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Journal of Management

Vol. 50 No. 1 March 2021

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Journal of Management

Vol. 50 No. 1 March 2021

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Vol. 50 No. 1, March 2021

Dr. Malabika Tripathi, Dr. Sweta Saraff, Nalanda Ray, Akangsha Roy 1
Glass Ceiling and Raising Aspirations: Exploring Managerial Roles of Women

Dr. Nirmalya Bagchi, Dr. Karnak Roy, Mr. Arpan Roychowdhury 15
A Base Line Model on Factors Affecting Girls' Enrolment in 650
Rural Blocks of Andhra Pradesh

Mr. Siddartha Ramakanth Keshavadasu 30
Thinking Beyond Just Mobility: Way Forward For India

Dr. Saugat Ghosh, Dr. Karnak Roy 36
Finding Service Quality Dimensions: A Study on
Digital Marketing Service Quality

Dr. Shamima Haque 49
A study on Dual-career Women's Stress, Satisfaction and
Career Salience over Family Life Cycle Stages

Dr. Atul Sen 70
Revisiting the Concept of Knowledge

Dr. SubodhKandamuthan, Mr. Hari Krishna Noule, Dr. Amrutha Pullanoor, 86
Dr. Harikrishna Bachu, Mr. Paavan Kumar, Mr. Sriman Kotas
A Case study on Rockwell Industries

Dr. Anuj Bhatnagar 91
Inter-Governmental Science and Technology Cooperation: A case study of
Indo-German Science and Technology Centre

ASCI Journal of Management 50 (1): 1–14

Glass Ceiling and Raising Aspirations: Exploring Managerial Roles of Women

Dr. Malabika Tripathi*, Dr. Sweta Saraff, Nalanda Ray***, Akangsha Roy******

Abstract

The new decade has observed more progress in the status of women than before. However, when compared to the predominant corporate advancement of men, women are yet to receive an equivalent momentum. Much of this may be attributed to the glass ceiling effect. It remains a harsh reality that reinforces discriminatory barriers which inhibit a woman's chances of reaching high-level positions within an organization. The present chapter comprehensibly explores the relationship between the glass ceiling and women's role within the workplace. Specific focus has been placed on the areas of whether businesses need women at the top, the interrelationship between work and family for women, the extent of adequate representation of women in management roles, their readiness for such roles, and how organizational agility can impact the glass ceiling. Additionally, the glass ceiling and its determinants have been analysed through the Elacqua model (Elacqua et al., 2009) to understand the variables that influence people's perceptions regarding the glass ceiling. Extensive review of literature has helped explicitly identify, analyze, and interpret relevant researches in the present domain. It shows that while discriminatory organizational behaviour remains prevalent today, there is no difference in the readiness and the level of job commitment by both men and women managers. Organizations must work towards integrating agility to adapt to the changing sociodynamics of today's world to promote gender-equal values. This chapter concludes that while women may be favoured to reach high rungs of the corporate ladder, organizations must promote them and invalidate the stereotypically male-favoured corporate environment.

Keywords: Business, glass ceiling, elacqua model, managerial roles, women.

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Introduction

The glass ceiling effect, more popularly known as the *invisible effect*, is often regarded as a more harmful form of discrimination compared to other forms of overt discrimination (Carvalho et al., 2019). Women managers were reported to have made personal sacrifices for finding success in their careers, which consequently predicted a pattern of self-distancing from their female subordinates and opposing the gender-related quotas that target these women (Faniko et al., 2017; Faniko, Ellemers, & Derks, 2021). In 1978, management consultant Marilyn Loden introduced the phrase "glass ceiling" at a panel discussion. Unfortunately, this term remains valid and relevant to date (Kaur, 2021). The concept of the glass ceiling has proven to be one of the strongest invisible barriers that inhibit the chances of women and other minorities to rise to typically male-dominated high-level positions at work (Pothuraju & Alekhya, 2021). Interestingly, as the country's progress at different paces, the degree to which this barrier is relevant is very culture-specific – i.e., its intensity may vary from country to country. There are four factors of the glass ceiling (individual, family, cultural and organisational) that seem to possess a 27% effect on the overall career development of women faculty in management institutes (Khachane, 2018).

A longstanding debate that has engulfed the business community is regarding its representation of women in the workforce and about them receiving equal opportunities as others in their professional fields. Over the years, a steady increase has been noted in the number of women working in various sectors and organisations (Floyd, 2021; Ishtyaq & Bisaria, 2021). The influx of women in the workforce has not only enriched diversification in terms of ideas and overall growth within organizations, but it has also transformed the previous approach that businesses had. Nevertheless, the reality does not always reflect such progress, whereby many women still receive minimal opportunities, as compared to their male counterparts, to showcase their full potential. In many cases, the former must work harder to succeed and work their way up to better positions (Sud & Amanesh, 2019).

The need for women in the workforce is highly essential in today's highly competitive and fast-paced world. Apart from adding to the pool of talent, it also adds up to better employee engagement and retention. In a research report by the Centre for Creative Leadership, it was found that an organization employing more women employees seemed to have made it a better place to work along. Furthermore, it increased job satisfaction, better organizational dedication, more amount of meaningful work, and comparatively lesser burnout rates (Clerkin, 2017). The Grant Thornton report (2014) "Women in business: beyond policy to progress" observed that from 2015-2018 an increase has been seen from 68% to 75% of businesses with at least one woman in the position of senior management. Simultaneously, the report noted an increase in the global percentage of the proportion of women holding senior positions from 22% to 24%. However, the same report also noted that

the percentage of women in senior roles in India was found to have increased just marginally from 17% to 20% in 2018. Significant variations in the percentage are seen across and within different regions. This is often due to the culturally driven stereotypes which need to be addressed from the very beginning otherwise they act as a barrier in the way of a woman's upliftment and success.

From an organisational point of view, the Human Resources department should introduce more policies that would encourage women to be promoted or advance in their professional careers just as their male counterparts (Babic & Hansez, 2021). In this chapter, we would have an overview of women in the workplace and managerial positions, as well as the various dynamics associated with it.

Women at workplace

Ever since the era of hunters and gatherers, women have mostly been associated with household chores. The 21st Century has brought about slow, but significant change where women are seen to be entering workplaces. Having women included in the workforce creates a balance and promotes better understanding among the employees, thus leading to a better working environment. Based on a report written by Reynolds (2017) and published by the Hult International Business School, it was observed that due to the difference in experiences and backgrounds both men and women have different outlooks and approaches towards their work. It encourages creativity and cultivates innovation which further helps an organisation to reach greater heights. Over the years it has been observed that good soft skills are some of the most desirable professional attributes among CEOs. Attributes such as empathy and effective communication skills are shown to boost employee morale which, in turn, improves the performance of businesses. The Hay Group (2016) observed that women performed better than men in 11 out of 12 key emotional intelligence competencies. This indicates that women may often be more effective leaders.

Women represent a huge segment of the consumer market – which is estimated to be more than 20 trillion dollars. Despite this, they are massively underrepresented in organizations. Employing women in key positions can enable corporates to explore this opportunity and gather valuable consumer insight. Research by McKinsey shows that gender-diverse businesses have a higher chance of financially outperforming the industry median.

Women in the workplace often want to understand the purpose of their work and not just a mere 9-5 engagement. Furthermore, having a "calling" at the workplace ensures higher job satisfaction. Therefore, it may be considered that women tend to prefer roles that provide a higher amount of job satisfaction. It has also been observed that women at the workplace stress the need for opportunities that are at par with men. As such, employers must ensure that women with higher skills or work efficiency are equally represented in leadership positions.

Do Businesses need Women at the Top?

People often question the necessity of women assuming leadership roles in organizations. It has been like this because the corporate world has predominantly associated leadership positions with men. Previously, the plausibility of a woman being an able leader of any business was rarely ever considered as an afterthought. However, years of advancement since has promoted the idea that women can also be equally adequate in managerial, executive-level, and/ or leadership roles.

Many companies such as IBM and General Motors have female CEOs. Bajwa (2020) mentioned that more revenues are generated by women-owned companies than those owned by men. In a 2019 report by International Labour Organisation, it was found that organizations with a female CEO were found to be 12% more likely to have women in senior managerial roles. This is indicative of a certain pull factor. Additionally, enterprises with a woman as the board chair have also been seen to have a better chance to achieve gender balance across all departments and management roles.

Work-family Interface for Women

There are numerous levels at which work and family tend to intersect each other including family responsibilities, health, leisure etc. at a personal level. The work-family interface is bidirectional and suggests that work can interfere with one's personal life or vice versa. The interface can be of two types – i.e., either it could be adverse and cause work-life conflict, or it could be beneficial and promote work-life enrichment. However, it is often the former that takes place.

The role that a family plays in terms of offering support to members in an organization enables family-to-work enrichment. Consequently, work-family synergies are a unique source of advantage for women (Sehgal & Khandelwal, 2020). On the other hand, while self-employed women seem to yield fewer working hours and lesser work-family conflict, they often show greater family-work conflict (Dinh et al., 2021). A family's financial support has been found to have a positive relationship with the performance of women entrepreneurs in businesses in less economically advanced countries like Morocco. In more economically advanced countries such as Turkey, the moral support provided by families seems to have a positive relationship with the performance of women at a firm (Welsh et al., 2018). Additionally, work-family enrichment was found to facilitate a stronger bond within family members alongside increasing the subjective wellbeing of working Indian women entrepreneurs (Khandelwal & Sehgal, 2018).

Glass Ceiling: An Overview

The glass ceiling is a popular metaphor coined by Marilyn Loden (1978) to describe an invisible barrier that primarily prevents women and minorities from rising beyond

a certain hierarchy level to managerial or executive levels at organisations. Over many decades, women have made significant growth in the sector of education and several non-traditional jobs, thus reducing the education-based gender gap. Simultaneously, many have been found to balance their families and careers, while demonstrating their ability to work, innovate, inspire, succeed, and effectively manage in various professional sectors. The idea of the glass ceiling has inevitably been there within the business world. The presence of biases such as men are 'born leaders', working mothers 'cannot give their best at work', are 'too emotional, and that 'there is no place for people who speak softly in the business sector' has only fuelled the existence and sustenance of the glass ceiling.

An association was found between the gender of faculty members of higher educational institutions and their respective designation, and their perceived sense of discrimination in a male-dominating culture. This was found to influence the perception of the glass ceiling effect (Abbas et al., 2021). The concept of the glass ceiling is still prevalent, despite many corporates invalidating its presence because the lack of women at higher organizational positions is because of the presence of dispositional factors that hinder their progress (Thiranagama, 2021). Rather than arguing over its existence or simply accepting the inevitability of the glass ceiling, organizations must globally acknowledge the said biases associated with the concept and try eradicating it.

Management Roles and Women: Are they Adequately Represented?

In the early 2000s, women's representation in management in India fluctuated between 5.8% to approximately 3% (Chadha, 2002; Kulkarni, 2002). The past decade has observed a distinct rise in this percentage, with the International Labor Office (2020) remarking that there has been an overall global hike in the greater representation of women in both leadership and management. India has reflected this progress as well. However, as per the report, the climb has been slow whereby representation has increased from 12.3% in 2010 to 13.7% in 2018. A Credit Suisse Research Institute (CSRI) report (2019) further supports this claim and has reiterated that female representation in senior managerial positions has shown slight improvement - from 6.9% in 2016 to 8.5% in 2019 (Pathak, 2019).

Hence, if India's progress were to be compared with and in itself, slow and steady growth in the representation of women in management may be observed. It is important to keep in mind that the country has had a long-standing affirmative outlook on an environment of patriarchy and general inequality in the status of women (Hooda, 2021). With the changing worldview towards women in managerial positions as well as a globally interconnected digital platform that help proliferate this worldview, it is no surprise that India's progress to a more gender-inclusive organizational outlook is gradually gaining momentum. However, if India's representation of women in managerial positions were to be compared to other

countries worldwide, the situation looks bleak. India holds the third-lowest global representation of women in management positions - succeeding only in South Korea and Japan (Kersley et al., 2019).

The question of being adequately represented brings in the question of 'adequate in comparison to what?'. When speaking on a global scale, Thornton (2020) noted that the proportion of females in senior managerial positions rose to an unprecedented 29% in 2019 and 2020. Despite this percentage hike, India ranks below the global average in the same regard. Therefore, in India, women are most certainly not represented adequately in managerial positions yet. When speaking on a gender pendulum, the global representation of men in managerial positions comes up to 62%, while women hold only 38% (McKinsey, 2019). On this count as well then, women are not adequately represented in management roles. Therefore, while the world is progressing gradually, there is quite a long way till the glass ceiling can be broken.

Are women ready for Managerial roles?

Depending on the source at hand, responses may vary while assessing the readiness of women for managerial roles. For instance, a study by Cortis & Cassar (2005) found that their male respondents were less likely to consent to women being managers, and would prefer a male dominance in managerial roles. On the other hand, female participants possessed a more approving outlook towards women in positions of management. Similarly, other studies further indicated that females had a comparatively more positive attitude than men concerning women being in managerial roles (Balgiu, 2013; Addai et al., 2017). However, when viewed from an objective standpoint, a woman's degree of readiness for management positions does not leave room for much speculation. Findings have shown that there remains no difference in the level of job involvement of both male and female managers (Burke, 2002; Cortis & Cassar, 2005).

If typical managerial traits are taken under consideration, some of the ones that women possess are as follows: well-developed interpersonal communication skills, work-oriented, competitive, high levels of resilience to stress, prioritization of psychological well-being, resilience to stress, and self-confidence (Gabdreeva & Khalfieva, 2016). Therefore, dispositionally speaking, women are indeed ready to take on managerial roles. Situational variables, however, provide a contrasting scenario.

In addition to one's own volition, their readiness may be attributed to their surroundings and the supportiveness of the environment that they reside in. In this case, the society that women live in plays a major role in influencing their perceived ability to assume management positions. To a large extent, society still rigidly holds onto the belief that women may not be as committed as men to their job due

to several factors - most of which circle family life and its associated obligations (Gulhati, 1990; Rafnsdóttir & Heijstra, 2013; Abel, 2019). While traditionally such gender-rigid roles were prevalent, today's age of global digitization and progress has propelled the world to embrace gender-fluid roles. Such stereotypical

bipolarities of either choosing between family and work-life or women being unable to balance both roles adequately must be disregarded if equality among all genders is to be promoted. Holding on to such stereotypical beliefs may instigate the development of a self-fulfilling prophecy for women which may lead them to question their readiness to assume managerial roles, despite being dispositionally favourable (Wood & Lindorff, 2001).

The bottom line remains, therefore, that there is no one particular person who can answer on behalf of all women when asked about whether they are ready for managerial roles. While many studies suggest that there remains no difference in the way that women fulfil managerial post requirements as compared to their male counterparts, the sole decision of readiness varies from one woman to another. Therefore, the only person who can truly answer the question of the dilemma at hand is a woman herself, and a progressive society!

The Elacqua Model

A crucial model to help gain a deeper understanding of an organizational perception of the glass ceiling is the Elacqua model. It was developed by Elacqua et al. (2009) and was proposed based on the data collected from 685 managers at an insurance company. The model elaborates on attitudes towards interpersonal variables and environmental factors within an organization that could influence the perception of people towards the differences in treatment received by men and women. Additionally, it also highlighted how this perception is related to the way that the glass ceiling is viewed.

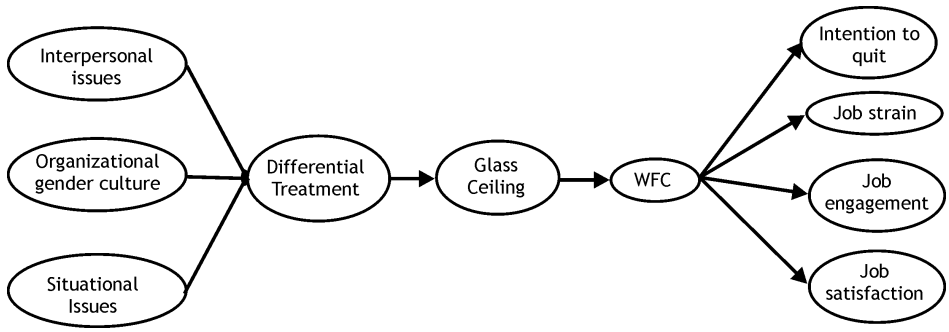

Figure 1: The Elacqua Model based on Elacqua et al. (2009).
Taken from Babic & Hansez (2021)
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The Elacqua model brings attention to the causes behind the creation and reinforcement of the glass ceiling that women face within their workplace - thereby restricting their organizational growth (Babic & Hansez, 2021).

As can be inferred, Elacqua et al. (2009) focused on the interrelationship between two organizational variables (interpersonal and situational factors), and one's perception of the glass ceiling. If magnified, the interpersonal factors looked into the aspects of relationships that affect how men and women may be treated differently within organizations. The dimensions of this factor that were studied included the informal network of senior managers, mentoring, and amicable relationship patterns with key decision-makers (Babic & Hansez, 2021). The model elaborates on how the existence of a predominantly male group of senior managers tends to obstruct the career development of women as it may engender low visibility and recognition of the latter's role within organizations (Elacqua et al., 2009). Regarding mentoring, it was found that the support of efficient mentors and guides was crucial to one's career development and chances of promotion. Elacqua et al. (2009) interestingly noted that not only is it important for an individual to gain the support and reap the benefits of having a mentor for their advancement but that this also shapes their perception of differential treatment in their organization. Therefore, those with mentors who provide them with promotional opportunities and growth are likely to assume that other employees receive the same as well - thereby reducing their perception of differential treatment. The third interpersonal dimension implores that the women in positions of senior managerial levels tend to overwork aspiring women, as they believe that their success was in credit to dispositional attributes rather than the influence of their senior management (Cech and Blair-Loy, 2010). Furthermore, as per the 'Queen Bee Syndrome', women are less likely to promote other women to similar positions because they believe that others should have to work just as hard as they did during their organizational climb (Zhao & Foo, 2016). Hence, the influence of all these interpersonal factors was found to influence the extent to which women in managerial positions were able to break the glass ceiling.

Situational factors, on the other hand, were divided into two aspects by the model. These included organizational processes such as employing workers and their promotion etc., and the other is the number of women in managerial roles who may be viable candidates to be promoted to higher positions due to the length of their work experience. The model finds that workers who believed in the objectivity of organizational processes were less likely to perceive differential treatment among men and women in the workplace. Therefore, the existence of the glass ceiling was perceived by those who believed that there was a discrepancy between genders about the way by which, for instance, appraisals, hiring procedures, and promotions were decided. Additionally, the perception of a woman being ready for higher levels of promotion may be dependent upon their pre-existing status in a managerial

role. Elacqua et al. (2009) note that such scenarios are not as prevalent as with their male counterparts, and therefore a perceived existence of differential treatment between men and women exists in their eyes. These further fuels the existence of the glass ceiling.

In addition to the previously considered interpersonal and situational variables, Babic and Hansez (2021) added a third determinant of differential treatment - i.e., organizational culture and its interrelationship with gender. This comprises the beliefs and attitudes that different members have towards the nature of social roles held by managers of both genders.

Therefore, the Elacqua model provides an unprecedented advantage to organizations because it potentially facilitates the narrowing down of the exact workplace factors that enforce discriminatory hurdles which prevent women from assuming managerial and leadership roles due to their gender (Li and Leung, 2001). Once problem areas are identified, adequate steps may be taken to eliminate those areas.

Glass Ceiling and Organizational Agility

While the existence of the glass ceiling may be considered an undisputed reality, its permanence in the organizational sector might not be guaranteed. Digitization has propelled the world to function at a doubled speed due to the availability of a global bank of information and the need to act upon this information. Adapting to the changing determinants of progress requires organizations to become increasingly agile if they are to survive in today's highly competitive business environment (Heckler & Powell, 2016). Today's world demands the inclusion of women in managerial and leadership roles within organizations - especially due to an increasing number of women who are now stepping into organizations (Sud & Amanesh, 2019).

The term 'glass ceiling' was coined approximately 43 years ago by a management consultant named Loden - and it still carries the same significance as it did all those years ago (BBC News, 2017). Ideally, with a rapid rate of progress, the term should have been rendered obsolete after so many years, had women not been actively ostracized from managerial roles. Additionally, the current state of the world rests upon the following statement: the Global Gender Gap Report 2020 stated that it may well be another 100 years before gender equality may be achieved if the current rate of advancement remains at the current state. The key to this is to consider the weight of the phrase "if the current rate of advancement remains stagnant". Therefore this 100-year prediction may be expedited if different sectors of society play an active role - especially the business community, as the economy rests upon it. With the internet creating an active user base of self-aware individuals and a supportive global community, women are now demanding fair rights in terms of employment. While change cannot be enforced overnight, gradual progress in terms of women identifying their priorities and working together as a force to

formulate solutions may help accelerate the breaking of the glass ceiling (Sud & Amanesh, 2019).

