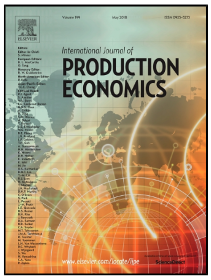

Examining the mediating role of innovative capabilities in the interplay between lean processes and sustainable performance

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Examining the mediating role of innovative capabilities in the interplay between lean processes and sustainable performance

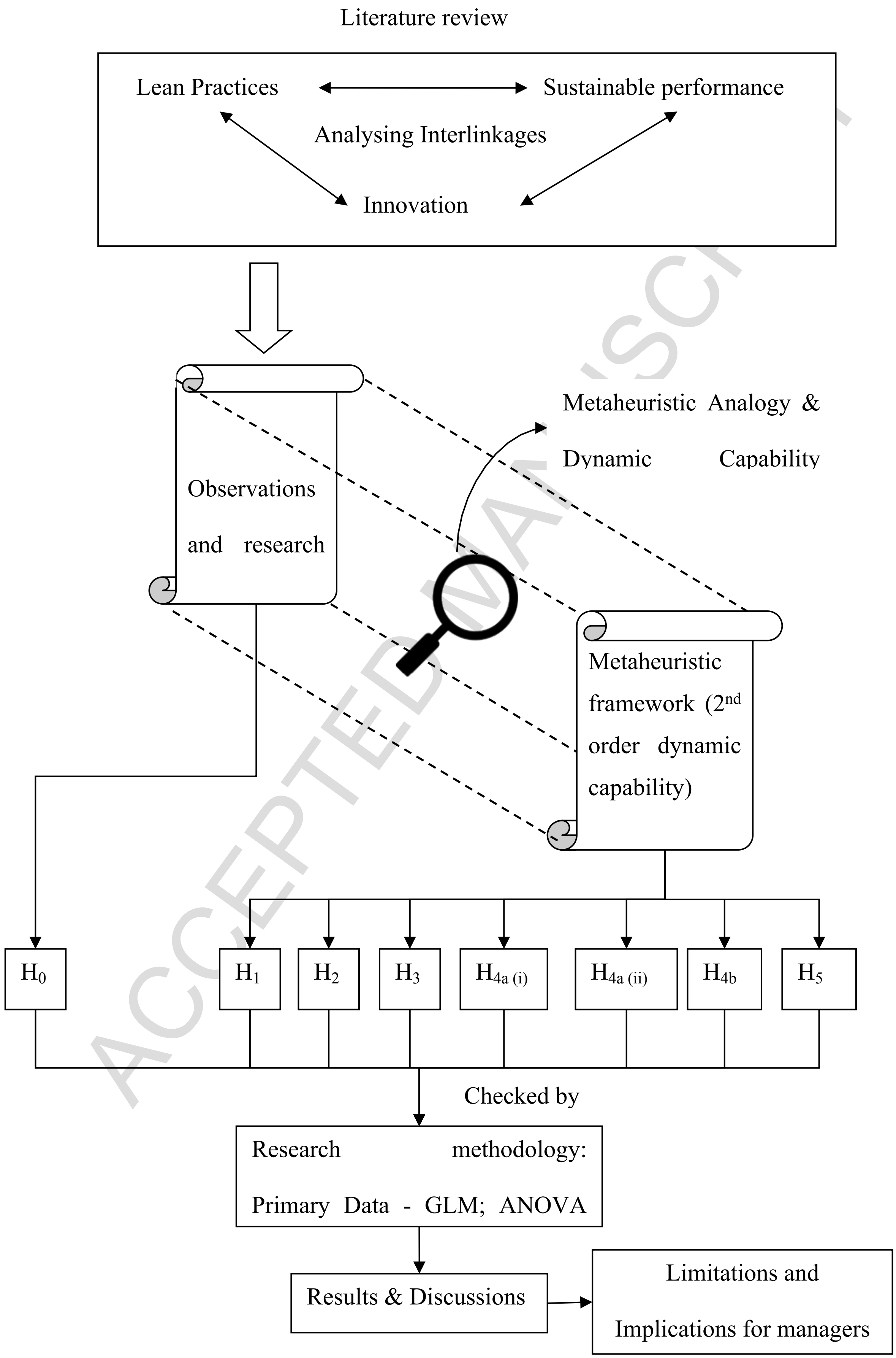
ABSTRACT

Literature, heretofore, has assumed the relationship between 'lean' systems and their sustainable performance as direct and static. Researchers have explored this relationship from various perspectives and have taken clear sides, as to whether lean practices are favourable or inimical to the sustainable performance of a firm. We argue that the 'for (or) against' debate has been overstretched and has assumed some contingencies that are uncalled for. This study offers a novel perspective of gauging the relationship between lean practices and a firm's sustainable performance from a dynamic stance. It recognizes that this relationship has both, synergistic and discordant phases. Synergistic phase revs up the sustainable performance and discordant phase is inimical to the sustainable performance of the firm. We propose that lean processes can positively (or) negatively affect a firm's sustainable performance depending upon the state of innovative capability of the firm. In this regard, we present an iterative and recursive two-phase framework which draws upon the principles of a metaheuristics and is undergirded in dynamic capability theory. This framework discusses the 'switching behaviour' of the firm controlled by decoupling point. Switching behaviour determines how a firm should manoeuvre its innovation strategy. The framework was tested by using primary and secondary data (content analysis) in order to triangulate the results. This framework puts forth a set of generic guidelines, which the firms can decipher in their own idiosyncratic environments to bring about the required synergy

between their lean processes and innovative capabilities. This synergy shall ensure that the 'the engines of their sustainable growth' are always fired up.

Keywords: Lean; Innovation; Dynamic Capabilities; Sustainability; Metaheuristic analogy.

GRAPHICAL ABSTRACT



1. INTRODUCTION

There has been considerable amount of debate on, whether lean practices enhance or inhibit a firm's potential in improving its environmental performance. 'Lean' is a philosophy which advocates 'waste minimization'. It is adopted by implementing a 'bundle of practices' which strive to achieve ever increasing levels of resource efficiency and elimination of non-value added activities (Carvalho et al., 2011; Netland and Ferdows, 2016). Heretofore, literature has demonstrated a 'for (or) against' approach in demonstrating the linkages between lean manufacturing practices and their impact on environmental performance of the firm. We argue that the categorical approach in determining the relationship between lean and environmental sustainability could possibly be misplaced. We submit that lean processes may enhance or inhibit sustainable performance of the firm depending upon the process life cycle and the type of innovative capability of the firm. This article proposes that the relationship between lean processes and sustainable performance of the firm is mediated by innovative capability of the firm. We suggest that this relationship is dynamic and has synergistic and discordant phases. Synergistic phase of the relationship propels a firm's sustainable performance whereas the discordant phase is inimical to a firm's sustainable efforts. The corresponding phase is determined by 1) the type of innovative capability of the firm, namely, exploitative and exploratory; and 2) the proximity of the firm to its performance frontier. A lean firm can alternate between exploitative and exploratory innovative capabilities in order to be in synergistic phase. A firm 'switches' its innovative strategy at the decoupling point. In this article we discuss the conditions which govern this switching point, also called the decoupling point. The decoupling point is dynamic and recursive in nature. We take refuge in the dynamic capabilities theory to propose a stabilised routine/ framework regarding the decoupling point which can be adopted by lean manufacturing firms to determine whether their innovative capabilities would contribute towards making it more sustainable or act as an impediment in the firm's journey of achieving its sustainable goals.

The rest of the paper is organised as follows- Section 2 discusses the extant literature. Section 3 delineates the theoretical underpinning and presents the metaheuristic framework followed by the hypotheses. Section 4 provides an exhaustive account of the research methodology used and sections 5 and 6 present the results, discussions and conclusions. Finally, section 7 discusses the limitations and research implications followed by the implications for managers and public policy in section 8.

2. LITERATURE REVIEW

Lean is a paradigm based on the principles of Kanban, Kaizen and JIT (Carvalho et al., 2011). Rothenberg, Pil & Maxwell (2001) classified lean practices and policies into three spheres, viz. buffer minimization, work systems and human resource management. Lean practices aim to minimize the 'slack' in the manufacturing process by eliminating wastes of transport, inventory, motion, waiting, over processing, over production and defects. Lean philosophy advocates adoption of 'best practices' and endorses continuous review of such practices in order to check if they need further improvement (Biggs, 2009). Literature is divided in establishing the relationship between lean processes and their impact on environmental performance of a firm.

Environmental practices are broadly of two types, viz., pollution prevention and pollution control (Rothenberg et al., 2001). Rothenberg et al., (2001) describe pollution prevention practices as pro-active in their approach towards environment as they involve making fundamental changes in the process. The focus of pollution prevention lies in resource efficiency and waste minimization (Albertini, 2013). Pollution prevention activities often come under the ambit of value added activities (Rothenberg et al., 2001). Pollution control practices, on the other hand are described as being reactive in their approach as they constitute the end-of-pipeline measures which can be appended in the existing processes without any major modification (Albertini, 2013). The aim of pollution control activities is primarily curtailing the impact of the pollutants which have already been emitted. These measures help the firm in meeting the regulatory guidelines (Nidumolu et al., 2009).

