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MODULARITY IN THE CONSTRUCTION INDUSTRY: A SYSTEMATIC MAPPING STUDY

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BACKGROUND

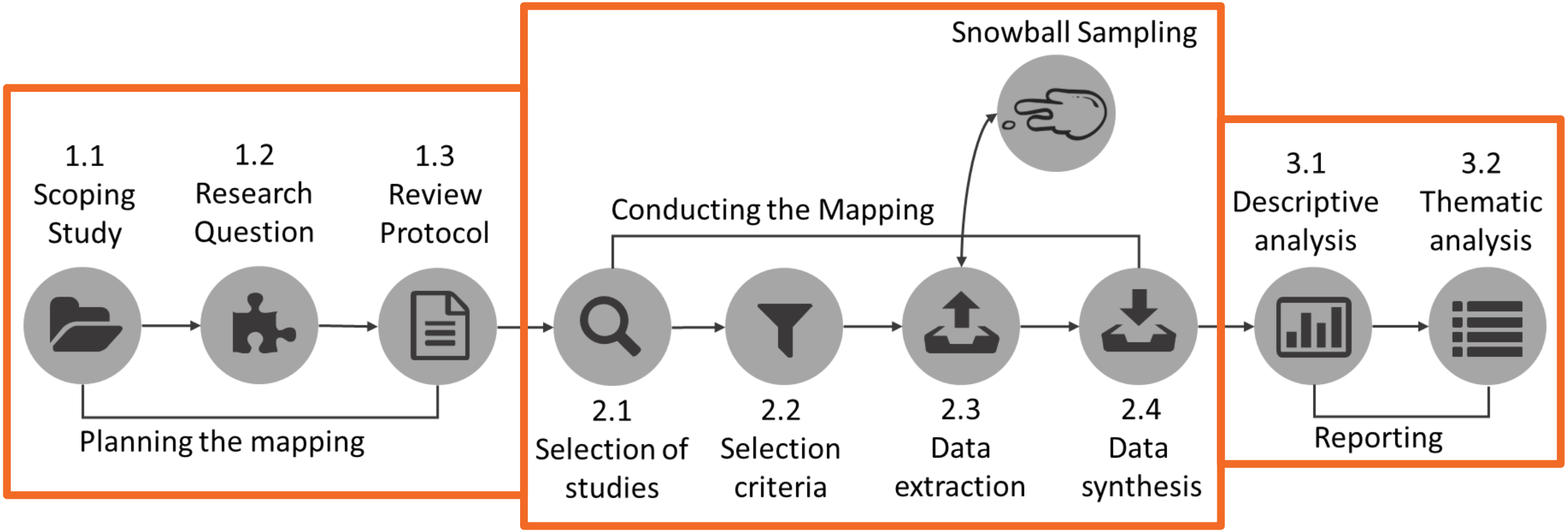
- **Modularity** is a well-known concept in the manufacturing industry.
- **Modularity** is a concept that has not been fully explored in the construction industry, as a mechanism to **improve cost**, **quality**, and **schedule performance**.
- Recently, two research projects have been carried out by **LAGERCON/UNICAMP** and **PPGCI/UFRGS** on the subject.

PROPOSAL

- to **understand the concepts** of modularity that are applicable to the **construction industry;**
- to identify how the literature relates modularity with **lean principles**
- to **identify opportunities** for further research on this topic

Systematic Mapping Study (SMS)

RESEARCH STRATEGY



SMS STEPS BASED ON PETERSEN et al. (2015) AND TRANFIELD et al. (2003)

PLANNING THE MAPPING

- RESEARCH QUESTION: “How modularity related concepts (topics) are covered in the construction industry literature?”