With women empowerment gaining a front seat in socio-political, economic, and cultural aspects, organizations must now adapt to the changing times and work towards eliminating the 43-year-old term. While organizational agility in its relation to the glass ceiling previously had its roots in compulsory *diversity and inclusion* initiatives, they rarely translate into actual advancement for adequately incorporating women in managerial and executive-level positions (Martineau & Mount, 2018). The new decade has brought about the necessity of organizations to go beyond such compulsions. In particular, leadership style has been found to play a significant role in this aspect. It potentially influences the degree of organizational agility and, consequently, perceptions of the glass ceiling.

Certain leadership behaviours that are positively correlated with organizational agility are exploratory, latitude, visionary, and reflective leadership styles (Gagel, 2021). When leaders enforce an organizational culture of freedom, purpose, responsibility, creativity, and challenge, other members will likely internalize such values as a trickle-down effect. Therefore, such organizational values in conjunction with high levels of agility may well help shatter the glass ceiling in the near future - definitively before the predicted 100 years.

The way forward

The business world has been traditionally customized to fit the glove of men, alongside its associated stereotypical traits of assertiveness and having to be free of familial obligations (Chakraborty & Saha, 2017). Therefore, its associated rigid gender roles forced women to assume a backseat in the corporate-run. However, the digitized world has revolutionized much of what used to be normative. It has facilitated an interconnected community of empowered members of society - particularly women who now fight to be adequately represented in managerial roles and actively work towards shattering the socially constructed glass ceiling. While progress is inevitable and is taking place, the speed at which it is occurring has yet to improve. Organizations and future researchers must acknowledge that alongside women being dispositionally favourable to assume managerial roles, situational variables also play a crucial role in influencing perceptions of the glass ceiling and how women are treated within workplaces (Elacqua et al., 2009). Therefore, organizational cultures must integrate agility and appropriate leadership styles to promote gender-equal values within members. Women may be ready to assume managerial and executive-level roles - however, it is the role of both organizations and society to join hands in promoting more women to high-level posts and shed the stereotypical male-favoured corporate environment.

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ASCI Journal of Management 50 (1): 15–29

A Base Line Model on Factors Affecting Girls' Enrolment in 650 Rural Blocks of Andhra Pradesh

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Abstract

Purpose: *The purpose of this paper is to study the effect of select set of school related indicators like average rural area covered by a school, number of girls' toilet in the schools, pupil teacher ratio and student classroom ratio in the schools and demographic indicators like percentage of schedule tribes' population in the block and gap between literacy percentage among men and women in the block on girls' enrolment in rural schools of Andhra Pradesh, India.*

Methodology: *The study has utilized a three years panel (2014 to 2016) consisting of 650 rural blocks of Andhra Pradesh. A pooled OLS model has been developed to analyse the effect of select set of school related and demographic indicators on girls' enrolment.*

Findings: *The result shows that indicators like the area covered by a school, percentage of schedule tribes and literacy gap between men and women are significant and negatively affecting the girls' enrolment in rural schools of Andhra Pradesh. Pupil teacher ratio and student classroom ratio also show negative association with girls' enrolment. However, number of girls' toilet in schools exhibit positive association with girls' enrolment.*

Originality/value: *There is a dearth of quantitative studies examining relationship between girls' enrolment in rural schools and school level and demographic indicators. The current paper fills this gap and explores the relations between girls' enrolment and different school related and demographic indicators in the rural blocks of Andhra Pradesh.*

Keywords: Enrolment, Girls, Rural, School, Schedule tribe, Literacy, pupil teacher ratio, student classroom ratio

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Introduction

Located in the southern peninsula of India, the state of Andhra Pradesh is one of the fast progressing[1] states in the country. Traditionally, the state is a forward-looking state placed among the top states in India in terms of good governance. As per Public Affair Index (PAI), 2018[2], Andhra Pradesh stood 9th in the best-governed states' ranking in India.

Andhra Pradesh has always been the pioneer in the field of information technology and implementing effective e-governance initiatives in the country.In its attempts to bring in transparency and accountability into governance, it has successfully implemented several popular e-governance projects like CARD, e-Seva, MeeSeva and e-procurement. Knowledge driven disruptive technologies such as blockchain, Internet of Things (IoT), data analytics, machine learning and cyber security have been adopted to make public service delivery systems more efficient.

This knowledge driven growth of Andhra Pradesh could largely be attributed to investment in education in which the state has fared well compared to its southern counterparts like Kerala, Tamil Nadu and Karnataka. As per census data, public expenditure in education as a percentage of GSDP in Andhra Pradesh stands at 2.63 in 2014-15 compared to 2.2, 2.55 and 1.99 in Karnataka, Kerala and Tamil Nadu,respectively.[3]

Although public expenditure as a percentage of GSDP in education in Andhra Pradeshis found higher than other south Indian states, conventional patterns of inequality have not been eliminated. 66.37% of total geographical area of Andhra Pradesh is rural. These rural areas observe large number of pockets that are substantially behind than the rest of the population in terms of education and other development achievements. This is reflected in Andhra Pradesh's female literacy rate (59.74%), which is way behind than other south Indian states like Karnataka (68.13%), Kerala (91.98%) and Tamil Nadu (73.86%)and stands almost 6% below than the national average (65.46%). [4]

Contemporary wisdom suggests that female enrolment is probably a function of two interrelated factors.

a) Effective public provisioning in education which include substantial investment in education to provide conducive infrastructure
b) An educational culture in the state that motivate people to recognize priceless value of education and thereby spreads better awareness across sexes, social groups and regions

States like Kerala, which has established itself as the front-runner in education in the country has created an environment where these two factors promoting literacy

stay closely connected. Central to Kerala's success story in education are three factors (Chandrasekhar *et al.*, 2001).

- early recognition of the link between mass education and mass schooling
- social movements to promote the value of school education.
- Massive support of state in setting up schools across the state

However, despite being placed at the forefront of information technology, it seems that these factors are missing in Andhra Pradesh leading to lower enrolment of girls in school especially in rural areas. It is in this backdrop this paper has analyzed 650 rural blocks in 13 districts of Andhra Pradesh and tried to identify the determinants of lower enrolment of girl students in rural school. The rest of the paper is structured as follows. Section 2 provides a brief literature review on factors affecting girls' enrolment in rural areas. Section 3 provides details about data collection, sample and methodology. Results of the empirical analysis have been provided in section 4. Discussions based on the output of the analysis are presented in section 5. Section 6 presents conclusion and policy implications of the study respectively.

Literature review:

There is a plethora of literature, which have addressed the factors affecting girls' enrolment especially in the developing countries. Studying 182 schools and surrounding community in Ethiopia, Abraha*et al*. (1990) pointed out that the low level of girls' enrolment seriously affects the level of overall literacy and eventually lowers the economic productivity. Hyde *et al*. (2005) conducted a study on girls' enrolment at schools in seven major regional states of Ethiopia and identified that there exists a negative correlation between distance from the schools and the girls' enrolment. Studying 252 village households in Oyo State, Nigeria, Rahji (2005) found that the school where low enrolment was reported, the students had to cover long distance to reach schools. Chimombo (2000) stated that absence of secondary schools in vicinity acts as the major impediment to students' enrolment in school. Various studies have identified cultural factors as the barriers of girl child education in the developing world. Studying the case of Prerna High School – an all girls' school serving the underprivileged section of society in Lucknow, India - Jain and Singh (2017) reported that in developing countries like India, girl child's education is not just a factor of financial strength of the family. Cultural bias, societal tradition, safety concerns are some of the major factors influencing girl child enrolment at rural schools.

Some of the study has talked about less prioritization of girl'seducation in tribal communities which results into lower enrolment of girls into school. Studying school attainment at tribal areas of Orissa, Mohanty and Biswal (2007) found that school attainment by women is much lower than their male counterpart. Covering village households at Dhenkanal district, Orissa, India, Mishra (2005) found that girls'

enrolment is much lower in tribal areas compared to non-tribal areas. Similar result was reported in studies like Bandyopadhyay and Subrahmanian (2008) and Sedwal and Kamat (2008).

Some studies (DFID, 2005) have talked about the positive impact of maternal education on girl student's enrolment. It is argued that mothers having higher education levels are more likely to send their girls to school.Based on the data collected between 1998 and 2011 in eastern Zimbabwe, Pufall et al. (2016) studied the relationship between parental education and children enrolment in schools and observed that population cohorts with higher parental education reported higher enrolment rate. Studying gender inequalities in education in rural China,Song et al. (2006) contented that there exists a strong association between maternal education and educational spending on the girl child. A higher level of maternal education tends to increase educational spending on daughters.

Some of the studies have talked about the positive impact; a good sanitation facility in school can bring on girls' enrolment. Studying 704 school respondents in Garissa county, Kenya, Njue and Muthaa (2015) found that the availability of good sanitation facilities positively impacts girls' enrolment and attendance in schools. The study by Khandker (1996) that covered some of the rural schools in Bangladesh revealed that separate sanitation facilities for boys and girls increase the probability of girls' Enrolment and grade attainment. The same was opined by Herz and Sperling (2004) in their study on developing economies like sub-Saharan Africa, Middle-East and South Asia.

Several studies in the past had tried to establisha relationship between class size and student achievement (Finn and Achilles, 1990; Krueger, 2003). It has been argued that schools having lower class size perform better and attract more students. Studying household-level and educational data of 340 districts of 30 countries of Arab League, Huisman and Smits (2009) found that a lower pupil-teacher ratio positively impacts students' enrolment and attainment. An empirical research study conducted by Lewit and Baker (1997) based on Schools and Staffing Survey (SASS) data ofthe U.S. Department of Education revealed that schools with smaller class sizes attract a higher number of students. Urquiola (2006) studied sets of schools in rural Bolivia and opined a negative relationship between class size and test scores.

Table 1 consolidates the factors considered in this study as the major influencers of girls' enrolment in rural schools.

Table 1: Factors influencing girls' enrolment in rural schools and related arguments

Factors	Arguments
Average rural area covered by a school	Increase in distance from school hinders girls' enrolment in rural areas (Rahji, 2005).
	Distance to school in rural areas is one of the major impediments to girls' enrolment (Hyde et al., 2005).
	Non-availability of secondary schools in vicinity hampers girl students (Chimombo, 2000).
Percentage of Schedule Tribes population	School attainment by women is much lower than their male counterpart in tribal areas (Mohanty and Biswal, 2007).
	Tribal population has a negative impact on girls' enrolment; Tribal girls are often deprived from basic education due to both their social status and gender (Mishra, 2005).
Gap between literacy percentage among male and female	Higher parental education minimizes the gap between literacy among men and women and leads to increase in child enrolment at schools (Pufall et al., 2016).
	Maternal education has strong relationship with spending on girl child education (Song et al., 2006).
Number of girls' toilet in the schools	Sanitation facility has positive influence on participation of girl-child in schools (Njue and Muthaa, 2015; Khandker, 1996; Herz and Sperling, 2004).
Pupil teacher ratio	Pupil teacher ratio has negative impact on student enrolment at schools (Finn and Achilles, 1990; Krueger, 2003).
Student classroom ratio	Fewer class size leads to better performance of the students and attracts new students, thus increases the student enrolment (Urquiola, 2006).

Section 3: Data and research methodology

The study has utilized block level data for three consecutive years (2013-14, 2014-15 and 2015-16) of 650 rural blocks in 13 districts of Andhra Pradesh. Data were extracted from the School Report Cards website, hosted and maintained by the National University of Educational Planning and Administration (NUEPA).[5]

Table 2 shows the number of blocks in each of the 13 districts of Andhra Pradesh.

Table 2: Number of rural blocks in 13 districts in Andhra Pradesh

Districts	No. of blocks
Ananthapur	63
Chittoor	65
East Godavari	56
Guntur	57
Krishna	49
Kurnool	53
Nellore	46
Prakasam	56
Srikakulam	37
Visakhapatnam	39
Vizianagaram	34
West Godavari	45
YSR Kadapa	50
Total	**650**

The primary variables for which three years data were extracted includes girls' enrolment at schools, number of schools in a block, area (sq. km) of the block, number of girls' toilet within the schools, pupil teacher ratio, student classroom ratio, male and female literacy percentage at rural blocks and percentage of Scheduled Tribes (STs) population at rural blocks etc. These variables are categorized into two major groups: school-level variables and demographic variables. The table below shows the variables categorized in two groups.

Table 3 categorizes the factors into two broader groups – school level and demographic variables.

Table 3: Variables categorized into two different groups

Group	Variables
School level	Girls' enrolment at schools
	Number of schools in a block
	Number of girls' toilet within the schools
	Pupil teacher ratio
	Student classroom ratio
Demographic	Area (sq. km) of the block
	Male literacy percentage
	Female literacy percentage
	ST percentage

Further, new variables were derived using two or more primary variables. The average area covered by a school was measured by dividing the block's area (sq. km) by the total number of schools within the block. This derived variable is basically a proxy used to find outthe average distance a girl has to cover to reach school. Another derived variable isthe literacy gap, obtained from the difference between male and female literacy percentages. The two variables, namely Pupil teacher ratioand student classroom ratio,are taken as dummy variables.

A panel dataset was prepared based on three years block level data extracted from School Report Cards database. The panel was balanced and consisted of 1950 (650*3,i.e. cross-sectional unit x time point) observations.

Variables used in the empirical model

Table 4 shows the list of variables and its definitions used in the empirical model.

Table 4: Definition of variables used in the empirical model

Variables	Variable Name	Empirical Definition
Dependent variable		
Number of girls enrolled in schools	$ENROL_{it}$	Natural logarithm of number of girls enrolled at i^{th}block in t^{th} year
Independent variables		
Average rural area covered by a school	$AREA_{it}$	Natural logarithm of rural area covered by the school at i^{th} block in t^{th} year
Percentage of Schedule Tribes population	$STPERCENT_{it}$	Natural Logarithm of ST percentage at i^{th}block in t^{th} year
Gap between literacy percentage among male and female	$LITGAP_{it}$	Natural Logarithm of literacy gap at i^{th} block in t^{th} year
Number of girls' toilet in the schools	$GTOILET_{it}$	Natural Logarithm of number of girls' toilet at i^{th}block in t^{th} year
Pupil teacher ratio dummy	PTR_{dummy}	It is 1 if pupil teacher ratio at the block is below 24; otherwise it is 0.
Student classroom ratio dummy	SCR_{dummy}	It is 1 if student classroom ratio at the block is below 27; otherwise it is 0.

Table 5 shows descriptive statistics of 650 rural blocks of Andhra Pradesh over 2013-14, 2014-15 and 2015-16.

Table 5: Descriptive statistics of the variables

Variables	Minimum	Maximum	Mean	Std. Deviation
Number of girls enrolled in schools in a rural block	539	15698	3951.42	1806.666
Total number of schools in a rural block	17	215	77.83	27.629
Avg. rural area covered by a school (Sq. Km.)	0.2309	9.4228	2.823557	1.629572
Gap between male and female literacy percentage	0.6661	27.5415	14.90647	5.56165
ST population percentage	0.0786	96.2375	7.170476	15.63028
Girls' toilet available in schools within a rural block	6	202	58.74	26.883
Pupil teacher ratio at rural block	12	60	23.16	5.589
Student classroom ratio at rural block	12	48	23.51	4.098

Results

Panel data regression model (pooled OLS)was employed where number of girls enrolled in schools in a rural block ($ENROL_{it}$) was considered as the dependent variable. The predictor variables were average rural area covered by a school ($AREA_{it}$), percentage of schedule tribes' population in the block ($STPERCENT_{it}$), gap between literacy percentage among male and female in the block ($LITGAP_{it}$), number of girls' toilets in the schools within a block ($GTOILET_{it}$), pupil teacher ratio dummy (PTR_{dummy}) and student classroom ratio dummy (SCR_{dummy}). The following equation estimated the girls' enrolment in rural blocks of Andhra Pradesh.

$$ENROL_{it} = \hat{a}_1 AREA_{it} + \hat{a}_2 STPERCENT_{it} + \hat{a}_3 LITGAP_{it} + \hat{a}_4 GTOILET_{it} + \hat{a}_5 PTR_{dummy} + \hat{a}_6 SCR_{dummy}$$

Where, $\hat{a}_i$ is the coefficient of the predictor variables.

Table 6 explains the Correlation between the variables considered under the empirical model.

Table 6: Correlation between the variables

		$ENROL_{it}$	$AREA_{it}$	$STPERCENT_{it}$	$LITGAP_{it}$	$GTOILET_{it}$
$ENROL_{it}$	Pearson Correlation	1				
	Sig. (2-tailed)					
$AREA_{it}$	Pearson Correlation	-.422**	1			
	Sig. (2-tailed)	0				
$STPERCENT_{it}$	Pearson Correlation	-.125**	0.024	1		
	Sig. (2-tailed)	0	0.296			
$LITGAP_{it}$	Pearson Correlation	-.217**	.367**	.146**	1	
	Sig. (2-tailed)	0	0	0		
$GTOILET_{it}$	Pearson Correlation	.458**	-.377**	.067**	-.150**	1
	Sig. (2-tailed)	0	0	0.003	0	

** Correlation is significant at the 0.01 level (2-tailed).

The coefficients of the Pearson correlation exhibit low and moderate level of correlations between the variables. No strong correlations between the predictor variables are observed.

In panel data regression, multicollinearity is a common problem, which could provide misleading information about the model. Hence, collinearity among the predictor variables is checked through Variance Inflation Factor (VIF). VIF assesses the increase in variance of the regression coefficients if the predictors are correlated. The table below shows the collinearity statistics of the variables.

Table 7 shows the collinearity statistics (variance inflation factors) among the explanatory variable used in the study.

Table 7: Collinearity statistics of the variables

Variables	Tolerance	VIF
$AREA_{it}$	0.755	1.324
$STPERCENT_{it}$	0.969	1.032
$LITGAP_{it}$	0.845	1.183
$GTOILET_{it}$	0.815	1.227
PTR_{dummy}	0.755	1.325
SCR_{dummy}	0.766	1.305

The result indicating VIF of all predictor variables near 1 explained that multicollinearity is not a concerning factor in this case.

Table 8 shows the output of the panel data regression model employed for 650 blocks in Andhra Pradesh.

Table 8: Result of panel data regression

Dependent Variable: $ENROL_{it}$	Unstandardized Coefficients		P value
	B	Std. Error	
(Constant)	7.686	.078	.000
$AREA_{it}$	-0.229*	.014	.000
$STPERCENT_{it}$	-0.039*	.005	.000
$LITGAP_{it}$	-0.028***	.014	.053
$GTOILET_{it}$	0.297*	.016	.000
PTR_{dummy}	-0.298*	.016	.000
SCR_{dummy}	-0.229*	.020	.000
Adj. R Squared	0.517		
Prob. > F	0.000		

*, **, *** indicates level of significance at 1%, 5% and 10% level respectively

F test value < 0.05 confirms that the model is a good fit and the slope coefficients of the independent variables are significantly different from zero.

Adjusted R squared 0.517 indicates that about 52% of total variability of the model is explained by the predictors. The derived equation from panel data regression as follows –

$ENROL_{it}$ = - 0.229 $AREA_{it}$ – 0.039STPERCENTit– 0.028$LITGAP_{it}$ + 0.297$GTOILET_{it}$ – 0.298 PTR_{dummy} – 0.229SCR_{dummy}

Explanation of panel data regression model

The result of the empirical exercise shows that the rural area covered by a school (average distance a girl has to cover to reach school) is statistically significant at 1% level and negatively affecting the girls'Enrolment at rural blocks. The result indicates that one-unit increase in theaverage distance a girl has to cover to reach school decreases the girls' enrolment by 0.229 units. Schedule Tribes percentage at the rural block level is significant at 1% level and negatively affecting the girls' enrolment. While keeping the other variables unchanged,one-unit increase in ST percentage decreases the girls' enrolment by 0.039 units. The gap in literacy of rural males and females is negatively significant at the 10% level. Keeping other variables unchanged, one-unit increase in literacy gap between rural males and females decreases the girls' enrolment by 0.028 units. The number of girls' toilets in schools is positively significant at 1% level. This shows that a one-unit increase in a number of girls' toilets in rural schools increases the girls' enrolment by 0.297 units. Pupil teacher ratio (PTR) and student classroom ratio (SCR), considered as dummy variables, are significant at 1% level and negatively affecting girls' enrolment at rural schools. PTR_{dummy} indicates that girls' enrolment is rather low at the schools with pupil teacher ratio below 24, while SCR_{dummy} shows that girls'Enrolment is low at the schools having student classroom ratio less than 27.

