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Interrelationship between international trade and environmental performance: Theoretical approaches and indicators for sustainable development [1]

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Abstract

In recent years, a great deal of research has analyzed the impact of trade openness on the environment, with the aim of determining whether internationalization contributes to the improvement of environmental performance or, on the contrary, hinders the achievement of sustainable development. The objective of the present work is to conduct a systematic literature review on the interrelationship between international trade and environmental performance (EP) at the micro and macroeconomic levels, analyzing the existent theoretical approaches and the EP indicators utilized in practice. The most prominent theories found are firm heterogeneity, at a microeconomic level, and the pollution haven/halo hypotheses, at a macroeconomic level. Also, the EP indicators have been classified according to five dimensions: energy consumption, resource consumption, emissions, risk potential and toxic potential, of which pollutant gas emissions and energy consumption are the most used. The results obtained show evidence of the interrelationship mentioned from the perspective of the different theories. In addition, this analysis helps to identify several gaps in this line of study.

Keywords: international trade, environmental performance, sustainable development, indicators, theoretical framework, systematic literature review.

1. Introduction

Today, the increase in environmental protection awareness has led countries and companies to undertake ecological initiatives with the goal of increasing EP. As a result, there has been a rise in interest in the search for measures to control pollutant gas

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emissions and reduce the consumption of raw materials and energy, while also promoting recycling and the use of renewable energy sources.

As defined by the World Business Council for Sustainable Development (WBCSD, 2006), eco-efficiency or environmental performance (EP) "is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity." Indeed, eco-efficiency is a business management tool aimed at finding environmental improvements that translate into economic benefits.

In recent years, measuring environmental efficiency has become a key strategic factor, having been demonstrated that ecological management improves both business competitiveness and economic performance in the long term (Rao and Holt, 2005). According to neo-institutional theory, companies operate within a social framework and must display suitable behavior to avoid pressure and gain social approval and legitimacy in new markets (Shah, 2014; Yu et al. 2017).

However, in practice, different environmental indicators are utilized which contemplate various dimensions of EP, thus relativizing comparisons between studies.

In this context, the growing internationalization of the global economy has produced a debate on whether internationalization benefits or harms the environment. The impact of environmental policy on international trade has often been analyzed by means of traditional hypotheses on comparative advantages, such as differences in productivity and factor endowment (Porter and Van der Linde, 1995).

Grossman and Krueger (1993) and Copeland and Taylor (1994) developed a theory differentiating three effects of internationalization on the environment. The first is the scale effect, showing that the increase in a country's production can increase polluting emissions. The second is the composition effect, which occurs in the sectoral structure of the markets if international transactions cause a change in the proportion of cleaner and dirtier industries. And the third is the technical effect, caused by the introduction of eco-efficient technological innovations. Therefore, the total effect on the environment will be the result of the synergy of these three effects.

In contrast to these macroeconomic hypotheses, a new line of research was developed called "new trade theory", focused on explaining the role of firm heterogeneity in international trade. According to this theory, companies that export are larger, more productive, more intensive in technical knowledge and capital and pay their employees better than non-exporting companies (Bernard et al., 2012). Moreover, larger firms obtain higher environmental productivity and are more likely to invest in pollution abatement technologies (Galani et al., 2012; Qi et al., 2021). The most widely-accepted argument is that a stronger international orientation favors growth and productivity, making exporting companies more productive than non-exporting companies. However, these causality relationships may owe to different factors, which has led to the development of two hypotheses. On one hand, the so-called self-selection hypothesis suggests that it is high productivity that induces companies to opt for internationalization, considering that only the most productive companies can bear the hidden costs involved in entering new markets (Roberts and Tybout, 1997; Clerides et al., 1998; and Bernard and Jensen, 1999). On the other hand, the learning-by-exporting theory argues that exporting activity is a driver of productivity, as it exposes national companies to the best international practices and the transfer of new technologies. In addition, the increase in competition at the

international level implies the development of competitive strategies to remain in the market (Grossman and Helpman, 1993; Evenson et al., 1995; and Pack and Saggi, 2001).

Thus, the existence of international trade not only favors the economy, it can also contribute to the improvement of environmental efficiency (Shirazi y Manap, 2005; Hye et al., 2013). Various authors have confirmed that the opening of trade improves national revenue and, consequently, intensifies public demand for environmental protection. Similarly, international trade promotes greater investment in technologies that respect and take care of the environment. In line with these arguments, the pollution halo theory states that internationalization allows the most advanced ecological technologies and environmental management systems to be passed on from developed countries to developing countries (Zhou et al., 2018).

However, other investigations, such as those by Eskeland and Harrison (2003), Cole (2004), Taylor (2004) and Shen et al. (2019), maintain that trade aggravates environmental pollution. Trade promotes large scale industrial production and, therefore, increases pollutant gas emissions and energy and toxic resources consumption, which intensifies environmental degradation. Furthermore, certain countries with weaker environmental regulations attract the attention of multinationals (Li et al., 2018). This scenario is the basis of pollution haven theory, which states that regulations will transfer the pollutant activities associated with trade products to the poorest countries, given that environmental regulations in developing countries are more lenient (Eskeland and Harrison, 2003; and Copeland et al. 2021).

The Environment Kuznets Curve (EKC) hypothesis emerges as a connection between the aforementioned viewpoints. It proposes the existence of an inverted U-shaped relationship between environmental quality and economic development, in many cases determined by the level of internationalization. This hypothesis implies that, initially, economic growth will lead to environmental degradation due to either a lack of or ineffective prioritization of the environment as a political objective. However, subsequently, as the level of revenue increases, environmental protection is promoted, meaning deterioration would decrease and a cleaner environment would emerge in countries with a higher revenue level (Vincent, 1997; and Tisdell, 2001). Currently, studies on the effects of exporting on EKC and EP are still emerging due a lack of evidence.

Although the nexus between economic growth, environmental efficiency and internationalization has been widely studied in the literature, the results are sometimes contradictory and ambiguous (Singhania and Saini, 2021). Moreover, there are no literature reviews that analyze either these interrelationships by differentiating the existent theoretical approaches or the environmental indicators utilized to measure this performance.

Thus, the main objective of this article is to conduct a review and analysis of the theoretical approaches towards the different directions of causality between internationalization and EP, incorporating into the investigation an overview of the current state of the literature on the relationship between these variables at both the micro and macroeconomic levels. Similarly, this study seeks to compile information on the different indicators used to measure EP, classifying them according to the measurement provided by the BASF analysis: resources consumption, energy consumption, pollutant emissions, toxicity potential and risk potential (Sailing et al., 2002), and identifying the existent trends on this subject, determining the most important indicators and discovering

paths for future research. Figure 1 summarizes the theoretical framework of this investigation.

Therefore, the article contributes to the literature in mainly two ways. On one hand, it offers an updated general view of the theories that support the interrelationship between internationalization and environmental efficiency, apart from analyzing and comparing the results of the studies. In addition, it contributes to the development of a body of knowledge to analyze the indicators of EP using 5 dimensions: resources consumption, energy consumption, pollutant emissions, toxicity potential and risk potential. In this way, the study makes it possible to relativize comparisons between countries, industrial sectors and companies. On the other hand, it constitutes a useful reference tool providing business decision-makers with data on all the aspects they must consider to evaluate their EP and diagnose existent problems, with the aim of making improvements on ecological practices.

