

**FACTORS AFFECTING CREATIVITY OF SCIENTISTS:
A STUDY OF R & D ORGANISATION**

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**FACTORS AFFECTING CREATIVITY OF SCIENTISTS:
A STUDY OF R & D ORGANISATION**

By

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to the



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Dedicated
to
My Grandfather
Late Shri. Chaman Lal Bansal

CERTIFICATE

This is to certify that the thesis titled “**Factors Affecting Creativity of Scientists: A Study of R&D Organisation**”, being submitted by **Mr. Manish Bansal** to the Indian Institute of Technology Delhi, for the award of the degree of **Doctor of Philosophy (Ph.D.)**, is a record of bonafide research work carried out by him. He has worked under our supervision and has fulfilled the requirements for the submission of this thesis, which has attained the standard required for Ph.D. degree of the Institute. The results presented in this thesis have not been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

R&D activity is of paramount importance to an economy, so much so that technological advancement is often used as a measure of the country's competitiveness and overall development. For any organization to excel, it is imperative that the workforce is able to realise its true creative potential. The study was carried out with an aim to understand the various individual and contextual factors that may affect creativity of scientists in a R&D Organisation working in the area of defence research, characterized by creativity within boundaries. The study builds on the ongoing investigations of factors influencing employees' creativity.

The objective is addressed through two studies. The first study is conducted to analyse from the perception of scientists, the various factors that affect their creativity. In the first study, the qualitative data collected through a semi structured interview from 30 scientists is used to understand the context, identify the various individual and contextual factors that may be influencing creativity of scientists. The results of the first study and literature review formed the basis for development of the models to be tested in the second study. Second study is an empirical study to identify the various factors affecting creativity of scientists. A total of 430 responses were used to test the effects of constructs such as intrinsic motivation, creative self-efficacy, lack of perseverance, team climate, trust, challenging work, transformational leadership and leader member exchange on creativity.

Confirmatory factor analysis (CFA) for all the variables was carried out using AMOS version 21. CFA model provided an acceptable fit to the data. The convergent and discriminant validity of the measures was then established using SPSS16 and AMOS 21. Cronbach alpha, composite reliability and average variance extracted is used to establish convergent validity. The results suggest that the variables exhibit good convergent validity and reliability (Cronbach alpha, composite reliability more than 0.7 and average variance extracted more than 0.5). Discriminant validity is assessed employing Fornell-Larcker criterion and checking the square root of AVE of the construct with the correlation coefficients of all other constructs (in AMOS 21). Harman's single factor test was conducted to test for common method bias. The validation of these results was furthered to check if any of the correlations exceeded the value 0.9 in correlation matrix (Pavlou et al. 2007). Common method bias was not

a concern in the study. The data collected for all the variables was further tested by using the Structural Equation Modelling (SEM) using AMOS 21.

Overall structure of the thesis: the thesis is structured to capture the contextual nuances that merit R&D set ups as rich research sites for investigation of creativity (chapter 1), followed by a thorough review of the exiting studies on creativity (chapter 2). Methodology details pertaining to the two studies – exploratory and empirical are captured in Chapter 3. Chapter 4 captures the results pertaining to direct effects, indirect effects through mediator and the impact on scientists' creativity in the presence of a moderator which are then discussed in chapter 5. At its close the thesis outlines the implications for practice and directions for future research (chapter 6).

The unique contribution of this thesis lies in its contextual mapping of the R&D set up and highlighting factors facilitating creativity therein. The results reveal that intrinsic motivation, creative self-efficacy, team climate, trust, challenging work, leader member exchange and transformational leadership positively influence scientists' creativity. Intrinsic Motivation was found to mediate the relationship between their creative self-efficacy, team climate, trust, challenging work, leader member exchange and creativity. Intrinsic motivation neither mediated the relationship between transformational leadership & creativity nor between lack of perseverance & creativity. The results also depicted that the relationship between intrinsic motivation and creativity is dampened in the presence of high transformational leadership. Thus, transformational leadership was found to moderate the relationship between intrinsic motivation and creativity.

This study augments the available literature on creativity under constraints by identifying the predictors that influence creativity bounded by specification and time based constraints.

The results offer practical implications for managers working for research organizations responsible for managing the creativity of employees.

