JIT and Environmental Performance: an empirical analysis

Alessa Aila[1*], Astrid Holström[1†], Eemil Rantala[1‡], John Anderson[1§] and Valtteri Luodemäki[1¶]

[1]*Department of Industrial Engineering and Management, Aalto University*

Abstract
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1. Introduction

Over the past decade there has been an increase in the research published on the synergies and trade-offs between lean manufacturing and environmental performance (Henao et al., 2019; Abualfaraa et al., 2020; Dieste et al., 2019; Lobo Mesquita et al., 2022; Garza-Reyes, 2015; King and Lenox, 2009).

These combined approaches, often dubbed 'lean-green', typically cites the Triple-Bottom-Line concept, which postulates the need for performance in economic growth, environmental preservation, and social responsibility, in order to achieve sustainability (Henao et al., 2019). Motivated by this body of research as well as our interest in sustainability studies, we have decided to study the effect of environmental and lean practices on environmental performance.

Abualfaraa et al. outline several research gaps and opportunities for those interested in lean-green manufacturing. In their Structured Literature Review of articles published between 2000 and 2018, they have identified several research directions in both the synergies and incompatibilities between environmental and lean practices (Abualfaraa et al., 2020). On one line, it is argued that lean practices may work as a catalyst for environmental practices and innovation through its focus on waste reduction and continuous improvement. On the other, the incompatibilities between the two approaches are also studied. Just in time (JIT) practices have been specifically highlighted. For example JIT manufacturing practices such as small lot sizes and high replenishment frequency implies more frequent transportation, higher CO2 emissions and more packaging waste (Dieste et al., 2019).

*E-mail: alessa.aila@aalto.fi
†E-mail: astrid.holmstrom@aalto.fi
‡E-mail: eemil.rantala@aalto.fi
§E-mail: john.anderson@aalto.fi
¶E-mail: valtteri.luodemaki@aalto.fi

Literature reviews also pointed out the need for more quantitative research with a focus on robust, well-defined sustainability metrics (Abualfaraa et al., 2020). Through an empirical analysis of JIT and environmental practices, our goal is to contribute to this research agenda.

2. Literature Review

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RQ 1: What effect do lean JIT practices have on environmental practices and environmental performance?

RQ 2: What is the effect of JIT practices on C02 emissions and packaging waste?

3. Hypothesis

WIP

H1: Environmental practices and JIT practices are complementary: the implementation of JIT practices increases the marginal return of environmental practices on environmental performance and vice versa.

H2: JIT practices negatively moderates the effect of environmental practices on emissions to air and solid waste generation.

4. Methods

WIP

Confirmatory factor analysis for establishing legitamacy of 3 bundles

Complimentarity of lean JIT/ environemntal practices

Moderating effect of lean JIT

TABLE 1
Confirmatory Factor Analysis

Bundle	HPM Code	Item Description	Loading	SE	t-value
Environmental Practices	ENVRTX21	Environmentally preferable packaging for the products that you produce (recycled content, less volume, reusable packaging)	0.63***	0.06	11.11
	ENVRTX37	Using a third party to monitor working conditions at supplier facilities	0.8***	0.08	9.75
	ENVRTX02	Water efficiency	0.88***	0.07	12.97
	ENVRTX22	Substituting environmental preferable direct materials or supplies for harmful or non-renewable ones	0.69***	0.06	11.44
	ENVRTX39	Providing design specification to suppliers in line with environmental requirements (e.g. green purchasing, black list of raw materials)	1.06***	0.08	13.5
	ENVRTX23	Environmental improvements in the disposition of your organization’s scrap or excess material (re-use, recycling, etc.)	0.58***	0.05	10.82
	ENVRTX18	Working with customers to help them achieve environmental objectives	1.12***	0.08	14.25
	ENVRTX13	Complying with a customer’s supplier code of conduct	0.91***	0.08	11.8
	ENVRTX33	Starting or maintaining a formal M/WBE supplier purchase program	1.0***	0.08	11.79
	ENVRTX03	Reducing waste in internal processes (e.g., improving yield or efficiency)	0.61***	0.05	11.79
	ENVRTX20	Life-cycle analysis of the “cradle to grave” environmental impact of materials/products	1.19***	0.08	14.62
	ENVRTX38	Incorporating environmental considerations in evaluating and selecting suppliers	1.16***	0.07	15.53
	ENVRTX08	Decreasing the likelihood or impact of an environmental accident	0.67***	0.05	12.3
	ENVRTX05	Pollution prevention (eliminating emissions or waste)	0.72***	0.06	12.89
	ENVRTX30	Giving preference to materials with third party certifications, such as Green Seal, FSC or Energy Star	1.02***	0.08	13.2
	ENVRTX24	Environmental improvements in the disposition of your organization’s equipment	0.97***	0.06	15.36
	ENVRTX32	Purchasing from minority- or women-owned business enterprise (M/WBE) suppliers	0.98***	0.08	12.96
	ENVRTX34	Visiting suppliers’ plants or ensuring that they are not using sweatshop labor	1.07***	0.09	12.5