The article is organized as follows. Section 2 explains the research method used to search for and select the publications analyzed. Section 3 presents a descriptive analysis and discusses the results, classifying the articles according to relationships found between the variables and the theoretical approaches on which they are based. Section 4 specifies and classifies the EP indicators. Finally, Section 5 concludes with the key findings and limitations of the study and offers suggestions for future investigations.

2. Methodology

A systematic literature review was carried out with the aim of analyzing the contributions related to this research subject. This procedure is a precise and structured method, which makes it possible to locate, select and evaluate contributions made to the existent literature addressing a specific research topic, allowing information to be analyzed and synthesized (Denyer and Tranfield, 2009). The present study follows the methodology proposed by Tranfield et al. (2003), which proposes a three-step process: planning, execution and presentation of reports and dissemination.

Firstly, the problem is defined. As previously mentioned, the general objective of this investigation is to analyze the existent literature related to international trade and environmental efficiency to find answers to our research questions: Is there a relationship between degree of internationalization and level of environmental performance? Does EP help firms or countries to increase international trade? Does there exist a bidirectional relationship? And, if so, is it positive or negative? Are there differences at the micro and macroeconomic levels? What theories support these relationships? What environmental indicators are utilized in practice?

To guarantee the quality of this review, we utilize Scopus and Web of Science—the two main research databases with access to countless high-impact journals. The search was conducted in 2021, with no time restrictions, including documents from 1970 to April 2022. In the end, however, the sample selected encompassed documents from 1994, as it was in the 1990s when topics related to sustainable development began to gain importance among stakeholders.

In order to achieve objectives, a systematic search was carried out combining different keywords (Figure 2). These combinations were selected taking into consideration the keywords related to this field and the most widely used by researchers. The search was performed among titles, abstracts and keywords in articles in the databases mentioned. On one hand, relating to environmental efficiency, we introduced the environmental synonyms *sustainable*, *green*, *ecologic*, *ecology* or *clean* followed (at a maximum

difference of 2 words) by *performance*, *efficiency*, *efficacy*, *outcome*, *damage*, *spillover*, *quality*, *benefit* or *productivity*. On the other hand, to filter only the publications that analyze the interrelationship with the internationalization, we include the required condition that the words *export*, *international* or *trade openness* appear in the documents[1].

Using these search criteria, we found 19,756 documents. With the aims of making the analysis feasible and selecting the documents most focused on the topic, we filtered only those that contained the search strings in the title and keywords. Thus, we obtained a database of 1,625 documents. Next, we eliminated any duplicates (128) and removed 1,104 documents during the title screening stage. Subsequently, we read the abstract of every article and the complete articles to evaluate whether they considered internationalization to be an influential variable on environmental efficiency. If this criterion was not fulfilled by a given article, the latter was not kept for the final review analysis. In this way, the sample was reduced to 96 documents. In the final step, we conducted a "snowball" method or cross-reference analysis to identify additional documents, considering the list of references and citations in the articles previously selected (Petticrew and Roberts, 2012) and 22 new references of interest to this topic were included. As a result, a total of 118 documents were finally selected for comprehensive analysis. The entire search process is illustrated in Figure 3.
After having identified the relevant articles, the information was systemized using a Microsoft Excel spreadsheet. The articles were coded according to their publication year, study type and other contextual dimensions, such as geographic approach, object of study (micro or macroeconomics) and industrial sector approach. Furthermore, the articles were classified according to the measurement of the environmental indicators utilized in each study, the results obtained, theoretical approaches and methodologies applied. We delve further into the details of this classification in the following sections.

3. Results and discussion: Theoretical analysis and interrelationship between variables

Figure 4 shows that it is not until 2015 that the publications on the interrelationship between trade openness at the international level and the eco-efficiency level gained greater importance. In fact, more than 50% of the publications are concentrated in the period from 2018 to the present day, so the topic is an emergent research subject.

By geographical area, the continent standing out the most is Asia, followed by America and Europe. On the other hand, about 30% of the studies make a comparison between developing and developed countries (Figure 5).

66.94% of the articles focus on macroeconomics, 31.35% on microeconomics and there are only 2 literature reviews which contemplate both levels. Among the publications focusing on microeconomics (Figure 6), the most prevalent are analyses on the manufacturing sector and those that consider various industries, accounting for 64.86%, while there is a clear lack of research at the microeconomic level for the rest of the sectors.

Focusing on the microeconomic level, Table 1 shows that 72.9% of these studies analyze the influence of international experience on environmental performance, 21.62% examine whether EP helps companies increase international trade relations, and only 2 articles study the bidirectional relationship between foreign trade and EP.

51.35% of microeconomic studies confirm that internationalization had a positive effect on EP. But not only can internationalization positively influence EP, four articles demonstrate that companies with greater EP can also gain competitive advantages in the international market (Bellesi et al., 2005; Galdeano-Gómez, 2010; Sung et al., 2017; Al-Ghwayeen and Abdallah, 2018). In this sense, Rodriguez-Rodriguez et al. (2012) and

Antonietti and Marzucchi (2013) demonstrate a bidirectional relationship between EP and international trade. As for other analyses, 27.02% of the microstudies are inconclusive and only two investigations show a negative effect of international trade on environmental efficiency.

With regard to the macroeconomic level, Table 2 shows that all the articles analyze the effect of international trade on environmental efficiency, and only one of them tries to identify a bidirectional relationship between these variables. The results are not so optimistic at this level: 35.4% of the analyses find that international trade has a positive effect on EP, 32.9% fail to obtain conclusive results, 29.11% state that internationalization negatively influences environmental efficiency and only one study finds a bidirectional relationship between the variables.

Nonetheless, it must be noted that all the articles coincide in that this relationship is found to be negative in developing countries. It can be observed that most of these studies were carried out in China, South America and Africa, and those that study various countries find differences between the results of developed and developing countries, which may indicate the existence of the pollution haven hypothesis.

This section describes the different theories about the causal relationships between international trade and environmental efficiency. For each theory or hypothesis, we develop the technical evidence of the review articles, comparing the results and highlighting open questions. In each approach we distinguish the analyzes carried out at the microeconomic level, from the approaches at the macroeconomic level (see Tables 1 and 2).

3.1. Comparative advantages

The effects of international trade on the environment have often been analyzed through comparative advantages and factor endowments. According to this theory, countries with stricter environmental regulation specialize in cleaner goods, and countries with less environmental regulation find a comparative advantage in the production of polluting goods. This reallocation of trade creates a gap between the countries benefiting from globalization and those harmed by it. (Gouldson et al., 2014; Zhou, 2020).

In contrast, the study by Perroni and Wigle (1994) argues that, although internationalization can negatively influence environmental efficiency, its impact is limited. Their findings suggest that trade represents a small part of world production, or that a large proportion of international transactions is made up of clean goods.