- SEARCH STRINGS:

MODULARITY		CONTEXT
MODULE OR MODULARIZ(S)ATION OR MODULARITY	**AND**	“CONSTRUCTION INDUSTRY” OR “BUILDING INDUSTRY” OR “BUILDING CONSTRUCTION”

- SELECTION CRITERIA:

INCLUSION	EXCLUSION
Only papers from journals	Not in the context of the construction industry
Qualitative, quantitative and multiple methods	Systematic mappings or literature reviews
It has to address modularity	Not Portuguese or English

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DATABASES

Scopus®

EBSCO

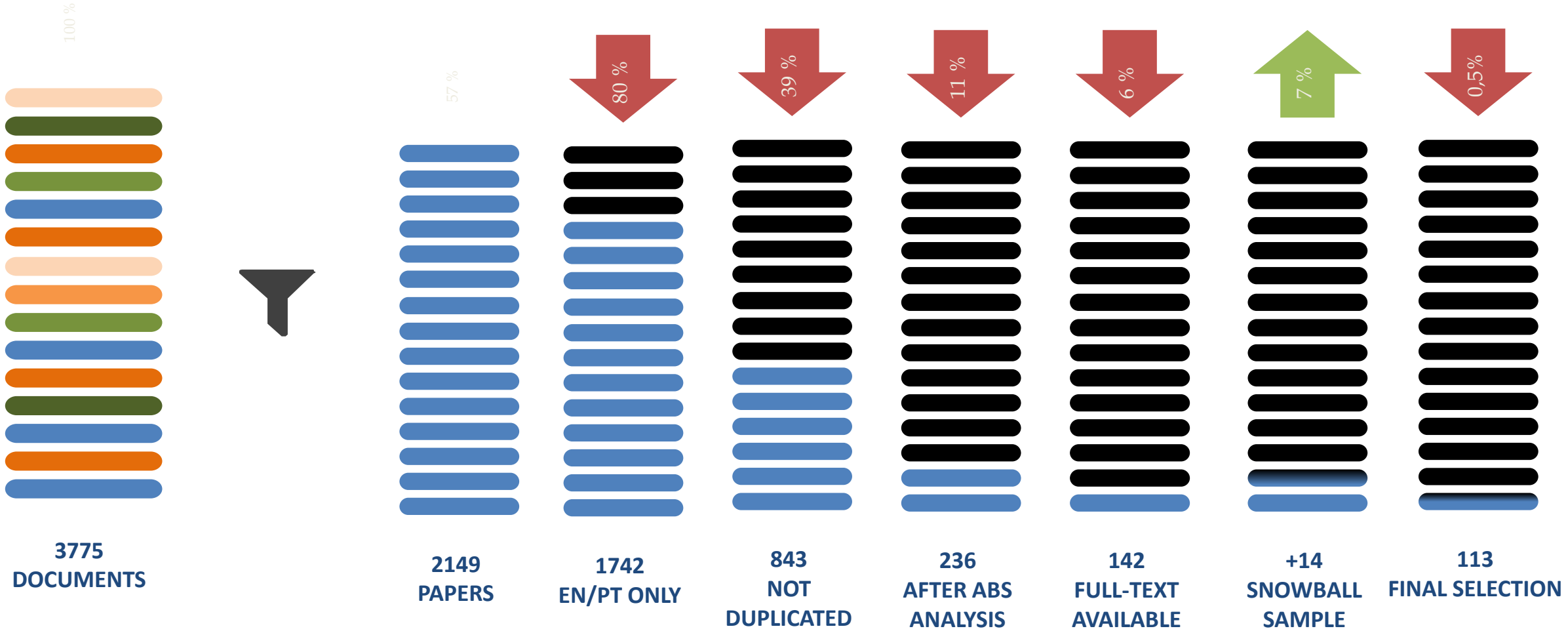
Compendex on Engineering Village

ScienceDirect

ELSEVIER

WEB OF SCIENCE™

SCREENING STEPS



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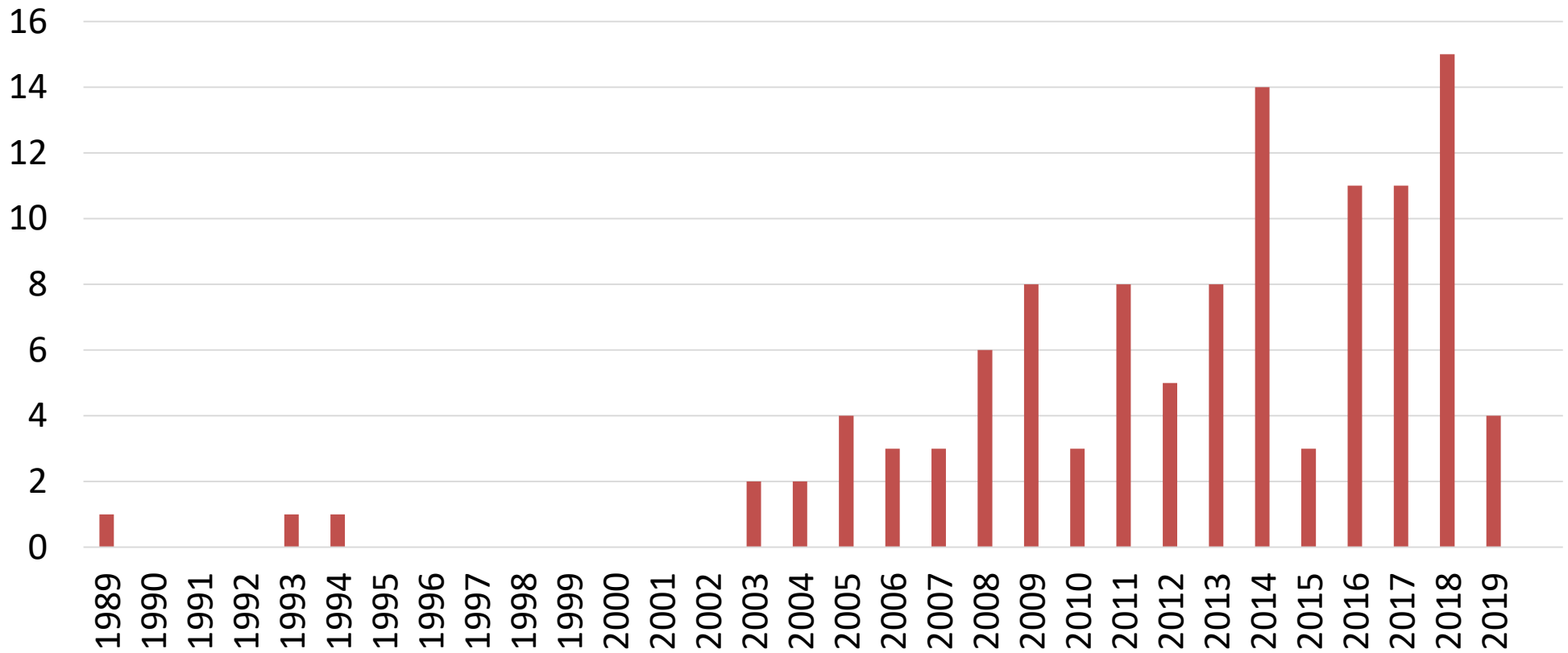
DESCRIPTIVE RESULTS

RELEVANT PAPERS DISTRIBUTION PER YEAR



TOP 5 JOURNALS

JOURNAL	N	PAPERS
Journal of Construction Engineering and Management	15	Blacud et al. (2009); Choi et al. (2016); Dzeng et al. (2005); Dzeng et al. (2004); Gill et al. (2005); Goodrum et al. (2009); Gosling et al. (2016); Ikuma et al. (2011); Larsson et al. (2016); Lee and Hyun (2019); Murtaza et al. (1993); Nahmens and Bindroo (2011); O´Connor et al. (2014); Ramaji and Memari (2016); Song et al. (2005)
Construction Management and Economics	10	Agren et al. (2014); Brodetskaia et al. (2011); da Rocha and Kemmer (2018); Jaillon and Poon (2010); Johnsson and Meiling (2009); Meiling et al. (2014); Pan et al. (2008); Peltokorpi et al. (2018); Schmidt III et al. (2014); Wikberg et al. (2014)
Automation in Construction	6	Eastman (1994); Hsu et al. (2018); Martinez et al. (2019); Nasereddin et al. (2007); Olearczyk et al. (2014); Said et al. (2017)
Journal of Management in Engineering	6	Choi et al. (2019); Hall et al. (2018); Hyari and El-Rayes (2006); Liu et al. (2017); Tatum (1989); Yu et al. (2013)
Canadian Journal of Civil Engineering	5	Kim et al. (2005); Li et al. (2013); Moghadam et al. (2012); Wang et al. (2009); Westover et al. (2014)