Whether lean processes enhance or impede a firm's sustainable performance is a contentious issue. Researchers have argued for both motions, namely, for and against, with equal fervour. The literature, until now, has assumed that, (i) this relationship is static and, (ii) there is a direct association between lean processes and a firm's environmental performance. The following two paragraphs discuss the literature regarding the positive and negative association between lean practices and environmental performance respectively.

The proponents of a positive direct association between lean practices and environmental performance argue that they are complementary capabilities (Mollenkopf, Stolze, Tate, &Ueltschy, 2010). Lean manufacturing practices curtail the marginal cost of finding pollution reduction possibilities by augmenting employee awareness and information flow, thus making it easier for the firms to adopt environmental management systems (King and Lenox, 2001). Although lean and green practices may have different definitions of 'wastes', but both target and eliminate the same wastes of inventory, transportation and production of by-products (Dües et al., 2013). This leads to gains for green practices by lean implementation. Similarly, green practices in process operations address the aspects of reverse flows, product stewardship and end-of-life disposal resulting in enhanced resource efficiency, and thus making the firm more lean (Corbett and Klassen, 2006). Dutt & King (2014) state from a more balanced standpoint that lean processes are positively associated with pollution prevention type of environmental practices but are negatively correlated with pollution control environmental practices.

Critics, however, state that the benefits reaped out for one program as a result of implementing the other are 'incidental' (Biggs, 2009). Lean and environmental practices address the same types of wastes, but they both have different drivers and motives (Angell, 2001). Dües et al., (2013) state that lean practices consider environment to be a resource whereas environmental management systems treat environment as a constraint, and thus they are bound to differ. Biggs (2009) and Rothenberg et al., (2001) point out that lean practices don't address environmental impact of some activities such as noise pollution. Carvalho et al., (2011) take a strong stand by stating that environmental practices need to stay away from lean practices in order to be effective. Their rationale is based upon the argument that lean practices promote frequent replenishments to cut down inventory, but in turn, lead to an increase in the emissions from transportation which is unequivocally detrimental to environmental improvement practices.

In this article, we argue that observing the lean-green relationship from a static and independent standpoint is simplistic. It is our contention that the relationship between lean processes and environmental performance is dynamic and is mediated by the innovative capability of a firm.

Innovations in a manufacturing firm are usually a first order dynamic capability (Winter, 2003). March (1991) broadly classified innovative practices as exploitative and exploratory. Exploitative innovative practices are steeped in a firm's technological resources. They are incremental and ingenious development over their predecessor practices. They are less uncertain, give quick results and are trenched in existing knowledge of a firm (Benner and Tushman, 2002). Exploratory innovative practices, on the other hand, are revolutionary and bring about significant change in the resource structure of the process. They can shift the technological trajectory of the firm and guard it from the competition and save its margins (Rosenkopf and Nerkar, 2001). Exploratory innovations are costly, riskier and have longer payoff times.

Literature, unanimously, concludes that there is a positive association between innovative capabilities and environmental performance of a firm. Etzion (2007) and Pagell & Wu (2009) posit that innovations are the pivotal drivers of improved environmental performance. Nidumolu et al., (2009) propound that sustainable practices are the treasure trove of innovations. Chang (2011) defined green innovations as the innovations which address the issues of energy saving, pollution prevention and control, waste management. Berrone, Fosfuri, Gelabert, & Gomez-Mejia (2013) posit that environmental innovations are a source of competitive advantage. However, literature doesn't deliberate on the nature of linkages between a firm's innovative capabilities and its approach to sustainability.

2.1 Research contribution: This article explores the causal relationship between the innovation strategy of a lean firm and its approach to sustainability. Further, we deliberate upon the nature of this relationship and hypothesize that it is dynamic and has synergistic and discordant phases. Synergistic phase of the relationship propels a firm's sustainable performance whereas the discordant phase is inimical to a firm's sustainable performance. We propose a second order dynamic capability framework which uses a decoupling point to determine whether the lean firm is in synergistic (or) discordant phase. The framework seeks inspiration from a metaheuristic analogy and discusses switching behaviour (at the decoupling point) in a lean firm's innovation strategy. Finally, we hypothesize numerous factors that affect the decoupling point, in the sense that, under what circumstances should a lean firm transcend from one innovative strategy to other in order to ensure sustained growth in its environmental performance.

3. THEORETICAL UNDERPINNING AND HYPOTHESES DEVELOPMENT

3.1. Exploitative and exploratory innovative practices

Exploitative innovative practices stand for incremental improvements which do not require revamping the resource configuration of the firm and are rooted in the existing knowledge of the firm. We argue that this innovation perspective drives a firm towards adopting a transitional approach to sustainability. In this approach, a firm tries to curtail the environmental damage that has been done by its products and processes (Borland et al., 2016). It puts the firm in 'damage control mode' in the sense that instead of making necessary and radical changes in order to root out the very causes of the environmental damages, this approach tries to annul the damages without making significant changes in the 'infrastructural apparatus' of the firm (Borland et al., 2016). Its core principles are: reduce, reuse, repair, recycle, and regulate with a focus on doing the best a firm can under a given resource configuration. On the other hand, exploratory innovation is more in sync with the transformational approach to sustainability. Transformational approach takes a more proactive approach by treating the ecosystem as a constraint and re-designing the processes and products by significantly revamping the 'infrastructural apparatus' of the firm to ensure that they are well within the sustainable limits (Borland et al., 2016). The principles of transformational approach are: rethink, reinvent, redesign, redirect, and recover; which conform to principles of exploratory innovative practices. Thus, we hypothesize that,

H0: In lean firms, exploitative innovative practices lead the organization towards transitional approach of sustainability whereas exploratory innovative practices steer the firm towards transformational approach of sustainability.

3.2. Recursive and iterative exploitative and exploratory stages

In this era of ferment, product lifecycles are becoming short and new technologies are being churned out at an expeditious rate. Firms are increasingly operating in more uncertain and dynamic environments. Innovative practices are momentary. New products are imitated very frequently and they either become the norm of the industry or become obsolete. Lean firms accelerate the learning rate in an organization (Netland and Ferdows, 2016). These aspects of change, uncertainty and learning in an organisation lay the ground for assessing the relationship between lean firms and their innovative capabilities from the standpoint of dynamic capability theory.

Dynamic capability theory is based upon the learning process of an organization and is used as basis for developing systematic and structured routines which enable the organization to transform itself according to the changing and competitive environment. Dynamic capabilities are stabilised, systematic and higher order routines of a firm which intend to modify its operational routines (the ones which earn a firm its revenue) in order to make them more effective in the present environment and more pertinent in the future environment (Zollo and Winter, 2002). Dynamic capability theory is postulated on the premise that the firm's environment is transformational in nature. Innovative capabilities are pivotal in transforming the organizations. They bring about 'change' and thus it is imperative that innovations are analysed from this very pseudo inertial frame of reference. Thus, we assess the interlinkages between lean practices and innovative capabilities from the purview of dynamic capability theory and propose a dynamic capability framework/routine for the switching behaviour of the firms vis-à-vis the 'decoupling point'. This framework puts forth a set of generic guidelines that can be used by lean manufacturing firms to determine the appropriate innovative capability which renders enhanced sustainable performance. By using this framework, lean organizations can have a reasonable semblance about when they should switch (decoupling point) from investing in exploitative innovative capabilities to exploratory innovative capabilities and vice versa, in order to ensure synergy between lean processes and innovative capabilities. This synergy subsequently leads to enhanced sustainable performance. Firms can interpret this dynamic capability framework in their own resource-configuration specific environments and harness this framework as a competitive advantage (Eisenhardt and Martin, 2000). We derive this framework by establishing a metaheuristic analogy. We draw inspiration from the 'No-free-lunches theorem' (Gendreau & Potvin, 2010, p. 115) of metaheuristics and which states that no metaheuristic performs equally well in all types of optimisation problems. Likewise, we argue that no innovative capability, namely, exploitative and exploratory performs equally well across all firms and at all times. For instance, a firm A which has had a long experience with lean practices may not do very well by investing in its exploitative innovative capabilities but may improve upon its sustainable performance by developing its exploratory innovative capabilities. On the other hand, a firm B which is relatively inexperienced in lean principles may improve upon its sustainable performance by developing its exploitative innovative capabilities. Developing exploratory innovative capabilities may require significant investments and may not render sufficient returns on its investment. Also, a firm C which has, lately, overhauled its process structure significantly by developing exploratory innovative capabilities may do well to revert back to developing exploitative innovative capabilities in order to maximise the returns on the investment that the firm has already made. We posit that the relationship between lean practices and environmental innovations fluctuates and oscillates between being 'apposite' and 'opposite'. Like there exists no metaheuristic which holds good in all problems, similarly there is no single state of lean-innovation relationship which holds good in all circumstances. This lean-innovation relationship is defined by a decoupling point which signifies the switching point from exploitative to exploratory innovative capability and vice versa. This switching behaviour is iterative and recursive and depends upon internal and external factors which are discussed in section 3.2.1.