Discussion & Conclusion

In the present study, an attempt has been made to identify the factors affecting girls' enrolment in rural schools in Andhra Pradesh.It is found that as the distance from the school increases in rural area, girls' enrolment tends to fall. The result is consistent with past studies (Hyde et al., 2005; Rahji, 2005). The study also reveals that girls' enrolment is lower in the areas with a higher tribal population. Previous studies like Mohanty & Biswal (2007), Mishra (2005), Bandyopadhyay and Subrahmanian (2008) etc., contended the same. It is also observed from the study that an increased literacy gap (i.e. male literacy –female literacy) negatively affects girls' enrolment in rural areas. Studies in different countries also identify literacy of parents as a major factor influencing child's education (Pufall et al., 2016; Song et al., 2006). The study also reveals that separate sanitation facility for girls and

boys at schools is an important factor affecting girls' enrolment. In rural areas many schools don't have separate sanitation facilities for boys and girls. This discourages the girl child to enrol and attending school. Some of the previous studies also exhibited similar findings (Njue and Muthaa, 2015; Herz and Sperling, 2004; Khandker, 1996). Pupil teacher ratio and student classroom ratio are used as dummy variables, and both show a negative relationship with girls' enrolment. As per the report published by the Ministry of Human Resource Development, Government of India, average pupil teacher ratio at the national level varies between 24:1 to 27:1. At elementary level,on an average an Indian school has 1 teacher per 24 students. The present study considers pupil teacher ratio as a dummy variable which takes the value 1 when it is below 24. The result shows that enrolment of the girl child at school decreases when pupil teacher ratio becomes below 24. The earlier studies also supported the argument that pupil teacher ratio has a negative relationship with student enrolment at schools (Huisman and Smits, 2009). As per the data available at the Open Government Data (OGD) Initiative by the Government of India, as on April 2016, the average student classroom ratio at elementary level school is 27. The student classroom ratio is considered as a dummy variable in the study, which takes the value 1 when itis foundto be below 27. The study reveals a negative relationship between student classroom ratio and girls' enrolment in rural schools.This result is similar to earlier studieslike Finn and Achilles, 1990; Krueger, 2003; and Urquiola, 2006.

Analyzing 650 rural blocks of Andhra Pradesh, the study reveals the factors influencing girls' enrolment in the schools. The outcome derives some policy level insights toward the Government. The Government may play a crucial role in establishing new schools in the rural areas. This could increase the girls' enrolment in the to the schools in the vicinity. Another area of focus is targeted initiative toward the scheduled tribes inhabited blocks to encourage enrolment of girls in schools. Panchayat could take the initiative to reach out to the scheduled tribe families to make them understand the importance of educating their girl child.

Further, it has been observed that blocks with high literacy gap are prone to low number girls' enrolment. The Government may take the initiative to minimize the gap between male and female literacy by organising education programs regularly. NGOs could help in this regard. A decrease in the literacy gap could result in a higher level of girl child enrolment into the schools. Sanitation being one of the most important issues across the country, rural schools must need proper sanitation facilities with separate lavatory for boys and girls. Unavailability of girls' lavatory or unhygienic condition of the lavatory always refrain the girl child from attending the school. Local authorities could look upon this matter to provide hygienic and separate girls lavatory in rural schools. An increase in pupil teacher ratio could result in loss of attention of the teacher toward the students and vice versa. Thus, the sole purpose of education hampers in a class with a huge number of students

per teacher. The Government may focus on recruiting new teachers to keep the pupil teacher ratio at a particular standard over the years. Further, a high student classroom ratio also affects the quality of education. The construction of new classrooms could solve the issue of higher student classroom ratio and lead enrolment of new students.

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Endnotes

[1] The Gross State Domestic Product (GSDP) of Andhra Pradesh has observed a growth of 11.22% for 2017-18 as against the All India GDP growth rate of 6.6%.

[2] Public Affairs Index (PAI) is an information driven stage to rank the 30 States of India from the focus of administration. Public Affairs Centre (PAC) has created PAI as a special measurable device to assess the execution of administration in the states of India. Primary research and secondary data from Union Government ministries and departments are the sources of data for PAI. PAI 2018 comprises of 10 broad themes, 30 focus subjects and a gamut of 100 indicators across different sectors.

[3] State-wise budgeted expenditure on Education along with percentage to Gross State Domestic Product (GSDP) in India (2014-15).

[4] Literacy Rate 7+ years (%), NITI Aayog, Government of India

[5] School Report Cards is a website under the database platform namely District Information System for Education (DISE), hosted and maintained by National University of educational Planning and Administration (NUEPA). The organisation is established under the aegis of Ministry of Human Resource Development, Government of India.

ASCI Journal of Management 50 (1): 30–35

Thinking Beyond Just Mobility: Way Forward For India

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Introduction

Electric mobility has been trending for quite a couple of years, and at least a dozen Indian states have notified Policies for E mobility. Indian energy and transportation scenario have changed drastically in the last decade. India has become an energy surplus country, and India has recorded the highest growth rate in terms of mobilization (Sharma et al. (2011)) in the last decade. With high volatility in liquid fuel prices in the international market and ever-increasing indirect taxes on fuel, electric vehicles look like a better alternative to ICE vehicles.

The Govt. of India has made its intentions clear on promoting electric vehicles through FAME schemes. Almost a dozen Indian states have announced additional incentives over and above the incentives under FAME schemes. Telangana state has gone a step ahead and have included Energy Storage under the ambit of policy and have announced additional incentives promoting Energy Storage/ battery manufacturing, reusing and recycling.

However, the role of electric vehicles shouldn't be restricted to just mobility. The Paris Climate Summit delegations have deliberated firm and aggressive targets on restricting temperature rise, which can be only possible by reducing GHGs, which is only possible with a shift from fossil fuels to renewable energy sources.

In line with the Paris Summit targets, the Government of India has announced very aggressive targets of Renewable Energy Capacity Addition 175GW of RE capacity by 2022 and 450GW of RE capacity by 2030. Solar and Wind Power Capacity have a king's share in the total capacity addition targets, and they being intermittent energy sources, poses severe challenges to grid stability. Ancillary services will play a huge role in mitigating the risks posed by the Renewable Energy capacity addition.

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Besides, with dynamics like mismatch in demand-supply locations and inadequate Power distribution capacity, the Indian Power Sector needs to think of innovative solutions to handle the issues.

Against this backdrop, Electric Vehicles can provide a solution to at least a couple of problems of the Indian Power Sector. They can also help in addressing the challenges posed by new advancements. The solutions which Electric Vehicles can offer is discussed in this article. The solutions, which can be offered by Electric Vehicles, are divided into two categories, (A) distribution grid with the integration of electric vehicles charging infrastructure (B) EV charging infrastructure integration with distribution grid Utilization of EVs for better RE grid integration (C) Value Chain.

A. Review on the distribution grid's planning and operation with the integration of electric vehicles charging infrastructure: The distribution side of the Indian Power Sector can be intervened by the Electric Vehicles in terms of Congestion Management, Acting as Virtual Power Plants, Demand Side Management, Ancillary Services etc. Each aspect is further deliberated below.

(a) Congestion Management: The development of deregulated power systems has resulted in overloading transmission networks or network congestion and will be a significant factor in increased EV penetration to the grid. We need to study the distribution grid of cities where the roll-out of EVs and EV charging infrastructure has started. We should determine the application of various congestion management methods, including Generators Rescheduling (GR), load shedding, the optimal location of Distributed Generation (DG), Nodal Pricing, cost-free methods, Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Mixed-Integer Nonlinear Programming (MINLP), Shuffled Frog Leaping Algorithm (SFLA), Fuzzy-Logic System approaches. The additional renewable energy and battery storage systems using their international case studies.

(b) EVs as part of Virtual Power Plants (VPPs): VPPs play a critical role in the stabilizing and balancing of variable renewable energy and grid load. To accelerate the capacities of VPPs efficiently and quickly, the use of the batteries in EVs are being considered to be grouped and coordinated to form a VPP. VPPs can be used for various grid services whose revenue can be used to offset the cost of charging and raise the competitiveness/ profitability of the charging network/operators' competitiveness/ profitability.

Existing cases in the USA (especially in California), EU, UK, and East Asia may be studied to make India's relevant case. Various variants of VPPs and corresponding technical features for the VPPs inclusive of EVs may be analyzed and adapted for India.

(c) Demand Side Management: The ministry of power made recommendations to power distribution utilities to think beyond smart meters, intending to alter the end-use of electricity – whether to increase demand, decrease it, shift it between high and low peak periods, or manage it when there is peak demand like EV Charging requirement during peak hours or increase in penetration of EVs in cities.

Learnings based on international best practices and their experience in designing advanced distribution systems may be adopted. Learnings can be made from different countries and city grid systems for preparing them for EV Charging Infrastructure as EV penetration increases.

(d) Ancillary Services: India's ancillary services mechanism to be studied and learnings from international experience in Europe and particularly in Germany may be considered for adoption. The existing mechanism, recommendations from power system operator POSOCO, Central Electricity Regulatory Authority (CERC), and other countries' learnings needs to have collaborated for the Purpose.

The ancillary services are meant to relieve transmission congestion and minimize frequency fluctuations in the Indian national grid. These services are provided by primary (response time from few seconds to 5 minutes), secondary (response time from 30 seconds to 15 minutes), fast tertiary (5-30 minutes) and slow tertiary (15-60 minutes) reserves (CEA guidelines). India has a minimal ancillary services market with only slow tertiary benign utilized. A framework, policy and guidelines to be prepared for increasing ancillary services for the planning of EV infrastructure and scaling for increasing penetration of EV year-on-year.

Maintenance of primary reserves are mandated by India Electricity Grid Code but far from the open market. International experience in enhancing these measures for India and readying for EV Charging infrastructure can be used to make recommendations for the use of regulation-up and regulation-down services and list necessary steps to remove restrictions through various progressive changes, both technical and commercial incentives) internationally and as per recommendations of various stakeholders like CERC, CEA and POSOCO etc.

B. Planning and interconnection studies related to EV charging infrastructure integration with distribution grid Utilization of EVs for better RE grid integration

Information from the above chapters to be considered to summarize and further elaborate on the details on the Utilization of EVs for better RE grid integration, including the following:

- Global and Indian review on experiences related to charging EVs utilizing renewable energy must be studied.
- An account of scheduling the fleet of electric vehicles when duly assisted with information from the day ahead forecasting of RE must be studied.
- EVs' potential to store electricity during surplus generation (E.g., high RE production times) should also be enumerated. A short account of all possible benefits for RE integration (including reduced curtailment of RE generation) on EV integration must be studied.
- EVs' Possibilities to respond to real-time fluctuations in RE output and support in-system ramping needs should be documented. An account of potential deferment of installation of conventional power plants due to better integration of RE aided by EVs must be studied.
- A brief analysis of how smart charging (either one-way or two-way) can be linked with renewable resources and contribute to more stable distribution systems must be studied.

The current scenario of the distribution grid in India and its readiness for EV charging infrastructure integration must be detailed. An overview of India's situation in the distribution grid for peak load situation, voltage variations, congestion management, power quality issues, etc. In the context of EV charging infrastructure grid integration, has to be discussed. The DISCOMs readiness for smart grid, smart charging coordination should be understood.

A brief description of the fleet of EVs' prospect to be treated as a dispatchable source/load that the control centre could schedule. Based on global and Indian experiences, the impact of EV penetration on reliability indices like System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI) and Customer Average Interruption Duration Index (CAIDI) can be elaborated. According to the global and Indian situation, the effect of battery technology and environmental conditions on vehicle grid integration aspects can be detailed. Role of EV aggregators to provide various essential services, namely ancillary services, demand response, etc. utilizing the potential of EVs

C. Value Systems should be studied to enhance user experience and utility planning. Some such applications are deliberated below:

(a) Vehicle2X systems: Vehicle-to-everything encompasses various connections of the EV vehicle such as Vehicle-to-Grid (V2G), Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I). The main aspects involved are the connection to charging infrastructure, relevant communication with roadside units and fleet management systems. Therefore, the analysis shall also include communication technologies such as Direct Short-Range

Communication (DSRC) or Edge Computing Systems. For this study, the most relevant V2X applications are V2G services, further V2X applications, e.g. for fleet management services, should be studied.

Existing studies in the USA, EU, UK, East Asia should be studied. The following outputs may be derived from the assessment:

- Various available V2X applications and corresponding technical features for the scheme of V2X systems relevant for EV operation.
- Hardware and software requirements are needed to enable V2X, including real-time data exchange, advanced metering, cybersecurity layers and standard interfaces between vehicle and grid.
- The costs of hard- and software solutions for relevant V2X services
- The overall benefits and disadvantages of V2X and particularly V2G applications. Here, particularly the effect of repeated battery cycling when the vehicle is feeding power to the grid and the effect of bidirectional power flow on EVSE components and distribution grid, maybe detailed. This aspect on EV owner willing to participate in V2G services should also be studied.

(b) Smart Charging Products and Services: The existing knowledge from projects in Europe, Asia and other locations may be studied to implement smart charging services. The key stakeholders involved in smart charging include drivers, the charging station and operators of charging networks. The use of widely accessible communication and consumer technology can be analyzed, such as smartphone apps, QR codes, tokens, contactless identification, Bluetooth, etc., for authentication, payment, tracking and updates. The smart charging infrastructure shall allow for better management of charging locations, timings, power flow & direction and tariffs. Existing studies in the USA, EU, UK, East Asia can be considered. The following outputs can be derived from the studies:

- Understanding the various smart charging products and services in commercial operation and corresponding technical features for smart charging. The understanding includes details of significant components involved, Information and Communication Technology (ICT) systems that are essential for this specific purpose and a note on the functionalities of the smart meters designed specifically for EV charging infrastructure.
- A brief overview of the costs of hard- or software solutions needed for smart charging and A breakdown of costs per component (app development, platform operation).

- An overview of key drivers for smart charging, including consumer acceptance, significant data analyses using Artificial Intelligence or block-chain technology.

- The impact of simultaneous charging of EVs on different distribution grid assets, e.g., distribution transformer. Potential benefits of smart charging that could save costs related to new investments in grid infrastructure. The various benefits associated with charging the EVs during off-peak times in the load curve shall be enumerated, and lessons learnt from the experiments in managing the timing of electric vehicle charging. The concept of smart charging for maximizing the charging of EVs directly from renewable energy sources shall be detailed. A short note on scheduling the fleet of EVs with the linking day ahead forecasts of renewable energy availability shall be presented.

- Finally, a summary of the entire set of benefits related to smart charging for relevant stakeholders can be understood for replication or adoption in India.

ASCI Journal of Management 50 (1): 36–48

Finding Service Quality Dimensions: A Study on Digital Marketing Service Quality

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Abstract:

Quality is the most important parameter of all businesses and service industries are no exceptions. Digital marketing companies are one of the fastest growing service industries which cater the need of different industries to make their presence in the digital platform and thereby reach to their target customers. With the growing demand of digital marketing services, a large number of digital marketing companies are budding up and thereby increasing the level of competition in this field. With the increase of competition, service quality and customer satisfaction have become crucial parameters for the sustenance of the digital marketing organizations. Knowledge about the service quality dimensions associated with the digital marketing services has become essential for designing suitable strategy for the business. The present research work aims to address this issue. The research work identifies the service quality dimensions of the digital marketing service qualities. The findings of this research will be helpful for all digital marketing companies to identify the areas of improvement and also to design better services to meet the expectations of their clients.

Keywords: Digital Marketing Services; Service Quality; Service Quality Dimensions; SERVQUAL Model; Perceived Service;

Introduction

In the past few years, digitalization of Indian economy has proceeded rapidly and the sudden outbreak of pandemic has fueled this pace. Present day businesses, irrespective of their products, services, size and customer types, have become bound to make their presence in the digital platform. Customers of both B2B and B2C markets are becoming increasingly dependent on digital marketing platforms.,

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and thus, to reach to their target population, organizations have to start, increase and grow their presence in digital arena. The prediction of the experts in the marketing field claims that companies without their presence in digital platform are soon going to be outdated and collapse. To cater the changing pattern of customers, several organizations have opened-up their digital marketing wing, through which they started connecting with their target population. Some organizations are in a process of converting a larger portion of their traditional marketing department to digital marketing cells by means of changing technology, hiring experts in this field and also through training of existing staffs of the department. Apart from these two groups, a large number of organizations are dependent on the services of different digital marketing companies. These digital marketing companies provide a vast array of services to their clients. Their services include, Search Engine Marketing, Search Engine Optimization, Website design and Strategy formation, Social Media Marketing, Content Marketing, E-mail marketing, Quality link building, and so on. Their job is to identify the requirements of their clients, design a suitable strategy to fulfil the requirement and execute the strategy. As the field of digital marketing is highly dynamic due to continuous innovation, the requirements of the clients are becoming increasingly challenging. Thus, quality of the service delivery is of high concern. But while dealing with the quality of the services, identification of the relevant service qualities is of primary importance. Besides this, identification of the dimensions of service qualities of a particular service is of extreme importance. But such an attempt is vaguely found in the research works conducted in the domain of digital marketing services. The purpose of the present research paper aims to addresses these gaps. The work is a mixture of both qualitative and quantitative study. Primarily an exploratory study was conducted to assemble the service qualities associated with the digital marketing services. From this gathered pool of service qualities, relevant and unique service qualities, which are related to digital marketing services, were identified. Finally, on the basis of the unique digital marketing related service qualities, data related to consumer's perception about the expected service quality were collected and then these perception data were analyzed to identify the service quality dimensions of digital

marketing companies. The findings of this study will be useful for the digital marketing organizations, while the methodology used in this study will be beneficial for the researchers, as they can use the similar methodology to evaluate the dimensions of service qualities of different service sectors.

Literature Review

Quality consciousness is one of the primary characteristics of present-day market place and as regarded by Lee (2005), there is a rapid increase in customer's demand for higher quality, especially in service sectors. Business organizations, according to Berry et. al. (1985), are in continuous struggle to deliver according to consumer's

expectations and sometimes even beyond it. The same is true for service manufacturing organizations and Cook and Verma (2002) pointed out that the biggest challenge of the service organizations is to provide services qualities which are world class and at the same time cost effective. Researchers, in the field of service quality, have explained the concept in different ways. Eshghi et. al. (2008), defined service quality as an overall evaluation of the service made by the customers. According to Oliver (1980), service quality could be defined by keeping two main components into account, customer's expectation about the service and their perception about the service. Following the same philosophy, Munusamy et al., (2010) defined service quality as a gap between the expected and perceived quality of the service. Asubonteng et al., (1996); Wisniewski and Donnelly, (1996) defined service quality on the basis of its capability to attain or meet to the expectations of the customers, regularly. Czepiel, (1990) highlighted the importance of the perception of consumers in defining the service quality and states that quality of a service depends upon the perception of the consumer about how much the service quality is able to meet to their expectation. Oliver (1980) also stressed the importance of the perception of consumers in defining the quality level of the services.

Measuring service quality is one of the most important and difficult tasks and Parasuraman et. al. (1985) attempted to measure service quality by estimating the comparison between expectation and delivery of the service quality. Further, in 1988, Parasuraman et. al. developed SERVQUAL model which facilitated the measurement of service quality. Five perceived service quality dimensions, tangibility, reliability, responsiveness, assurance and empathy were identified, which were also used to measure the service qualities. Parasuraman et. al. also explained the different dimensions of service qualities. Tangibility is represented as the presence of equipment, physical amenities, personnel and written materials, while reliability is

manifested by keeping service promises, timeline and accuracy of service delivery, maintenance of error free documentation and handling consumer's problem. Responsiveness is represented as timeline of service and willingness of the employees to deliver service while assurance, another service quality dimension is build-up by the ability of the employees to create trust and confidence in the mind of the consumers. Finally, the fifth dimension of service quality, empathy, is embodied by Parasuraman et. al. (1985) as the level of care, understanding of the needs of the consumers and personalized attention give to consumer's problems.