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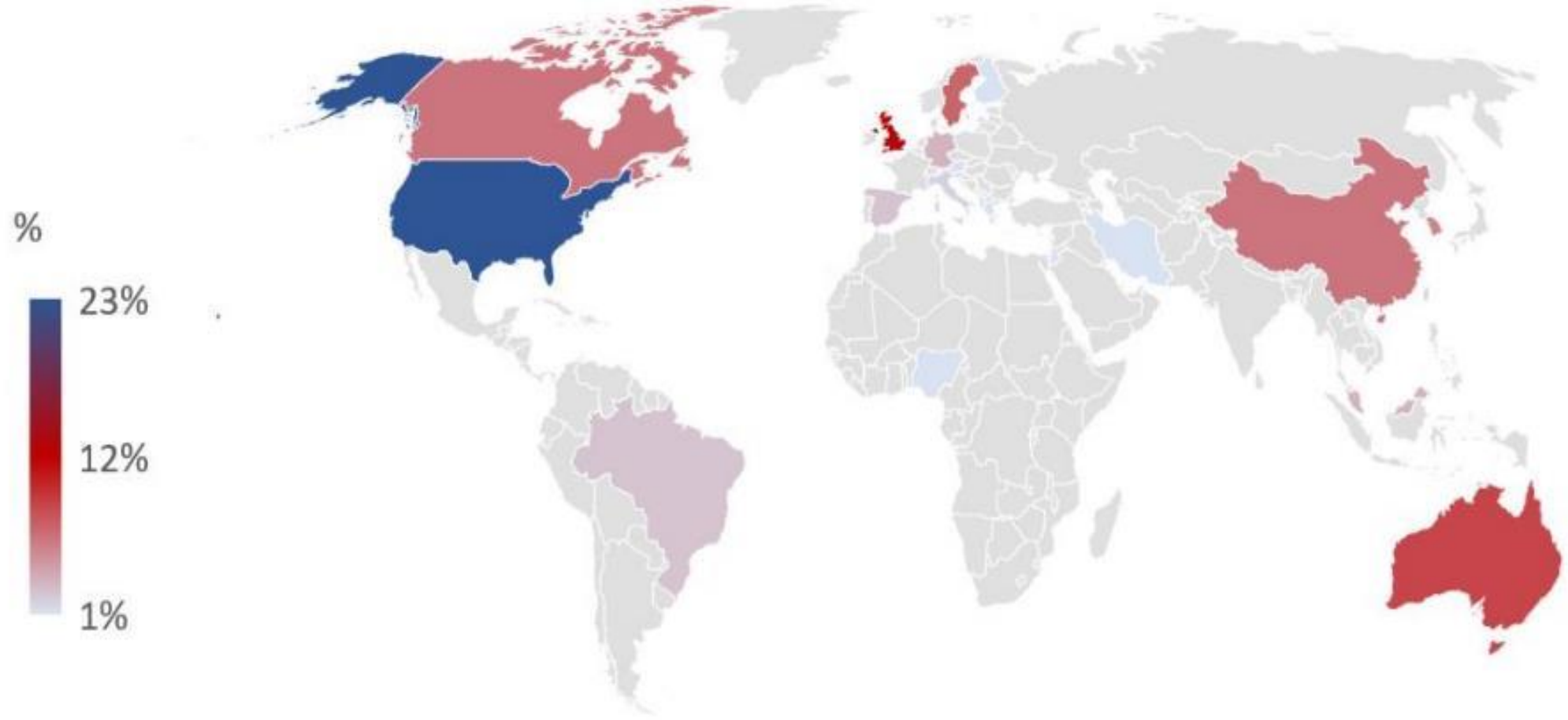
