

Crisis Driven Literature in PPPs: A Network Analysis

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# Crisis Driven Literature in PPPs: A Network Analysis

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**Abstract.** COVID-19 crisis has simultaneously triggered a global economic crisis whose consequences will lead to a dichotomy where several governments' debt has grown to unprecedented levels and simultaneously is required to promote new infrastructure supply. This global economic crisis scenario endangers current Public-Private Partnership (PPP) programs given their dependence on payment from the user and/or government subsidies in long-term lifecycles. This study aims for unravelling the PPP research agenda derived from the last global economic crisis in 2008 and the current one for understanding the trends developed as a tool for building a post-pandemic PPP research agenda. For understanding the last global financial crisis PPP literature review and its time and geographic evolution since 2008, this study developed a literature review employing Network Analysis. Therefore, crisis- and PPP-related keywords were combined for establishing the search in the Web of Science database. After removing duplicate papers, 67 peer-reviewed articles were identified for recognizing underpinning topics, potential gaps, and time evolution. The network analysis revealed seven clusters driven by payment sources (i.e., public financial aspects, user payments, and demand), contract mechanisms (i.e., contractual governance, and risk valuation), and project performance (i.e., project performance under crisis and project efficiency). This paper contributes to the PPP body of knowledge by unraveling the post-global economic crisis agenda and its gaps in proposing a new research agenda for overcoming the consequences of the global economic crisis derived from the COVID-19 pandemic.

**Keywords:** Public-Private Partnership, COVID-19, financial crisis, literature review, bibliometric analysis

## 1. Introduction and Background

Public-Private Partnerships (PPPs) have been developed widely for more than 30 years in developed and developing countries [1–3]. The continuity of these projects is based on their sustainability, which can be defined as the aggregation of their economic (i.e., profit), environmental (i.e., planet), and social (i.e., people) dimensions [4–7]. Economic sustainability is focused on guaranteeing the necessary financial government resources demanded by PPPs throughout their life cycle [8].



Environmental sustainability highlights the impact that PPPs have on ecosystems (i.e., downstream water pollution, resource distress, ecological affectation) [4,9]. Social sustainability is "...the degree of satisfaction based on the perspective of social justice, human dignity and participation from a sociological standpoint" [10].

The COVID-19 pandemic jeopardized the overall sustainability of PPPs worldwide [11]. At the same time, the public sector is increasing expenditure, public debt, and fiscal pressure; the private sector has been unable to keep their employees given the lockdowns and the reduction of demand, and the social sector is faced with higher rates of unemployment and reduction of its incomes. As a result, the sustainability of the maintenance and development of infrastructure is endangered. Public-Private Partnerships (PPPs) programs are a suitable solution for the government's budget restrictions, the private sector's needs for sustainable long-term revenues, and the social sector's requirements for employment and public facilities supply. PPPs programs allow for solving the needs of responsible stakeholders (i.e., the public and private sector) and impacted stakeholders (i.e., social sector) [12].

Nevertheless, there could be macroeconomic crises that affect all PPP projects at the same time (such as the current COVID-19 crisis). Changes in financial markets greatly affect PPPs. One of the major uncertainties affecting road PPP projects is macroeconomic issues [13,14]. Additionally, economic crises affect countries heterogeneously, regions, and even, could vary according to local economic environments affecting projects differently.

This paper aims for unravelling the PPP research agenda driven by the crisis. For doing so, traditional bibliometric analysis is complemented by network analysis that is suitable for increasing understanding [15,16].

## 2. Research Methodology

This study seeks to expose the body of knowledge of the PPP research derived from the previous financial crisis in 2008 and the current economic crisis generated by the COVID-19 pandemic. For doing so, the authors developed a comprehensive literature review. Next, the papers resulting from the search were used for building networks based and various attributes. Finally, bibliometric and network results were analysed.

### 2.1. Paper selection, filtering, and analysis

The first step consisted of defining the search criteria for the search and filtering process of papers for defining the Boolean expression, database, inclusion, and exclusion criteria, following prior research [17–19]. Table 1 shows the Boolean expression employed. Topics and journals from unrelated domains were excluded (e.g., social sciences, health care sciences, immunology). As a result, 67 papers resulted.