Several studies have also been conducted in measuring the e-service qualities and also their dimensions. Focusing on the website design, Dabholkar (1996) identified seven dimensions of e-service marketing and argued that these dimensions could be considered as the basic parameters for judging e-service qualities. To measure the online service quality, Yoo and Donthu (2001) developed a four-dimensional

scale named SITEQUAL, and the four dimensions are ease of use, aesthetic design, processing speed and interactive responsiveness. In comparison to traditional service quality dimensions, Cox and Dale (2001) developed a six-dimensional scale while Wolfinbarger and Gilly (2002) developed eTaliq (previously known as COMQ) which is a four-dimensional scale to measure the e-service qualities.

Although a lot of study is dedicated to the identification of service quality dimensions, some grey areas, which are listed as research gaps, are still there which requires further illumination. The research gaps are as follows:

Research Gaps:

RG1: Identification of relevant service quality components, in relation to digital marketing services was never done

RG2: Although much is said about the relevance of service quality dimensions, no significant work is found to measure the same in the digital marketing service companies

Research Objectives:

RO1: To identify the relevant service quality components related to digital marketing services

RO2: To identify the service quality dimensions of digital marketing service organizations and check their relevance with the traditional SERVQUAL model

Research Hypothesis:

RH1: Relevant service quality components will be identified for the digital marketing services

RH2: Significant service quality dimensions of digital marketing services will be identified and the identified service quality dimensions will have relevance with the traditional SERVQUAL model

Research Methodology:

Creating the pool of service qualities:

To identify the dimensions of service qualities, the primary requirement was to identify service qualities related to the digital marketing. In quest of gathering these service qualities, and exploratory study was conducted where data were collected from both service makers, i.e., the employees of the digital marketing organizations and service takers, i.e., the customers or the B2B clients. In this stage, responses were collected from 100 respondents of both the groups mentioned earlier, and all the respondents were asked to mention service qualities and facilities

which they feel important for providing services associated with the digital marketing services. The gathered service qualities were then subjected to removal of repetitions to identify set of unique service qualities. Finally, after the removal of repetitions, 20 unique service qualities were identified, which were used in the next stage for collecting consumer's perception.

Identification of Relevant and Unique Service Qualities related to Digital Marketing Services

The gathered service qualities were then subjected to removal of repetitions to identify set of unique service qualities.

Gathering consumers' perception about the expected and perceived service of Digital Marketing Companies:

The gathered unique set of service qualities, which were gathered in the earlier stage, was used as a tool to collect the data related to the consumer's perception about the expected service qualities from the digital marketing companies. The identified service qualities were used to frame a structured questionnaire where consumers were asked to rate these qualities based on their expectations of the service qualities. A five-point Likert scale was used to collect the data where 1 meant "Completely Disagree" and 5 meant "Completely Agree". The sample size, as suggested by Nunally (1978), should have to be ten times than the number of variables. Here in this case, the sample size was fifteen times of the number of variables, which is more than the suggested sample size.

Methodology to identify the dimensions of Service Quality associated with Digital Marketing Services and measuring the gaps between expected and perceived service:

To identify the dimensions of service qualities of the digital marketing organizations, a factor analysis was administered on the data related to the expected service quality of the digital marketing services. According to Costello & Osborne, (2005); Field, (2009); Tabachnik & Fidell, (2001), Factor Analysis can only provide a reliable result if the sample size is bigger. As the number of sample size exceeds the number suggested by Nunally (1978), we can expect that the results given by the factor analysis is reliable.

Data Analysis, Findings and Interpretations:

Finding the Unique and Relevant Service Qualities

As discussed in the earlier stage, 100 respondents were interviewed and were asked to mention the expected service qualities of the Digital Marketing Services. After removal of the repetition, twenty unique service qualities were retrieved. The qualities are as follows:

Table 1: Unique Qualities associated with Digital Marketing Services

Technologies used by the company are updated	The company has attractive physical facilities which shows that they can prepare the services	Employees are always eager to help	Staffs provide the service as promised
Company employees takes care of personal requirements	The service delivery dates are always maintained	Staffs are knowledgeable about the domain they are working	Staffs are truly available to client for service 24 X 7
Promises to build the reach to the target customers are ensured	Staffs and consultants are very well behaved and courteous	Staffs are competent to identify the requirement of the clients and offer them the required service	The business proposals, deliverables, transactions are transparent and neatly done
Employees are motivated to address issues as and when raised	Staffs are very punctual in their meeting deadlines	Clients always receive the required and timely responses from the staffs	Employees give highest priority to understand Client's interest
The company has sincere staffs who are always ready to solve the problems	The content of the message designed for marketing our company/product/outlets/ others and billings are neatly made and error free	Behaviors of the staffs builds confidence in customers	The technology installed by the company are well equipped to understand and deliver the required service

Findings related to Dimensions of Service Quality:

As discussed in the previous stage, to find out the dimensions of service quality, a factor analysis is conducted on the perception data of the consumers. The findings are as follows:

KMO and Bartlett's Test Value

Table 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.771
	Approx. Chi-Square	1229.817
Bartlett's Test of Sphericity	df	91
	Sig.	.000

The findings of KMO and Bartlett's test of sphericity is a test of sample adequacy. Both of these tests help to determine factorability of the variable matrix is

determined by these two tests. The adopted theory about these two tests states that the value of KMO test should be > 0.5 and Bartlett's test of sphericity should have a P value < 0.05. In this case (Table 2), the value of KMO test is 0.771 which is > 0.5 and the value of p value of Bartlett's test of sphericity is 0.000 which is < 0.05. Thus, this could be assumed that the sample size is adequate to determine the factorability of the matrix.

Findings related to Descriptive Statistics – Communalities

Table 3: Communalities

	Initial	Extraction
Technologies used by the company are updated	1.000	.635
Company employees takes care of personal requirements	1.000	.844
Promises to build the reach to the target customers are ensured	1.000	.869
Employees are motivated to address issues as and when raised	1.000	.541
The company has sincere staffs who are always ready to solve the problems	1.000	.774
The company has attractive physical facilities which shows that they can prepare the services	1.000	.610
The service delivery dates are always maintained	1.000	.689
Staffs and consultants are very well behaved and courteous	1.000	.719
Staffs are very punctual in their meeting deadlines	1.000	.477
The content of the message designed for marketing our company/ product/outlets/others and billings are neatly made and error free	1.000	.659
Employees are always eager to help	1.000	.605
Staffs are knowledgable about the domain they are working	1.000	.510
Staffs are competent to identify the requirement of the clients and offer them the required service	1.000	.463
Clients always receive the required and timely responses from the staffs	1.000	.466
Behaviors of the staffs builds confidence in customers	1.000	.683
Staffs provide the service as promised	1.000	.460
Staffs are truly available to client for service 24 X 7	1.000	.696
The business proposals, deliverables, transactions are transparent and neatly done	1.000	.477
Employees give highest priority to understand Client's interest	1.000	.459
The technology installed by the company are well equipped to understand and deliver the required service	1.000	.541
Extraction Method: Principal Component Analysis.		

The table of communalities show the level to which one item correlates to other items for the extracted components. As evident in the findings (Table 3), all items had extraction values more than 0.4 and thus none of the items was dropped from the model. For example, 86.9% of the variance in the item 'Promises to build the reach to the target customers are ensured' was loaded on the factor space while only 46.3% of the variance in the item 'Staffs are competent to identify the requirement of the clients and offer them the required service' was accounted for the same.

Findings related to Total Variance Explained

Table 4: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.095	21.712	21.712	4.095	21.466	21.466	3.852	18.937	18.937
2	3.416	16.296	38.008	3.416	16.443	37.909	2.927	14.678	33.615
3	2.167	11.847	49.855	2.167	11.946	49.855	1.819	9.189	42.804
4	1.357	8.781	58.636	1.357	8.781	58.636	1.192	7.681	50.485
5	1.231	5.443	64.079	1.231	5.443	64.079	1.015	4.376	54.861
6	0.813	5.197	69.276						
7	0.801	3.112	72.388						
8	0.756	3.622	76.01						
9	0.739	3.109	79.119						
10	0.628	3.026	82.145						
11	0.616	2.702	84.847						
12	0.529	2.612	87.459						
13	0.502	2.559	90.018						
14	0.473	2.023	92.041						
15	0.417	1.792	93.833						
16	0.367	1.623	95.456						
17	0.327	1.194	96.65						
18	0.307	1.129	97.779						
19	0.257	1.115	98.894						
20	0.202	1.106	100						
Extraction Method: Principal Component Analysis.									

The number of factors, which denotes the dimensions of the digital marketing service qualities, could be generated based on the initial eigen values. According

to the theories of factor analysis, eigen values e" 1 decides the number of factors. According to Field (2009), the eigen values associated with each component explains the variance of the particular linear component. As evident in Table 4, which reflects the findings of Total Variance Explained shows five components with eigen values e" 1, i.e., 4.095, 3.416, 2.167, 1.357 and 1.231, for components 1 to 5 respectively; and therefore, we have five factors or five dimensions of digital marketing service qualities identified from this factor analysis. These components also explained the variance of 21.712%, 16.296%, 11.847%, 8.781% and 5.443%. Moreover, these five components could explain cumulative variance of 64.079%. The remaining components, which have eigen values < 1 were non-significant.

Rotated Component Matrix(a)

Table 5: Rotated Component Matrixa

	Component				
	Reliability	Responsiveness	Assurance	Empathy	Tangibility
Technologies used by the company are updated					.627
Company employees takes care of personal requirements				.716	
Promises to build the reach to the target customers are ensured			.582		
Employees are motivated to address issues as and when raised	.723				
The company has sincere staffs who are always ready to solve the problems	.573				
The company has attractive physical facilities which shows that they can prepare the services					.512
The service delivery dates are always maintained		.591			
Staffs and consultants are very well behaved and courteous			.728		
Staffs are very punctual in their meeting deadlines		.706			
The content of the message designed for marketing our company / product/ outlets / others and billings are neatly made and error free	.613				
Employees are always eager to help		.537			
Staffs are knowledgable about the domain they are working	.579				

Staffs are competent to identify the requirement of the clients and offer them the required service			.501		
Clients always receive the required and timely responses from the staffs		.616			
Behaviors of the staffs builds confidence in customers			.532		
Staffs provide the service as promised	.507				
Staffs are truly available to client for service 24 X 7				.708	
The business proposals, deliverables, transactions are transparent and neatly done					.652
Employees give highest priority to understand Client's interest				.591	
The technology installed by the company are well equipped to understand and deliver the required service					.614
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.					
a. Rotation converged in 6 iterations.					

Using the Varimax orthogonal transformation, the resulted principal components were rotated orthogonally and the 20 items were reduced to five factors, independent from each other (Table 5). The findings show that factor loadings from 0.723 to 0.507 were substantially loaded on Component 1; factor loading 0.706 to 0.537 were substantially loaded on Component 2; factor loading 0.728 to 0.501 were substantially loaded on Component 3; factor loading 0.716 to 0.591 were substantially loaded on Component 4; factor loading 0.652 to 0.512 were substantially loaded on Component 5.

Component 1 – Reliability

The findings of Table 5 demonstrates that the items, which are loaded under component 1 indicates the issues related to reliability of the digital marketing service qualities and thus, the factor is names as "Reliability". The factor explains 21.712% of the variability (Table 4) and the factor loading of the five variables loaded under this factor ranges from 0.723 to 0.507.

Component 2 – Responsiveness

The second factor houses four variables which reflects the issues connected with the responsiveness of the digital marketing service quality and thereby the factor

is named as "Responsiveness". The factor explains 16.296% of the variability (Table 4) on all components and the four variables loaded under this factor ranges from 0.706 to 0.537 (Table 5).

Component 3 – Assurance

Variables under the third factor reflects the issues connected with the Assurance dimension of the quality of the digital marketing services and thus the factor is named as "Assurance". The four variables under this factor explains 11.847% of the variability (Table 4) and the four variables loaded under this factor ranges from 0.728 to 0.501 (Table 5).

Component 4 – Empathy

Component four houses three variables which reflects the service qualities connected to the empathy of the digital marketing services and thus this factor is termed as "Empathy". The three variables under empathy explains 8.781% of the variability (Table 4) on all components and the factor loading of the three variables ranges from 0.716 to 0.591 (Table 5).

Component 5 – Tangibility

The fifth and the final factor houses four variables and explains 5.443% variability (Table 4) on all components. The factor loading of the variables under this factor ranges from 0.652 to 0.512 (Table 5) and the nature of the variables reflect the service qualities related to tangibility of the digital marketing services. Thus, this service quality dimension of the digital marketing services is termed as "Tangibility".

Thus, from the findings of the factor analysis conducted on the perception of the customers about the service qualities of the digital marketing services, it has been observed that five distinct factors have been retrieved, which were named as Reliability, Responsiveness, Assurance, Empathy and Tangibility. The findings also show that these factors follow the theoretical construct provided in the SERVQUAL model of Zeithaml, Parasuraman and Berry (1990).

Conclusion:

The present research work aimed to achieve two objectives, to identify the unique set of service qualities dedicated to digital marketing services and to identify the service quality dimensions. Both the objectives are achieved and we have also found the resonance of the SERVQUAL model of Zeithaml, Parasuraman and Berry (1990) in the findings. The following research work was conducted by taking responses of the clients of digital marketing companies of Kolkata, and this could be cited as a limitation of this research work. Similar research conducted by taking data from the clients of different parts of the country could reveal a more detailed

picture. The methodology used in this research could be used to find out service qualities associated with different services and also could help to find out the service quality dimensions of other services.

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A study on Dual-career Women's Stress, Satisfaction and Career Salience over Family Life Cycle Stages

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Abstract:

With her roles of marital and occupational career in context, dual-career women's tasks and responsibilities are reoriented and negotiated in accordance to the family life cycle stages. The present study attempts to highlight women's experience of perceived stress, satisfaction and career salience over family life cycle. 195 career-oriented married women are considered for the study with two stress and two dual-career family dimensions as dependent variables. Results indicate that family life cycle stage is an important predictor of the variables under study. Nurturing stage indicates high role expectation conflict as well as maximum satisfaction. Career salience is also indicative of interesting perceptual disposition of dual-career women who makes career adjustments to merge her parental, career and marital roles.

Keywords: dual-career women, career salience, role expectation conflict, family life cycle stages

Introduction

In the face of rapid urbanization and an array of accompanying cultural and social changes there has been a transformation in the conventional family formation patterns giving way to more customized family structures. With changing role of women in particular, family role theorists speculated that gender-segregated role of men and women should recede gradually; shifting from the traditional gender role socialization ideologies to more adaptive and symmetrical family interaction patterns.

Specializing on the career facet, dual-career family emerged as a contemporary prototype differentiating from the dual-earner formation, which gained recognition with increased educational impetus, feminine awareness and career aspiration pursuance. The widespread acceptance of the dual-career pattern has been

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considered as signs of fundamental change in the allocation of breadwinning responsibility in families, thereby challenging the "myth of separate worlds"(p. 8) described by Kanter (1977) where the nurturing female is restricted in the private sphere and breadwinner male in the domain of work.

In a 'dual-achiever' pattern, 'his' and 'her' career rests on an equal footing, requiring realignment of role allocation in occupational and conjugal setting for both partners focusing on a proportioned sharing of roles and responsibilities in both spheres. Potuchek (1992) asserts that the emergence of the dual-earner pattern within marriages does not necessarily correspond with a rise in egalitarianism and an equitable role-sharing arrangement (Haas, 1980) is only a theoretical possibility, rarely found in practice.

Reorientation of the gender role attitude from conventional to egalitarian pattern was smoother for women than men. The feminine chores of egalitarianism are non-congruent to men's ideology of masculinity hence they are less willing to accept roles that are "de-masculinizing" and beyond the conventional gender dichotomy (Chodorow, 1989). Women in dual-career families continue to be 'domestic role specialist' (Maret & Finlay, 1984, p. 357) and still bear substantial responsibilities for household, elderly and children (Darroch & Mugford, 1980).

Within the restriction of identity tension line, women accommodated her career aspirations through role expansion thereby expanding their perspectives in an internal and psychological manner without renouncing conventional 'feminine' obligations (Yogev, 1981). With her roles of marital career intact, multiple role juggling leads to stress, marital discord and interruptions in women's career aspirations. Velsor & O'Rand (1984) posited that scheduling norms related to "timing and sequencing of career and family life events" in synchronization with life course is particularly pertinent for women (p. 366). The roles and tasks are reoriented and negotiated in accordance to the family life cycle stages making it more difficult for dual career women to choose between accommodation and autonomy. Nevertheless, in search of personal gratification and a more meaningful life, women strive hard to strike a balanced chord to get the best of the two worlds within a dual-career family.

Research Objective

The present study attempts to highlight women's experience of perceived stress, satisfaction and career salience over family life cycle. In reference to previous research studies it is assumed that the stage in family life cycle has a significant impact on women's perception of satisfaction, career salience, role-expectation conflict and role overload. This can be ascribed to changing occupational and marital roles in every phase of life in relation to presence of children and the age of children, because the responsibilities and subsequent pressures vary significantly

when a family has no children or have children either in pre-school, teenage or those in post teens. In response to the 'guilt thing' (Guendouzi, 2006, p.908) women's experience of stress role conflict is attenuated through adjustment in career outcomes seeking personal satisfaction and poise of work and family domains.

Literature Review

Dual-career marriage, though fewer in existence, evolved as a divergent family structure that attracted interest of the academia to comprehend how contemporary couples are integrating the gainful employment with demands of family sphere. Rapoport and Rapoport (1969) coined the term 'dual-career' family, and are conceptualized to include both partners of marriage (husband and wife) to pursue a career and not mere jobs. Hiller and Dyehouse (1987), made an extensive literature review in search of consistent operationalization of dual-career family pattern. They conceptualized career with advanced qualitative connotation in comparison to jobs combining three important aspects: strong personal commitment to work, a sense of self-identity with work and an aspiration for continuous growth. Apart from occupational career such families also have additional responsibilities of domestic career(Silberstein, 1992) or family career (Neault & Pickerell, 2005). Levner (2000) reconceptualized the 'two-career family' as family with 'three careers' – his ca reer, her career and career of the family - to expand the frame of reference towards inclusion of all areas of familial kinship (p. 29-30).

Rapoport and Rapoport (1975) found that women are caught in a dilemma by conservative attitudes taken towards work and family - traditional feminine quality of nurturance clashes in the workplace with the conventional masculine quality of dominance. Balancing domestic and professional roles leads to dialectical dilemma reported as feelings of guilt or inadequacy among career-oriented married women (Guendouzi, 2006). Consequently, women are seen to sacrifice career and ambition in order to maintain domestic life (Hochschild & Machung, 1989).

Family life cycle is conceptualized as 'developmental stages from inception to dissolution, distinctive from each other by circumstances and events' (Schafer & Keith, 1981, p. 360) and is viewed to be 'a system moving through time' (Carter & McGoldrick, 2005, p. 1) and a particular stage in the life cycle is an important predictor of an individual's experience of life. The breakdown of family life cycle stages with critical transition points lacks consensus but Carter and McGoldrick (2005) conceptualized it to be flexible where the 'predictable stages with appropriate emotional tasks'(p. 5) for individuals and family members rest significantly on family structure, cultural milieu and historical era. Proponents of family life ideology, differ in the number of stages identified as necessary to adequately describe the family life cycle (Schnittger & Bird, 1990). Duvall (1971) identified eight stages in family life cycle, namely, beginning families, childbearing families, and families with pre-school children, families with school-age children,

families with teenagers, families as launching centers, families in the middle years and aging families. However, researchers have conceived and modified the stages in accordance to research relevance - like Hall and Hall (1979) elaborated on six stages; Anderson, Russell, and Schumm, (1983), Hill (1986) and Schnittger and Bird (1990) further refined it to five family stages.

The stratification of life is hypothesized to predict variation in different dependent variables – marital quality and happiness, career satisfaction and aspirations, stress experience, emotional relationships, commitments, coping strategies and similar others (Anderson, Russell, & Schumm, 1983; Voydanoff & Kelly, 1984). Stages in life cycle are arbitrary breakups – with culture, presence of children, age of children, women's work involvement, length of marriage, age of individual – to be some dimensions that are utilized for stratification (Spanier, Lewis, & Cole, 1975; Mattessich & Hill, 1987). Whereas some studies have strongly recommended the efficacy of 'dimensions in combination' for higher predictability (Spanier et al., 1975), several others are of the notion that variables under study should be the determining factor for stratification; (Anderson et al., 1983) and family life cycle stages on the basis of age of children is best suited when married women and her life experience is the research condition (Spanier et al., 1975; Mattessich & Hill, 1987).