Mao and He (2017) carry out an empirical analysis in different Chinese cities and find that regions with comparative advantages in polluting production are more likely to be affected by international trade. However, the increase in exports generates the phenomenon of agglomeration of industries that will generate external economies, resulting in an improvement in efficiency. Therefore, in the long term, these companies will be able to incorporate the environmental cost into their productive activity.

At the microeconomic level, Sakamoto and Managi (2016) find that energy and environmental efficiency can be a source of comparative advantage in industries and improves export performance. In contrast, Managi and Karemera (2005) confirm that the improvement of efficiency does not have a significant impact and that countries lose comparative advantages due to strict environmental regulations.

Among the articles in the sample, 10 consider comparative advantages theory. Among them, only 20% find a positive influence of international trade on environmental

efficiency, 30% obtain opposite results, one article concludes that environmental efficiency has a negative effect on export performance, and the rest obtain inconclusive results.

3.2. Pollution haven hypothesis

The pollution haven hypotheses arise as a result of comparative advantages. These hypotheses examine whether differences in environmental regulations between countries generate a transfer of pollution to places with weak regulation, either through FDI or through increased imports of polluting goods. In general, developing countries have little environmental regulation, which can become an opportunity for polluting investments (Antweiler et al., 2001; Copeland et al., 2021).

Cole (2004) compares pollutant emissions from developing and developed countries and finds an inverse relationship between emissions of 10 air and water pollutants and the rise of imports of environmental damaging goods from developing countries. In line with this result, Yu et al. (2022) and Le and Le (2022) conclude that trade openness positively influences environmental efficiency only in high-income countries.

At the micro level, an analysis of the battery recycling sector found how tightening environmental regulations in the US shifted production to Mexico, where environmental regulations were more permissive (Tanaka et al 2021). In contrast, the study of Gómez-Bolaños et al. (2018) finds a positive relationship between internationalization oriented towards developing countries and environmental management in the energy sector.

These results highlight the role of environmental regulation in the level of pollution in countries. Shapiro and Walker (2018) point to environmental regulation as most responsible for the observed reduction in polluting emissions from US manufacturing. Huang and Liu (2021) defend that the implementation of strict environmental regulations can promote the transformation of the industrial structure from pollution-intensive to clean. In contrast, the study by Mao and He 2017 (2017) finds that environmental regulations in China are inefficient in promoting innovation.

With regard to the importance of international regulations on international trade, the study by Ikram et al. (2020) concludes that the ISO 14001 certification contributes more to economic development than ISO 9001 and SA8000, both in developed and developing countries. Similarly, it reveals that the adoption of Quality, Environmental and Social (QES) standards has a positive and significant effect on the exportation of goods and services in developing countries.

In summary, 37.93% of articles refer to this theory, but only 34.48% of them support the pollution haven hypothesis and most do not obtain conclusive results to confirm the existence of these relationships.

3.3. Pollution halo hypothesis

At the microeconomic level, 13 studies base the positive relationship between the study variables on the pollution halo hypothesis. Eskeland and Harrison (2003) find that foreign multinationals are more efficient than their competitors in developing countries. According to the analyses of Christmann and Taylor (2001), Albornoz et al. (2009) and Blyde and Ramirez (2021) the property of multinational companies and the exports to developing countries significantly contribute to environmental commitment, as they do to the probability of adopting environmental management systems (EMS), such as the ISO 14000 certification. Exporting to high-income countries induces companies to reduce

polluting emissions. This is because markets in developed countries value clean environments more than consumers in developing countries. Therefore, companies targeting these markets must improve their EP to meet the requirements (Blyde and Ramirez, 2021). In line with this argument, Bellesi et al. (2005) considers that the European market is more conscientious than those of other industrialized countries, as companies are held in high regard if they possess these systems, such as ISO 14001. Thus, countries that adopt these systems obtain a competitive advantage over the European Union. In this sense, Al-Ghwayeen and Abdallah (2018) introduce management of the green supply chain as a tool that ensures competitiveness in the global market.

With regard to the macroeconomic level, 12 consider this theory and 58.33% of them support this hypothesis. Ali et al. (2020) finds an inverse relationship between international trade, eco-innovation and the consumption of renewable energy with the carbon emissions of the top ten emitting countries. Ibrahiem and Hanafy (2021) unveiled international trade and foreign direct investment enhance the shift towards renewable energy and energy efficient technology. Qamruzzaman (2021) reveals the presence of a bidirectional relationship between institutional quality and trade openness. In this sense, Bosetti et al. (2008) defends the positive effect of international trade on the environment as a consequence of the free flow of new technologies and ideas across different firms, industries and regions around the world.

3.4. Environmental Kuznets Curve (EKC) hypothesis

Nearly all the macroeconomic articles utilize the EKC hypothesis as theoretical support. However, while some validate its existence, others either do not obtain conclusive results or deny the existence of this hypothesis in different countries. Focusing on the articles that defend the existence of a positive relationship between international trade and environmental efficiency, 60.7% validate the EKC hypothesis, supporting the existence of an inverted U relationship between economic development and environmental efficiency. Most of these studies confirm this relationship between the degree of internationalization and the level of pollutant emissions, mainly $C0_2$ (Antweiler et al., 2001; Cole, 2004; Managi et al., 2009; Shahbaz et al. 2013; Jiang, 2015; Sadat and Alom ,2016; Gozgor and Can, 2016; Hasanov et al. 2018; Ponce and Alvarado, 2019; Rahman et al., 2019; Dogan et al. ,2020; Ngoc-Tham et al. ,2020; Sajid et al., 2020; Ibrahim and Ajide 2021-b; Nchofoung and Asongu, 2022). Meanwhile, Duman and Kasman (2017) and Trinh et al. (2022) provide a more complete perspective by also considering energy use. Similarly, Destek et al. (2018), Liu, Kim et al. (2018), Alola (2019) and Kazemzadeh et al. (2022) consider a more realistic indicator, namely ecological footprint.

The studies by Alola et al. (2019) and Khan et al. (2020) incorporate renewable energies in the international trade model as one of the significant economic growth variables. Their findings provide technical support for the drafting of ecological policies, taking into account the role of renewable energies to achieve environmental sustainability and economic growth.

Another noteworthy analysis is that of Managi et al. (2009), as it demonstrates the sensitivity of the results between OECD countries and developing countries. According to this study, international trade reduces CO_2 and SO emissions both in the short and long term only in countries belonging to the OECD. However, it also finds that trade has a beneficial effect on biochemical oxygen demand emissions throughout the world.

