOS, 2014, p.90). The results of this ES, whether in Pearson's *r* or Cronbach's Alpha, are presented in the Forest Plot, which shows the researcher the visualization of each specific finding, its weight or importance, and compared them with the correlation between the results, the effect size (VIEIRA, 2020). In this type of graph "each line represents one study, with the last line representing the combination of results (the effect size of the meta-analysis) which is symbolized by a diamond. The result of each study is described in the form of squares, which represent the risk ratio" (BERWANGER et. al., 2007, p. 478).

Meta-analysis also allows the evaluation of heterogeneity between studies, that is, to assess the amount of variability between the findings, which may be small or very dilated (HUNTER; SCHMIDT, 2004, apud VIEIRA, 2020). To statistically measure heterogeneity two data are used, the chi-square (X^2), or I-square

(I^2) that ranges from 0% to 100%, with up to 50% considered a significant level, between 50% and 75% considered substantial heterogeneity, and above 75% considerable (PEREIRA; GALVÃO, 2014). The greater the heterogeneity, the more questionable will be the correlation of results, i.e., the effect size.

Finally, in the analysis of the results, the so-called publication bias was also evaluated, through the funnel scatter plot, which is the tendency of the published results to be systematically different from reality (PEREIRA; GALVÃO, 2014). The funnel plot is plotted with the x-axis containing the correlations coefficient and on the y-axis the variance (or sample size), representing that studies with greater variability appear at the top of the funnel and around the mean (BORENSTEIN et. al., 2009).

To arrive at these data and results, as well as to generate the necessary graphics, the software jamovi version 1.2.27.0 and Microsoft Excel version 16.43 will be used.

There are three variables in this study, Intellectual Property (*IP*), Innovation (*In*) and Technological Development (*TD*). Agribusiness is not a variable, but the sector in which the variables will be tested, it will be represented by a. *PI* and *In* will be independent variables and *DT* will be dependent. The sequence of formulas and procedures of Mackelprang and Nair (2010) and Nair (2006) based on Hunter and Schmidt (2004) will be followed, and each calculation step will be explained thoroughly using the software jamovi, using a moderator variable if necessary.

So that the correlations may be in accordance with the objective, the various Pearson's *r* of each study will be grouped according to the variables involved at three moments, as follows: the first correlation will be between the Pearson r's of the variable *PI* and those of the dependent *DT*, obtaining the result *r'*; the second will be between the independent variable *In* and the dependent *DT*, to obtain the correlation *r''*; and the third will be a correlation of the two previous results, *r'* with *r"*, thus generating the correlation *r* as the result of the meta-analysis, that is, the *effect size* (ES) (VIEIRA, 2020).

4. Results and Discussions

Once the bibliometry and the systematic review were performed, 24 articles (Table 4) were obtained for the meta-analysis. Since not all the selected articles directly provided Pearson's *r*, it was necessary to use mathematical equations, using Microsoft Excel software version 16.45, to obtain the desired correlation coefficient.

Table 4. Data for the meta-analysis

Number	Authors	Pearson (r) or Cronbach's Apha	Sample (*n*)	Variable
1	Odongo et al. (2016)	0,268	150	DT
2	Ngwenya e Mashau (2020)	0,317	202	DT
3	Westengen et al. (2019)	0,418	1965	DT
4	Visioli et al. (2016)	0,963	35	DT
5	Chisanga, Mbega e Ndakidemi (2019)	0,379	390	DT
6	Cucui et al. (2018)	0,871	36	DT
7	Zorrilla-Muñoz, García-Sedano e Agulló-Tomás (2019)	0,935	463	DT

8	Chaowanapong, Jongwanich e Ijomah (2018)	0,000	41	PI
9	Handayani et al. (2020)	0,759	50	In
10	Girma et al. (2020)	0,447	387	In
11	Daniel e Fabio (2020)	0,685	178	In
12	Piwowar (2020)	0,020	1101	In
13	Wiratmadja, Profityo e Rumanti (2020)	0,960	223	In
14	Simion et al. (2019)	0,316	122	In
15	Jack et al. (2020)	0,504	703	In
16	Niedbała et al. (2019)	0,787	50	In
17	Delecourt, Joannon e Meynard (2019)	0,702	16	In
18	Junior, Oliveira e Yanaze (2019)	0,303	36	In
19	Cunico et al. (2017)	0,452	33	In
20	Baggio e Kuhl (2018)	0,407	199	In
21	Camargo et al. (2019)	0,223	166	In
22	Krishnan e Foster (2018)	0,903	320	In
23	Haberli Junior et al. (2019)	0,794	448	In
24	Krell et al. (2020)	0,195	577	In

Finding to be used in the meta-analysis with their respective correlation indices

Findings to be used in the meta-analysis with their respective correlation índices Lipsey and Wilson (2001) and Cohen (1998) established correlation levels of Pearson's *r* (Table 5), Lipsey and Wilson's (2001) parameters were adopted.