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TABLE 1
Confirmatory Factor Analysis

Bundle	HPM Code	Item Description	Loading	SE	t-value
	ENVRTX04	Improving the workforce environment (e.g., indoor air quality)	0.57***	0.05	11.27
	ENVRTX29	Encouraging suppliers to improve the environmental performance of their processes	1.28***	0.08	16.88
	ENVRTX41	Involvement of suppliers in the re-design of internal processes (e.g. remanufacturing, reduction of by-products)	1.02***	0.07	14.73
	ENVRTX40	Co-development with suppliers to reduce the environmental impact of the product (e.g. eco-design, green packaging, recyclability)	1.09***	0.07	15.24
	ENVRTX09	Reduction/avoidance of land consumption	1.13***	0.09	13.24
	ENVRTX17	Carbon tracking/carbon footprint calculation of supply chain	1.11***	0.09	12.68
	ENVRTX07	Remediation projects, such as cleanup or restoration from past practices	1.18***	0.09	12.57
	ENVRTX11	Improvements in outbound transportation, such as fuel efficiency or load matching	1.12***	0.08	14.1
	ENVRTX10	Improvements in inbound transportation, such as fuel efficiency or load matching	1.1***	0.08	14.38
	ENVRTX01	Energy efficiency or renewable energy	0.77***	0.07	11.55
	ENVRTX14	Complying with an industry-wide code of conduct	0.87***	0.06	14.21
	ENVRTX15	Other compliance or auditing program focused on your plant (not on your suppliers)	0.88***	0.06	13.72
	ENVRTX12	Seeking or maintaining ISO14001 certification	0.85***	0.09	9.73
	ENVRTX31	Requesting that your suppliers sign a code of environmental conduct	1.16***	0.09	12.72
	ENVRTX35	Ensuring that suppliers comply with child labor laws	1.12***	0.1	11.7
	ENVRTX36	Asking suppliers to pay a “living wage”	1.04***	0.09	11.17
	ENVRTX06	Pollution control (scrubbing, waste treatment)	0.76***	0.07	11.27
	EPRACX01	Implementation of a certified environmental management system, such as ISO 14000.	0.96***	0.09	10.3
	EPRACX02	Implementation of internal environmental management procedures (e.g. environmental training program, internal environmental audit, newsletter).	0.96***	0.08	12.34

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Confirmatory Factor Analysis