3.5. Scale, technique and composition effects

With regard to EKC hypothesis, several studies introduce an interesting theoretical model differentiating the effects of the scale, technology and composition of trade on pollution. Thus, while the scale effect caused by increased production implies an increase in emissions, the total effect of the combination of the three can prove either beneficial or harmful to the environment. On one hand, the technical effect tends to be positive due to technical improvements and the introduction of clean technologies as a result of international experience. On the other hand, the composition effect relates to the structural change in the industrial sectors of an economy. Therefore, when less pollutant sectors grow more rapidly than the most pollutant, the composition effect positively influences the natural environment. However, while the analyses by Antweiler et al. (2001), Managi et al. (2009), Shapiro and Walker (2018) and Holladay and Laplue (2021) obtain a combined positive effect, concluding that more open trade appears to be good for the environment, Cole (2006) suggests that the negative scale effect exceeds the positive effect of technique, which highlights that neither regulations nor technological improvements are found at the GDP growth level. Regarding the composition effect, evidence is found suggesting that energy intensive industries are subject to forces in conflict, as postulated by the factor endowment and pollution haven hypotheses. In this context, Murshed (2020) highlights a difference in the behavior of these effects depending on the stage of economic growth. Thus, while in the early stages the negative scale effect is greater and the composition effect is negative, in the later stages of growth the technical effect tends to dominate the scale effect and there is a tendency towards renewable energy consumption.

At the microeconomic level, only 2 contributions analyze the decomposition of these effects. Holladay and Laplue (2021) examine these effects in the US manufacturing sector and decompose the technique effect into four firm-level channels: reallocation among surviving firms, entry and exit of them and within-firms process changes. In line with the results of Shapiro and Walker (2018), this research proves that the decrease in polluting emissions in this sector is mostly due to the technical effect. Behind this effect, approximately two-thirds of the reduction in pollutant emissions comes from the reduction in the intensity of emissions in the surviving facilities, and the remaining portion is driven by the reallocation of production from relatively dirty establishments to cleaner establishments in the same industry. So, in this case, the selection of companies in and out of our sample is responsible for a very small increase in emissions.

3.6. Neo-institutional theory

The neo-institutional theory is defended by 4 microeconomic studies, such as the study by Christmann and Taylor (2001). This article suggests that globalization increases both institutional and customer pressure on companies to exceed environmental regulations in countries known as pollution havens. Similarly, findings by Shah and Rivera (2007) demonstrate that companies in developing countries, located in export processing zones (EPZ), achieve better corporate environmental performance, due to the institutional pressure exerted on them. Therefore, this study emphasizes the importance of formulating environmental policies to improve the environmental position of developing countries. In keeping with this theory, the articles by Cole et al. (2006) and Nguyen and Adomako (2022) investigates the mediating role of external drivers, which include external pressures from the government and other stakeholders. According to this viewpoint, companies feel subject to a "social license", imposed by the stakeholders, which pressures companies to adopt environmental measures that go beyond legislation. For this reason,

if a company wishes to be competitive internationally, it must achieve a strong corporate image.

3.7. Firm heterogeneity

Most of the articles at micro level connect this relationship with the explanatory models of firm heterogeneity. We should highlight that no article based on this approach finds a negative relationship between the variables.

In line with the self-selection approach, Girma et al. (2008), Cui et al. (2012), Cui et al. (2016), Antonietti and Marzucchi (2013) and Forslid et al. (2018) state that exporting firms, as they are more productive, have a greater capacity to invest in ecological technologies, given that they can distribute the fixed cost of the investment throughout their large-scale production, thereby achieving a higher level of environmental efficiency. Cao et al. (2016) also confirms this hypothesis but suggests that the investment pattern has an inverted U shape. This means that when productivity is low, an increase in productivity raises a company's level of investment, but when productivity is high, an additional increase in productivity lowers said level.

Testing the learning-by-exporting hypothesis, Galdeano-Gómez (2010) concludes that, although environmental activity is greater for large companies and for those that have been in the market longer, technological change and efficiency have a greater influence. This finding may indicate that independent of company size or age, companies that operate abroad must adapt to the environmental quality conditions required by environmental regulations and stakeholders. The study by Macchion et al. (2016) supports this hypothesis by stating that textile exporting companies are obliged to adopt environmental practices to comply with the environmental regulations of potential markets. The same study continues by also stating that the introduction of environmental certifications in the supply chain helps companies to not only improve environmental profitability, but to also differentiate themselves from the competition. Another study that defends this stance is Aguilera-Caracuel et al. (2012), which shows that the complex knowledge acquired from international environmental diversification helps to generate a source of value for the organization that is more tacit, ambiguous and unique. Moreover, it suggests that international experience in terms of time is not the key variable; instead, it is the capacity of each organization to learn from their experience in other markets and the commitment of each organization to achieve international environmental standards of quality.

4. Environmental performance measurements

This section describes the dimensions considered in the measurement of environmental efficiency (Table 3). For this purpose, the five dimensions were differentiated precisely as the BASF analysis describes (Saling et al., 2002): material consumption (MC), energy consumption (EC), emissions (E), risk potential (RP) and toxicity potential (TP).

These five dimensions should be considered to obtain realistic results on EP as they make it possible to evaluate total cost and environmental impact of a product or process over its entire lifespan, from input materials to elimination or recycling. However, in practice, it is difficult to find investigations that take these dimensions into account due to the effort required and the lack of internationally comparable data. As Table 3 shows, 80% of the articles in the sample focus on one or two dimensions. Nevertheless, it is worth noting that while 32.43% of the microeconomic studies consider more than two dimensions, only

11.39% of the macroeconomic analyses consider more than two dimensions of environmental development.

Some of the microeconomic analyzes use primary data sources to construct this indicator, mainly through surveys. For instance, Cole et al. (2006) and Barbosa et al. (2022) collect data on the five dimensions of environmental efficiency through different items. However, the greatest limitation of the indicator is its subjectivity since managers can offer information that does not correspond to reality. Other studies use secondary data from national business surveys. For example, Survey Regional Programme for Enterprise Development in Ghana (Cole et al. 2008); Swedish manufacturing census data (Forslid et al. 2018); China's Annual Survey of Industrial Firms (Mao 2022), GreenWatch Program Ranking System in China, Vietnam Enterprise Survey (Tran 2022) or Risk Screening Environmental Indicators database (Holladay, 2016 and Holladay and Laplue, 2021). Most of these articles only contemplate one dimension, either the use of energy or the amount of polluting emissions. This reflects the lack of firm-level data in public databases in this line of research.

At the macroeconomic level, studies build this indicator mainly with information published in national or international databases. The most used database is World Development Indicators (WDI), since it offers data on pollutant emissions or energy use from a wide variety of countries. However, an important limitation of this database is the lack of indicators on the other dimensions of EP. For this reason, most macroeconomic studies focus on one or two dimensions.

The most widely utilized dimension by far is pollutant gas emissions, followed by energy use, while risk and toxicity potential and material consumption receive less attention in the literature. Thus, 85.20% of the documents in the sample contemplate the emission of toxic substances, 47.8% energy consumption, 20% toxicity potential, 20% risk potential and only 13.9% materials consumption. However, it is important to highlight that toxicity potential is often analyzed indirectly. For example, the studies by Christmann and Taylor (2001), Andonova (2003), Bellesi et al. (2005) and Ikram et al. (2020), upon analyzing the implementation of environmental certifications like ISO 14000, implicitly examine toxicity potential, as a necessary condition for obtaining these certifications to comply with certain regulations and initiatives which are respectful of the environment.