A multitude of theoretical approaches indicate that roles are dynamic that change over time. The life course perspective posits that 'roles have career with multiple events and turning points marking different stages' (Pavalko & Woodbury, 2000, p. 91) and stress theory described processes of stress proliferation and adaptation across these role careers (Aneshensel et al., 1995; Thoits, 1995). Symbolic interactionist approach suggests that individuals actively choose their position 'into or out of the role' at different life cycle stages by managing and negotiating the role demands to capitalize on paybacks (Thoits, 1995). In absence of true egalitarianism, working mothers have multiple role involvements which lead to stress role overload and inter-role conflict. Research evidence indicates contradictory findings when psychological healthand multiple role combination of dual-career women is under the probing lens. Some studies report that multiple role handling develops her sense of autonomy, self-esteem and mental health (Tingey, Kiger, & Riley, 1996) whereas several others indicate that working mothers are subject to high psychological distress primarily due to negative work-family spillover and role overload from 'double duty' (Hochschild & Machung, 1989; Ross & Mirowsky, 1992).Tensions crop at critical points of transition in family (like child birth) and career life cycle (like relocation); some troubles heighten when family issues peak first so as to hinder occupational growth, or when career concerns maximize and consequently interrupt family arrangements leading to serious role cycling dilemmas. Stress is also generated when the developmental sequence of one of the partner's career conflicts with that of the other. Hock, McBride, & Gnezda's (1989) concept

of maternal separation anxiety calls attention to another role strain variant particularly salient for employed women with young children. Research findings of Hock and her associates suggest that maternal separation anxiety is significantly related to both mother's career aspirations and psychological well-being resulting in irritability, preoccupation, and fatigue (McBride, 1990).

The structural restraint and enticement of the work environment in early career stages usually develop high career commitment and dedicate more time to career-related tasks (Betz & Fitzgerald, 1987). Role strain for childless couples is nominal in the early years of career establishment but with addition of parental role to existing career and marital roles, feelings of satisfaction as well as feelings of overload and inter-role conflict is elicited (Barnett & Baruch, 1985).

Indian women tend to impose restrictions on their career aspirations (Desai, 1996) for family reasons or make compromises in accordance to stage in family life cycle like accepting/ rejecting global career opportunity (Harvey, Napier, & Moeller, 2009). Women develop different kind of orientations to their careers because, unlike men, they are constrained to reconcile their careers with prescribed family norms and phases which are potentially incompatible. Rapoport and Rapoport (1969) posit that dual-career women represent three career patterns; whereas in conventional form women intends to be a housewife and a mother by choice, those in interrupted pattern adjusts by taking a break and resumes eventually with attenuation in domestic activities. Women with continuous career orientation maintain incessant involvement in their careers with minimal interruption by childrearing obligations. Some past research, though not specific to life cycle stages, provides evidence of methods of adaptation and coping strategies in dual-career families, like prioritizing, compartmentalizing, compromising and structural role definition as tactics to balance professional and family roles (Betz & Fitzgerald, 1987; Poloma, 1972).Dual-career women prefer to have a career with 'restricted professional involvement' so that she can better manage her workplace responsibilities along with the duties of a mother and wife and seek self-efficacy and meaningful gratification for personal self.

Methodology

Research Question: How does stress dimensions and dual-career factors, more specifically role expectation conflict, role overload, satisfaction and career salience, vary across family life-cycle stages in dual career women?

Sample: The sample considered for present study includes women of divergent ages (approximate range – 21 – 65 years) essentially belonging to different stages in family life cycle. They all have a professional career of incremental nature to pursue, are married and are with or without children. The sample size is 195 and

respondents are primarily engaged as teachers, bank employees and administrative employees in organized sector.

Measures: Two research tools are used for the study; Organizational Role Stress Scale by Udai Pareek (2010) and Dual Career Family Scale by Pendleton, Poloma and Garland (1980). On the basis of literature review, two stress dimensions, namely role expectation conflict and role overload and two dual-career family characteristics, namely satisfaction and career salience were considered for the study. These four dependent variables are considered to be conceptually most significant and expected to indicate significant variance across family life cycle stages. When women face conflicting expectations from different roles, he or she experiences role expectation stress; again, too many of such expectations lead to role overload. The extent to which women's career is important vis-à-vis her roles as wife and mother measures her career salience and when women successfully merge both her career and domestic roles, she experiences satisfaction.

Analysis: The family life cycle is divided into five categories on the basis of age of children as couple (childless), nurturing (pre-school children upto 3 years), growing (school-going children from 4 to 12 years), teen (teenage children from 13 to 19 years) and shrinking (children about to leave home, 20 years and above) stages. As conceptually relevant dimensions were selected from the scales under consideration, confirmatory factor analysis (CFA) was conducted to validate the model by confirming composite reliability, average variance explained and discriminant validity. Multivariate Analysis of Variance (MANOVA) is computed to analyze the impact of family life cycle stages (predictor variable) on four dependent variables role expectation conflict, role overload, satisfaction and career salience.

Results

The internal consistency of the scale was tested with reliability test Cronbach's alpha. The result ranges from 0.923 to 0.901 (all higher than 0.7) indicative of good internal consistency (Hair et al., 2014) (Table 1).

The study conducted confirmatory factor analysis (CFA) to validate the model considered (Table 2). All the factors indicated loadings of more than 0.7, the AVE values of all factors are above 0.5 and the CR values are more than 0.7. Thus, the results confirm the convergent validity of all the measures (Hair et al., 2017).

Discriminant validity was calculated using the HTMT ratio of correlation (Henseler et al., 2015). Table 3indicates that all HTMT ratios are lower than the most restrictive threshold of 0.85, showing good discriminant validity. Full collinearity VIF values for all constructs are less than 3.3 indicating that the model is not affected by common method bias (Kock, 2015; Hair et al., 2017).

One-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of five stages of family life cycle on four conceptually related dependent variables – role expectation conflict, role overload, satisfaction and career salience of dual-career women. Outliers and multi-collinearity of dependent variables were checked and assumptions of normality were found to be non-significant. The test for homogeneity of variances could not be met, but with significant multivariate results of MANOVA, further analysis was concluded on the basis of Games-Howell post hoc tests to determine which specific family life cycle stage significantly differs from another.

Table 4 presents the descriptive statistics of the four dependent variables for the five stages of family life cycle. Table 5 is the multivariate results of MANOVA which indicates that there are significant differences among family life cycle groups on the linear combination of four different dependent variables used for the study. At 0.05 level of significance, Wilks' λ = .41, F (16, 571.9) = 12.2, p< .001, partial ç^2= .20. The multivariate ç^2 = .20, indicates that approximately 20% of multivariate variance of the composite dependent variables is associated with the independent group factor.

Follow up univariate ANOVA results (see Table 6) indicates that dependent variables, role expectation conflict, F (4, 190) = 7.5, p< .001, partial ç^2 = .14; satisfaction, F (4, 190) = 6.4, p< .001, partial ç^2 = .12 and career salience, F (4, 190) = 42.2, p< .001, partial ç^2 = .47 significantly differ across life cycle stages but role overload is non-significant, F (4, 190) = .75, p = .56, partial ç^2 = .02.

The results of pair wise comparisons are shown in table 7. For role expectation conflict, nurturing stage was statistically significant and different from all other stages of life cycle. For satisfaction, dual career women in nurturing stage, couple stage, growing stage and teen stage were significantly different from each other. Dual career women in couple stage was found to be significantly different from women of all other stages of family life cycle in relation to career salience. Findings corroborate to previous research and indicate that stage in family life-cycle is an important predictor of dual-career women's experience of stress, satisfaction and career orientation. Every stage is diverse by physical tasks and emotional responsibilities which have substantial effect on women operating in that particular life phase. The differences can be visually represented by plots generated using marginal mean scores of dependent variables (see Figure 1, Figure 2, Figure 3 & Figure 4).

Discussion

The eagerness to curb out a niche for her personal self, dual career women probably does not feel the pressure of role overload. The art of nurturance and mothering is imbibed as an 'unconscious psychological process' (Chodorow, 1989, p. 273) from

early childhood which she can easily implement in the balancing act as a mother herself. Working mothers do not perceive emotional labor as stress overload as they are socialized to view emotional work as the primary chore within female domain (Tingey, Kiger, & Riley, 1996). She indicates 'habituation or dampening' to stress reactivity (Mroczek & Almeida, 2004, p. 358; Haque, 2017) through skillful role cycling or efficient role management with paid support, role reallocation within family and spousal assistance. Families may be represented as a complicated emotional system with relationships that have shifting boundaries, roles and functions. Women playing pivotal role in maintaining connectedness and relationship in all life cycle transitions express severe dilemma. Multiple role involvement induces role expectation conflict, as role anticipations and role performances mismatch resulting in 'sense of guilt' that encompasses all life course stages. Transition from couple to nurturing stage is accompanied by extensive child-rearing responsibilities leading women in this stage to face heightened conflict balancing career and heavy domestic chores as compared to other stages (Carter & McGoldrick, 2005).At the same time, the joy of motherhood renders women at this stage, high satisfaction with career, family and life holistically which gradually falls as children age adding varied physical and mental liabilities to her domain. Career engagement results in increased self-esteem, independence, self-efficacy and status developing a 'liberating effect' in career women and personal satisfaction comes from sense of accomplishment (Tingey, Kiger, & Riley, 1996, p. 186).Career salience indicates interesting perceptual disposition of dual career women which is contradictory to previous research (Stewart 1980). In couple stage, with no competition for time and energy, women focus on career as part of formal role definition, but with children (irrespective of age) into her life she is under constraints requiring adjustments in her career commitments and orientations (Poole et al., 1991). Her career salience increases manifold as she now requires special efforts to keep her career, self-esteem and autonomy breathing. Keeping the identity tension line intact (Rapoport & Rapoport, 1975), she focuses on plausible adjustments in career by adopting relevant coping strategies like task prioritization, compromise, compartmentalizing work and family roles, utilizing social support, redefining structural and personal role, and reactive role behaviour (Hall 1972; Poloma, 1972). Though forced to 'tolerate domestication' (p. 533) she is determined to have a career whether, continuous or interrupted, and by the dint of her 'high will to succeed' she strongly focuses on all career opportunities available (Poloma & Garland, 1971).

Implications

Individual life cycle is a function of family life cycle. For dual-career women, conflicts stem from societal conventionalism, present takes the shape in accordance to 'understanding of responsibility and relationship' (p. 9) and future is directed towards 'search for meaning of individual life' (Carter & McGoldrick, 2005). In line

with the role enhancement hypothesis, dual-career women find increased personal worth and purpose of being (Tiedje et al., 1990, p. 65) when she handles her professional, marital and parental responsibilities with efficacy. Further research should explore factors like sense of perceived control, degree of familial support, power in relationship and resource bargaining and their probable effect on dual-career women's reasonable position in the role conflict – role enhancement matrix. Family life cycle is the natural context within which career women has to write her personal identity that demands perceptual reorientation of people around her - both in her family and place of work, having tremendous future research implications.

Figures

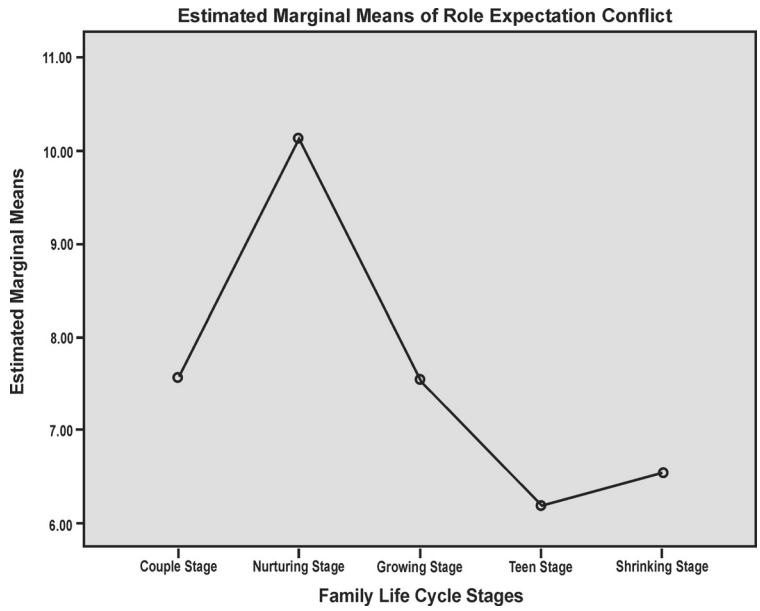

Figure 1: Plot indicating maximum marginal mean for dependent variable role expectation conflict in nurturing stage of family life cycle

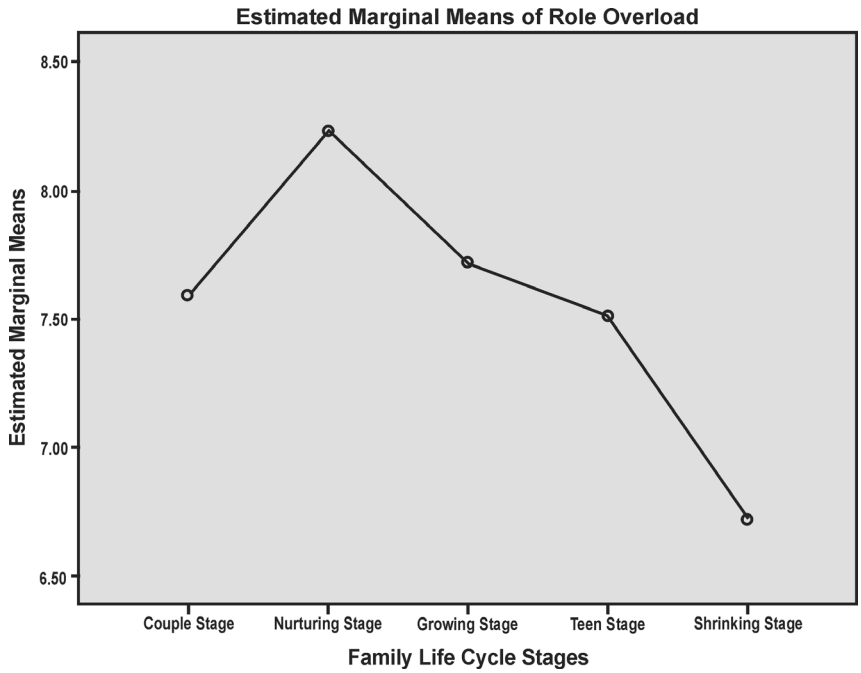

Figure 2: Plot indicating marginal means for dependent variable role overload over family life cycle stages

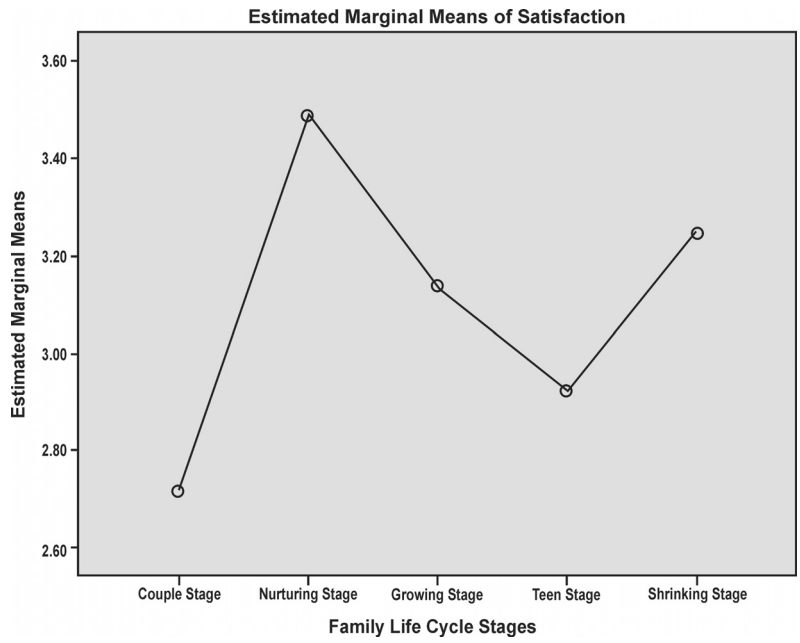

Figure 3: Plot indicating maximum marginal mean for dependent variable satisfaction in nurturing stage of family life cycle

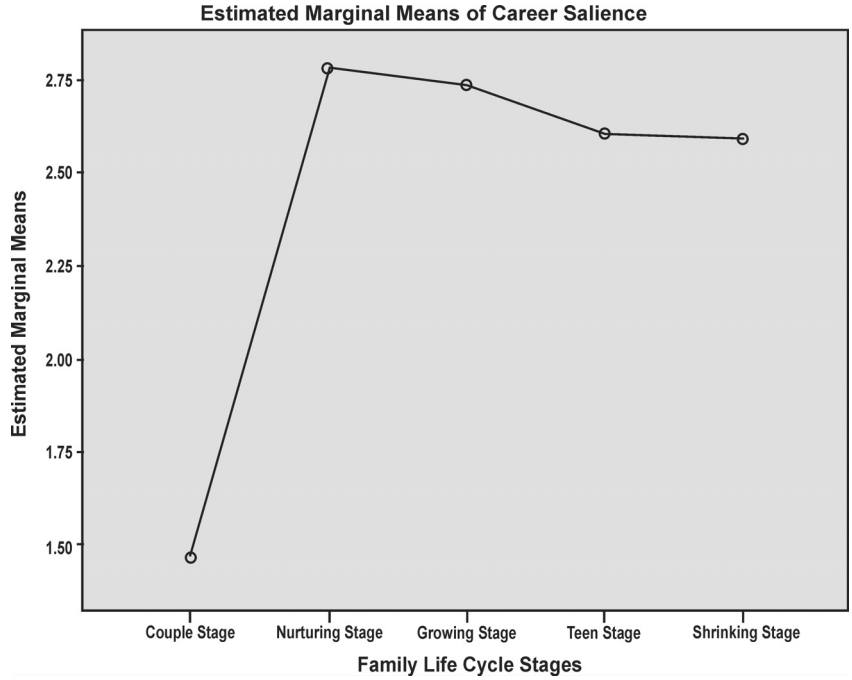

Figure 4: Plot indicating minimum marginal mean for dependent variable career salience in couple stage of family life cycle in comparison to other stages

Tables

Table 1: Cronbach α for constructs

Dependent Variables	Role Expectation Conflict	Role Overload	Satisfaction	Career Salience
Cronbach α	0.923	0.918	0.906	0.901

Table 2: Confirmatory Factor Analysis

Variables	**Items**	**Factor Loadings**	**CR**	**AVE**
Role Expectation Conflict	REC1	0.759	**0.894**	**0.629**
	REC2	0.842		
	REC3	0.808		
	REC4	0.764		
	REC5	0.789		
Role Overload	RO1	0.804	**0.907**	**0.661**
	RO2	0.866		
	RO3	0.882		

	RO4	0.789		
	RO5	0.713		
Satisfaction	S1	0.801	**0.87**	**0.691**
	S2	0.835		
	S3	0.856		
Career Salience	CS1	0.754	**0.942**	**0.67**
	CS2	0.85		
	CS3	0.845		
	CS4	0.818		
	CS5	0.833		
	CS6	0.864		
	CS7	0.791		
	CS8	0.785		

Table 3: Full Collinearity VIF & Discriminant Validity (HTMT Ratio)

Factors	VIF	1	2	3	4
1. REC	1.161	x			
2. RO	1.082	0.568	x		
3. Sat	1.134	0.326	0.313	x	
4. CS	1.897	0.426	0.468	0.627	x

Table 4: Means and Standard Deviations of the dependent variables over family life cycle stages

Dependent Variables	Family Life Cycle Stages	Mean	SD	N
Role Expectation Conflict	Couple Stage	7.56	3.76	39
	Nurturing Stage	10.13	2.48	39
	Growing Stage	7.54	3.34	39
	Teen Stage	6.18	4.82	39
	Shrinking Stage	6.54	2.72	39
	Total	7.59	3.75	195
Role Overload	Couple Stage	7.59	4.73	39
	Nurturing Stage	8.23	4.69	39
	Growing Stage	7.72	3.36	39
	Teen Stage	7.51	2.86	39
	Shrinking Stage	6.72	3.71	39
	Total	7.55	3.93	195