Bundle	HPM Code	Item Description	Loading	SE	t-value
	EPRACX03	Use of cleaner technologies in the production process (e.g. abatement equipment) to reduce pollution emissions and/or resource use.	0.98***	0.07	14.2
	EPRACX04	Environment-friendly product design.	1.21***	0.08	15.58
	EPRACX05	Environmental improvement of packaging.	1.0***	0.07	14.74
	EPRACX06	Use of environment-friendly raw materials.	0.99***	0.07	14.6
JIT Practices	LAYOUTN01	We have laid out the shop floor so that processes and machines are in close proximity to each other.	0.71***	0.06	11.66
	LAYOUTN02	The layout of our shop floor facilitates low inventories and fast throughput.	0.79***	0.07	12.04
	LAYOUTN03	Our processes are located close together, so that material handling and part storage are minimized.	0.88***	0.07	11.87
	LAYOUTN04	We have located our machines to support JIT production flow.	1.03***	0.08	13.77
	JITDELN01	Our suppliers deliver to us on a just-in-time basis.	1.09***	0.09	12.74
	JITDELN02	We receive daily shipments from most suppliers.	0.8***	0.09	9.13
	JITDELN03	Our suppliers are linked with us by a pull system.	1.1***	0.09	12.2
	KANBANN01	Suppliers fill our kanban containers, rather than filling purchase orders.	0.73***	0.09	8.39
	KANBANN02	We use a kanban pull system for production control.	1.05***	0.09	11.34
	KANBANN03	We use kanban squares, containers or signals for production control.	1.08***	0.09	11.56
	LINKCN01	Our customers receive just-in-time deliveries from us.	1.04***	0.08	12.82
	LINKCN02	We always deliver on time to our customers.	0.71***	0.06	10.97
	LINKCN03	We can adapt our production schedule to sudden production stoppages by our customers.	0.77***	0.07	11.39
	LINKCN04	Our customers have a pull type link with us.	1.18***	0.09	12.66
	LINKCN05	Our customers are linked with us via JIT systems.	1.24***	0.09	13.44

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TABLE 1
Confirmatory Factor Analysis

Bundle	HPM Code	Item Description	Loading	SE	t-value
	SCHEDN01	We usually meet the production schedule each day.	0.75***	0.06	12.46
	SCHEDN02	We usually complete our daily schedule as planned.	0.68***	0.05	12.59
	SETUPN01	We are aggressively working to lower setup times in our plant.	0.76***	0.07	10.88
	SETUPN02	We have low setup times of equipment in our plant.	0.81***	0.07	11.53
	SETUPN03	Our workers practice setups, in order to reduce the time required.	1.04***	0.09	11.84
Environmental Performance	EPERFX01	Overall environmental performance.	0.83***	0.06	14.96
	EPERFX02	Raw materials consumption.	0.77***	0.05	14.78
	EPERFX03	Energy consumption.	0.96***	0.06	16.74
	EPERFX04	Water consumption.	0.94***	0.06	17.02
	EPERFX05	Emissions to air.	0.89***	0.06	15.69
	EPERFX06	Releases to water.	0.81***	0.06	14.38
	EPERFX07	Solid waste generation (e.g. landfill capacity consumed).	0.7***	0.05	13.53
	EPERFX08	Waste recovery (e.g. recycling).	0.59***	0.05	11.7
	EPERFX09	Fines or other violations of environmental rules/regulations.	0.84***	0.07	11.57

5. Results

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6. Discussion

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Non english speaking literature often filtered out

Diffirent national contexts

Different industries

Critique of tripple bottom line is lack of novelty around the hardest problem, social sustainability

Solutions to the JIT/Green dilemma: They suggest that this can be done by, for example, selecting suppliers from a certain geographic area to enable truckload sharing for delivering or, when small amounts have to be delivered, managing the routes in order to supply multiple customers in the same area.

BACKLOG:

- Create skeleton for Lit Review with article references and share with Alessa and Astrdid

- Create environemental practice "bundles" using EFA (DONE)

- Run a CFA between JIT and EP - Understand how to properly deal with NA values in CFA

- Run correlations

- Check for complimentarity between JIT and EP bundles as per complimentarity paper approaches

- See if there is a better way then just dropping all NA rows

- Test moderating effect of JIT on EP bundles as per china paper

- We need to ask the specifics of the likert scale for the JIT measures

- Apply spell check to latek sections before submitting

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