The metaheuristic framework seeks inspiration from the principles of variable neighbourhood search algorithm, in which the solution space is searched in two iterative and recursive phases. The appropriate phase is switched on by the decoupling point. In the first phase, all the solution points in the immediate neighbourhood are tried in an attempt to find the 'best solution in the neighbourhood'. This phase, also called the 'local search' is analogous to the incremental improvements phase executed by the firm or the exploitative innovative practices undertaken by the firm. In this phase a process is 'continually improved' in order to find the best practice under the 'given infrastructural apparatus'. For this framework, incremental improvements are made until the practice comes close to the performance frontier (Schmenner and Swink, 1998) after which they are stopped. As the firm's processes come close to their performance frontier, the decoupling point is triggered and that signifies the onset of the second phase. In the second phase of variable neighbourhood search algorithm, an attempt is made to explore far flung neighbourhoods by trying out random solution points. If the solution points come out better than the incumbent, then neighbourhood is switched to that of the newly found solution point for phase I to start off again (recursive), else search for better solution point ensues in the far flung areas of solution space. This phase is called the 'global search' which is analogous to a firm's scrutinizing activities in the horizons of diverse technological advancements or the exploratory innovative capabilities undertaken by a firm in which it tries to shift the technological trajectory by bringing in some fundamental changes in the processes. These practices usually require significant investment to bring about significant changes in the 'infrastructural apparatus' of the firm. This phase is all about trying to find novel and better ways of conducting firm operations which can bring in significant financial benefits with reduced environmental impacts. If the firm 'finds' a novel practice which is better than the current firm practice, then it adopts the new practice (change of neighbourhood) and switches (or) decouples to phase I of making incremental improvements (exploitative) again; otherwise it keeps on investing in finding that 'novel practice'. It is noteworthy to mention that this phase includes the investments made by the firm in 'technology adoption' which can be termed as imitative innovation, in order to keep up with the technological advancements in the industry. This two phase sequential search is carried out in an iterative and recursive manner by controlling the transition from one phase to another by a de-coupling point which is governed by factors like a firm's resource configuration, external environment, industry, position in the value chain and a firm's span of practising current practices. The framework is as shown below.

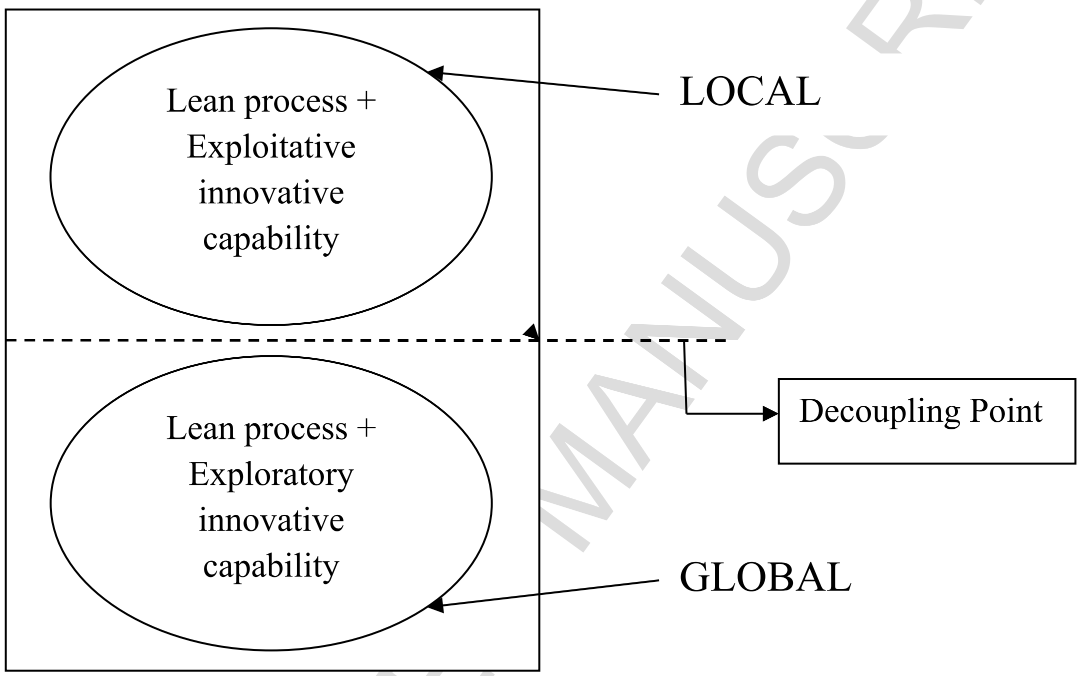


Fig. 1: Metaheuristic Framework for lean-innovation synergy

In the context of lean processes, we would like to emphasize that 'continual improvement' which is a basic principle of lean philosophy should be used like an 'on-off switch' in a firm's environmental innovative strategy. Continual improvements drive a firm ahead on the present technological trajectory. It makes a firm thrive in the competitive market and enables it to reap the 'maximum fruits' that it can under the 'given infrastructural apparatus'. But as the firm starts to reach the limits of its incremental improvements, or when it comes close to its performance frontier, continual efforts can entrap a firm in the pursuit of insignificant benefits achieved at the expense of very high costs. This could hinder a firm's ability to transform, hence making it more susceptible to fall into 'competency traps' (Rosenkopf and Nerkar, 2001). We propose that the philosophy of 'continual improvement' should be pursued intermittently to synergise environmental innovative capabilities of a firm with its lean practices. When a firm, while 'continually' striving for incremental improvements, reaches a point close to its performance frontier where it finds that there are no more 'low hanging fruits' available, then it needs to trigger its decoupling point and steer away from the philosophy of 'continual improvement'(only to come back later!). It should then invest in developing exploratory innovative capabilities. It should consider exploring diverse technological advancements in order to radically change and revamp its products and processes. After a firm has explored enough, it should switch back to its philosophy of 'continual improvement' (by triggering its decoupling point) and make incremental improvements in its lean processes until the firm reaches close to its performance frontier again. This switching behaviour goes back and forth in a dynamic and recursive manner and is controlled by the decoupling point as shown in Fig. 2.

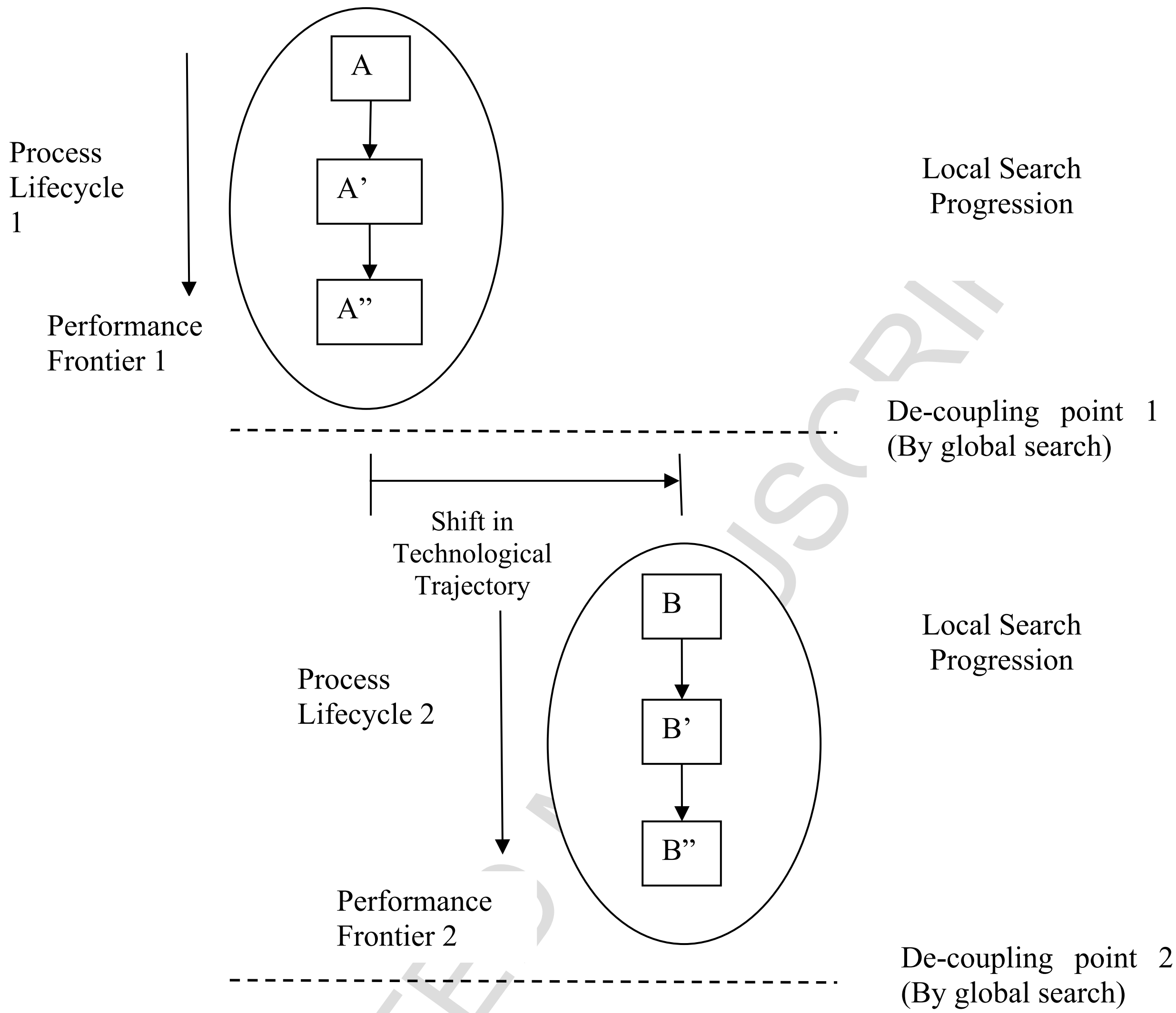


Fig 2: Depicting recursive and iterative exploitative and exploratory stages

The framework undergirds the dynamic capability view by being structured and iterative, the two 'must-haves' for a dynamic capability (Zollo and Winter, 2002). In line with the view of Eisenhardt & Martin (2000) on dynamic capabilities, this framework gives generic guidelines to the firms as to how they can synergise their innovation strategy with lean processes for sustained improvement in environmental performance. These guidelines can be implemented in accordance with a firm's resource configuration, internal or external environment and other such factors. Also, by deliberating on the 'flip-flop' mechanism of managing innovative capabilities, which themselves are a first order capability for a manufacturing firm (Winter, 2003), this framework seems to be in congruence with the requirements of a second-order dynamic capability.