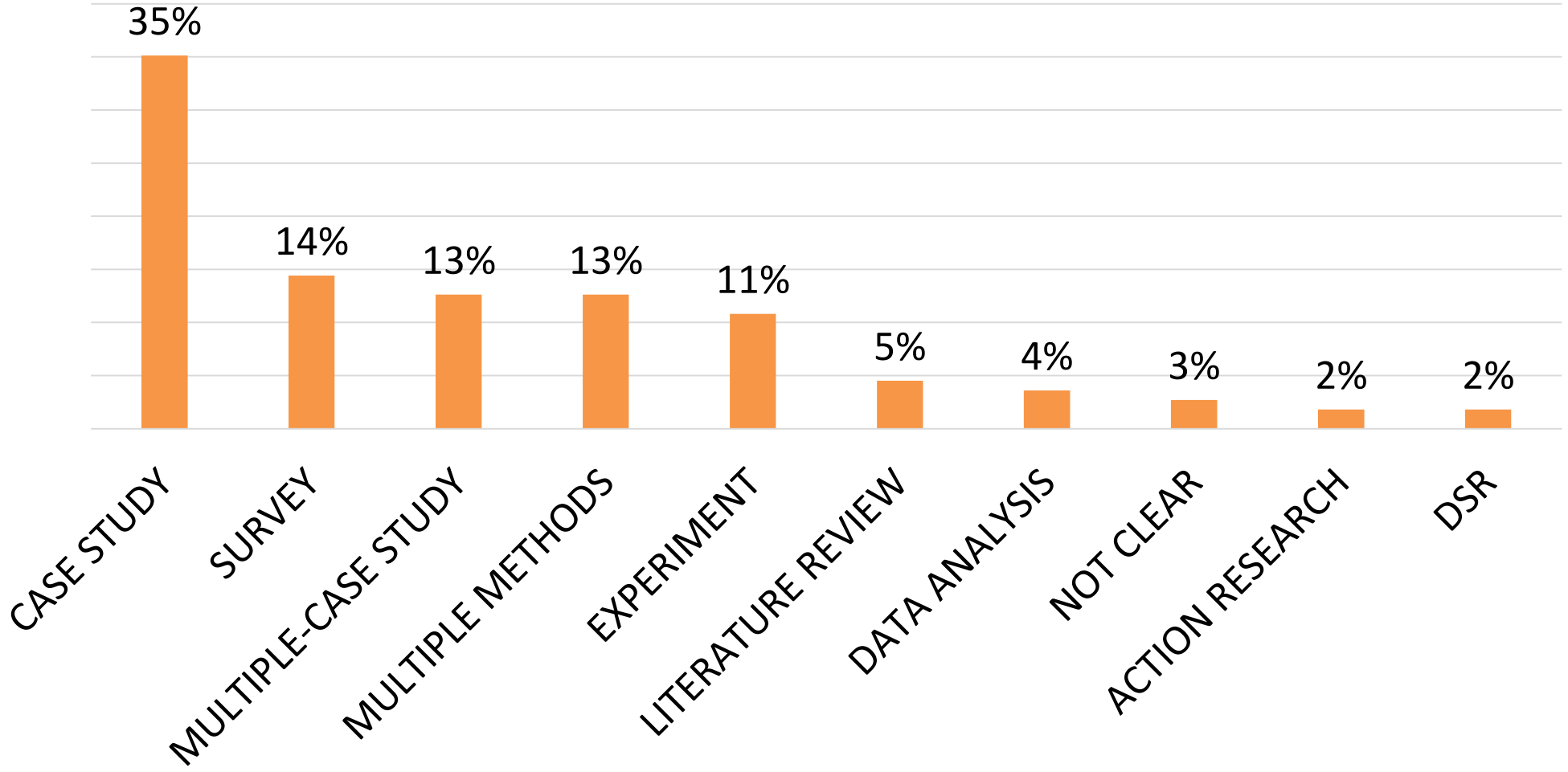
% PAPERS PER COUNTRIES