**Table 1.** Search Strategy

Steps	Description
Keywords and Boolean expression	(Title-Abs-Key ("public private partnership" OR "public private partnerships" OR "build and operate transfer" OR "build-operate-transfer" OR "build/operate/transfer" OR "private finance initiative" OR "concession" OR "pfi" OR "PPP/PFI" OR "PFI/PPP" OR "toll expression road" OR P3 OR PPP) AND (COVID OR "COVID-19" OR pandemic OR coronavirus OR recession OR crisis OR bailout OR "force majeure"))
Language	English
Timespan	2008-2020
Databases	Web of Science

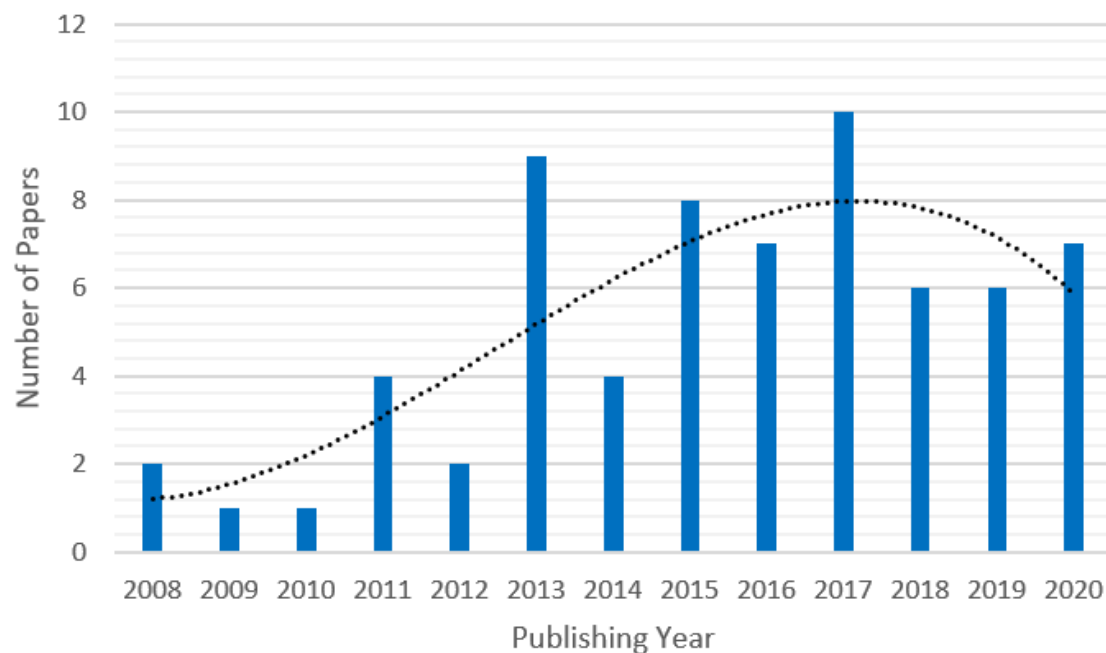
## 2.2. Network development

Similarities matrixes were developed based on the co-occurrence of data by using VOSViewer®. This software package allows for optimizing the Euclidean distance function between every pair of nodes for developing the networks for further analysis [20–22].

## 3. Findings

### 3.1. Chronological and geographic evolution

The PPP literature driven by the crisis has grown in a non-linear way as is shown in Figure 1. Interestingly the most prolific years were 2013, 2015, and 2017, which implies that this research agenda gained momentum in the middle term of the first precursor, 5 years later than the crisis. One suitable reason for this trend is that this research agenda is conducted significantly based on a case study approach. As a result, the consequences of the crisis must be observable to the PPPs/institutions, then the research is conducted, and finally, the publishing process is developed. Nevertheless, the current crisis has boosted publications in 2020. This could indicate that the unprecedented nature of some aspects of this crisis is motivating researchers and editors to trigger studies focused on this research area.