3.2.1. Factors affecting the decoupling point:

3.2.1.1. Firm's position in the value chain of the product:

Eskandarpour et al., (2015) point out that the environmental impact of the firms which are placed upstream in the supply chain is higher as compared to the firms placed downstream. They discuss the greater damage caused by polluting raw materials when they enter the supply chain in the early stages as compared to later stages. Corbett & Klassen (2006) underscore that the firms have different focus on the basis of their position in the supply chain. For instance, upstream firms focus more on process design and material selection whereas downstream firms focus more on transportation and assembly efficiency. We argue that firms which are placed upstream of the supply chain such as, automobile part suppliers and OEM's have far reaching impact on sustainability, and thus should 'decouple' early on as compared to firms placed downstream in the supply chain. Firms downstream would eventually follow suit. Martin, Worrell, & Price (1999) examine the effect of the advent of vertical roller mill technology (an innovative product of OEM's) in US cement industry and state that it lead to 17% reduction in carbon footprint and 20-50% reduction in energy consumption across all cement firms. Such innovations in upstream partners in the supply chain have the capacity to not just affect one firm, but have the potential to take the whole industry by storm. We hypothesize that,

H1: Decoupling point (switching from exploitative to exploratory innovative practices) in a lean firm which is placed upstream in the supply chain is triggered early on as compared to lean firm which is placed downstream.

3.2.1.2.Internal resources: Internal resources of a firm mediate how well the firm respond to lean practices (Berrone et al., 2013). Internal resources of a firm are of two types, namely, slack and specificity. 'Slack' signifies having a little extra resource than needed and 'specificity' refers to the extent of fluidity of an organization's assets in reinvestment. Slack in a firm and their impact on innovative practices and environmental performance is a contentious issue (Etzion, 2007; Nohria and Gulati, 1996). Nohria & Gulati (1996) proposed that slack and innovative practices have an inverse-U relationship, meaning thereby, that 'too little' and 'too much' slack is inimical to innovative practices. We assume that lean firms already practice 'buffer minimization' and it is highly unlikely that slack levels are excessive. However, if the firm has been practising lean practices for quite a long time, it could be possible that the 'firm is managing with the bare minimum level of resources needed to ensure the smooth functioning of the firm. We argue that in such a scenario, at such low levels of slack, a firm would not be able to undertake any more fruitful exploitative innovative practices. Thus, at such low levels of slack, the firm should change its innovation strategy and 'switch' (at the decoupling point) to building exploratory innovative capabilities. This 'decoupling' in its innovation strategy would change the resource requirements of the firm by changing its technological trajectory. On the other hand, 'specific resources' are long term durable assets like real estate, machinery which can't be redeployed without incurring significant risk and loss of value (Berrone et al., 2013). We argue that a firm with lesser specificity in resources would be more nimble in adapting to the significant changes in the infrastructural apparatus brought about by environmental exploratory innovations.

> **H2:** With regard to the internal resources, decoupling point in a lean firm with lesser slack and specificity is triggered early on as compared to a lean firm with higher slack and specificity.

3.2.1.3. Effect of supply chain coordination:

Environmental innovative practices are complex (Wagner, 2008). They need varied technological capabilities and intra-organizational knowledge (Geffen and Rothenberg, 2000). Supply chain coordination gives the firm access to complementary knowledge and assets and thus boosts innovative capacities (Carrillo et al., 2015; Cohen and Levinthal, 1990). Nudurupati et al., (2015) underscore the role played by suppliers in co-creation of value in innovative activities. Companies like Honda, Proctor and Gamble and Walmart create innovative value by relying on their suppliers (Fawcett et al., 2012). Exploratory innovations, in particular, need multifarious skill sets and knowledge in order to be able to create novel, inter-disciplinary processes and products. A lack of such heterogeneous mix of knowledge makes a firm more inclined to incrementally innovate rather than explore radical innovation strategies (Geffen and Rothenberg, 2000). It is our contention, that better supply chain coordination helps in fostering all innovative practices (Dey et al., 2015), but is a necessary pre-requisite for exploratory innovative practices. A firm which has built its inter-firm linkages on the basis of trust, robust information exchange and fair incentive sharing systems will be better prepared in 'switching' (at the decoupling point) from exploitative to exploratory innovative practices.

H3: Decoupling point in a lean firm with higher level of supply chain coordination is triggered early on as compared to a lean firm which is not as well connected with its supply chain partners.

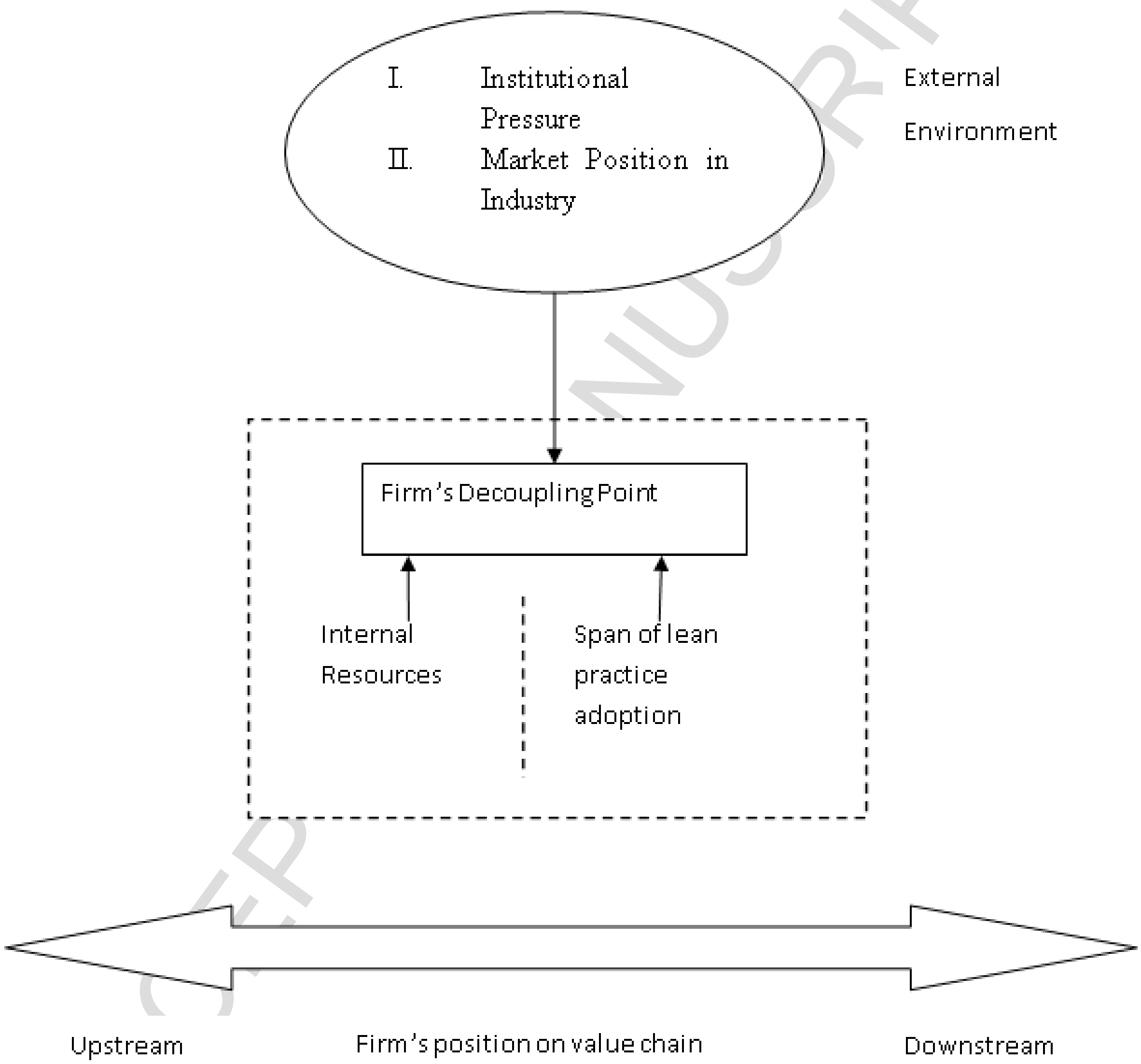


Fig. 3: Factors affecting decoupling point

3.2.1.4. External environment

A lean firm's path in environmental innovations is guided by factors like institutional pressure, industry reputation and other environmental characteristics (Ambec et al., 2013). We deliberate on such socio-political factors which affect a lean firm's strategy for environmental innovations.