सार

आर एंड डी गतिविधि एक अर्थव्यवस्था के लिए अति महत्वपूर्ण है। तकनीकी प्रगति अक्सर देश की प्रतिस्पर्धात्मकता और समग्र विकास के माप के रूप में उपयोग की जाती है। किसी भी संगठन को उत्कृष्ट बनाने के लिए यह जरूरी है कि कार्यबल अपनी वास्तविक रचनात्मक क्षमता का एहसास कर सके। इस अध्ययन को विभिन्न व्यक्तिगत और प्रासंगिक कारकों को समझने के उद्देश्य से किया गया था जो कि रक्षा अनुसंधान के क्षेत्र में काम करने वाले अनुसंधान और विकास संगठन के वैज्ञानिकों की क्रिएटिविटी को प्रभावित कर सकते हैं, ऐसी क्रिएटिविटी सीमाबद्ध होती है। यह अध्ययन कर्मचारियों की क्रिएटिविटी को प्रभावित करने वाले कारकों की चल रही जांच को आगे बढ़ाता है।

उद्देश्य दो अध्ययनों के माध्यम से संबोधित किया गया है। पहला अध्ययन वैज्ञानिकों की धारणा का विश्लेषण करने के लिए आयोजित किया गया है, कि कौन से विभिन्न कारक हैं जो उनकी क्रिएटिविटी को प्रभावित करते हैं। पहले अध्ययन में, 30 वैज्ञानिकों से सेमि स्ट्रक्चर्ड इंटरव्यू के माध्यम से एकत्र किए गए गुणात्मक डेटा का उपयोग संदर्भ को समझने के लिए किया गया है तथा वैज्ञानिकों की क्रिएटिविटी को प्रभावित कर रहे विभिन्न व्यक्तिगत और प्रासंगिक कारकों की पहचान करने के लिए किया गया है। पहले अध्ययन और साहित्य समीक्षा के परिणामों ने दूसरे अध्ययन में परीक्षण किए जाने वाले मॉडल के विकास का आधार बनाया। दूसरा अध्ययन वैज्ञानिकों की क्रिएटिविटी को प्रभावित करने वाले विभिन्न कारकों की पहचान करने के लिए एक एम्पिरिकल अध्ययन है। कंसट्रक्ट जैसे कि इन्ट्रिंसिक मोटिवेशन, क्रिएटिव सेल्फ एफीकैसी, लैक ऑफ़ परसेवेरेंस, टीम क्लाइमेट, ट्रस्ट, चल्लेंजिंग वर्क, ट्रांसफॉर्मेशनल लीडरशिप एंड लीडर मेंबर एक्सचेंज के प्रभावों का क्रिएटिविटी पर परीक्षण करने के लिए कुल 430 प्रतिक्रियाओं का उपयोग किया गया।

सभी वैरिएबलस के लिए कन्फर्मेटरी फैक्टर एनालिसिस (सीएफए) को AMOS संस्करण 21 का उपयोग करके किया गया था। सीएफए मॉडल ने डेटा को एक स्वीकार्य फिट प्रदान किया। कनवर्जेंट वैलिडिटी और डिस्क्रिमिनेट वैलिडिटी को तब SPSS16 और AMOS 21 का उपयोग करके स्थापित किया गया। क्रोनबेक अल्फा, कम्पोजिट रिलायबिलिटी और एवरेज वैरियन्स एक्सट्रैक्टेड का उपयोग कनवर्जेंट वैलिडिटी को स्थापित करने के लिए किया जाता है। परिणाम बताते हैं कि वैरिएबलस अच्छी कनवर्जेंट वैलिडिटी और रिलायबिलिटी प्रदर्शित करते हैं (क्रोनबाक अल्फा, कम्पोजिट रिलायबिलिटी 0.7 से अधिक और एवरेज वैरियन्स एक्सट्रैक्टेड 0.5 से अधिक)। डिस्क्रिमिनेट वैलिडिटी का मूल्यांकन फ़ॉर्नेल-लार्कर मानदंड को नियोजित करने और कंसट्रक्ट के एवीई के वर्गमूल को अन्य सभी कंसट्रक्टस के सहसंबंध गुणांक (AMOS 21 में) के साथ जांच कर किया जाता है। हरमन का सिंगल फैक्टर टैस्ट कॉमन मेथड बायस के परीक्षण के लिए आयोजित किया गया था। इन परिणामों के

सत्यापन के लिए यह भी जाँच की गई कि क्या सहसंबंध मैट्रिक्स में किसी भी तरह के सहसंबंध 0.9 से अधिक तो नहीं है (पावलौ एट अल 2007)। अध्ययन में कॉमन मेथड बायस चिंता का विषय नहीं था। सभी वैरिएबलस के लिए एकत्र किए गए डेटा को AMOS 21 का उपयोग करके स्ट्रक्चरल समीकरण मॉडलिंग (SEM) से आगे परीक्षण किया गया।