Satisfaction	Couple Stage	2.72	1.10	39
	Nurturing Stage	3.49	0.32	39
	Growing Stage	3.14	0.66	39
	Teen Stage	2.92	0.75	39
	Shrinking Stage	3.25	0.61	39
	Total	3.10	0.77	195
Career Salience	Couple Stage	1.46	0.95	39
	Nurturing Stage	2.78	0.39	39
	Growing Stage	2.73	0.35	39
	Teen Stage	2.60	0.32	39
	Shrinking Stage	2.59	0.32	39
	Total	2.43	0.72	195

Table 5: Multivariate tests indicate 20% of variance of the composite dependent variables is associated with the family life cycle stages

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power[d]
Intercept	Pillai's Trace	0.97	1496.167[b]	4.00	187.00	0.00	0.97	1.00
	Wilks' Lambda	0.03	1496.167[b]	4.00	187.00	0.00	0.97	1.00
	Hotelling's Trace	32.00	1496.167[b]	4.00	187.00	0.00	0.97	1.00
	Roy's Largest Root	32.00	1496.167[b]	4.00	187.00	0.00	0.97	1.00
Family_Stage	Pillai's Trace	0.70	10.01	16.00	760.00	0.00	0.17	1.00
	Wilks' Lambda	0.41	12.19	16.00	571.93	0.00	0.20	1.00
	Hotelling's Trace	1.20	13.93	16.00	742.00	0.00	0.23	1.00
	Roy's Largest Root	0.95	45.156[c]	4.00	190.00	0.00	0.49	1.00

Note:

a. Design: Intercept + Family_Stage

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Computed using alpha = .05

Table 6: Univariate tests for the effects of family life cycle on each of the four dependent variables

Source	Dependent Variables	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Obs Power[e]
Corrected Model	Role Expectation Conflict	372.103[a]	4.00	93.03	7.49	0.00	0.14	1.00
	Role Overload	46.287[b]	4.00	11.57	0.75	0.56	0.02	0.24
	Satisfaction	13.667[c]	4.00	3.42	6.37	0.00	0.12	0.99
	Career Salience	46.758[d]	4.00	11.69	42.20	0.00	0.47	1.00
Intercept	Role Expectation Conflict	11232.82	1.00	11232.82	904.69	0.00	0.83	1.00
	Role Overload	11126.82	1.00	11126.82	716.67	0.00	0.79	1.00
	Satisfaction	1877.02	1.00	1877.02	3501.50	0.00	0.95	1.00
	Career Salience	1154.64	1.00	1154.64	4167.98	0.00	0.96	1.00
Family_Stage	Role Expectation Conflict	372.10	4.00	93.03	7.49	0.00	0.14	1.00
	Role Overload	46.29	4.00	11.57	0.75	0.56	0.02	0.24
	Satisfaction	13.67	4.00	3.42	6.37	0.00	0.12	0.99
	Career Salience	46.76	4.00	11.69	42.20	0.00	0.47	1.00
Error	Role Expectation Conflict	2359.08	190.00	12.42				
	Role Overload	2949.90	190.00	15.53				
	Satisfaction	101.85	190.00	0.54				
	Career Salience	52.64	190.00	0.28				
Total	Role Expectation Conflict	13964.00	195.00					
	Role Overload	14123.00	195.00					
	Satisfaction	1992.54	195.00					
	Career Salience	1254.03	195.00					
Corrected Total	Role Expectation Conflict	2731.18	194.00					
	Role Overload	2996.18	194.00					
	Satisfaction	115.52	194.00					
	Career Salience	99.39	194.00					

Note:

a. R Squared = .136 (Adjusted R Squared = .118)
b. R Squared = .015 (Adjusted R Squared = -.005)
c. R Squared = .118 (Adjusted R Squared = .100)
d. R Squared = .470 (Adjusted R Squared = .459)
e. Computed using alpha = .05

Table 7: Pair-wise multiple comparisons of dependent variables over independent family life cycle stages

Dependent Variable		Mean	Std. Diff (I-J)	Sig. Error		95% Confidence Interval	
						Lower Bound	Upper Bound
Role Expectation	Couple Stage	Nurturing Stage	-2.5641*	0.72	0.01	-4.59	-0.54
		Growing Stage	0.03	0.81	1.00	-2.23	2.28
		Teen Stage	1.38	0.98	0.62	-1.35	4.12
		Shrinking Stage	1.03	0.74	0.64	-1.06	3.11
	Nurturing Stage	Couple Stage	2.5641*	0.72	0.01	0.54	4.59
		Growing Stage	2.5897*	0.67	0.00	0.72	4.46
		Teen Stage	3.9487*	0.87	0.00	1.50	6.39
		Shrinking Stage	3.5897*	0.59	0.00	1.94	5.24
	Growing Stage	Couple Stage	-0.03	0.81	1.00	-2.28	2.23
		Nurturing Stage	-2.5897*	0.67	0.00	-4.46	-0.72
		Teen Stage	1.36	0.94	0.60	-1.27	3.99
		Shrinking Stage	1.00	0.69	0.60	-0.93	2.93
	Teen Stage	Couple Stage	-1.38	0.98	0.62	-4.12	1.35
		Nurturing Stage	-3.9487*	0.87	0.00	-6.39	-1.50
		Growing Stage	-1.36	0.94	0.60	-3.99	1.27
		Shrinking Stage	-0.36	0.89	0.99	-2.85	2.13
	Shrinking Stage	Couple Stage	-1.03	0.74	0.64	-3.11	1.06
		Nurturing Stage	-3.5897*	0.59	0.00	-5.24	-1.94
		Growing Stage	-1.00	0.69	0.60	-2.93	0.93
		Teen Stage	0.36	0.89	0.99	-2.13	2.85
Role Overload	Couple Stage	Nurturing Stage	-0.64	1.07	0.97	-3.62	2.34
		Growing Stage	-0.13	0.93	1.00	-2.73	2.48
		Teen Stage	0.08	0.89	1.00	-2.41	2.56
		Shrinking Stage	0.87	0.96	0.89	-1.82	3.57
	Nurturing Stage	Couple Stage	0.64	1.07	0.97	-2.34	3.62
		Growing Stage	0.51	0.92	0.98	-2.08	3.10
		Teen Stage	0.72	0.88	0.92	-1.75	3.19
		Shrinking Stage	1.51	0.96	0.51	-1.17	4.19
	Growing Stage	Couple Stage	0.13	0.93	1.00	-2.48	2.73
		Nurturing Stage	-0.51	0.92	0.98	-3.10	2.08

		Teen Stage	0.21	0.71	1.00	-1.77	2.18
		Shrinking Stage	1.00	0.80	0.72	-1.24	3.24
	Teen Stage	Couple Stage	-0.08	0.89	1.00	-2.56	2.41
		Nurturing Stage	-0.72	0.88	0.92	-3.19	1.75
		Growing Stage	-0.21	0.71	1.00	-2.18	1.77
		Shrinking Stage	0.79	0.75	0.83	-1.30	2.89
	Shrinking Stage	Couple Stage	-0.87	0.96	0.89	-3.57	1.82
		Nurturing Stage	-1.51	0.96	0.51	-4.19	1.17
		Growing Stage	-1.00	0.80	0.72	-3.24	1.24
		Teen Stage	-0.79	0.75	0.83	-2.89	1.30
Satisfaction	Couple Stage	Nurturing Stage	-.7694*	0.18	0.00	-1.29	-0.25
		Growing Stage	-0.42	0.21	0.26	-0.99	0.16
		Teen Stage	-0.21	0.21	0.87	-0.80	0.39
		Shrinking Stage	-0.53	0.20	0.08	-1.10	0.04
	Nurturing Stage	Couple Stage	.7694*	0.18	0.00	0.25	1.29
		Growing Stage	.3507*	0.12	0.03	0.02	0.68
		Teen Stage	.5642*	0.13	0.00	0.19	0.94
		Shrinking Stage	0.24	0.11	0.20	-0.07	0.55
	Growing Stage	Couple Stage	0.42	0.21	0.26	-0.16	0.99
		Nurturing Stage	-.3507*	0.12	0.03	-0.68	-0.02
		Teen Stage	0.21	0.16	0.67	-0.23	0.66
		Shrinking Stage	-0.11	0.14	0.94	-0.51	0.29
	Teen Stage	Couple Stage	0.21	0.21	0.87	-0.39	0.80
		Nurturing Stage	-.5642*	0.13	0.00	-0.94	-0.19
		Growing Stage	-0.21	0.16	0.67	-0.66	0.23
		Shrinking Stage	-0.32	0.15	0.23	-0.76	0.11
	Shrinking Stage	Couple Stage	0.53	0.20	0.08	-0.04	1.10
		Nurturing Stage	-0.24	0.11	0.20	-0.55	0.07
		Growing Stage	0.11	0.14	0.94	-0.29	0.51
		Teen Stage	0.32	0.15	0.23	-0.11	0.76
Career Salience	Couple Stage	Nurturing Stage	-1.3110*	0.16	0.00	-1.78	-0.85
		Growing Stage	-1.2692*	0.16	0.00	-1.73	-0.81
		Teen Stage	-1.1378*	0.16	0.00	-1.59	-0.68
		Shrinking Stage	-1.1250*	0.16	0.00	-1.58	-0.67
	Nurturing Stage	Couple Stage	1.3110*	0.16	0.00	0.85	1.78
		Growing Stage	0.04	0.08	0.99	-0.19	0.28
		Teen Stage	0.17	0.08	0.22	-0.06	0.40

		Shrinking Stage	0.19	0.08	0.16	-0.04	0.41
	Growing Stage	Couple Stage	1.2692*	0.16	0.00	0.81	1.73
		Nurturing Stage	-0.04	0.08	0.99	-0.28	0.19
		Teen Stage	0.13	0.08	0.43	-0.08	0.35
		Shrinking Stage	0.14	0.08	0.32	-0.07	0.36
	Teen Stage	Couple Stage	1.1378*	0.16	0.00	0.68	1.59
		Nurturing Stage	-0.17	0.08	0.22	-0.40	0.06
		Growing Stage	-0.13	0.08	0.43	-0.35	0.08
		Shrinking Stage	0.01	0.07	1.00	-0.19	0.22
	Shrinking Stage	Couple Stage	1.1250*	0.16	0.00	0.67	1.58
		Nurturing Stage	-0.19	0.08	0.16	-0.41	0.04
		Growing Stage	-0.14	0.08	0.32	-0.36	0.07
		Teen Stage	-0.01	0.07	1.00	-0.22	0.19

Note: Based on observed means. The error term is Mean Square(Error) = .277.

* The mean difference is significant at the .05 level.

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ASCI Journal of Management 50 (1): 70-85

Revisiting the Concept of Knowledge

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Introduction

The concept of knowledge has been discussed for centuries. In the works of the ancient Greek philosophers, knowledge originates from people. Plato, for instance, put forward the idea that correct belief can be turned into knowledge by fixing it through the means of reason or a cause. Thus, he defined Knowledge as 'Justified true belief'. Aristotle thought that knowledge of a thing involved understanding it in terms of the reasons for it. In Western philosophy, knowledge is seen as abstract, universal, impartial, and rational. It is considered as a stand-alone artifact that could be captured in technology and which will be truthful in its essence (Brain Lehaney.et.al. 2004). The ambiguity about the understanding of information and knowledge is present despite myriads of definitions of the term available in the literature (Beckman, T. 1997; Tsoukas, 2000; Devenport and Prusak, 2000; Mishe, 2001).

The academic and IS community has spent years discussing and clarifying what constitutes data, information, and knowledge (John Sanders, 2016; Zins, 2007). Variations emerge in the definitions and the basic terminology used depending on the background of the author and the specific aim one pursues. In one of the papers, Zins (2007) has documented 130 definitions of data, information, and knowledge formulated by 45 scholars. Evidently, the three concepts are interrelated but the nature of relations among them is debatable, as well as their meaning.

Researchers working in the field of Knowledge management also feel that the concepts of 'Information' and 'Knowledge' have not been fully understood (Gopalakrishnan, 2008; Meyer, B and Sugiyama, K. 2007; Kostas et.al. 2005) and that there is still a need for a clear understanding of the term 'Knowledge' before attempting to manage it.

Current Understanding of Knowledge

Individuals can perform actions without being able to explain them and they can explain actions without being capable of performing them. From such observations,

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Polanyi (1966) concluded the existence of a silent dimension of knowledge named 'Tacit knowledge' which cannot be articulated.

Tacit knowledge is that part of knowledge that remains within the human mind. It is difficult to be articulated and hence cannot be captured in the hard form. This knowledge develops over a long period of time and is proprietary to individuals. Problem-solving skills, expertise, believe, intuition, empathy, attitudes and perceptions are few of the examples of tacit knowledge. Polanyi (1975) further emphasized that all knowledge acquired by an individual is personal knowledge since it is stored in the individual's mind and remains implicit. This knowledge can be classified into two categories - explicit knowledge and tacit knowledge.

Explicit knowledge (Nonaka and Takeuchi. 1995) is that part of human knowledge that can be easily articulated (codified) and converted into hard forms such as reports, books, manuals, engineering drawings, and process sheets, etc. This knowledge can be easily captured, stored, and disseminated efficiently using the latest information technology tools. If properly managed, this knowledge can help organizations in enhancing their product quality and productivity. However, since this knowledge is easy to be duplicated, it cannot provide a sustainable competitive advantage. A similar typology is introduced by Spender (1996), who differentiates between implicit (produced through action) and explicit (produced through communication) knowledge. Li and Gao. (2003) further differentiated between implicit knowledge and tacit knowledge depending upon their degree of codifiability .Implicit knowledge lies in between explicit and tacit knowledge in terms of codifiability. This term has been further explained in this paper.

Models from memory research (Squire, R.L, 2004; Tulwing, E, 2002) and cognitive models (Meyer, B. Sugiyama, K. 2007) have thrown light on knowledge representation. One such model is the 'content related memory model'. Content related memory model postulates two types of memories; short term memory and long term memory. Short term memory has a span of a few minutes that all information needs to pass through in order to be permanently stored in the long-term memory. This part of memory is active at a certain point in time and is therefore called 'working memory'. In long term memory, storage is practically unlimited. This is further divided in two types of memory systems; declarative (Explicit) and reflexive/non-declarative (Implicit) memory systems (Figure 1.). A declarative memory system refers to the memory that involves conscious recollection of information. This system is fast but not reliable. Forgetting and retrieval failure may occur. This declarative memory system is further divided into two types, episodic memory, and semantic memory. Episodic memory consists of singular events that can be specified according to time and space while semantic memory is built of general facts of the world. A reflexive or non-declarative memory system does not depend on conscious recollection. These systems are slow, reliable, and inflexible.

Reflexive memory is differentiated into three subsystems: procedural memory, the priming system, and the part of memory that is responsible for conditioning. The procedural memory system contains skills and habits. The Non-declarative or reflexive memory can be acquired independently of declarative memory.

There are two more cognitive models for knowledge representation systems namely 'propositional representation systems' and 'rule-based representation systems' not described here. Both representation systems describe individual knowledge representations and knowledge processes on a higher level. It may be noted that a ***network organization of knowledge*** is central to all the above models.

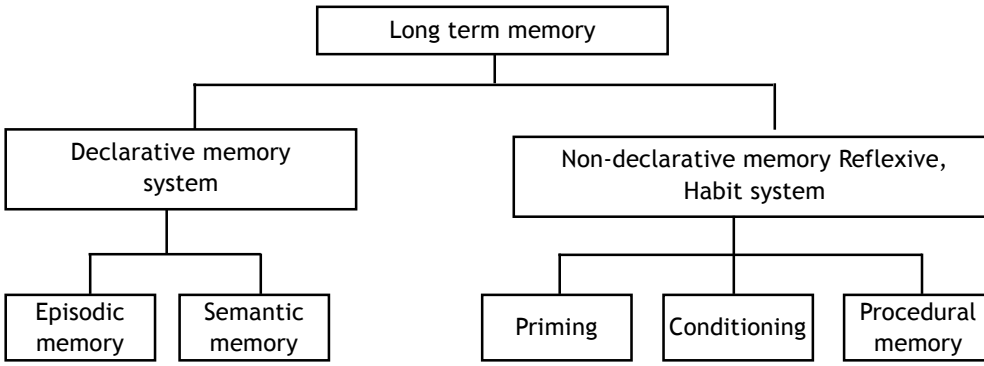

Figure 1: Overview of content related memory system

Since network organization is a central characteristic of all models, its organization is introduced as an independent characteristic of knowledge called 'Structural Knowledge'. It is a hypothetical construct referring to the organization of the relationships of concepts in long-term memory. Jonassen, et.al. (1993) assumes that structural knowledge is always explicit, i.e. the connections between concepts can always be expressed. However, there are empirical findings indicating that structural knowledge can be non-explicit also (Davis, M. A., Curtis, M. B., &Tschetter, J. D., 2003).

The famous psychoanalyst Sigmund Freud believed that behavior and personality were derived from the constant and unique interaction of conflicting psychological forces that operate at three different levels of awareness: the preconscious, conscious, and unconscious levels (Simon, Boag. 2017). He believed that each of these parts of the mind plays an important role in influencing behavior. The preconscious mind consists of anything that could potentially be brought into the conscious mind. The conscious mind contains all of the thoughts, memories, feelings, and wishes of which we are aware at any given moment. This also includes our memory, which is not always part of consciousness but can be retrieved easily and

brought into awareness. The unconscious mind is a reservoir of feelings, thoughts, urges, and memories that are outside of our conscious awareness.

Data and Information

Data is understood as discrete, atomistic, tiny packets that have no inherent structure or necessary relationship between them. As per Russell Ackoff (1989), "…. data is raw. It simply exists and has no significance beyond its existence (in and of itself)". It can exist in any form, usable or not. It does not have meaning in itself. Data is accumulated through the five senses by human mind. Although information scientists discuss the term 'data' in many ways, we take simplistic view of data to discuss further.

Davis & Olson (1985) proposed that data are sensory stimuli that we perceive through senses while information is data that has been processed into a form that is meaningful to the recipient. Holmes (2001) said that data is related to facts and machines while information is related to meaning and humans. Knowledge is meaning made by the mind (Marakas, 1999). Without meaning, knowledge is information or data. It is only through meaning that information becomes knowledge (Bhatt, 2000). Thus, the difference between information and knowledge depends on the user's perspectives. Therefore, knowledge is 'context-dependent' since 'meanings' are interpreted about a particular paradigm. By and large, in most of the literature on information, meaningful, processed or organized data has been treated as Information and meaningful information has been treated as knowledge.

While most people tacitly understand what 'context' is, they find it hard to elucidate. Previous definitions of context are done by enumeration of examples or by choosing synonyms for context. Schilit and Theimer (1994) refer to context as location, identities of nearby people and objects, and changes to those objects. Dey (2001) defines context as "any information that can be used to characterize the situation of an entity". An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves. Richter (2009) defines context at three different levels: general level, group level, and individual level. At the individual level, the context depends on the needs of the specific user. All the above authors have defined context while developing computer applications or they bring the concept of context while defining knowledge.

The author here defines context in another way - context is the set of dimensions pre-existing in the conscious human mind. A context may have one or more dimensions. Name of an object, person, place, event, or feeling could be dimensions of a context. It is the context that provides meaning to the data or algorithm to organize the data. Author defines information as data with context. Here the main assumption is that context (or meaning) comes at the stage of the capture of data

by the conscious human mind and without context, data cannot enter in the conscious human mind.

Let us understand how the data is registered in the human mind with an example. While walking on a road, an enormous amount of data is received by our five senses: people walking around, vehicles moving, birds in the sky, colors of flowers and trees around, several different sounds, the touch of breeze, the smell in the environment and numerous other things. However, we cannot possibly recall everything soon after. We can only recall certain things like a person we knew earlier, a song which we had been singing or a touch which we either liked or disliked earlier. Another behavior of the data capture by the conscious human mind is that the mind registers data only in a system that pre-exists in the mind. For example, if we understand the English language, then only data in the English language is registered in our minds. Data in any other language appears as noise and is not registered in our conscious mind. Similarly, if I understand the FPS system of measurement, then the length or height of an object is registered in feet and inches and not in meters and centimeters. This implies that there is something pre-existing in the mind which helps data to be registered in the conscious human mind. This is what is called 'Context' which is a set of dimensions preexisting in the human mind. The data corresponding to pre-existing relevant context dimensions only can enter the conscious human mind. The rest of the data which has no context do not enter in the conscious human mind. Instead, it goes to the proposed subconscious mind and hence cannot be recalled whenever desired. However, this data in subconscious mind sometimes, with an external stimulus, suddenly appears familiar and we feel that this melody or a smell or face is known. A broader context will have many dimensions while a specific context may have fewer and specific dimensions. Accordingly, when we look at things in broader context, we look into more dimensions, and hence more data is registered in our mind. On the other hand, if we look in a specific context, lesser dimensions are considered in the context and hence lesser data is registered in the conscious human mind. When we look deeper into a subject domain, newer and finer dimensions are created, and data is registered on these dimensions (Figure 2). This explanation is similar to the description of context dimensions by Richter and Weber, (2013); however, their definition of dimensions is at the knowledge level. Similarly, Dey (2001) also defines context and dimensions at the knowledge level. The author here defines context and dimensions at the data level.