MAIN RESEARCH METHODS



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THEMATIC ANALISYS

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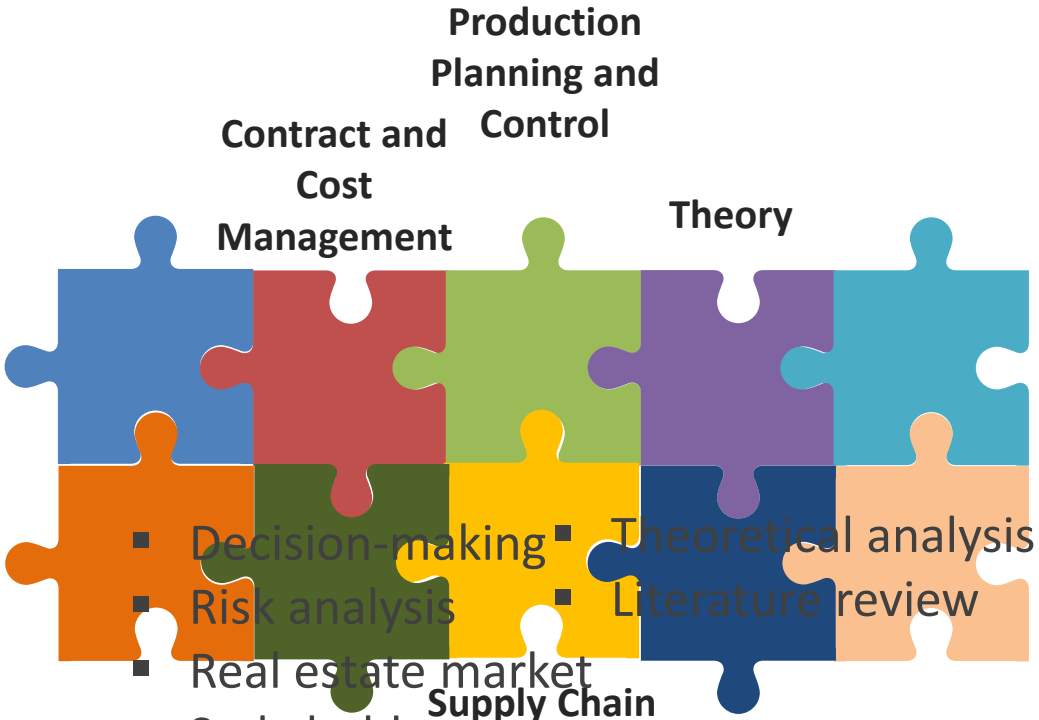
TOPIC AREAS