In the economic literature there is a tendency to use carbon dioxide (CO_2) emissions as an indicator of environmental degradation. Thus, 50.44 % of all the articles include this measure. Other studies, like Cole (2004) and Honma (2015), used different types of chemical emissions, such as NO, SO_2, SPM and VOC. Also, several analyses combine energy use and pollutant emissions. In this sense, Hossain (2011) explored carbon dioxide emissions and energy consumption for a sample of newly industrialized countries (NIC). Shahbaz et al. (2013) validates the existence of EKC hypothesis in relation to energy use and CO_2 emissions in Indonesia. Alternatively, Murshed (2020) analyzes the impact of trade openness on renewable energy consumption, intensity of energy use and carbon-dioxide emissions in various South Asian economies.

Ecological footprint is also analyzed in various studies belonging to the field of ecology. For example, Al-mulali and Sheau (2014) and Al-Mulali et al. (2015) conduct an analysis comparing data from developing and developed countries and find a positive relationship between international trade and ecological footprint, that is, trade liberalization negatively affects EP. Lim, Kim et al. (2018) provides a similar analysis for Asian countries.

On the other hand, a more complete indicator used by countries to numerically rate environmental efficiency is the Environmental Performance Index (EPI). This index is

assessed in six categories: environmental health, air quality, water resources, productive natural resources, biodiversity and habitat, and sustainable energy. However, only four articles in the sample consider this index. La (2018) examines how OECD importing countries prefer environmentally friendly products. This article considers that a country with a higher EPI exports more environmentally friendly goods. Mullen et al. (2009) concludes that while international trade increases CO_2 emission levels, exporting has a positive effect on the EPI. The results of Alhassan et al. (2020) and Le and Le (2022) indicate that the effects of EPI vary across income groups.

Similarly, by comparing Tables 1 and 3, it is observed that there exists a certain relationship between the indicators used and the results of the microeconomic analyses. Most of the analyses that find a positive interrelationship between international trade and environmental business efficiency consider more than two dimensions. Indeed, 80% of the articles that consider four or five dimensions of environmental efficiency obtain positive results. In contrast, 81.8% of those that obtain inconclusive or negative results or find no type of relationship, focus only on one or two dimensions.

Finally, unlike what occurs at the micro level, the macroeconomic analyses that demonstrate that international trade may contribute to the improvement of countries' EP consider only one or two dimensions, particularly pollutant gas emissions and energy consumption (Tables 2 and 3).

5. Conclusions

International trade tends to be seen as a threat to the natural environment. However, different studies have confirmed that, through proper management, it can positively influence environmental efficiency. The environmental impacts of international trade have been widely studied in the literature. Nevertheless, no study has analyzed nor compared the results of these investigations according to the international trade theories on which they are based. The present study attempts to fill this gap by studying the existent literature on the interrelationship between EP and international trade. In this case, we distinguish the studies analyzing whether internationalization harms or, conversely, can be beneficial to the environment, or in other terms, whether EP helps companies and countries to increase international trade, or if there exists a bidirectional relationship between these variables. Also, this article analyzes and compares the existent results and theoretical approaches and analyzes the environmental indicators utilized in practice.

In the last five years, the number of publications on this subject has risen considerably, demonstrating the increased importance of environmental efficiency as an indicator of sustainable development in the framework of economic globalization. With regard to the descriptive analysis, the key findings were the following: the leading continent is Asia, while the countries with the largest number of analyses were China and the USA; 67.5% of publications study macroeconomics, and at the microeconomic level manufacturing is the most commonly addressed sector. As for the relationship between the variables analyzed, 41.37% of investigations demonstrate that international trade has a positive effect on EP, and 4 microeconomic studies analyze the inverse relationship, that is to say, the influence of environmental performance on the increase of international trade of firms. Also, only 3 articles find a bidirectional relationship between internationalization and EP. However, we are unable to state with certainty that international trade contributes to the improvement of environmental efficiency, as 31.89% of the studies do not obtain conclusive results and 20.68% obtain negative results.

Similarly, differences can be observed according to study level. On one hand, at the micro level most of the results are positive and, in general terms, it can be concluded that international companies can positively contribute to the environment, validating the firm heterogeneity theory and the pollution halo hypothesis. Other studies support the neo-institutional theory, according to which companies feel pressured by different stakeholders to adopt a policy of social responsibility. On the other hand, most studies at the country level validate the existence of the EKC hypothesis. Moreover, a common conclusion among a great deal of these studies is the existence of differences between developed and developing countries, which could demonstrate the existence of the pollution haven hypothesis. Similarly, various articles highlight renewable energies and environmental certifications as key variables to achieve economic sustainability.

With regard to the indicators of EP, it has been confirmed that most of the studies consider only one or two dimensions of the BASF analysis, of which pollutant gas emissions and energy consumption are the most commonly used. Furthermore, most of the analyzes that consider four or five dimensions are focused on the microeconomic level and obtain the data mainly through conducting surveys. There is an evident lack of accessible data, both nationally and internationally, on the use and recycling of materials, investment in eco-innovation or quality certificates for exports and imports from different countries and industrial sectors, which would allow realistic analyses. As for the macroeconomic literature, it is observed that the environmental performance index generally considers only harmful chemical emissions, mainly CO_2, and energy consumption, which represents an important limitation. For this reason, the studies must include the EPI, since this index considers several dimensions of the environmental performance of countries.

However, it must be highlighted that this systematic literature review features some limitations. Firstly, the keyword search method utilized focused on words in titles and keywords to select the articles in the sample, which means there could be publications directly related to this subject which were not included. Secondly, the studies analyzed have different restrictions, meaning the results of this review are dependent on these conditions. Moreover, the geographical scope and the scope of industrial sectors in the literature related to this research topic are still rather limited. Finally, most of the studies consider only one or two dimensions of environmental efficiency, which means the measurements are not complete.

Therefore, future investigations should take into consideration the five dimensions of the BASF analysis, with the objective of obtaining more realistic results on environmental efficiency. Furthermore, it would be interesting to conduct a more specific classification, comparing only studies that utilize these measurements. Finally, almost all articles focus on the manufacturing sector, which shows a clear lack of research at the microeconomic level. Consequently, analyses should be expanded to industrial sectors that have received less attention in the literature and increase the number of countries analyzed, with the aim of obtaining a more complete view of reality.

It can be concluded that this study makes different contributions to the body of literature on sustainable development and eco-efficiency. Firstly, it can serve as a reference tool for academics, given that it offers a better perspective to identify the different international trade theories in relation to EP and understand the benefits and drawbacks of internationalization in environmental terms, also highlighting gaps in this research line. Secondly, it synthesizes and compares the results obtained in different countries and industrial sectors, analyzing the different causal relationships between environmental efficiency and export activity at the micro and macroeconomic levels. Thirdly, we must highlight the lack of an integrated frame for measuring EP, and the present work attempts

to fill this gap, compiling different measurements utilized in research and highlighting the studies that use the five standardized dimensions, in order that they serve as reference for future investigations. Fourthly, this review helps professionals in the business field as it provides key variables which must be considered when measuring the EP of a company. Finally, this article conveys an important message so that policy makers can visualize and understand the problems derived from increased trade and develop an action plan that guarantees the quality of exports. It has been demonstrated that developing countries suffer the most, mainly due to scarce environmental regulation. Therefore, this finding demonstrates the need to revise the legislation on environmental issues in these countries and implement additional incentives for certified industries, in order that they benefit from the transfer of practices and ecological innovations from higher income countries.