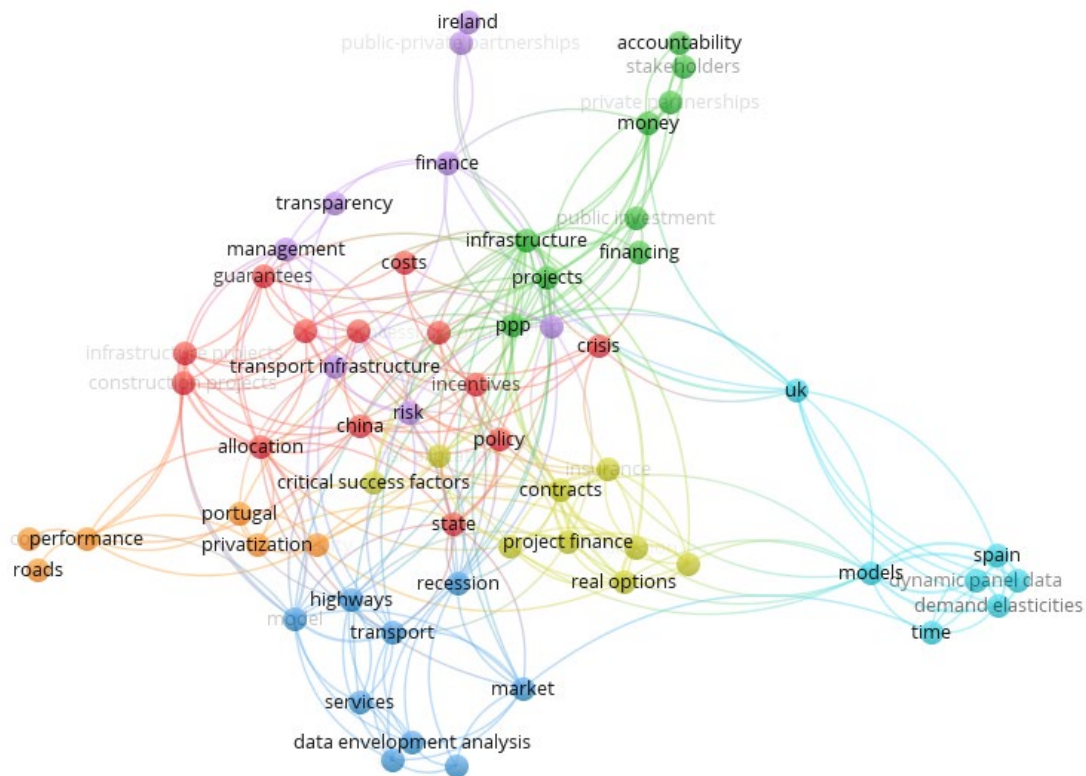


**Figure 1.** Chronological evolution

### 3.2. Network representation

The main network is shown in Figure 2, which depicts the constituent keywords of the papers and their connections. Network analysis revealed that the PPP research agenda driven by crisis could be unbundled on seven clusters, as shown in Table 2. The colors of the nodes identify each of the seven clusters identified.

The biggest cluster (i.e., red color) gathers contractual governance relate keywords, focused on specific mechanisms employed within PPP contracts. Interestingly, the only country within these keywords is China, which reflects that there is an interest in improving contractual governance for tackling uncertainty and guaranteeing clear rules for the private sector. Conversely, the smallest cluster (i.e., orange color) is driven by the project performance under crisis. This demonstrates the interest of researchers in performance indicators especially focused on road infrastructure, its costs, and capacity, which has been significantly studied in Portugal after the 2008 financial crisis.