(a) Institutional pressure: Berrone et al., (2013) pointed out the positive association of institutional pressure with environmental innovative practices. They emphasized that without enough institutional pressure, firms may not be willing to undertake risky investments. However, institutional pressures have various aspects (Dimaggio and Powell, 1983; Liu et al., 2010). We classify the institutional pressures as regulatory and non-regulatory pressures. Regulatory pressures are those mandatory norms and standards which firms need to adopt in order to function legitimately. They are levied by concerned regulatory bodies which represent the interests of the government as well. For e.g. European Union and United States follow market based regulations approach and India follows a command and control regulatory approach. Non-regulatory institutional pressures are the collective expectations of the consumer, stakeholder groups, NGO's, climate activists etc. They are not mandatory but play an important role in building the brand equity of a firm. We argue that it is the non-regulatory pressures which 'trigger' the switching behaviour from exploitative to exploratory innovative practices whereas regulatory pressures inhibit the process of this change by making the firms wary and inducing a 'play safe' behaviour. Firms see non-regulatory pressures as the battleground to win more consumers. They fight this battle out by developing novel products and services which differentiate the firm from its competitors and enhances its brand equity among consumers. With the rising tide of sustainability among consumers, non-regulatory pressures propel the firms to come up with novel contributions which can position the firm as being 'more green' than the other competitor. On the other hand, regulatory pressures are observed by firms as regulations which have to be followed in order to function smoothly in the region. As a result, firms tend to stick to bare minimum efforts, thus resulting in small incremental changes in products and processes.

H4.a.i: Higher the non-regulatory pressure, higher is the firm's propensity to 'switch' (at the decoupling point) from exploitative to exploratory innovative practices.

H4.a.ii: Higher the regulatory pressure, lesser is the firm's propensity to 'switch' from exploitative to exploratory innovative practices.

(b) Firm's position within the industry: Ambec et al., (2013) suggest that competitiveness of a firm affects its innovation strategy. Kagan, Gunningham, & Thornton(2003) classified firms on the basis of their approach towards environment in five categories in between 'environmental laggards' and 'true believers'. Laggards tend to imitate the innovative technologies of the true believers (e.g. Indian pharmaceutical industry (Chittoor et al., 2009)).Winter (2003) also points out this phenomenon by saying that rival firms often tend to practice imitative R&D. We suggest that most of the players in the market follow the actions of the market leader. Exploratory innovations are risky and thus, market leaders are better placed to undertake them. They have higher pool of resources, better financial viability, necessary lobbying power and scales of operation to pull off the 'explorations' successfully. We advocate that it is a market leader's social responsibility to introduce novel technologies to the industry. Such firms can earn significant first mover advantage and can make a business out of selling the technical knowhow it has achieved over the course of experimentation in order to effectively recuperate its R&D costs (Nidumolu et al., 2009).

H4.b: Decoupling point (switch from exploitative to exploratory innovation) in a market leader firm is triggered early on as compared to a firm with smaller market presence.

3.2.1.5 Firm's current practices:

In the proposed dynamic capability framework, the transition from exploitative to exploratory innovative practices is dependent upon how close the firm is to its performance frontier. This is also in congruence with the theory of learning which talks about a diminishing rate of return that as the organization does an activity in a repetitive manner its performance improves substantially at first and then levels off (Netland and Ferdows, 2016). Lean firms standardise the processes, reduce variation and enhance repetition in process implementation. Both the theories, learning curve and performance frontier, suggest that process improvements start to become feeble with deeper execution of lean practices (Netland and Ferdows, 2016). A firm's proximity to the frontier can be measured on the lines of measuring learning rate by "improvement half-life" measures i.e. the time required for the benefits to become halved (Henderson et al., 2015). It is our contention that firms which have been practising lean principles for a long time are better placed to 'switch' from exploitative to exploratory innovation strategy as it is likely that their process improvements have become trivial.

H5: Decoupling point in a firm which is experienced with lean processes is triggered early on as compared to a firm which is still a novice in its handling of lean processes.

4. RESEARCH METHODOLOGY:

The hypotheses were examined in the scenario of the Indian automobile industry (approx. 7.1% contribution in GDP). It is facing constant pressure on the front of environmental performance. It is evident in the Indian government's stand that in order to cut down the pollution levels, it plans to leap frog the transition from BS-IV to BS-VI, skipping the implementation of BS-V norms altogether (India Today, 2016). Automobile industry has a clear demarcation of supply chain echelons, namely the focal firms (automobile firms) and the firms upstream, such as automotive suppliers, component and ancillary firms. Both the echelons are fairly represented by associations like SIAM and ACMA respectively, which makes the data collection process lucid and robust.

We followed a two-pronged strategy for data collection. The dataset regarding a firm's innovative capabilities was collected in the form of annual reports and company websites whereas the dataset regarding institutional pressure, supply chain coordination was collected by survey method. The data regarding sustainability practices and lean practices adoption were collected, both, in the form of primary and secondary data to ensure the validity of the claims thereof. Sustainability reports published by the firm (secondary) and exploratory and structured questionnaires with the firm's managers (primary) served as the two streams of information for the sustainability database. The dataset regarding a firm's innovative capabilities and sustainability practices were content-analysed to determine firm's innovative inclination, i.e. whether the nature of its innovative practices is exploitative (or) exploratory and how these practices influence a firm's sustainable goals. Benner & Tushman (2002) pointed out that it is difficult to quantify innovations. We extrapolate their observation by propounding that, perhaps, it is even more difficult to classify the innovative practices as exploitative and exploratory. This classification is based on a lot of factors like industry, application and context. The use of a technology in one industry could be considered exploitative in nature whereas, in the other, it could be exploratory. For instance, any enhancement in GPS system of a car can be termed exploitative whereas GPS-enabled tractor which calculates the 'tilled area' in farming can be exploratory. Hence, in order to stratify the innovative practices of a firm, we saw through the eyes of a firm's management and tried to understand a firm's inclination towards exploitation (or) exploration by performing content analysis (Krippendorff, 2012) of the firm's research reports and disclosures. The annual report is used as the unit of analysis. Annual reports are the most authentic documents released by a company's management which discusses a firm's present performance and plans for future actions (Sharma and Henriques, 2005). Moreover, inferences based on secondary data such as annual reports and disclosures give a clearer picture of a firm's policy vis-à-vis innovation than the conclusions based on the responses of a single firm manager (Sharma and Henriques, 2005).

The data regarding a firm's sustainability practices and institutional pressure were collected by survey method through the use of structured questionnaires. The results were matched with the content analysis insights in order to achieve triangulation.

4.1. Content analysis for innovation and sustainability scores:

We collect the R&D expenses data for the automobile and automotive component companies from the CMIE (Centre for monitoring Indian Economy) database. The firms with over 45 million expenditure in research and development expenses were sorted and 36 lean firms were selected in each category, namely, automobile and auto component. We scrutinized the annual reports of the firms for the presence of quality improvement programs, implementation of JIT, TQM, TPM, inventory management etc. to ascertain whether the firm had adopted 'the bundle of inter related practices' necessary to qualify to be called 'lean' (Netland and Ferdows, 2016). The bar of 45 million was set to ensure that firms of comparable sizes are selected in an attempt to nullify the mediating effect of the size of the firm on its environmental performance (Etzion, 2007). The annual reports along with other disclosures were coded according to the coding definitions given in appendix A. Each firm was given a weighted aggregated score on the scale of 1 to 5 (1 being the farthest and 5 being the closest to exploratory innovation). The scores of '1 to 3' were categorized under exploitative innovation and '4'and '5' were clubbed under exploratory innovative practices. The aggregate score was calculated as a linear combination of the three individual scores given on the basis of three parameters, namely, 1) R&D to Net sales ratio, 2) coder's inference and 3) entry requirements for each category as given in code definitions in appendix A. The weights are attributed in the ratio of 1:1:1 respectively. R&D to net sales ratio is a quantitative measure of a firm's commitment towards innovative practices. Exploratory innovative practices are supposed to be more capital intensive than exploitative innovative practices (Benner and Tushman, 2002). This ratio measures a firm's propensity to take higher financial risks, and thus leads us to determine whether the firm has a more proactive stance or a more 'play-safe' or reactive stance. Coder's inference has been included as it brings to light some important aspects which otherwise would be missed in assigning the scores. The aggregated score was calculated as follows:

1) R&D/ Net sales ratio score: 5 (1.4% is the one of the highest ratios in the industry sample)

2) Coder's inference: 3 (in light of the above statements)
3) Entry requirements of category '5' satisfied (see appendix A).

   Aggregated score= 0.33*5+0.33*3+0.33*5 which is equal to 4.29 which rounds off to a score of '4'

Requirements for each category were defined so as to be exhaustive and exclusive (refer appendix A).