Abbreviations: BASF, Baden Aniline and Soda Factory; CIMEDES, Mediterranean Research Center on Economics and Sustainable Development; CO_2 , carbon dioxide; E, emissions; EC, energy consumption; EKC, environmental Kuznets curve; EMS, environmental management system; EP, environmental performance; EPI, environmental performance index; EPZ, export processing zones; FDI, foreign direct investment; GDP, gross domestic product; ISO, International Standards Organization; IT, international trade; MC, material consumption; NO, nitric oxide; OECD, Organization for Economic Cooperation and Development; QES, quality, environmental and social; RP, risk potential; SA, social accountability; SO, sulfur oxide; SO_2, sulfur dioxide; SPM, suspended particulate matter; TP, toxicity potential; US, United States; VOC, volatile organic compounds; WBCSD, World Business Council for Sustainable Development; WDI, World Development Indicators.

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Declarations of Competing Interest

The authors declare no conflict of interest.

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Tables

Table 1. Summary table of the theoretical approaches and relationship between the variables at the microeconomic level

Theoretical scope	**IT→ EP** [1]	**EP→ IT** [2]	**IT↔EP** [3]
Comparative advantages		**(-)** [4]**:** Managi and Karemera 2005 **(IC):** Sakamoto and Managi 2016; Mao 2022	
Pollution haven hypothesis	**(+):** Shapiro and Walker 2018 **(IC):** Cole et al. 2008; Riker 2013; Gómez-Bolaños et al. 2018	**(+):** Sung et al. 2017 **(-):** Tanaka et al. 2021 **(IC):** Mao 2022	
Pollution halo hypothesis	**(+):** Christmann and Taylor 2001; Cole et al. 2006; Shah and Rivera 2007; Albornoz et al. 2009; Blyde and Ramirez 2021; Barbosa et al. 2022 Tran 2022 **(IC):** Andonova 2003; Cole et al. 2008; Bu et al. 2011; Riker 2013; Gómez-Bolaños et al. 2018	**(+):** Bellesi et al. 2005	**(+):** Rodriguez-Rodriguez et al. 2012
Scale, technique and composition effects	**(+):** Shapiro and Walker 2018; Holladay and Laplue 2021		
Neo-institutional theory	**(+):** Christmann and Taylor 2001; Nguyen and Adomako 2022 **(IC):** Shah 2014; Gómez-Bolaños et al. 2018		
Firm heterogeneity	**(+):** Cole et al. 2006; Kennelli and Lewis 2006; Girma et al. 2008; Aguilera-Caracuel et al. 2012; Batrakova and Davies 2012; Cui et al. 2012; Cui et al. 2016; Holladay 2016; Macchion et al. 2016; Forslid et al. 2018 **(IC):** Cui and Qian 2017; Gómez-Bolaños et al. 2018; Liu et al. 2021-b	**(+)** Galdeano-Gómez 2010; Sung et al. 2017; Al-Ghwayeen and Abdallah 2018; Mao 2022 **(IC):** Mao 2022	**(+):** Rodriguez-Rodriguez et al. 2012; Antonietti and Marzucchi 2013

[1] International trade (IT) affects environmental performance (EP)
[2] EP influences the international activity of companies
[3] Bidirectional relationship exists between EP and IT
[4]
(-): Negative relationship between the degree of internationalization and EP
(+): positive relationship between the degree of internationalization and EP
(IC): inconclusive results

Table 2. Summary table of the theoretical approaches and relationship between the variables at the macroeconomic level

Theoretical scope	**IT→ EP** [1]	**IT↔EP** [2]
Comparative advantages	**(+)** [3]: Managi et al. 2009; La 2018 **(-):** Cole 2006; Sajid et al. 2020; Zhou 2020 **(IC):** Perroni and Wigle 1994; Mao and He 2017	
Pollution haven hypothesis	**(+):**Antweiler et al. 2001; Wheeler 2001; Honma 2015; Murshed, 2020; Rahman and Vu 2021; Ding et al. 2022 **(-):** Heil and Selden 2001; Cole 2006; Al-Mulali and Ozturk 2015; Koengkan 2018; Udemba 2019; Yang and Li 2019; Sajid et al. 2020; Zhou 2020; Huang and Liu 2021; Ibrahim and Ajide 2021-b; Liu et al. 2021-a; Kazemzadeh et al. 2022; Nchofoung and Asongu 2022 **(IC):** Eskeland and Harrison, 2003; Cole 2004; Mullen et al. 2009; Li and Wang 2014; Shahbaz et al. 2015; Le et al. 2016; Yue et al. 2016; Mao and He 2017; Chang and Chang 2020; Fathi et al. 2021; Soylu et al. 2021; Khan A.A. et al. 2022; Khan I. et al. 2022; Le and Le 2022; Trinh et al. 2022; Yu et al. 2022	**(+):** Qamruzzaman 2021
Pollution halo hypothesis	**(+):** Niho 1996; Bosetti et al. 2008; Ali et al. 2020; Ikram et al. 2020; Khan et al. 2020; Ibrahiem and Hanafy 2021 **(-):** Yang and Li 2019 **(IC):** Eskeland and Harrison 2003; Li and Wang 2014; Shahbaz et al. 2015; Yue et al. 2016	
EKC hypothesis	**(+):** Antweiler et al. 2001; Taskin and Zaim 2001; Dean 2002; Managi et al. 2009; Shahbaz et al. 2013; Jiang 2015; Gozgor and Can 2016; Duman and Kasman 2017; Destek et al. 2018; Hasanov et al. 2018; Liu, Kim et al. 2018; Alola et al. 2019; Ponce and Alvarado 2019; Rahman et al. 2019; Murshed, 2020; Ngoc-Tham et al. 2020 **(-):** Cole 2006; Al-Mulali and Sheau 2014; Al-Mulali et al. (2015); Rahman 2017; Kurniawan and Managi 2018; Martín-García 2018; Liu, Zhao et al. 2018; Jiang et al. 2019; Udemba 2019; Ahmad et al. 2020; Dogan et al. 2020; Sajid et al. 2020; Ibrahim and Ajide 2021-b; Kazemzadeh et al. 2022; Nchofoung and Asongu 2022 **(IC):** Cole 2004; Hossain 2011; Shahbaz et al. 2015; Tang and Tan 2015; Halicioglu and Ketenci 2016; Le et al. 2016; Shahbaz et al. 2016; Wang and Ang 2018; Salman et al. 2019; Alhassan et al. 2020; Chang and Chang 2020; Rahman 2020; Alvarado et al. 2021; Trinh et al. 2022	
Scale, technique and composition effects	**(+):** Antweiler et al. 2001; Managi et al. 2009; Murshed, 2020; Zhang 2021 **(-):** Cole 2006; Martín-García 2018 **(IC):** Mao and He 2017; Wang and Ang 2018; Trinh et al. 2022	
Neo-institutional theory	**(+):** Ikram et al. 2020	