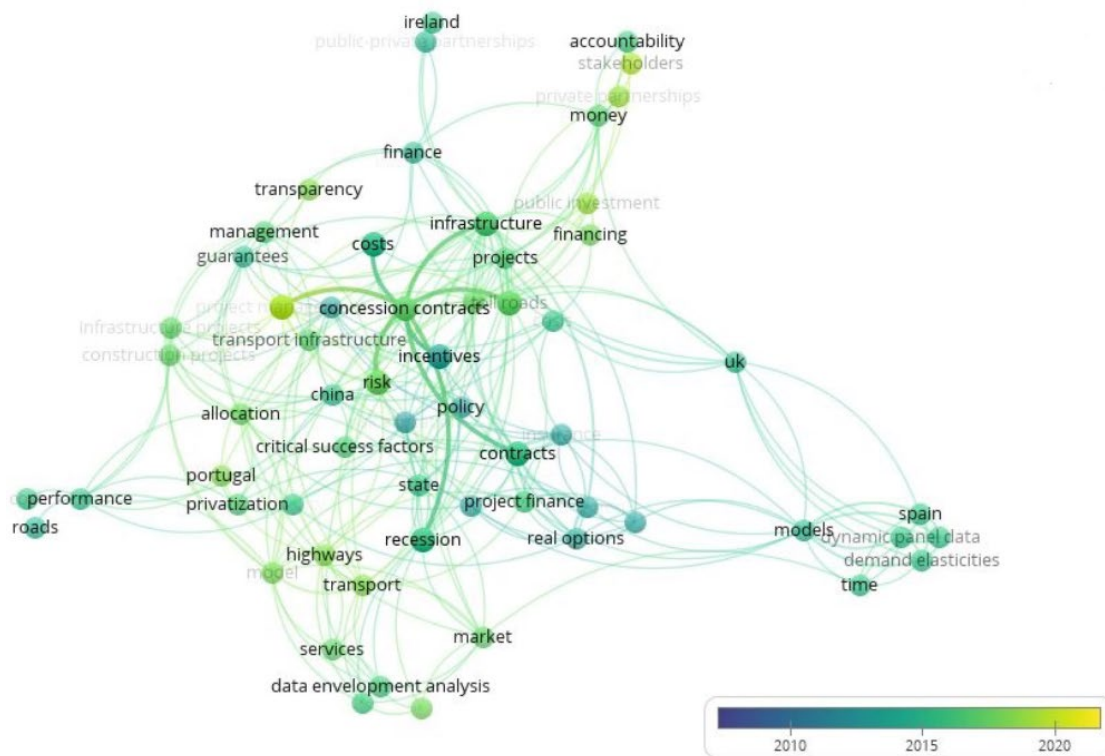


**Figure 2.** Main Keywords' Network

**Table 2.** Cluster Interpretation

Cluster	Color	Example of Keywords
1. Contractual Governance	Red	Concession contracts, guarantees, incentives, policy, China
2. Public Financial Aspects	Green	Value for money, public investment, stakeholders, accountability
3. Project Efficiency	Blue	Data envelopment analysis, market, model, services
4. Risk Valuation	Olive	Risk allocation, risk management, real options, insurance, valuation, simulation
5. User-Payments	Violet	Toll roads, finance, transport infrastructure, Ireland
6. Demand	Cyan	Demand elasticities, time, models, dynamic panel data, Spain, UK
7. Project Performance under Crisis	Orange	Performance, cost, capacity, roads, Portugal

There are five clusters among those extremes. The green cluster represents the financial aspects of PPPs mainly from the public sector lens focused on the analysis of strategies for facing fiscal pressure and guaranteeing the achievement of the life-cycle value for money of projects. This cluster is complemented by the violet cluster, which is focused on user payments. User payment is the main alternative payment source for reducing long-term fiscal pressure on governments that have been significantly developed in Ireland, which has studied its toll road PPPs. Another closely related cluster with the two previous is the cyan colored, which represents demand studies. The implications of the economic crisis on PPPs are significant. Scholars have demonstrated that financial and economic crises affect downward traffic [23], which is especially relevant in user-financed (e.g., toll roads) and user-driven payments (e.g., shadow tolls) PPPs. These topic has been studied significantly inquired in the UK and Spain.



**Figure 3.** Network analysis on Cluster Evolution

The blue cluster is motivated by inquiring about project efficiency topics. Models and other approaches have been employed for establishing opportunity cost, technological and technical efficiency. Finally, the olive cluster is focused on risk valuation. Risk and uncertainty are significant concerns of researchers focused on risk management using approaches such as simulation models or real options.