थीसिस की समग्र संरचना: थीसिस को रचनात्मक बारीकियों को पकड़ने के लिए संरचित किया गया है जो क्रिएटिविटी की जांच के लिए समृद्ध अनुसंधान स्थलों के रूप में आरएंडडी सेट अप को मेरिट करते हैं, इसके बाद क्रिएटिविटी (अध्याय 2) पर मौजूदा अध्ययन की गहन समीक्षा की गई है। दो अध्ययनों से संबंधित कार्यप्रणाली का विवरण एक्सप्लोरेटरी और एम्पिरिकल अध्याय 3 में कैप्चर किया गया है। अध्याय 4 डायरेक्ट इफ़ेक्ट से संबंधित परिणामों को कैप्चर करता है, मीडिएटर के माध्यम से इनडायरेक्ट इफ़ेक्ट और एक मॉडरेटर की उपस्थिति में वैज्ञानिकों की क्रिएटिविटी पर पढ़ने वाले प्रभाव को कैप्चर करता है। इन परिणामों की अध्याय 5 में चर्चा की गई है। अंत में थीसिस (अध्याय 6) प्रैक्टिकल इम्प्लिकेशन्स और भविष्य के अनुसंधान के लिए निर्देशों की रूपरेखा तैयार करता है।

इस थीसिस का अनूठा योगदान आरएंडडी सेट अप के अपने प्रासंगिक मानचित्रण और इसमें क्रिएटिविटी को बढ़ावा देने वाले कारकों को उजागर करने में है। परिणाम बताते हैं कि इन्ट्रिंसिक मोटिवेशन, क्रिएटिव सेल्फ एफीकैसी, टीम क्लाइमेट, ट्रस्ट, चल्लेंजिंग वर्क, लीडर मेंबर एक्सचेंज और ट्रांसफॉर्मेशनल लीडरशिप वैज्ञानिकों की क्रिएटिविटी को सकारात्मक रूप से प्रभावित करते हैं। इन्ट्रिंसिक मोटिवेशन वैज्ञानिकों की क्रिएटिव सेल्फ एफीकैसी, टीम क्लाइमेट, ट्रस्ट, चल्लेंजिंग वर्क, लीडर मेंबर एक्सचेंज और क्रिएटिविटी के बीच के संबंधों को मीडिएट करता है। इन्ट्रिंसिक मोटिवेशन ने न तो ट्रांसफॉर्मेशनल लीडरशिप और क्रिएटिविटी के बीच और न ही लैक ऑफ़ परसेवेरेंस और क्रिएटिविटी के बीच संबंधों को मीडिएट किया। परिणामों ने यह भी दर्शाया कि इन्ट्रिंसिक मोटिवेशन और क्रिएटिविटी के बीच संबंध उच्च ट्रांसफॉर्मेशनल लीडरशिप की उपस्थिति में कम हो जाता है। इस प्रकार, इन्ट्रिंसिक मोटिवेशन और क्रिएटिविटी के बीच संबंधों को ट्रांसफॉर्मेशनल लीडरशिप मॉडरेट करता पाया गया।

यह अध्ययन स्पेसिफिकेशन और समय आधारित बाधाओं से बंधी क्रिएटिविटी को प्रभावित करने वाले प्रिडिक्टर्स की पहचान करके बाधाओं के तहत क्रिएटिविटी पर उपलब्ध साहित्य को बढ़ाता है। यह परिणाम, अनुसंधान संगठनों के लिए काम करने वाले प्रबंधक जो की कर्मचारियों की क्रिएटिविटी के प्रबंधन के लिए जिम्मेदार हैं, उनके लिए प्रैक्टिकल इम्प्लिकेशन्स भी प्रदान करते हैं।

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LIST OF ABBREVIATIONS

AMOS	Analysis of a Moments Structue
AVE	Average Variance Extracted
C	Creativity
CFA	Confirmatory factor analysis
CFI	Comparative Fit Index
CMIN/df	Chi square per degree of freedom
CR	Composite Reliability
CSE	Creative Self-efficacy
CSIR	Council of Scientific and Industrial Research
CW	Challenging Work
GFI	Goodness of Fit Index
IA	Idealized Attributes
IB	Idealized Behavior
IM	Intrinsic Motivation
IS	Intellectual stimulation
IC	Individual Consideration
LMX	Leader Member Exchange
LMXM	Leader Member Exchange as reported by member
ML	Maximum likelihood
MLQ	Multifactor Leadership Questionnaire
R&D	Research and Development
RMSEA	Root Mean Square Error of Approximation
SEM	Structure Equation Modeling
SFI	Support For Innovation
SPSS	Statistical Package for the Social Sciences
SRMR	Standardized Root Mean Square
TC	Team Climate
TCI	Team Climate Inventory
TO	Task Orientation
TLI	Tucker–Lewis index