[1] International trade (IT) affects environmental performance (EP)
[2] Bidirectional relationship exists between EP and IT
[3]
(-): Negative relationship between the degree of internationalization and EP
(+): positive relationship between the degree of internationalization and EP
(IC): inconclusive results

Table 3. Dimensions of environmental performance indicators by authors

Macroeconomic Level						Microeconomic Level					
Authors	**EC₁**	**MC**	**E**	**RP**	**TP**	**Authors**	**EC**	**MC**	**E**	**RP**	**TP**
Perroni and Wigle 1994			X			Christmann and Taylor 2001				X	
Niho 1996			X			Andonova 2003				X	X
Antweiler et al. 2001			X			Bellesi et al. 2005				X	X
Heil and Selden 2001			X			Managi and Karemera 2005				X	X
Taskin and Zaim 2001			X			Cole et al. 2006	X	X	X	X	X
Wheeler 2001			X			Kennelli and Lewis 2006				X	X
Dean 2002			X			Shah and Rivera 2007				X	
Eskeland and Harrison, 2003	X					Cole et al. 2008	X				
Cole 2004			X			Girma et al. 2008		X	X		
Cole 2006	X					Albornoz et al. 2009	X	X	X	X	X
Bosetti et al. 2008	X		X			Galdeano-Gómez 2010	X	X	X	X	
Managi et al. 2009			X			Bu et al. 2011		X	X	X	X
Mullen et al. 2009	X	X	X	X	X	Aguilera-Caracuel et al. 2012	X	X	X	X	
Hossain 2011	X		X			Batrakova and Davies 2012	X				
Shahbaz et al. 2013	X		X			Cui et al. 2012			X		
Al-mulali and Sheau 2014	X		X			Rodriguez-Rodriguez et al. 2012	X	X	X		
Li and Wang 2014	X		X			Antonietti and Marzucchi 2013		X			
Al-Mulali and Ozturk 2015	X		X			Riker 2013	X		X		
Al-Mulali et al. 2015	X		X			Shah 2014				X	
Honma 2015			X			Cui et al. 2016			X		
Jiang 2015			X			Holladay 2016			X	X	X
Shahbaz et al. 2015	X		X			Macchion et al. 2016		X		X	X
Tang and Tan 2015			X			Sakamoto and Managi 2016	X		X		
Gozgor and Can 2016			X			Cui and Qian 2017			X		
Halicioglu and Ketenci 2016	X		X			Sung et al. 2017			X		
Le et al. 2016			X			Gómez-Bolaños et al. 2018	X		X	X	X
Sadat and Alom 2016	X		X			Al-Ghwayeen and Abdallah 2018	X	X	X		X
Shahbaz et al. 2016			X			Forslid et al. 2018			X		

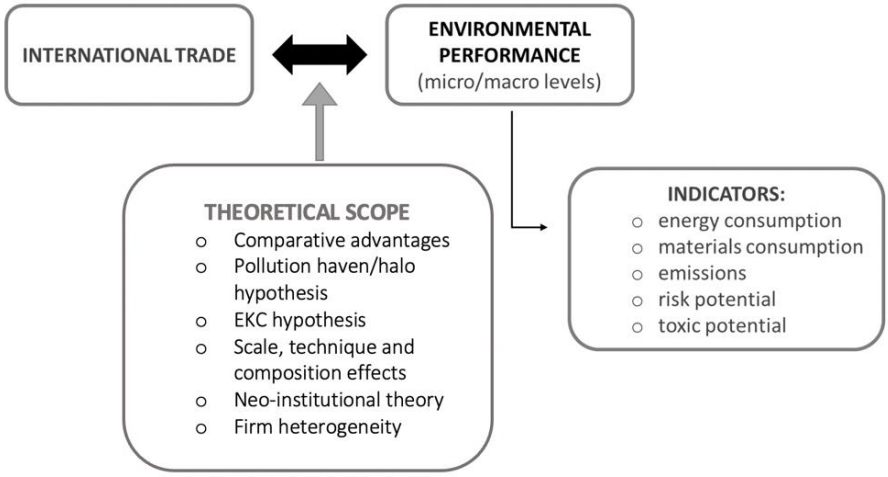
Yue et al. 2016	X		X			Shapiro and Walker 2018			X		
Duman and Kasman 2017	X		X			Blyde and Ramirez 2021			X		
Mao and He 2017			X			Holladay and Laplue 2021			X		
Rahman 2017	X		X			Liu et al. 2021-b	X	X	X	X	X
Destek et al. 2018	X		X			Tanaka et al. 2021			X		
Hasanov et al. 2018			X			Barbosa et al. 2022	X	X	X	X	X
Koengkan 2018	X					Mao 2022			X		
Kurniawan and Managi 2018	X					Nguyen and Adomako 2022				X	X
La 2018	X	X	X	X	X	Tran 2022			X		
Liu, Kim et al. 2018	X		X		X						
Liu, Zhao et al., 2018			X								
Martín-García 2018	X		X								
Wang and Ang 2018			X								
Alola et al. 2019	X		X		X						
Jiang et al. 2019	X		X								
Ponce and Alvarado 2019			X								
Rahman et al. 2019			X								
Salman et al. 2019	X		X								
Udemba 2019			X								
Yang and Li 2019		X	X								
Ahmad et al. 2020	X		X								
Alhassan et al. 2020	X	X	X	X	X						
Ali et al. 2020			X								
Chang and Chang 2020			X								
Dogan et al. 2020			X								
Ikram et al. 2020				X	X						
Khan et al. 2020			X								
Murshed 2020	X		X								
Ngoc-Tham et al. 2020			X								
Rahman 2020	X		X								
Sajid et al. 2020			X								
Zhou 2020			X								
Alvarado et al. 2021	X		X		X						
Fathi et al. 2021	X		X								
Huang and Liu 2021	X		X								
Ibrahim and Ajide 2021-a			X								
Ibrahim and Ajide 2021-b			X								

Ibrahiem and Hanafy 2021	X		X		
Liu et al 2021-a	X		X	X	
Qamruzzaman 2021			X		
Rahman and Vu 2021			X		
Soylu et al. 2021	X		X		
Zhang 2021	X		X		
Ding et al. 2022	X		X		
Kazemzadeh et al. 2022	X		X		
Khan A.A. et al. 2022	X		X		
Khan I. et al. 2022	X		X		
Le and Le 2022	X	X	X	X	X
Nchofoung and Asongu 2022			X		
Trinh et al. 2022	X		X		
Yu et al. 2022	X	X	X	X	

[1] EC (energy consumption); MC (material consumption); E (emissions); RP (risk potential); TP (toxicity potential).