Table 5. Pearson's *r* correlation levels

Coefficient *r*	Lipsey and Wilson (2001)	Coefficient *r*	Cohen (1998)
0,00 - 0,10	low	0,10 a 0,23	low
0,11 - 0,39	medium	0,24 a 0,36	medium
0,40 - 1,00	high	0,37 a 1,00	high

Specification of correlation levels according to Lipsey and Wilson (2001) and Cohen (1998)

The correlation between the three variables, *PI*, *In* and *DT*, result in the *effect size* (ES), or effect size of the correlation. First the contribution of each of the twenty correlated frame finds was shown in the *Florest Plot graph* (Figure 1), analyzing the weight of each and its coefficient range.

The *Florest Plot* (Figure 1) shows a horizontal line for each of the twenty-four findings, a rectangle in each of them, a dashed vertical line in the center, and a rhombus. The horizontal lines measure the maximum and minimum interval of each study, the rectangles represent the contribution of each of these findings, the vertical line indicates the division of the axis, on the right side are the positive values and on the left the negative ones, and the rhombus shows the *effect size*, that is, the overall result of the correlation *r* (VIEIRA, 2020). The only study whose interval can be negative is finding 8. It also has the only correlation value of 0.00 and the largest interval, but its weight in the analysis is the smallest. This explains why the values of

r' and r'' were equal (0.56).

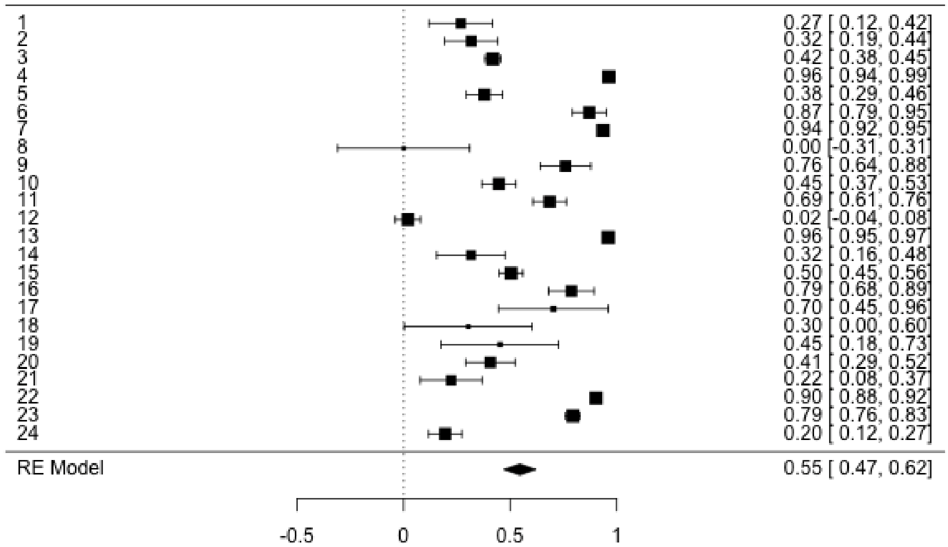

Figure 1. Florest Plot of ES

Correlation indices for each separate study and the effect size, produced by the authors using Jamovi software.

Findings 17, 18 and 19 stand out as having one of the largest coefficient ranges. On the other hand, findings 3, 4, 7, 13, 22 and 23 show the smallest coefficient intervals. As for the weight of each finding in the meta-analysis, it can be seen that most of them have very close weights, while four findings have weights that are not very relevant. This shows that most of the findings are considered significant for the *effect size* result. It can also be seen (Figure 1) that all the findings are located to the right of the graph, which shows that all the studies have a positive correlation. The two findings at the extremes of the positive range of Pearson's r (0.00 to 1.00), are studies 7 and 13, with 0.96 and 0.00, respectively.

The rhombus shaped RE Model shows the ES, $r = 0.55$. The horizontal diagonal of the rhombus indicates the range in which the r coefficient can be shown, it is from 0.47 to 0.62.

Following the level parameters of Pearson's correlation coefficient (Table 5), this value of $r = 0.55$ indicates a high positive correlation between the variables. Thus, the meta-analysis object of this study shows that IP, innovation and technological development in agribusiness are related, such that intellectual property and innovation highly and positively influence technological development in this sector.