The network evolution is shown in Figure 3. Therefore, this research agenda has evolved from methodologies such as real options and simulation especially focused on traditional topics at the institutional level such as risk management to topics at the organizational level focused on stakeholders and relational governance for improving the performance of PPPs.

#### 4. Clusters' Discussion

Network analysis revealed seven clusters. Three of them are closely related to payment and financing sources, namely, public financial aspects, user payments, and demand. These clusters include a special emphasis on user-driven and user-financed PPPs. COVID-19 has triggered significant unprecedented government decisions affecting PPPs, such as stay-at-home, telecommuting, and travel-ban orders, which have affected payment sources such as user payments and fuel taxes [24]. Despite the systematic reduction of payment sources in the short- and middle-term, the infrastructure must be built, operated, and maintained, which requires innovation and flexibility for ongoing PPPs, so to design future PPP programs with significant improvements for increasing resilience [25]. Besides the traffic underperformance derived from travel bans and stay-at-home orders, demand in user-pay PPPs is expected to keep under the projections because of the high correlation of demand with GDP, as was demonstrated in the GFC [26]. Consequently, the countries whose economies are the most impacted by COVID-19 are expected to perform the highest impacts in the long term. This highest effect may be related to the countries that have the longest delays in the vaccination rollout because these countries will be the last countries to completely reactivate their economies. This differentiated reactivation will be reflected in inequality in the development of the current and next PPP programs, where the countries with the highest impacts due to COVID-19 could be those that struggle most with renegotiations, early terminations, and financial closures. Researchers have led efforts for optimizing



risk transfer and the corresponding discount rate for improving value-for-money assessments. However, they have faced significant challenges in accessing information due to a lack of transparency of PPP financial data [27]. Future research avenues should focus on increasing alternative sources of payment as a strategy, for example, to face the need for increased capacity of health infrastructure or to compensate for the underperformance of revenues in user-pay PPPs [12]. Future research efforts may explore alternatives for reducing demand volatility in social infrastructure such as diversifying the business within PPPs and developing mixed-used buildings linked to transportation developments.

Two clusters are focused on contract mechanisms (i.e., contractual governance and risk valuation). In this regard, risk allocation theory argues that exogenous risks, such as macroeconomics risks, can only be controlled by the public sector, therefore, the government should bear this risk [28,29]. Despite various governments bearing the traffic risk [30,31] some other countries are allocating this risk to the private sector that allocates this risk to the private sector without any traffic guarantees [32]. This divergence implies that remaining heterogeneous practices that will arise diverse challenges under a global crisis scenario and the mobility restrictions imposed worldwide because of the COVID-19 pandemic.

Conversely, traffic risk has been partially transferred to the private sector through flexible-term PPPs, which aim for increasing the concession period rather than increasing public subsidies when traffic is lower than expected on toll roads. This strategy has been employed in countries such as the UK, Chile, Portugal, and Colombia [32,33]. Nevertheless, the rigidity of isolated contractual governance is not enough to properly address uncertainty. Addressing uncertainty in complex long-term infrastructure projects requires the incorporation of features such as adaptability, changeability, and flexibility [14,34].

PPPs awarded before the COVID-19 pandemic and the ones that will be procured in the post-pandemic could face the risk of early termination because of the effects derived from the aftermath of the crisis. These PPPs could avoid early terminations by improving project cost forecasting [35]. Alternatively, it is possible reducing the costs of ongoing PPPs by changing the project's scope or achieving cost reductions in the shaping phase accordingly. Changing the project's scope is only feasible in the shaping phase to avoid sunk costs; in any case, the intended reduction of the project's scope must achieve value for money [28]. Cost reductions can also be achieved in PPPs even without reducing the projects' scope, by reducing financial costs or maintenance costs. This area of inquiry is likely to be studied significantly in the upcoming years within the PPP body of knowledge because of the lack of research on this matter.

The ongoing materialization of exogenous risks triggered by the COVID-19 crisis could also motivate changes in the stakeholder positions under complex environments, provoking renegotiations such as occurred after the 2008 GFC [36]. Future research may inquire about suitable mechanisms for strengthening relational governance for avoiding renegotiations and, even under a renegotiation situation improve the outcomes by strengthening trust and improving communication to avoid unrealistic expectations of the potential outcomes of the renegotiation.