Dimensions are created in two ways: by memorization and by experiences, however there is a difference in the characteristics of dimensions created by the two different ways. Dimensions created through memorization are temporary and are likely to be forgotten easily while dimensions created through experiences are more permanent and hence are retained for a longer time. This happens because during an experience, data is registered through all the five senses and hence takes deeper

roots. For example, during the early stages of development of a child, the focus is more on creating new dimensions in the child's mind through memorization. Subsequently, as the child grows, more permanent dimensions are created through exposure to new experiences.

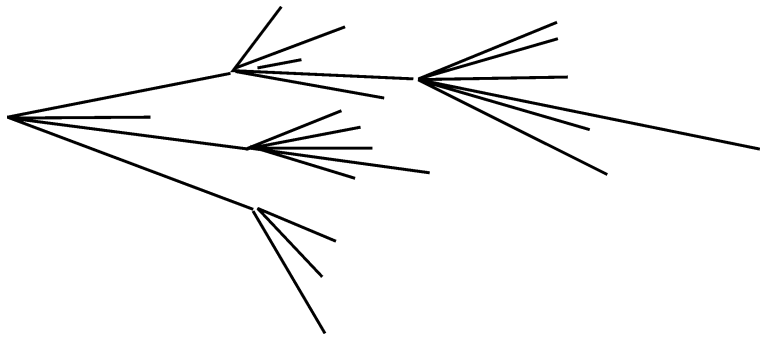

Figure 2: Context and dimensions in conscious human mind space

Let us try to understand this process with another example. Figure 3 depicts a typical set of data with no context.

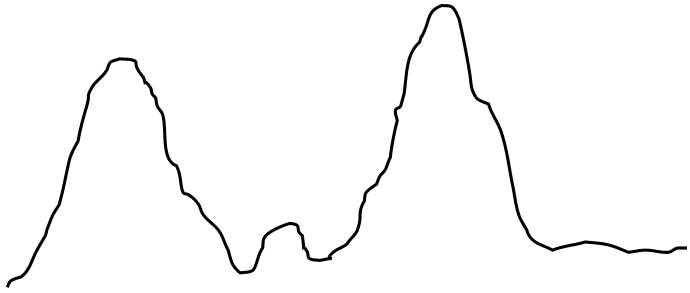

Figure 3: A typical data set

This dataset does not enter our mind as it is. It is captured in conscious human mind as a dataset with two peaks or some similar object because that is the context that may pre-exists in a human mind. If that context is also absent in our minds, this dataset will go into our subconscious mind and we will not be able to recall it. Suppose I give a context to this dataset (Figure 3.) as x-ray diffraction pattern of XYZ alloy, it is captured with context 'x-ray diffraction pattern' and can be recalled as and when desired.

Based on the above discussions, one can make the following observations regarding the process of capture of new data by human mind.

- Human mind can be divided in two parts, the conscious mind from where data can be recalled as and when desired and the subconscious mind from where data cannot be recalled on demand.
- The five senses keep on accumulating the data all the time.
- Context is the set of dimensions that pre-exist in the conscious human mind.
- When a relevant dimension in the context pre-exists in the conscious human mind, external data gets registered into the conscious mind.
- The remaining data goes to some other place in human mind called subconscious mind and cannot be recalled as and when desired. However, this data sometimes, with an external stimulus, may suddenly appear in the conscious human mind

  Let us make this process of accumulation of data more explicit by mathematical representation:

Let (x1, x2, x3……. xn.) be the data about an object X

Let C (c1, c2, c3) be the context with only three dimensions c1, c2, c3 that pre-exist in the human mind. Then the data (c1x1, c2x2, c3x3) gets registered in the conscious human mind in the form of information packet and data (x4, x5…. xn.) go to the subconscious mind. This is further explained in Figure 4.

Let conscious human mind be an N-dimensional mind space. Since, it is very difficult to represent an N-dimensional space pictorially; author has represented the concept of data and information as an example with 3-dimensional mental space which can be extrapolated to N-dimensional space. Here data is represented as coordinates x1, x2, x3 on context C with 3 dimensions c1, c2, c3, then information is the point (x1, x2, and x3) in this 3-dimensional space.

Based on the above observations, we can define **Information** as "the set of data points mapped along context dimensions in the conscious human mind". Rich information means more and more data mapped on different dimensions in a particular context.

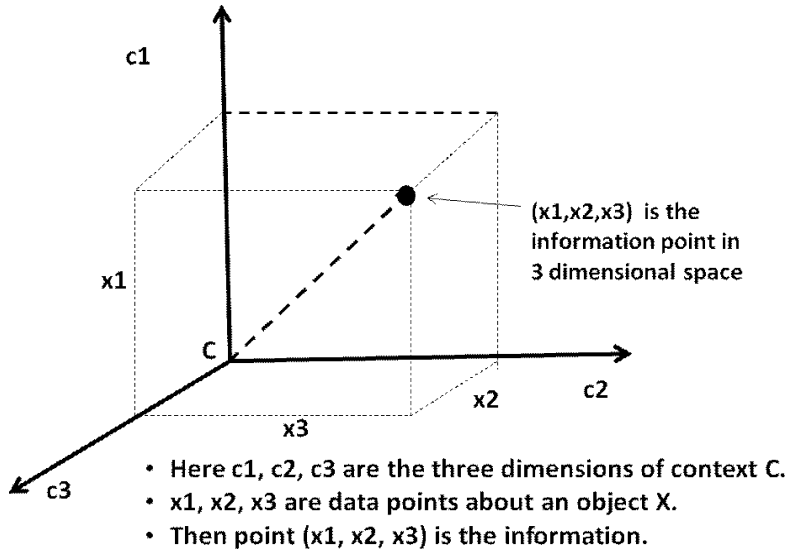

Figure 4. Representation of data and Information in 3-dimensional space

Cognitive model of Knowledge Creation

As a general observation, we can say that whenever two or more information points interact in the human mind, knowledge is created. However, the process of knowledge formation is not all that simple. There are several forces that act on the data and information points before the creation of knowledge.

Figure 5 elaborates on the cognitive process through which new knowledge is created in the human mind. In Figure 5, the space shown within the ellipse is represented as the conscious mind (intellectual space) while the space outside the ellipse is represented as the subconscious mind space. The data captured by the 5 senses pass through many processes before creation of Knowledge.

The first step is the context that has been explained in detail in the previous paragraphs. The data enter in the conscious mind space only when the relevant context dimensions pre-exists in the conscious mind. Each incoming packet of data is mapped against the dimensions present in the context. The data which does not have an existing context is deflected to the subconscious mind. The data along with context passes through perceptions, attitudes, values, and beliefs which are formed based on the past experiences gathered over a long period of time. Author defines them as “Knowledge Clusters’.

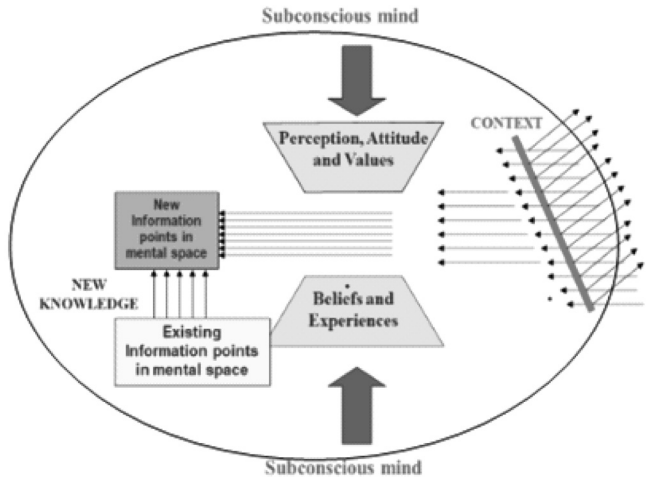

Figure 5: Cognitive process of knowledge Creation

These clusters exert attractive and repulsive forces on the data and distort the 'true dataset' before the formation of information. Knowledge clusters have been shown as magnets to symbolize the acting forces on incoming data and information. Repetitive experiences strengthen these clusters and they become stronger and stronger and hence exert stronger attractive and repulsive forces.

This distorted dataset form the information point which further interacts with other information points and create connectivity among different information points. This connectivity or relationship among different information points is defined as **'Knowledge'.**

This explains why the knowledge created in different people is different because the context dimensions and the knowledge clusters acting on the incoming data are different in different human minds. Obviously, when the data and information are based on distorted dataset as explained in previous paragraphs, how can the knowledge created based on this information be true? The quality of knowledge depends on how much distortion had taken place due to knowledge clusters. Thus reducing the effect of knowledge cluster the quality of knowledge can be improved.

In the earlier paragraph, we defined Information as a point in N-dimensional mental space. Similarly, **Knowledge is defined as *"the connectivity (relationship) between two or more information points in N-dimensional mental space"*.** Meyer B and Sugiyama K (2006) also defined '"Knowledge as a set of structural connectivity patterns whose contents have proven to be viable for the achievements of goal". "Contents viable for the achievements of goal" is nothing but the data mapped over number of dimensions enough for attaining the specific goal.

Model of Knowledge

Based on the above discussions, author proposes following model of knowledge:

- The human intellectual space called 'Mind' is divided into two parts. One is called Conscious mind and the other is called the Subconscious mind.
- The conscious mind is an N-dimensional mental space.
- Context is the set of dimensions pre-existing in the human mind.
- In the presence of context, incoming data enter into the conscious human mind and are mapped on the relevant dimensions resulting in a point in N-dimensional mental space. This point is called Information.
- Knowledge is the connectivity (relationship) between two or more Information points in N-dimensional mental space.
- Perception, attitude, values, believes, and past experiences are the Knowledge Clusters that cannot be expressed in explicit form and are defined as tacit knowledge in literature. These knowledge clusters exert attractive and repulsive forces on new incoming data and distort them before creation of knowledge.

Definition of Knowledge

Based on the above model, following definition of knowledge is suggested.

"Knowledge is the connectivity (relationship) between two or more Information points in an N-dimensional conscious mind."

Such relationships exist everywhere in the physical and social world. However, they are observed (differently by different people) and replicated in the human mind (as Knowledge) and again created explicitly by individuals (creative people) in the form of art and literary works, scientific theories and Technologies.

Discussions

In the present paper author has suggested several new hypothesis to understand the process of knowledge creation which can be further researched and refined to understand the concept of knowledge in a better way.

Author's concept of subconscious and conscious mind appears to be similar to short term memory and long term memory suggested by content related memory model (Squire, R.L.2004, Tulwing, E, 2002). Subconscious mind is also similar to the preconscious mind suggested by Freud (Simon, Boag. 2017).

The existence of context and its dimensions in the N-dimensional conscious mind is the first hypothesis suggested by the author. Here the main assumption is that

context (or meaning) comes at the stage of the capture of data by the conscious human mind. Without the pre-existence of the context, incoming data cannot enter in the conscious mind. Literature suggest, as discussed in earlier paragraphs, that concept of context exists as per several authors (Dey, 2001, Richter, 2009) but at the knowledge level. For the first time author has proposed the context at the data level, as a set of dimensions that allow data to enter in the conscious mind. The existence of context in conscious human mind is same as the awareness about a particular subject. More and more awareness will have more and more dimensions in the context

The next hypothesis proposed by the author is the definition of the information as "the set of data points mapped along context dimensions in the conscious human mind". It is proposed that incoming data is mapped on the corresponding context dimensions in the N-dimensional mental space and is stored as information points for each dataset (Figure 4). These information points are stored in the conscious mind similar to declarative memory system and can be easily communicated. Nonaka and Takeuchi (1995) referred to this as part of explicit knowledge. Although this is more of information but it can be categorized as knowledge because the dataset passed through the knowledge clusters and got distorted and personalized before being stored as information.

The third assumption is that the information points in N-dimensional mental space keep on interacting with other information points and create connectivity (relationships) among themselves. These interactions happen automatically and also deliberately during the analysis and imagination process. This connectivity is knowledge. Thus, the author defines knowledge as "the connectivity (relationship) among two or more Information points in N-dimensional mental space." This assumption is supported by the structural knowledge concept suggested by Güldenberg (1999) (cross-reference from Meyer, B., Sugiyama, K., 2007) and Jonassen, et.al. (1993, p. 4).

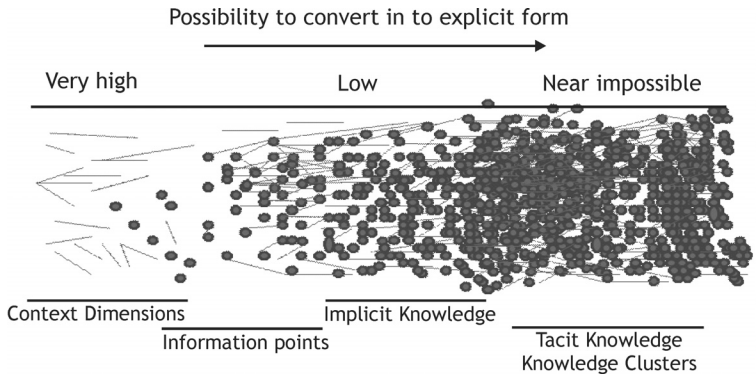

Figure 6: Context dimensions, information points and their connectivity in conscious human mind.

Figure 6. represents various knowledge elements present in the conscious human mind: the context dimensions (awareness), information points (information) and connectivity among information points (Knowledge). Context dimensions and information points can be very easily communicated in explicit form.

While information points are easy to be articulated in explicit form, connectivity among information points (Knowledge) is difficult to be articulated because it arises due to interaction among two or more information points. In order to articulate connectivity, we need to first know full context (attributes) of interrelated information points before articulation. More the connectivity among information points more is the difficulty in articulation. Heavily connected information points appear as clusters of connectivity and hence are very difficult to be articulated in explicit form and hence remain with the individuals. Polanyi (1966) defined this knowledge as tacit dimension or Tacit Knowledge.

Information points that are connected with only few or limited number of other information points can partly be expressed in explicit form through research, analysis and imagination. Nonaka and Takeuchi (1995) explained it as conversion of tacit knowledge into explicit knowledge. Spender (1996) suggested the concept of implicit knowledge which lies in between explicit and tacit knowledge. Author classifies the knowledge with limited connectivity as Implicit knowledge. Scientific theories, mathematical formulas, engineering drawings and abstract art objects are few of the examples of implicit knowledge which are expressed in explicit form but cannot be understood without the background knowledge. It is similar to structural knowledge as suggested by Jonassen, et.al. (1993). Although Jonassen et al. suggested implicit knowledge as purely explicit knowledge, there are empirical findings indicating that structural knowledge can be non-explicit also (Davis, M. A., Curtis, M. B., &Tschetter, J. D. 2003) as suggested here by the author. The non-explicit part of implicit knowledge is in tacit form and results in domain expertise.

Based on the above explanation, author suggests the answer to the question raised by Zins. (2007). Zins asked whether Albert Einstein's famous equation "$E=MC^2$" is information or knowledge? The answer is that the equation is an example of implicit knowledge because it expresses the relationship between E, M, and C in explicit form but this relationship can be understood only with some back ground knowledge in the observer's mind.

The other part of Tacit Knowledge is related to the social knowledge that is perceptions, attitudes, values, and beliefs. This knowledge is built by every day social observations and interactions over a long period of time over varied context dimensions. Because of huge number of observations and many dimensions the connectivity appears in the form of clusters as shown in Figure 6. Author defines them as knowledge clusters responsible for formation of attitudes, perceptions, values, believes, emotions and other traits in individuals. These clusters exhibit

attractive and repelling forces on incoming data and information (Figure 5). Ability to control these clusters manifest in the form of creativity and wisdom

In the following table author has attempted to classify different types of knowledge.

Table: 1 Classification of types of knowledge

S. No.	Process Stages	Characteristics of different stages	Examples	Type of Knowledge
1.	Context and standalone Information points	Can be made explicit very easily	Description of an object, event, episode or a person	**Explicit Knowledge**
2.	Information points with relationships among few or limited Information points	Difficult to be made explicit. One needs to first understand other information points that act as background knowledge.	Idioms and phrases, Basic scientific knowledge, Logics and Trends etc.	**Explicit Knowledge** (Explicit part of Implicit Knowledge)
3.	Information points with many complex and interrelated information points in a particular subject domain	Difficult to be made explicit. Can be made explicit only through R&D and analysis, Art and literary work	Engineering drawings, Research papers, Manuals, Scientific theories, Abstract art, Poems etc.	**Explicit Knowledge** (Tacit Part of Implicit Knowledge partly converted into explicit form) Results in **Expertise** in a subject domain
4.	Information points with many complex and interrelated information points resulting in dense clusters in different social domains	Near impossible to be made explicit.	Values, believes, perceptions, attitude, emotions, traits and abilities etc.	**Tacit Knowledge, (Knowledge Clusters)** Results in **Creativity and Wisdom,** if one can control knowledge clusters

Conclusion

In this paper, author has attempted to model knowledge empirically. New concepts on 'Dimensions' and 'Context' have been introduced to understand the data capture and knowledge creation process. Based on this knowledge creation process, mathematical models of information and knowledge have been proposed. The definition of knowledge clusters, their role on the data and information has been explained. New light has been thrown on understanding of implicit and tacit knowledge, based on which difference between expertise and wisdom has been proposed. It is suggested that controlling these knowledge clusters is the key to creativity and wisdom. Apart from this, the paper has also thrown new light on several existing concepts. Further research on mathematical modeling of the knowledge creation process may throw new understanding on information and knowledge.

The limitation of the study has been that in order to be focused on present discussion, several characteristics of knowledge and memory have not been taken into consideration

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ASCI Journal of Management 50 (1): 86–90

A Case study on Rockwell Industries

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Introduction

The Covid 19 has brought into the focus the importance of medical equipment likeVentilators, Oxygen, ICU Beds, Vaccines, cold chain equipment like Vaccine freezers, medicine freezers, walk in coolers etc. Severe shortage of the items mentioned above was faced by all states and Union territories in India. It was realized that we were heavily dependent on the imports of many items and the future has to be where we become self-reliant in the wake of any future pandemic. As part of the Make in India campaign of Government of India, many industries in India have voluntarily come forward to help the country during this crisis. The Centre for Health Care Management at ASCI in this context undertook a case study of Rockwell Industries based out of Hyderabad.

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1. History of Rockwell: Rockwell Industries Limited was founded in the year 1986 by Mr Ashok Gupta (first operations in a car garage) and has later steadily grown to become a leader and reputed manufacturer of commercial refrigeration appliances aimed at supporting the retail chain of our business partners. Rockwell is an **ISO9001:2015** certied company having pioneered several products such as:

1. CFC free products
2. HCFC free freezers
3. PCM Technology based Coolers & Freezers
4. Hybrid Solar Freezers

In 2020, Rockwell also started the manufacturing of Vaccine, ILRS and Medical Freezers.

Rockwell is spread across over 200,000 Sq.ft.and has two state of the art manufacturing facilities in Hyderabad, India with an annual production capacity of **400,000+ units**. Backed by a strong R & D team equipped with a temperature & humidity controlled precision type test lab, Rockwell has the unique ability to design, develop and manufacture customized refrigeration solutions for its customers speciûc requirements. Rockwell currently exports to over 27 countries across the globe with 12 branches and more than 450 plus business partners.