Similarly, sustainability practices were coded on a scale of '1'to '5' according to the coding definitions given in appendix B. The firms which seemed to have realised the intertwining relationship between innovative capabilities and the realisation of sustainable goals were rated higher. For instance, the sustainability practices of Tata Motors Ltd were rated with a score of '5'as it discussed 'environmental innovation' in its reports, the only automobile firm to have used the term explicitly.

The following section describes the instrument development process for primary data collection.

4.2. Instrument Development

In order to develop the scale for measurement of institutional pressure on Indian automobile industry, we reviewed the relevant literature on institutional pressure groups and after a careful comparative analysis, we chose items from Henriques & Sadorsky(1999), Buysse & Verbeke (2003), Sharma & Henriques (2005), Murillo-Luna, Garcés-Ayerbe, & Rivera-Torres (2008), Delmas & Toffel (2008), Sarkis, Gonzalez-Torre, & Adenso-Diaz(2010) and Berrone et al., (2013). We further refined the scale with the help of an expert panel. The respondents ranked each institutional pressure group on a five-point scale from 'no influence' (coded 0.2) to 'very strong influence' (coded 1). Table 1 presents the results of the factor analyses. Two factors emerged with large positive eigenvalues (1.68 and 1.26), which together accounted for 83.6 percent of the total variance (with subsequent varimax rotation).

<INSERT TABLE 1 ABOUT HERE>

Measures for sustainability practices were generated by considering a pool of items from the existing literature (Hart, 1995; Russo & Fouts, 1997; Sarkis et al., 2010; Sharma & Henriques, 2005; Sharma & Vredenburg, 1998; and so on). New items to this initial pool were added in instances where all dimensions of the construct had not been sufficiently covered.

Further, to enhance the construct validity of the survey measures, we conducted a pretest with the help of an expert panel. This panel comprised of 17 people: 6 business professionals dealing with business sustainability issues, 4 sustainability management consultants, 4 representatives from national and regional public institutions which deal with environmental issues, and 3 faculty members actively conducting research in supply chain management. All members of expert panel were familiar with the management of sustainability issues at the manufacturing facility level. The panel members used Likert scale to appraise two aspects of the initial questionnaire: (1) the ease of understanding the items and (2) their relevance for the objective of this study. We also encouraged them to add new items of interest for this research. The responses were recorded in the form of the following five-point scale, with the coding in parentheses: 'not being considered' (1), 'future consideration' (2), 'planning to implement' (3), 'currently implementing' (4), and 'successfully implemented' (5). By using such a scale, we obtained a measure that was more nuanced than a simple dichotomous response as to whether or not the facility had already adopted sustainability practices. Based on the discussion with expert panel as well as content analysis of secondary data on sustainability practices, two factor analyses were performed (see Tables 2 & 3). The two sets of items were separated because the two sets of practices reflected very different environmental strategies: transitional versus transformational. Transitional approach contained items that highlighted sustainability initiatives which aimed at curbing the adverse environmental impact by making changes under the given infrastructural apparatus of the firm. Transformational contained sustainability practices which aimed at redesigning the process by making significant changes in the infrastructural apparatus of the firm. Table 2 presents the results of the factor analyses for transitional and Table 3 presents the results of the factor analyses for transformational sustainability practices. Two factors with positive eigenvalues of 1.57 and 1.06 accounted for about 74.9 percent of the total variance for transitional sustainability practices. Three factors with positive eigen values of 1.72, 1.46 and 1.08 accounted for 83.6 percent of the total variance for transformational sustainability practices.

<INSERT TABLE 2 & 3 ABOUT HERE>

Measures for supply chain coordination were taken from Fawcett et al., (2012). We performed confirmatory factor analysis and found one factor which explained the 78.3 of the total variance. Finally, to measure the firm's current practices we asked the respondents to rate the adoption of lean practices like TQM, TPM, quality circles etc. on a five point Likert scale (1 adopted for more than 5 years and among the industry leader) to 0.2 (recently adopted or industry follower).

4.3. Survey Method

Data were collected for institutional pressure, sustainability practices, supply chain coordination, and firm's current practices. Initially, a one-page survey report and an introductory letter requesting participation were sent to all the selected firms. Each firm was asked to select a manufacturing plant for participation and provide details of the contact person in that plant. Of the 72 firms contacted, 51 agreed to participate and provided the necessary contacts at the plant level.

This study followed Dillman's (2000) five-point contact protocol. We received 51 complete responses in stage 1 with a score ≥ 6 on the respondent's level of confidence.

To test for nonresponse bias, we examined the differences between respondents and non-respondents for our final sample. T-tests showed no significant differences in terms of sales and annual ROA. We also used a chi-squared test of independence to compare early and late respondents, as well as the mode of the survey (i.e., mail vs. Internet) in terms of demographic characteristics and survey measures. These comparisons did not reveal any significant differences ($p<0.05$).

We also checked for common-method bias in the data. As our data is collected from single respondent (representative of each plant) and collected with a cross-sectional research design, common-method variance may cause systematic measurement error (Huber and Power, 1985). To ensure that the data does not suffer from common method bias, we conducted Harmon's single factor test (Podsakoff et al., 2003).

<INSERT TABLE 4 ABOUT HERE>

We tested internal consistency for each factor as follows. First, we checked the Cronbach alpha reliability coefficient value which was found to be above the common threshold of 0.7 (Table 4) for every factor (Nunnally and Bernstein, 1994)). Second, we calculated composite reliability (ρ_c) which was above the threshold value of 0.7 (Fornell and Larcker, 1981) and ranged from 0.85 to 0.94 (Table 4). This establishes adequate internal consistency. Third, we calculated the AVE (ρ_{ave}). As can be seen in Table 4, the AVE (average variance extracted) values ranged from 0.62 to 0.77, and exceeded the threshold value of 0.50 (Fornell and Larcker, 1981). As observed in Table 5, the AVE for each construct was found to be significantly higher than the calculated squared correlations between the construct and all other constructs. Therefore, discriminant validity is established. We used general linear model (GLM) to examine the hypotheses. GLM is a flexible generalization of ordinary linear regression that allows response variables to also have error distribution models.

<INSERT TABLE 5 ABOUT HERE>

5. RESULTS:

H0 which suggests that exploitative innovative practices in a lean firm conform to the transitional approach to sustainability and exploratory innovative practices lead the firm on the path of transformational approach to sustainability was supported (Table 6), thus deliberating on the nature of linkages between innovative practices and sustainability policy of a firm. The hypothesis was seconded by the insights from content analysis also. For instance, Hero MotoCorp ltd which practiced “innovation as improvement” policy (exploitative innovation) launched three ‘revised’ models of Splendor motorbike with increased fuel efficiency is in line with the principles of transitional approach to sustainability. On the other hand, Tata Motors which subscribed to ‘environmental innovation’ (exploratory) launched green future technology vehicles like Magic Iris Electric which emit zero emissions and use solar energy. Their innovation strategy conforms to the requirements of transformational approach to sustainability.

<INSERT TABLE 6 ABOUT HERE>

H1 which propounds that the firms placed upstream in the supply chain tend to switch (at the decoupling point) from exploitative to exploratory innovative practices early on as compared to firms which are placed downstream in the supply chain was also found to be significant. We conducted ANOVA tests on the innovation scores of the automotive component companies (upstream) and automobile firms (downstream) and found the innovation scores of automotive companies to be significantly higher. This result is supported by the insight that we develop by content analysing the annual reports that unlike automotive component firms, the automobile firms have a higher share of ‘technology adoption expenses’ as a percentage of their R&D expenses. This insight signifies the ‘trickle down’ effect of innovative practices and technologies i.e. the downstream automobile firms seem to attribute a large share of their R&D expenses to the costs incurred in adopting the innovations made by the component suppliers. Honda, for instance attributes 85% of its innovative potential to its suppliers (Fawcett et al., 2012). Thus, it seems convincing that firms placed upstream have a greater responsibility to tread the ‘unknown’ path of exploratory innovative practices as compared to the firms placed much downstream in the supply chain.

<INSERT TABLE 7 ABOUT HERE>

H2 which suggests that lesser slack in a lean firm triggers the decoupling point (switch from exploitative to exploratory innovative capabilities) early on as compared to a firm with greater slack was not supported and was found to be insignificant (Table 7). This incoherency is seconded by our insights from secondary data as well. Like Geiger & Makri (2006), we used current ratios as a measure of available slack. For instance, we found that Maruti Suzuki, the market leader in passenger car segment, had the lowest current ratio of 0.63 but performed high on innovation whereas Bajaj Auto Ltd had the highest of the current ratios (1.56) in the automobile industry but was found to be on the path of exploitative innovation and "faced slowdown dues to lack in new launches" (HDFC Bank Investment Advisory Group, 2015).The reason for this inconclusive finding, could purportedly be, the presence of other mediating factors like firm size and pan industry data which we have chosen to dispense with in the analysis. Also, we could not check the impact of 'specificity' in a firm's internal resources on its innovative practices, as we believe, it can only be determined on a dataset that spans across industries. The specificity in resources, purportedly, is an industry level phenomenon which in an automobile industry would be the similar for almost all the firms as they use similar technology and need similar resources in the form of land, technology and other assets. On the other hand, it is quite probable that specificity in resources would be different in automobile firms than in electronic manufacturing firms. Given to the limitations of the data used for this analysis, we suggest testing this part of the hypothesis as a future research gap.