In this research avenue, some keywords are expected to strengthen the post-COVID pandemic crisis, such as optimizing risk allocation and risk valuation for improving project and performance management [37,38]. The pandemic crisis has challenged traditional risk allocation and valuation given the emergence of unprecedented restrictions as the travel bans affect traffic and revenues in roads and airports in conjunction with the lockdown regulations that affect most of the social infrastructure [25]. Conversely, health infrastructure was put under excessive demand pressure requiring increasing its capacity in record time because of the unprecedented amount of critical patients requiring mechanical ventilation [39]. Valuation and assessment of risks also allow the private sector to optimize their bids rather than making aggressive offers under the expectation of renegotiating them once the PPP is ongoing [26,37].

One significant driver of the risk literature within the PPP body of knowledge in the next future may be the implications of multiple risk allocation among different countries facing extreme events that arose from the COVID-19 aftermath. Risk allocation theory argues that exogenous risks, such as macroeconomics risks, can only be controlled by the public sector, therefore, the government should



bear this risk [28]. Despite various governments bearing the traffic risk [30,31], some other countries allocate this risk to the private sector without any traffic guarantees [40]. These heterogeneous risk allocation practices will trigger differential challenges under both a global crisis scenario and mobility restrictions imposed worldwide because of the COVID-19 pandemic.

The remaining two clusters are related to the project's performance (i.e., project performance under crisis and project efficiency). Efficiency can be achieved by reducing the costs of ongoing PPPs by changing the project's scope or achieving financial cost reductions under alternative finance schemes, for example, by using bridge-to-bond structures. In this scheme, the concessionaire borrows a short-term loan until the implementation phase finishes. Later, this loan can be refinanced by issuing long-term bonds backed by well-rated firms to achieve an AAA score. Currently, any financial cost reduction benefits the concessionaire's profits that these foreign funds partially buy rather than represent a reduction of overall costs of the project, and consequently, a reduction in toll tariffs. These alternatives are suitable for reducing financial costs based on an adequate risk allocation because the financing market will translate an improper risk allocation as an increase in the financing rates.

Maintenance costs can be reduced by lowering service levels to an acceptable minimum, extending heavy maintenance periods, and reducing heavy or light maintenance costs. This strategy was employed successfully in Portugal for reducing public subsidies to the PPP program as a requirement of the Troika (i.e., the International Monetary Fund, the European Central Bank, and the European Union) to receive their financial assistance [36].

## 5. Conclusions and Further Research

This study allows for analyzing comprehensively the crisis-driven PPP literature from the global financial crisis of 2008 until the current COVID-19 financial crisis. For doing so, network analysis has been conducted for understanding the constitutive topic clusters and the connexions between them.

The evolution of this research agenda has shown that the previous global financial crisis led to a research peak after 5 years. Nevertheless, the current COVID-19 crisis has quickly triggered specific research within the overarching conjunction of editors that created special issues exclusively focused on this topic and researchers' interests.

Overall, network analysis revealed seven clusters driven by payment sources (i.e., public financial aspects, user payments, and demand), contract mechanisms (i.e., contractual governance, and risk valuation), and project performance (i.e., project performance under crisis and project efficiency).

Future research avenues should focus on multiple goals. First, increasing alternative sources of payment as a strategy to face the need for increased capacity of health infrastructure or to compensate for the underperformance of revenues in user-pay PPPs. Second, future research may explore alternatives for reducing demand volatility in social infrastructure such as diversifying the business within PPPs and developing mixed-used buildings linked to transportation developments. Third, future research may inquire about suitable mechanisms for strengthening relational governance for avoiding renegotiations and, even under a renegotiation situation improve the outcomes by strengthening trust and improving communication to avoid unrealistic expectations of the potential outcomes of the renegotiation. Last but not least, one significant driver of the PPP risk literature in the next future may be the implications of multiple risk allocation among different countries facing extreme events that arose in the COVID-19 aftermath.