Product Development and Design Management

- Products
- Components
- Design process

- Decision-making
- Risk analysis
- Real estate market
- Stakeholders

- Theoretical analysis
- Literature review

Sustainability

- Environmental impact
- Green Technologies

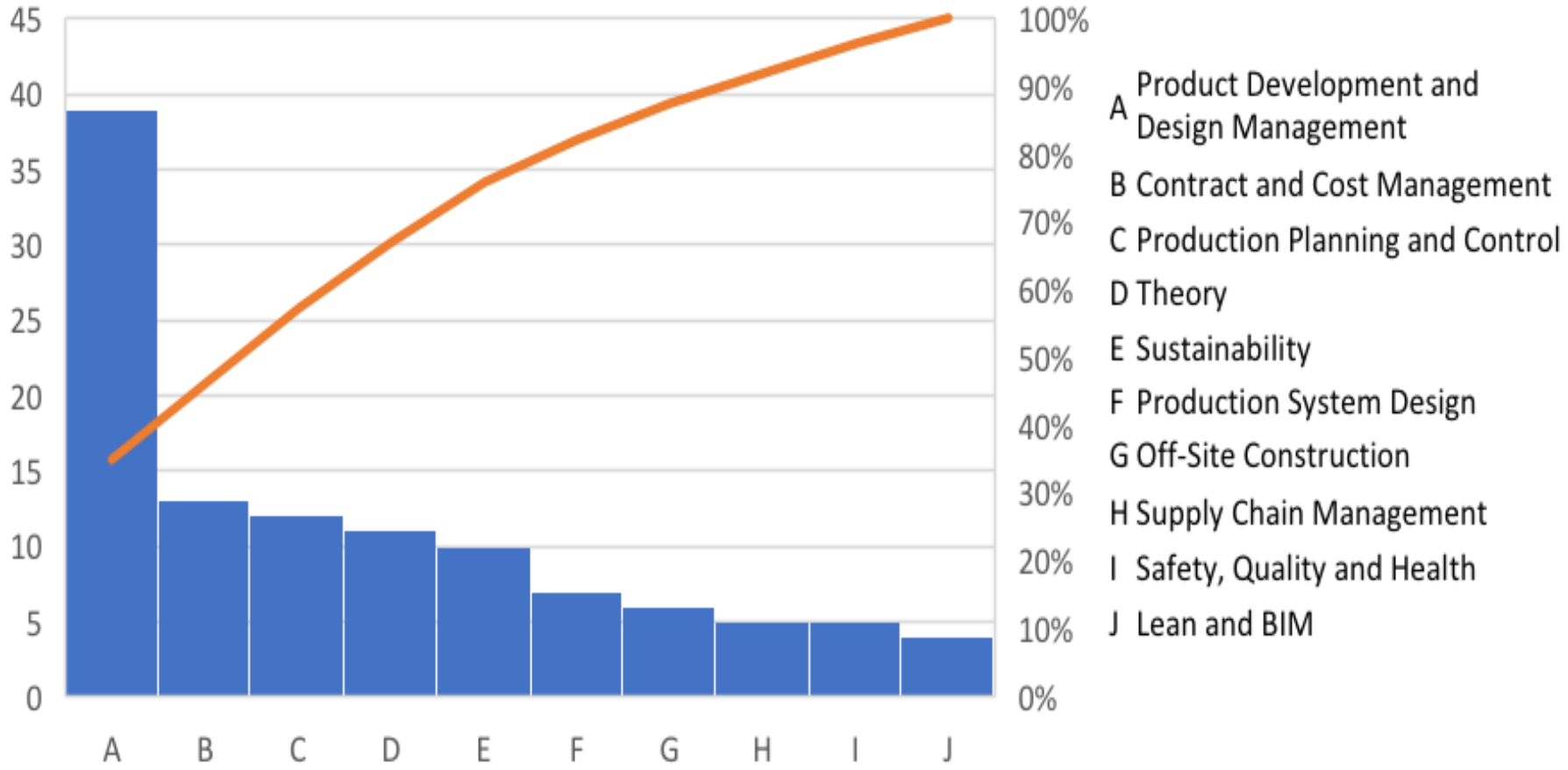
- Use of modularity and safety performance

- Manufacturing
- Transportation

- Design and execution
- Assembly techniques
- Automation

BASED ON THE IGLC TOPIC AREAS

TOPIC AREAS DISTRIBUTION



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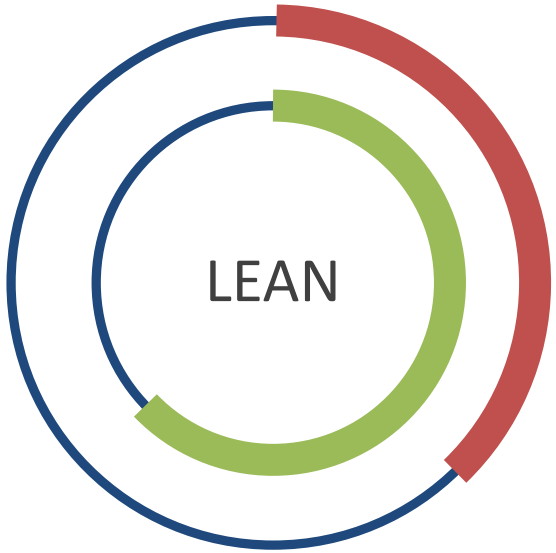
LEAN AND MODULARITY