Table 6. Statistical Heterogeneity of ES

Tau	Tau^2	I^2	H^2	R^2	Df	Q	p
0,176	0.0311(SE=0,0172)	98,95%	95,550	.	23.000	2958,326	<,001

Prepared by the authors using Jamovi software

The variability among the findings, indicated by the I-square (I^2), is demonstrated by statistical heterogeneity; it will have considerable levels if $I^2 > 57\%$ (VIEIRA, 2020). This meta-analysis resulted in $I^2 = 98.95\%$ (Table 6), which shows considerable heterogeneity, meaning that there is great variability among the findings subject to analysis (Figure 1), as there are findings with a correlation of 0.00 (finding 8) and close to 1.00 (finding 13, 0.96). Even though there is variability among the findings, they are significantly relevant, because the significance of heterogeneity ($p < 0.001$) is high.

Publication bias is indicated by the funnel scatter plot (KNOTTNERUS, 2002, *apud* VEIRA, 2020). This graph (Figure 2) shows the tendency for results to be systematically different or not from reality (PEREIRA; GALVÃO, 2014). Each point in the *Funnel Plot* represents one of the studies (also showing their distribution), the dotted line corresponds to the true effect size for a given intervention, the points higher up indicate the findings with higher publication variability, those lower down indicate the findings with lower variability, and those outside the funnel indicate results that are very diverse from the one found (VIEIRA, 2020). The asymmetric funnel shape suggests the existence of publication bias (SOUSA; RIBEIRO, 2009).

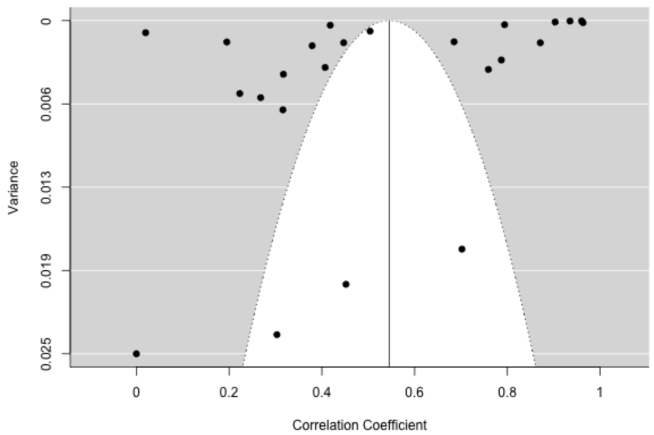

Figure 2. ES Funnel Plot
Produced by the authors using the Jamovi software

Analyzing the points of the funnel plot it is noticeable that only four findings are within the funnel, showing that twenty of them have results different from those found in the meta-analysis. Since there is a concentration of points at the top of the funnel and relatively distant from the mean, it can be inferred that most of the findings have great variability and, given the asymmetric shape of the distribution of the studies, it can be concluded that there is publication bias. This can be explained because of the samples, their size is the strongest influencer of publication bias (SOUSA; RIBEIRO, 2009), as large samples make it easier to find significant results (VIEIRA, 2020).

5. Conclusion

The main objective of this article was to identify and understand the relationship between IP, the innovation process and technological development in the agribusiness sector, seeking to know whether intellectual property and innovation influence, positively or negatively, technological development in the field. The study analyzed the behavior of three variables, two independent, intellectual property (*IP*) and innovation (*In*), and one dependent, technological development (*TD*). Pearson's r correlation resulted in $r = 0.55$ (Figure 1), which means a large and positive *effect size* (Table 5), that is, intellectual property and innovation influence directly, positively and significantly the technological development in the agribusiness sector.

As for the variability among the findings, measured by heterogeneity and taking the I-squared value, I^2 = 98.95% (Table 6), as a parameter, it can be stated that the statistical calculations resulted in considerable heterogeneity, even though the findings were of high significance ($p < 0.001$). The tendency for the findings to be systematically diverse was measured by publication bias (Figure 2), it indicates the presence of publication bias given the asymmetric shape of the funnel.

This research contributes academically to the framework of publications of studies involving the three variables with the quantitative approach provided by the meta-analysis and to indiscipline, since the research addresses topics from two subareas Applied Social Sciences, Administration and Law. For the agribusiness community, the research contributes to show that investments in research and development are able to produce innovation and generate development in the field, contributing to greater profitability and food security. The same can be said of the management of intellectual property protection in the field, since it guarantees the owners the exclusivity of the exploitation and, consequently, the return on investments, the conquest of new markets and exclusivity of the new technology.

The limitations of this research are in the quantity of findings used in the meta-analysis, 24 articles, despite being a quantity close to what Nair (2006) used, 23 studies, and Mackelprang and Nair (2010), 25 articles, in the small quantity of findings involving the variable intellectual property (IP), only one article, and in the time lapse of five years, from 2016 to 2020.

It is suggested, as opportunities for future research, studies that may involve the three variables of this study addressing quantitative analysis, so that it can analyze the correlations statistically. Specifically in relation to some variables, we suggest future research that focuses on intellectual property and its role in technological development, as well as other modes of development. It is also possible to replicate the research in other economic sectors.

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