## References

- [1] Hodge G A and Greve C 2016 On Public–Private Partnership Performance: A Contemporary Review *Public Work. Manag. Policy* **22** 55–78
- [2] Garvin M J and Bosso D 2008 Assessing the Effectiveness of Infrastructure Public–Private Partnership Programs and Projects *Public Work. Manag. Policy* **13** 162–78
- [3] Osei-kyei R and Chan A P C 2017 Developing a Project Success Index for Public–Private Partnership Projects in Developing Countries *J. Infrastruct. Syst.* **23** 1–12
- [4] Koppenjan J F M and Enserink B 2009 Public–Private Partnerships in Urban Infrastructures: Reconciling Private Sector Participation and Sustainability *Public Adm. Rev.*
- [5] UNEP 1998 *Protecting Our Planet Securing Our Future* (The World Bank)

- [6] Hueskes M, Verhoest K and Block T 2017 Governing public–private partnerships for sustainability. An analysis of procurement and governance practices of PPP infrastructure projects *Int. J. Proj. Manag.* **35** 1184–95
- [7] Castelblanco G and Guevara J 2022 Building Bridges: Unraveling the Missing Links between Public-Private Partnerships and Sustainable Development *Proj. Leadersh. Soc.*
- [8] Nair D, Enserink B, Gopikuttan G, Vergragt P, Fraaij A and Dalmeijer R 2005 A CONCEPTUAL FRAMEWORK FOR SUSTAINABLE – AFFORDABLE HOUSING FOR THE RURAL POOR IN LESS DEVELOPED ECONOMIES *The 2005 World Sustainable Building Conference* vol 2005 pp 27–9
- [9] Castelblanco G, Guevara J, Rojas D, Correa J and Verhoest K 2022 Environmental Impact Assessment Effectiveness in Public-Private Partnerships: Study on the Colombian Road Program *J. Manag. Eng.*
- [10] Yuan J, Li W, Guo J, Zhao X and Skibniewski M J 2018 Social Risk Factors of Transportation PPP Projects in China: A Sustainable Development Perspective *Int. J. Environ. Res. Public Health* **15** 1–25
- [11] Castelblanco G, Guevara J and Mendez-Gonzalez P 2022 In the Name of the Pandemic: A Case Study of Contractual Modifications in PPP Solicited and Unsolicited Proposals in COVID-19 Times *Construction Research Congress 2022*
- [12] Castelblanco G, Guevara J, Mesa H and Hartmann A 2022 Social Legitimacy Challenges in Toll Road PPP Programs: Analysis of the Colombian and Chilean Cases *J. Manag. Eng.* **38** 1–15
- [13] Castelblanco G, Guevara J and Mendez-Gonzalez P 2022 PPP Renegotiation Flight Simulator: A System Dynamics Model for Renegotiating PPPs after Pandemic Crisis *Construction Research Congress 2022*
- [14] Dewulf G and Garvin M J 2020 Responsive governance in PPP projects to manage uncertainty *Constr. Manag. Econ.* **38** 383–97
- [15] Rojas R, Bennison G, Gálvez V, Claro E and Castelblanco G 2020 Advancing Collaborative Water Governance: Unravelling Stakeholders’ Relationships and Influences in Contentious River Basins *Water (Switzerland)* **12** 1–25
- [16] Guevara J, Salazar J and Garvin M J 2020 Social Network Analysis of Road PPP Equity Markets in Canada, Chile, and the United States *J. Manag. Eng.* **36** 04020058
- [17] Castelblanco G, Guevara J, Mesa H and Sanchez A 2021 Semantic Network Analysis of Literature on Public-Private Partnerships *J. Constr. Eng. Manag.* **147** 1–16
- [18] Guevara J, Garvin M J and Ghaffarzadegan N 2020 The Forest and the Trees: a Systems Map of Governance Interdependencies in the Shaping Phase of Road Public-Private Partnerships *J. Manag. Eng.* **36**
- [19] Mahdavissharif M, Cagliano A C and Rafele C 2022 Investigating the Integration of Industry 4.0 and Lean Principles on Supply Chain: A Multi-Perspective Systematic Literature Review *Appl. Sci.* **12**
- [20] Bautista S, Camargo M, Morel L and Bachmann C 2018 Sustainable Management of Roadside: Towards a Research Agenda *2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 - Proceedings (IEEE)* pp 1–9
- [21] Castelblanco G, Guevara J and Mendez-Gonzalez P 2021 Sustainability in PPPs: A Network Analysis *Interdisciplinary Civil and Construction Engineering Projects. ISEC-11* (Fargo, ND, USA: ISEC Press) pp 1–6
- [22] Marcellino M, Castelblanco G and De Marco A 2022 Building Information Modeling for Construction Project Management: A Literature Review *IOP Conference Series: Materials Science and Engineering*
- [23] Estache A, Guasch J-L, Iimi A and Trujillo L 2008 Multidimensionality and Renegotiation: Evidence from Transport Sector PPP Transaction in Latin America *Rev. Ind. Organ.* **2** 34
- [24] Castelblanco G, Guevara J and Salazar J 2022 Remedies to the PPP Crisis in the Covid-19 Pandemic: Lessons from the 2008 Global Financial Crisis *J. Manag. Eng.* **38** 1–18