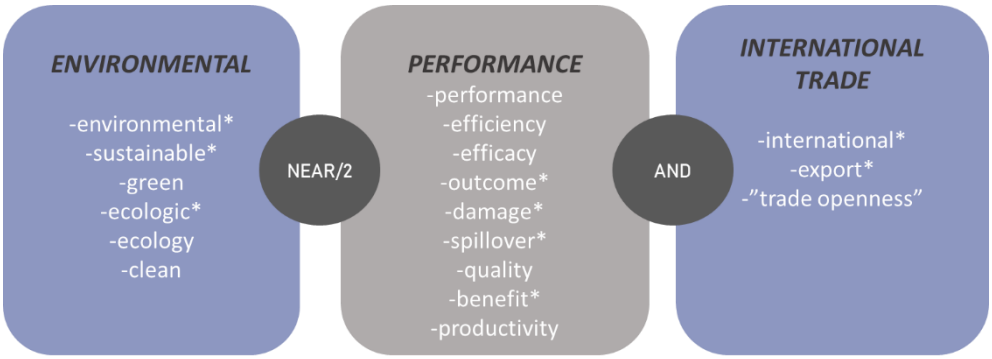
Figures

Figure 1. Theoretical framework



Source: Own elaboration

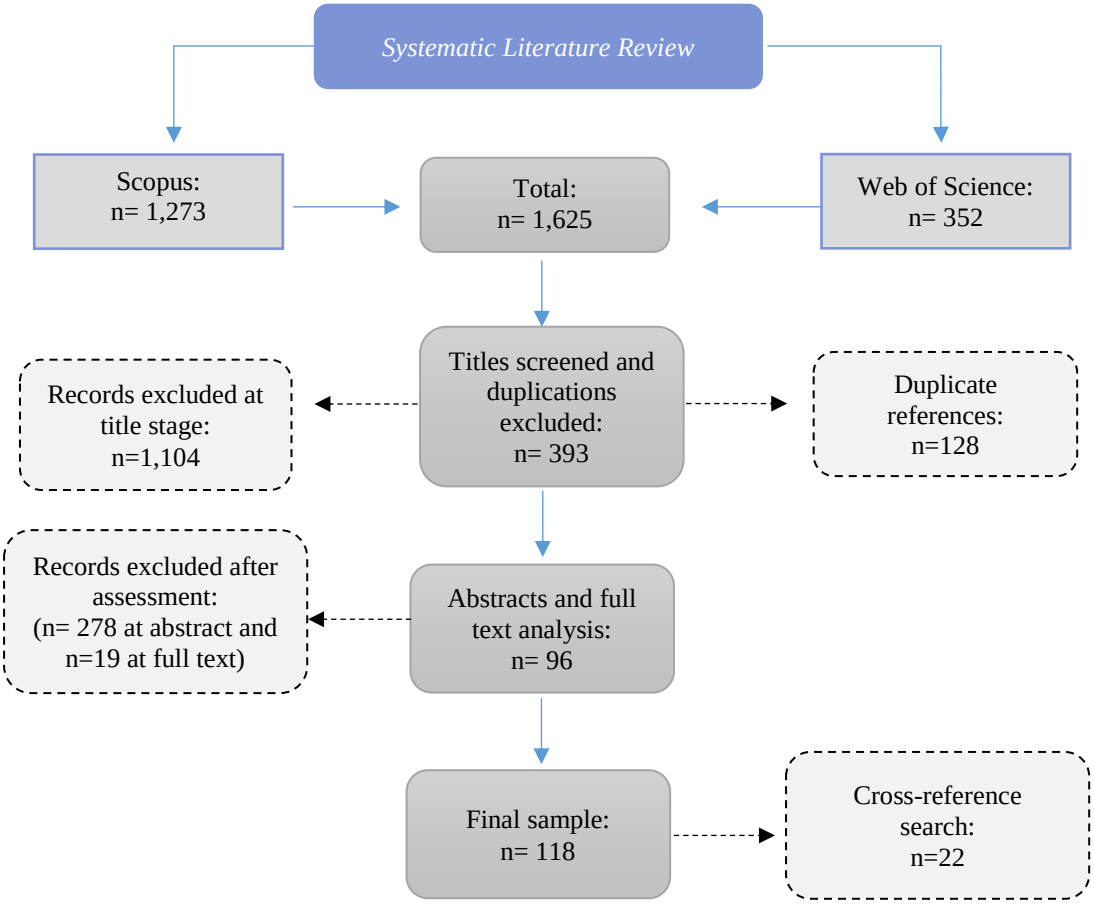
Figure 2. Keywords of search



Source: Own elaboration[2]

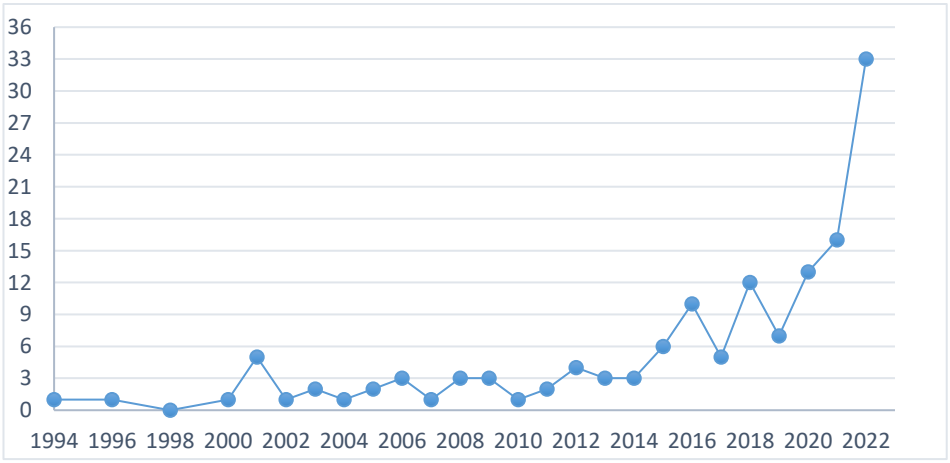
[2] The asterisk after the words is a commonly used wildcard symbol that broadens a search by finding words that start with the same letters.

Figure 3. Search methodology



Source: Own elaboration

Figure 4. Number of publications per year



Source: Own elaboration

Figure 5. Geographical distribution of analysis

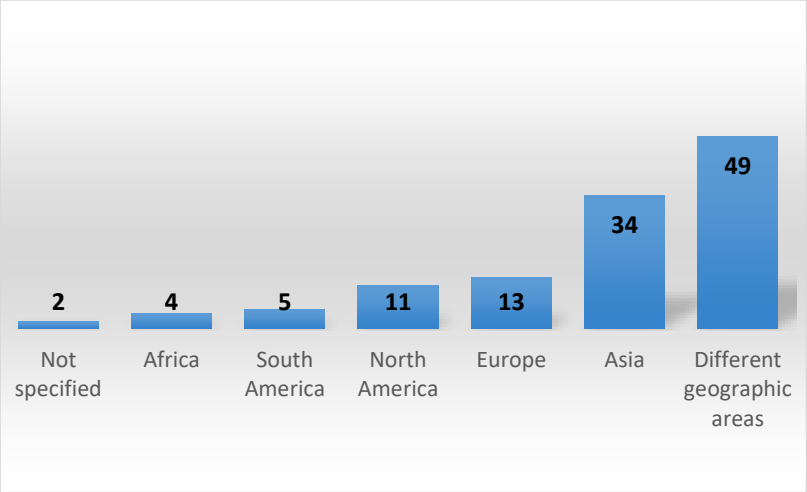


Figure 6. Distribution by sectors