% PAPERS MENTIONING LEAN



33 % **PAPERS THAT MENTION LEAN**

66 % **PAPERS THAT SPECIFICALLY RELATE LEAN TO MODULARITY**

AUTHOR'S LEAN APPROACHES RELATED TO MODULARITY

Topi	Description	Authors
Autonomation	Concepts of lean construction and design for manufacture and assembly, enable the development of modular products by robotics systems onsite.	Martinez et al (2008)
	A higher automation level is desirable to increase the productivity level.	Martinez et al (2008) Orlowski et al (2018)
Elimination of	Big modules transportation and assembly offsite are a significant waste of space, against lean philosophy. Production like kit-of-parts and onsite assembly in temporary factories can reduce waste of time and space of big modules.	Martinez et al (2008)
	Consumer-oriented approaches in which quality and value for money drive the requirement to reorganize production.	Barlow et al (2003)
	Offsite re-design, waste costs, time savings can be achieved by the design of products to be manufactured and assembled during the design stage.	Martinez et al (2013)
Flexibility	Improvements in quality and meet the individual needs of different customers have been driven by consumer-oriented approaches.	Barlow et al (2003)
	Lean production is applied to the design of new materials and products with different levels of finishing that make modular assembly possible. The design of new materials and products with different finishing are enabled by concepts related to lean production, making modular assembly possible.	Martinez et al (2008)
	There are high levels of customization in buildings, making building modules one of a kind, this variety can be supported by lean principles.	Yu et al (2013)
	Ease of training, ease of change, paced implementation and the opportunity for strategic alignment would seem to dominate processing efficiency and consistency arguments of large-scale ERP proponents.	Arif et al (2011)
General	Carry out an extended analysis which investigates the impact modularization has on other organizational initiatives such as lean.	Hvam et al (2017)
	Full implementation of Lean in the industrialized housing industry may further improve processes in terms of both efficiency and safety.	Nahmens and Ikuma (2009)
	Construction practitioners argue that construction is distinct from auto manufacturing and that lean production is not applicable. The research approaches lean focusing on balancing the production line process stability rather than improving productivity	Yu et al (2013)
	Offsite prefabrication/preassembly depends on the lean concept of moving the work to the workers in a controlled production environment.	Said et al (2017)
	Relates the lean principles and techniques, such as standardized work and visual management to organize the workplace in construction.	Yu et al (2013)
	Utilize simulation as a decision tool to assist the design of a new factory to incorporate lean principles as flexibility, responsivity and efficiency.	Nasereddin et al (2007)
KAIZEN	The case study applies the lean production tool, Kaizen, in a modular housing manufacturing facility.	Ikuma et al (2011)
	Evaluates the impact of Kaizen in workers safety at a modular homebuilder.	James et al (2014)
	5S proved to be an effective way to get people involved in lean initiatives and enthused about lean by realizing immediate results.	Yu et al (2013)
	A set of lean principles are used to reduce waste over a range of factory activities. It is proposed a modularization production method to improve modular factory production flow based on work activity relationship.	Lee et al (2017)
Sustainability	Relates large-scale lean efficiencies in the design and construction process to sustainability	Zakaria et al (2018)
	Management based on lean principles optimize carbon emission.	Gong et al (2015)
	By improving the delivery process of modular houses, lean strategies improve the economic, social and environmental dimensions.	Nahmens and Ikuma (2011)

- **AUTONOMATION**
- **ELIMINATION OF WASTE**
- **FLEXIBILITY**
- **GENERAL IDEA**
- **KAIZEN**
- **SUSTAINABILITY**

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	Consumer-oriented approaches in which quality and value for money drive the requirements to reorganize production.	Barlow et al (2003)
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Flexibility	driven by consumer-oriented approaches.	
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Elimination of waste

Big modules transportation and assembly offsite are a **significant waste of space**, against lean philosophy. Production like kit-of-parts and onsite assembly in temporary factories can reduce waste of time and space of big modules.	Martinez et al. (2008)
Consumer-oriented approaches considering quality and value drive the requirements to reorganize production.	**Barlow et al (2003)**
Eliminating **on-site re-design, waste costs, time savings** can be achieved during the **design stage** of modular products.	Martinez et al. (2013)

CONCLUSIONS

- This paper presents the results of a SMS regarding modularity in the construction industry, as a **preliminary stage** of a future **Systematic Literature Review** effort.
- Most of the papers selected were related to the **development of modular products**. However, this category involves a **great diversity of aspects**, since it encompassed both the design process and the development of modules or modular components.
- Regarding the Lean Philosophy, only **19%** of the papers properly explained the connection of modularity and Lean, although intrinsic characteristics of lean production systems can be found in several papers.
- The **next steps** of this research will deepen the literature review, identifying the main contributions of these research studies and possible gaps.

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Thank you.

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