H3 which posits that firms with better supply chain coordination are better placed in 'decoupling' from exploitative to exploratory innovative capabilities is well supported from the data (Table 7). This hypothesis is an extrapolation of the well-established position in literature that supply chain collaboration is a precursor to the development of innovation capabilities.

H4.a.i and **H4.a.ii** envisage the twin roles that institutional pressure has on a firm's innovation policy. Both the claims, that the non-regulatory pressures facilitate and the regulatory pressures impede the switching behaviour in lean firms are well supported. This proposition is also fortified by the insights developed on the basis of content analysing the annual reports of the firms. In the light of adjudging the impact of non-regulatory pressures, we find that firms focus more on novel innovative practices to improve upon the customer value proposition of their products. For instance, Tata Motors Ltd chairman in his message to the shareholders claimed to have improved their JD Power customer satisfaction index by delivering "sustainable financial profitability", delivering "exciting innovations" and "building a futuristic organization". The chairman discussed at length the development of electric hybrid buses in Mumbai, a 'first of its kind' green project in association with the Indian government "to meet the future transport needs of the smart cities". On the other hand, under regulatory pressure, firms like Ford India Private Ltd expressed their apprehension regarding the adverse impact to their financial health caused due to acting under duress of the various regulatory bodies. In the light of the above arguments, it seems convincing that regulatory pressure makes a lean firm risk averse and hence impedes the switching behaviour. Such pressures inhibit the transition from cost effective exploitative innovative practices to the more costly and uncertain exploratory innovative practices.

H4.b which propounds that market leaders 'switch' from exploitative to exploratory innovative practices quicker than other firms in the industry was ratified on the basis of insights from the secondary data. Newspaper reports, financial investment reports etc. were used to determine the market leaders in various segments. For instance, Maruti Suzuki was the market leader in passenger vehicles segment with almost 47% share (Sengupta, 2016), Hero Moto Corp continued to be the market leader in the two wheeler segment (HDFC Bank Investment Advisory Group, 2015) and TATA and Mahindra were found to be the market leaders in the M&HCV's and utility segments respectively. It was observed that these firms had high innovation scores and specifically their innovation was focussed in markets in which they had a dominant position. For instance, Maruti launched Celerio in the passenger car segment which received various awards for the best innovative model; and TATA, being a M&HCV segment leader launched models of hybrid electric buses in Mumbai. On the other hand, Bajaj Auto was observed to lose its market share because of lack of novel offerings (HDFC Bank Investment Advisory Group, 2015). In light of these facts, a positive link between being market leader firms and high innovation capabilities was established. We find that a market leader firm is not just more capable of building exploratory innovation capabilities but in fact, these capabilities are a precursor and an inevitable resource without which the firm might lose its market leadership position.

H5 which posits that firms which have been practising lean principles for a long time would 'decouple' sooner than firms which have less experience with lean processes was supported. The result was in congruence with the insights derived from the secondary data. We went through the previous reports of those companies which had their innovative scores above '4' to detect a company's adoption of lean practices like TQM, TPM, quality circles etc. We found that almost all such firms had been practising these practices for a period of atleast three to four years. This insight also endorses the premise of our metaheuristic model that firms follow the path of exploratory innovation practices only after the returns from the exploitative innovative practices start waning. The results are summarised in Table 8 as follows.

<INSERT TABLE 8 ABOUT HERE>

6. DISCUSSION AND CONCLUSIONS

This study hypothesizes and establishes that the relationship between lean firm and its sustainable performance is mediated by its innovative capability. Further, it hypothesizes about the factors that affect the switching behaviour (decoupling point) of a firm in terms of manoeuvring its innovation strategy. It suggests that this relationship has synergistic and discordant phases. Lean firms need to be in synergistic phase in order to improve upon their sustainable performance. The corresponding phase is determined by the type of innovative capability, namely, exploitative and exploratory. The type of innovative capability determines whether lean processes in a firm are positively or negatively associated with the firm's sustainable performance. This article proposes a second order dynamic capability framework to ascertain which type of innovative capability would improve a firm's sustainable performance. It deliberates upon the alternating and dynamic nature of this relationship by striking a metaheuristic analogy undergirded in the dynamic capability theory.

The results suggest that exploitative innovative practices propel the firm on the path of transitional approach to sustainability; and exploratory innovative practices set the firm on the path of transformational approach to sustainability. This finding is pivotal as it sets the stage by establishing a causal link between a firm's innovation strategy and its approach to sustainability. It is found that the switch from exploitative to exploratory innovative policy i.e. the decoupling point is dependent upon the position of the firm in the supply chain. Automotive component companies were found to be making this switch earlier than automobile companies i.e. to say that firms placed upstream in the supply chain with functions such as sourcing, raw material processing, ancillary and component production would make ‘the switch’ earlier as compared to firms placed downstream in the supply chain with functions such as assembly and distribution. This study establishes that better supply chain coordination in a firm enhances a firm’s skill set and contributes to its early switching behaviour at the decoupling point. Effective information channels based on trust and mutually approved incentive sharing systems lay a fertile ground for joint R&D programs and result in prolific innovation ideas. An interesting insight that we find is that institutional pressure, as such, can be both, strangulating as well as expediting, for a firm’s innovative capabilities. This article also emphasizes that market leaders in every industry are better placed in making the transition across the decoupling point. Lastly, this study fetches an important insight that exploratory innovative practices are adopted by firms only after they have been practicing exploitative practices for a sufficiently long period of time. This insight fortifies the premise of the metaheuristic framework that exploratory innovative practices are adopted by firms only after they have been practicing exploitative practices for a sufficiently long period of time. This insight endorses one of the basic assumptions of neo classical economics that ‘firms maximize their profits’. Unless the firm has reaped the significant benefits of the ‘low hanging fruits’ which come by as a result of exploitative innovation capabilities, it is not pragmatic to expect that the firm would embark on the path of more riskier, more uncertain and more costly trajectory of exploratory innovations. In this study, the mediating role of innovation strategy is analyzed in determining the relationship between lean manufacturing firms and their sustainable performance.

7. LIMITATIONS AND RESEARCH IMPLICATIONS

The foremost limitation of this study is that the data pertains to only one industry, i.e. the automobile industry. For a robust adjudication of this metaheuristic framework, we recommend using a more extensive pan industry database. Moreover, we suggest using panel data to further check the veracity of **H5** in order to triangulate the results better. We have used longitudinal secondary data but we realise that the number of data points were limited because of the fact that automobile industry is quite consolidated and regulated. Many of the companies post their data as a part of their conglomerates. For instance, Hyundai Motors, like GM (India) were not considered in this study as they didn't post a separate balance sheet for its functions in India on its website and they didn't respond to the mails either. Consequently, to go with the limited data we applied Generalised linear regression to test our hypotheses as it doesn't require a large sample. With an exhaustive database, high level analysis tools like SEM etc. can be applied. Future research is encouraged to check the applicability of this model in firms pertaining to different industries. We present this study as a starting point for taking a more pragmatic, equivocal and nuanced approach on the lean-innovation relationship and determining how this relationship affects sustainable goals of a firm.

8. IMPLICATIONS FOR MANAGERS AND PUBLIC POLICY

Managers need to adopt lean process and ascertain the stage of their process life cycle. They need to judge if the implemented lean process is in congruence with their innovation policy. If the lean process is relatively new and has got remarkable potential to enhance resource efficiency and cut wastes without incurring considerable costs i.e. the low hanging fruits are available, firm managers should continue making incremental improvements (exploitative innovation) in line with the principles of lean philosophy. But, if the firm has been 'lean' for sufficiently long time and has already reaped the 'the big benefits', then the firm needs to dissociate or 'decouple' from treading the same technological trajectory (exploitative innovation) and focus on changing its technological trajectory altogether (exploratory innovation). After the firms have successfully shifted their technological trajectory they can continue to 'exploit' the new trajectory again in accordance with the principles of exploitative innovation. This switching behaviour would ensure continued growth in sustainable performance. This study proposes a metaheuristic framework that lays out a generic set of guidelines for the firm managers to ascertain whether they need to 'exploit' or 'explore' in terms of their innovation policy.

Moreover, by establishing the adverse effects of regulatory pressures on innovation-led sustainable efforts, this study also gives cues to the policy makers that excessive and frequent change in regulations may impede a firm's stride in developing innovative capabilities and could act as a dilatory factor in achieving its sustainable goals. Additionally, we find that the NGO's and the other non-regulatory stakeholders have an important role to play in boosting a firm's assortment of novel offerings as these entities build up non-coercive pressures which are extremely effective in motivating firms to act proactively.

ANNEXURE 'A'

ENTRY CONDITIONS FOR INNOVATION SCORES:

'1' is allotted to a firm if

- No information is given on its innovative practices. The companies whose annual reports could not be accessed lie in this category.
- Also there are some big players which are subsidiaries of their global parent conglomerates. For instance, Hyundai India motors is a subsidiary of Hyundai Korea (the parent organisation) and its R&D efforts are aimed at supporting the innovative practices at the headquarter level. These companies don't post their annual reports on their Indian websites. Also it becomes difficult to gauge what is their contribution in the whole innovation of the parent firm. Thus we have only taken innovative practices which have fructified in the Indian context and not elsewhere.