- [25] McGee C and Mayer M 2021 Pitfalls and Potholes: Examining the Impacts of Covid-19 on the North Carolina Department of Transportation *Public Work. Manag. Policy* **26** 13–8
- [26] Vassallo J M, Ortega A and Baeza M de los Á 2012 Impact of the Economic Recession on Toll Highway Concessions in Spain *J. Manag. Eng.* **28** 398–406
- [27] Loxley J 2012 Public-private partnerships after the global financial crisis: Ideology trumping economic reality *Stud. Polit. Econ.* **8552** 7–38
- [28] Yescombe E R and Farquharson E 2018 *Public-Private Partnerships for infrastructure: Principles of policy and finance* (Butterworth-Heinemann)
- [29] Marcellino M, Castelblanco G and De Marco A 2022 Contract Renegotiation in PPPs: Evidence from Italy *IOP Conference Series: Materials Science and Engineering*
- [30] Castelblanco G and Guevara J 2020 Risk Allocation in PPP Unsolicited and Solicited Proposals in Latin America: Pilot Study in Colombia *Construction Research Congress 2020* pp 1321–9
- [31] Castelblanco G, Guevara J, Mesa H and Flores D 2020 Risk allocation in unsolicited and solicited road public-private partnerships: Sustainability and management implications *Sustain.* **12**
- [32] Carpintero S, Vassallo J M and Sánchez A 2015 Dealing with Traffic Risk in Latin American Toll Roads *J. Manag. Eng.* **31** 1–10
- [33] Engel E, Fischer R and Galetovic A 2013 The basic public finance of public-private partnerships *J. Eur. Econ. Assoc.* **11** 83–111
- [34] Sánchez-Silva M 2019 Managing infrastructure systems through changeability *J. Infrastruct. Syst.* **25** 1–12
- [35] Ottaviani F M and De Marco A 2021 Multiple Linear Regression Model for Improved Project Cost Forecasting *Procedia Computer Science* vol 196 pp 808–15
- [36] Reis R F and Sarmiento J M 2017 “Cutting costs to the bone”: the Portuguese experience in renegotiating public private partnerships highways during the financial crisis *Transportation (Amst)*.
- [37] Almarri K, Alzahrani S and Boussabaine H 2019 An evaluation of the impact of risk cost on risk allocation in public private partnership projects *Eng. Constr. Archit. Manag.* **26** 1696–711
- [38] Marcellino M, Castelblanco G and De Marco A 2022 Multiple Linear Regression Model for Project’s Risk Profile and DSCR *IOP Conference Series: Materials Science and Engineering*
- [39] Baxter D and Casady C B 2020 A Coronavirus (COVID-19) Triage Framework for (Sub) National Public–Private Partnership (PPP) Programs *Sustain.* **12** 1–6
- [40] Carpintero S, Vassallo J M, Soliño A S, Jose ;, Vassallo M, Sánchez A and Soliño S S 2014 Dealing with Traffic Risk in Latin American Toll Roads *ascelibrary.org* **31**