'2' is allotted to a firm if

- The firm claims to have significant R&D investment but has not substantiated its claims by giving specific examples. This leads us to believe that their efforts have not reached fruition.

'3'is allotted to a firm if

- The firm has a R&D page on the website.

- Focusses on quality improvement, adopts process management programs like TPM, TQM, Quality awards, certifications etc. This signifies the exploitative innovative practices.
- The report gives examples of technologies which were upgraded and improved.

'4' is allotted to a firm if

- The firm has exquisite focus on sustainability innovation i.e. the innovative efforts are directed towards better environmental performance.
- Claims of having made *novel* contributions to the industry by citing examples. For instance, "India's first or world's first something". These contributions can be 'upgradations or improvements'.
- Projects of radical and new technologies are in process.

'5' is allotted to a firm if

- The firm has highest of the R&D to net sales ratio.
- The firm claims in its report that R&D and technical knowhow is a source of income for the company.
- The firm gives specific examples of novel contributions in alternative fuel technology or in a way that has not been previously done in auto industry. Also, list of patents filed is presented.
- The company is seen making forays into alternative fuels/ non-renewable sources of energy. For instance solar cells or hydrogen cell technology developed by TATA etc.

ANNEXURE 'B'

ENTRY CONDITIONS FOR SUSTAINABILITY SCORES

'1' is allotted to a firm if

- No information is given on its sustainability practices. We don't include a firm's CSR activities to be a part of its sustainable efforts.
- Also some firms like Harita seating systems whose business proposition is about consumer comfort only come under this category. For instance, in designing 'seats' the focus is on providing comfort primarily.

'2' is allotted to a firm if

- The firm claims to have significant pollution control and fuel efficiency claims but has not substantiated its claims by giving specific examples.

'3'is allotted to a firm if

- The firm gives examples where pollution control and resource efficiency were demonstrated.

'4' is allotted to a firm if

- In addition to above requirements, the firm should have a separate sustainability report.

'5' is allotted to a firm if

- In addition to above requirements, the firm should have undertaken projects and technologies developed in alternate fuels and renewable resources.

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Table 4: **Psychometric property of first order measurement scales**

S. No	Latent Variables	Mean	Variance	Number of items	Cronbach's alpha	Composite reliability	Average variance extracted
1	Supply Chain Collaboration	0.36	0.08	7	0.93	0.94	0.73
2	Regulatory Pressure	0.19	0.06	5	0.93	0.94	0.73
3	Non-Regulatory Pressure	0.30	0.01	5	0.83	0.90	0.74
4	Pollution Control	0.36	0.02	2	0.76	0.86	0.68
5	Eco-efficiency	0.28	0.03	3	0.79	0.86	0.77
6	Source reduction	0.23	0.03	3	0.88	0.91	0.71
7	Eco Design	0.25	0.04	2	0.73	0.85	0.65
8	Business redefinition	0.22	0.05	2	0.88	0.91	0.73
9	Firm's current practices	0.51	0.03	1	0.81	0.87	0.62

We calculated *composite reliability* (ρ_c) as; ρ_c = [(Σ standardized loading)^2/ [(Σ standardized loading)^2 + Σϵ_j], where ϵ_j is the measurement error.

We calculated the 'average variance extracted (AVE)' (ρ_{ave}) as ρ_{ave} = Σ (standardized loading^2) / [Σ (standardized loading^2) + Σϵ_j].

Table 5: Correlations between constructs (square root of average variance extracted in the diagonal)										
Construct	1	2	3	4	5	6	7	8	9	10
1	**0.83**									
2	0.39**	**0.85**								
3	-0.29*	0.11	**0.86**							
4	0.05	0.07	0.34*	**0.82**						
5	-0.16	0.18	0.43**	0.08	**0.82**					
6	-0.39**	0.13	0.37**	0.12	0.17	**0.88**				
7	0.42**	0.19	-0.58**	0.27*	0.12	0.14	**0.84**			
8	0.25*	0.10	-0.32*	0.19	-0.21	0.05	0.16	**0.81**		
9	0.31**	0.16	-0.41**	0.32*	-0.19	0.26*	0.20	0.04	**0.79**	
10	0.28*	0.29*	0.04	0.14	0.23*	0.11	0.15	0.24*	0.23*	**0.85**

1. Innovation 2. Supply Chain Collaboration 3. Regulatory Pressure, 4. Non-Regulatory Pressure, 5. Pollution Control, 6. Eco-efficiency, 7. Source reduction, 8. Eco Design, 9. Business redefinition, 10. Firm's current practices

* p<0.05 (2-tailed); ** p<0.01 (2-tailed)

Table 8: Hypotheses summary

Hypothesis	Outcome	Insights from content analysis
H0	Supported	Seconded by instances of Hero MotoCorp Ltd. & Tata Motors
H1	Supported	High share of 'technology adoption expenses' in automobile firms
H2	Not Supported	Seconded by instances of Maruti Suzuki & Bajaj Auto Ltd.
H3	Supported	
H4.a.i and H4.a.ii	Supported	Seconded by instances of Ford India Private Ltd & Tata Motors Ltd
H4.b	Supported (on the basis of secondary data)	Seconded by instances of market leaders like Mahindra, Hero MotoCorp Ltd. & Tata Motors
H5	Supported (on the basis of secondary data)	Firms which are experienced with lean practices scored high in innovation (R&D)

Table 1: Institutional Pressure Factor Analysis		
Item	Factor 1 (Regulatory Pressure)	Factor 2 (Non-Regulatory Pressure)
Government regulatory pressure	***0.80***	0.12
Government information	***0.72***	0.09
SIAM*/ACMA** information	***0.69***	0.23
Informal network information	***0.88***	0.14
Competitor information	***0.77***	0.20
Environmental organization/NGO pressure	0.34	***0.69***
Customer pressure	0.25	***0.57***
Media pressure	0.17	***0.55***
Shareholder pressure	0.13	***0.71***
Employee pressure	0.22	***0.63***
*Society of Indian Automobile Manufactures **Automotive Component Manufacturers Association of India		

Table 2: Transitional approach to sustainability factor analysis		
Item	Factor 1 (Pollution Control)	Factor 2 (Eco-efficiency)
Environmental compliance and auditing programme (such as ISO 14001)	***0.84***	0.09
Detoxification of water and air	***0.87***	0.11
Using less material per unit produced	0.18	***0.85***
Using less energy per unit produced	0.13	***0.79***
Producing less waste per unit produced	0.07	***0.89***

Table 3: Transformational approach to sustainability factor analysis			
Item	Source reduction	Eco Design	Business redefinition
Reduction in the variety of materials employed in manufacturing the company's products	***0.77***	0.11	-0.05
Reduction in raw material	***0.83***	0.05	-0.11
Avoidance of materials that are considered harmful, but not illegal	***0.79***	0.12	-0.08
Designing product for easy disassemble or reuse	0.23	***0.86***	0.14
Product life-cycle analysis	0.19	***0.81***	0.21
Introduction of new generation of environmental friendly products	-0.08	0.34	***0.86***
Enter new sustainable technology field	-0.13	0.27	***0.80***

Table 6: **Multivariate general linear model results of the relationship between innovative practices and sustainability practices[a] (Hypothesis H_0)**

Independent variables	Transitional approach to sustainability		Transformational approach to sustainability		
	Pollution Control	Eco-efficiency	Source reduction	Eco Design	Business redefinition
Intercept	-2.423(-1.63)	-3.276** (-2.43)	-0.021(-0.03)	-0.557(-0.43)	0.083(-0.17)
Exploitative Innovation	0.337**(2.93)	0.248**(2.27)	0.064(0.37)	0.045(0.40)	0.028(0.19)
Exploratory Innovation	-0.057(-0.31)	-0.100(-0.60)	0.487** (2.73)	0.713*** (3.25)	0.586***(3.47)
R^2	0.380	0.450	0.570	0.492	0.297

[a] The number of observations is 40. T- values in parentheses. *** $p < 0.01$ and ** $p < 0.05$

Table 7. Multivariate general linear model results of the relationship between innovative practices and Firm Slack, Supply Chain Collaboration, Regulatory Pressure, Non-Regulatory Pressure , Firm's current practices[a] (Hypothesis H_2 to H_5)

Independent variables	Dependent Variable	
	Exploitative Innovation	Exploratory Innovation
Intercept	-3.465*** (-2.35)	-0.020 (-0.26)
Firm Slack (H_2)	0.158 (0.97)	0.062 (0.37)
Supply Chain Collaboration (H_3)	0.317(1.38)	0.545***(3.78)
Regulatory Pressure ($H_{4a.i}$)	0.119**(2.43)	-4.245***(-3.53)
Non-Regulatory Pressure($H_{4a.ii}$)	0.317(1.49)	0.242**(2.16)
Firm's current practices (H_5)	0.140(1.07)	0.332**(2.57)
R^2	0.397	0.458

[a] The number of observations is 40. T-values in parentheses. *** $p < 0.01$ and ** $p < 0.05$
Firm slack is measured by current ratio of the firms.