Highlights of the innovation products: The vaccine and medical freezers are the need of the hour now. The products which are available in the market are mostly imported from advanced countries like Denmark, Netherland, China, USA, Canada etc. Rockwell took the lead and developed these freezers and got tested at WHO PQS Certified laboratory at Denmark and are compliant with stringent WHO norms."NABL certified laboratory within the company in-house with excellent facility headed by 15 young engineers working in the R & D Lab and they took initiative of developing these products. Since it is a running refrigeration company with various commercial Refrigeration appliances products in factory, all human resources and infrastructure were in place as the basic processes for producing the medical and vaccine freezers more or less are the same. All in-house resources were used to develop this product. Rockwell financed this innovative R&D project the company took entire load of expenses and financed from internal accruals. The products developed by Rockwell are futuristic with digital freezer and developed one step ahead of what is available in the market. This product has been incorporated IOT (Internet of Things). It means the vaccine freezer wherever available throughout the globe can have complete control of freezers health from control room and the Real Time Live data is available through mobile app round the clock. Maintenance of temperature at right point is the most crucial feature of vaccine freezer. The pricing of these freezers are also much lower than the imported freezers.

These Vaccine Medical Freezers/Ice Pack Freezers are designed for freezing ice-pack as well as storage of specic vaccines including Covid vaccines. They have been designed keeping in mind harsh usage condition which may be present in rural locations of India and in developing countries.

Specications	**MFR150**	**MFR250**
GrossVolume(Ltr.)	110.4	206
TemperatureRange	-15pCto-25pC	-15pCto-25pC
DimensionsWxDxH(mm)	587x630x940	860x730x895
Colour	Blue/White	Blue/White
Baskets	4	4
Doors	1	1
InternalMaterial	SS304	SS304
ExternalMaterial	PPGI	PPGI
Refrigerant	R134a	R134a
Insulation	PUF	PUF
Voltage	190-254V,AC,50Hz	190-254V,AC,50Hz
GroundClearance(mm)	75	75
Holdover(Hr:Min)	2:35	2:38
Certifications	CE,WHOPQS	CE,WHOPQS

2. **Leadership and organization structure**: Rockwell is headed by Managing Director Mr. Ashok Kumar Gupta accompanied by 9 Company Directors.

3. **Implementation Road map**: An initial order was received from Dr. Reddy Laboratories for 500 Nos of Vaccine freezers for storing sputnik vaccine and was completed in short period of 15days. Many other orders have been received from Germany, Japan for similar vaccine/medical freezers and are in the process of being supplied depending on the various specifications. More than 150 private clients including corporate hospitals from across the country have given the orders for the vaccine/ Medical freezer. Below are the list of few clients:

AIG Hospital	Rainbow Hospital
Apollo Hospital	KIMS
Yashoda Hospital	Care Hospital
Fortis	Medanta
Ankura Medical Research Centre	Vijaya Dianostics

4. **Monitoring and reporting mechanism:** Monthly Management Review Meeting and weekly review meeting which are conducted periodically has helped in development of a good quality product and has given good results in timely addressing of any issue that has come up.

5. **Sustainability and Scalability of the initiative:** Since Rockwell has got enough capacity in a 2 State-of-Art of manufacturing facility have capacity to produce even 1000 vaccine freezers a day. The initial processes followed for Vaccine/ Medicine freezers and other refrigeration products like ice cream freezers are the same and thus this model become sustainable.

6. **Impact–Health and other socio-economic indicators especially during Covid:** The biggest advantage of this product is that these vaccine and medicine freezer scan be supplied with IOT as an optional feature. This gives a huge leverage over the existing suppliers across the globe because vaccine is always temperature sensitive. Any change in the temperature can deteriorate the potency of the vaccine so from that perspective IOT enable vaccine freezer are more suitable, and can ensure that the vaccine given to any person is absolutely safe and effective.

7. **Critical Success Factors:**

    1. Rockwell has been in the field of refrigeration appliances manufacturing for almost 35years.
    2. They have built a strong base of R&D designing, manufacturing etc.
    3. State of the art factories with excellent facilities in terms of equipment's, manpower, skilled officials, etc. Enough scope to ramp up production with available infrastructure. The products get to the market only after careful testing of around 23 parameters.
    4. Very strong R & D department who have designed this product keeping in mind the field realities; The team can make dedicated designs to suit any country/state/UT depending on their needs
    5. Strong leadership led by Mr Ashok Gupta and his dedicated team of directors
    6. Quick turnaround time to supply the products to clients: This is extremely important considering the urgent needs due to the pandemic. With branches all over the country, they can supply to all over the country in India;
    7. The Products are fully manufactured in India with no to practically minimum imports and hence it's a make in India and Green product. The prices are also cost effective.
    8. Rockwell has strong after sales service support at 375 locations spread across India.

8. Conclusion

As we are struggling to contain the Covid pandemic with newer variants emerging, we are sure that vaccination is the only way to provide us protection. In this scenario the government would want to strengthen the cold chain of the country with adequate logistics support so that vaccinations can be provided to all in the country. All the Primary Centers and Health and Wellness centers can be provided with cold chain equipment like Vaccine and medicine freezers. The innovative vaccine and medicine freezers by State Health Departments for the same and it will be quite cost effective to them.

We sincerely thank Dr. Nirmalya Bagchi, Director General (I/C) ASCI for facilitating this case study. We also sincerely thank Mr. Ashok Gupta - MD, Rockwell, Mr. N.N.Rao, Technical Director, Rockwell, Mr. Jejeswar Rao, V.P. Manufacturing, Mr. Prasad, Manager –Sales & Marketing Rockwell for all their support.

ASCI Journal of Management 50 (1): 91–109

Inter-Governmental Science and Technology Cooperation: A case study of Indo-German Science and Technology Centre

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Abstract

Inter-Governmental cooperation in the field of scientific research and technological development has mutual benefits. The needs and aspirations of the citizens, availability of human and financial resources in partnering countries,and mutual trust are some of the factors that determine the landscape of this cooperation. The science and technology programmes are executed by researchers from the two countries and monitored by experts to achieve the targeted results.Indo-GermanScience and Technology Centre is one such inter-governmental initiativethatcame into existence in March 2010. It aimed to bring the research and technology synergy between India and Germany, involving government andthe private sector. A case study based on the ongoing and completed projects of the Indo-German Centre is presented here.The analysis of available data brings out some critical pointsrelated to its activities that need to be addressed to meetfuture challenges.

Introduction

The Indo-German relations are based on decades of friendship and cooperation [1]. The first symbol of cooperation inScience and Technology dates back to 1959 when IITMadras was setup with German technical assistance.The German Academic Exchange Service (DAAD) established its New Delhi office a year later. This was followed by an agreement between the Council of Scientific and Industrial Research (CSIR) and DAAD to exchangescientists. In addition, the Indian and German governments formally concluded several agreementsand special arrangements.This includedthe 1971 agreement on cooperation for Peaceful Usesof Atomic Energy and Space Research [2].

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The major bilateral cooperation in the field of science and technology was initiated in 1974 by signing an inter-governmental agreement. In the subsequent years, this agreement served as an umbrella for a series of arrangements between R&D institutions of the two countries. TheIndian Space Research Organisation (ISRO)and Deutsche Forschungs-und Versuchsanstaltfur Luft- und Raumfahrte.V., DFVLR(today called Deutsche Forsch-ungsanstalt furLuft-und RaumfahrtEv., DLR) agreed for cooperationin the field of space technology in 1974.In the same year, Council of Scientific and Industrial Research (CSIR) and Kernforschungsanlage Julich GmbH(KFA) agreed forcooperation in the field ofscientific research and technologicaldevelopment.The Indian Council of Medical Research (ICMR) and Gesellschaft fur Strahlen- und Umweltforschun GmbH (GSF) started cooperation in the fields of medicine and biology in 1976. CSIR andDeutsche Forschungs- and Versuchsabnstaltfur Luft-und Raumfahrte.V. (DLR)initiated working together in the fieldof aeronautical science in 1982.Various other inter-governmental initiatives were taken in the later years as depicted in Fig.1.The detailed analysis of Indo-German collaborative researchin terms of co-authored publications during 1996-2000[2] and 2004-2009 [3] help us to identify weak and strong areas of bilateral research.Prospects for Indo-German Collaboration in High-Technology Manufacturing and alsoas Strategic Partners for Innovation have been discussed in other reports [4, 5].

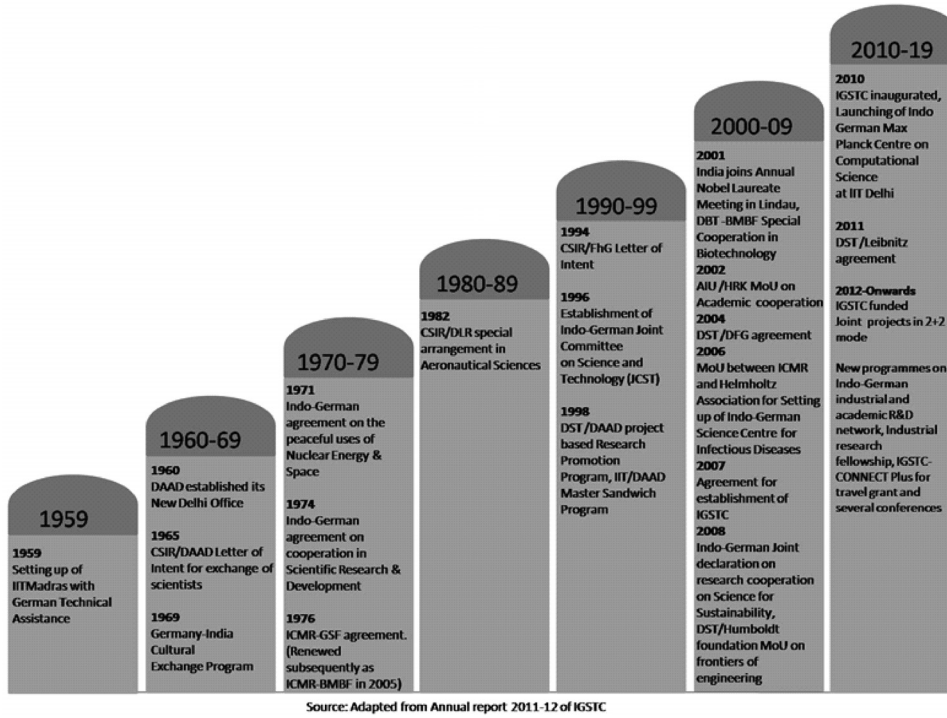

Fig.1: History of Indo-German S&T cooperation

Indo-german Science And Technology Centre (IGSTC)

The growing cooperation between Indian and German institutions necessitated the need for a nodal organization to better manage inter-governmental activities. In 2006, the Prime Ministerof India and the Chancellorof Germany agreed to expand the horizon of Indo-GermanS&T engagement. The signing of an MoU followed this at the ministerial level to establish Indo-German Science and Technology Centre (IGSTC), with an annual funding commitment of 2 million Euros by each side.The Union Cabinet approved the establishment of IGSTC in India on 25th March 2010. The new Centre was thus born and formally inaugurated on 7thDecember 2010 at Gurugram, India.

This event coincided with India's declaration of 2010-20 as the "Decade of Innovation" to develop an ecosystem to stimulate translational research and Germany's "High Tech Strategy 2020" with its aim of connecting science with industry. These strategies worked in favour of Indo-German Strategic Partnership in S&T and also gave impetus to the newly formed IGSTC. This marked the beginning of a new era inthe Indo-German S&T relationship connecting science and industry across the boundaries through research partnershipsof industrial relevance. The first Director of IGSTC had shared his views in one of its annual reports and stated,"*IGSTC looks forward to fulfilling its mandate in the years ahead. It seeks new horizons to bring together immense scientific talent in both countries to work together and resolve immediate and future Science and Technology challenges. These challenges are enormous, but so are the opportunities*".

The Centre entered its Second Phase of activities on 5th October 2015, with the joint declaration signed between India's Ministry of Science and Technology and the Federal Ministry of Education and Research of Germany, granting an extension to 2022 and beyond. The bilateral funding was also enhanced from 4 million Euros to eight million Euros per annum in 2016.

Administration

IGSTC is a bi-national S&T Centre under the International Cooperation Division of the Department of Science and Technology (DST), Government of India. It is established under the inter-governmental arrangement between India and Germany. The governing body of IGSTC has an Indian Co-Chair from DST and a German Co-Chair from BMBF Germany along with other eminent members. The Director of IGSTC is responsible for providing vision, leadership and direction to the Centre. In addition, he is responsible for the proper administration and funds management. Director works under the aegis of the administration of the IGSTC and thus reports to the 2 Co-Chairs. The IGSTC and its administrative arrangement are shown in Fig.2. The German project office coordinates for the projects executed in Germany.

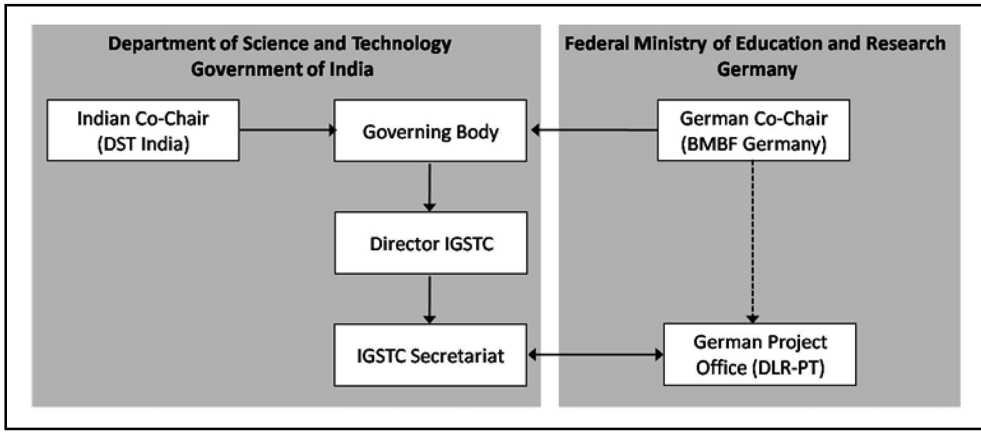

Fig. 2: IGSTC and its administrative arrangement

The Mission & Vision statement of the organization [4] is to carry out advance industrial research in partnership with mutuality of interest and respect. It aims to develop knowledge networks for the industrial sectors to enhance competitiveness. The purpose is to address global challenges by establishing joint knowledge pools. IGSTC is expected to serve as a centre to promote Indo-German technology partnership.

The organisation's mandate under the Indo-German Inter-governmental framework is to facilitate and promote bilateral collaborations in basic & applied science, research and technology. Promote publicprivate partnerships (PPP) to cultivate elements of innovation and application. It aims to develop a sense of mutual trust, leadership/partnershipand entrepreneurship.Nurture the contacts between young and midcareer scientists.

The organization has identified some key objectives to meet future challenges, such asfacilitating industry participation in joint R&D projects.The networking of scientists and institutions from both the countries is very important in the growth of IGSTC activities and has been identified as a key objective.The organisation aims to assist in mobilising resources for industrial R&D projects.Promote dissemination of information by electronic means and compile state-of-the-art reports on topics of interest prepared by highly qualified scientists and technologists. Facilitate and promote Indo-German bilateral collaborations among government, academia and industry in basic and applied science involving research and technology. Cultivate a culture of cooperation in research, development and innovation based on public-private partnerships (PPP) and assist individuals, institutes and industries from Indo-German sides to identify areas of mutual cooperation and suitable partnerships.

R&D Program

TheMission and Vision statementof IGSTC is reflected in its research program. In 2010-11, it launched a 2+2 research project partnership involvingacademia and industry from India and Germanyin the PPP mode to catalyze innovation-centric projects. The emphasis here is on connecting R&D in applied science with the industry. It aimed to support joint R&D+I projects of industrial relevance through"2+2 Mode of Partnership". The number of project partners can be a minimum of four and a maximum of six, with the participation of at least one Indian and one German research institution as well as one Indian and one German industry partner.The selection of thematic areas for project funding is based upon two countries' mutual interests. The project duration is typically three years, extendable by two years in certain cases. The Indian side receives project funding of Rs. 230 lakhs, and the German partners get € 450000 to execute their plan. These key features of 2+2 mode projects are also shown in Fig.3.

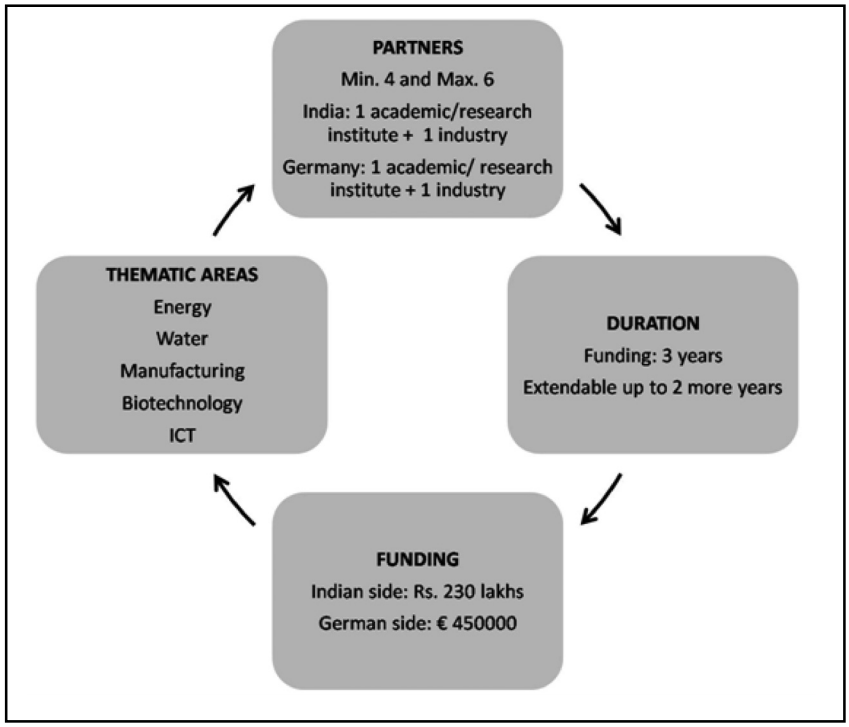

Fig.3: Key features of 2+2 mode projects involving academic/R&D institutes and industries from India as well as Germany

In addition,IGSTC is also administering and implementing the DST-Max Planck Society Program. The "Max Planck Partner Groups at Indian Institutions" and "India-Max Planck Visiting Fellowship" schemes are covered under this program. A new programme IGSTC-CONNECT Plus was also launched recently with the Humboldt Foundation to support short-term research stays in India and Germany

India and Germany: Some Facts and Figures

The total GDP of the world in 2019 was 87.697 Trillion US$as per the World Bank national accounts data.United States has the highest GDP of 21.428 Trillion US$ among all the countries in the world. China ranks second with 14.343 Trillion US$ followed by Japan 5.082Trillion US$.The GDP of Germany and India comes at4th and 5thplaces respectivelyin the top ten economies ranking of the world.The population of India was 16.36 times the population of Germany as per the data given in the United Nations-2019 report. India is 8.53 times the size of Germany according to the land area of the two countries given in Wikipedia. UNESCO Institute for Statistics report has provided information on the R&D investment in various countries in PPP terms. Macroeconomic analysts use the "Purchasing Power Parity (PPP)" term to compare different countries currencies through the "basket of goods" approach. The PPP allows economists to compare economic productivity and standards of living between the countries. The R&D investment in Germany is nearly double the similar investment in Indiain PPP terms.The area, population, GDP and R&D investment data collected from various sources are given in table 1. This information is very useful when looking at the ways and means to improve the lives of citizens of the two countries using technology. India has huge challenges to tackle due to higher population, lower GDP and vast geographic expanse compared to Germany. However,the vast pool of scientists and engineers in India can serve as a resource in solving some of the common problems faced by the two countries.

Table-1: Facts and figures about Germany and India

		Germany	India	Ratio
Area (km^2)		348,672	2,973,190	1: 8.53
Population		83,517,045	1,366,417,754	1:16.36
GDP	**In million USD**	3,845,630	2,875,142	1: 0.75
	PPP In million USD	4,659,795	9,611,679.3	1: 2.06
R&D investment	**% of GDP**	3.09	0.65	1:0.21
	PPP in USD	137.9	68.2	1: 0.49

IGSTC Related Data Gathering Mechanism And Analysis

Data on S&T cooperation between India and Germany in various forms is available on the internet. Two aspects related to data are essential here. The firstone is the need to collect reliable data from authentic sources. The second one is toprocess gathered data to draw valuable insights for future planning. Since IGSTC is an inter-governmental organisation, the major stakeholders in funding and overall policy directions are the Indian and German governments. IGSTC is only the executive arm to implement and monitor the activities. The starting point of this exercise is

first to identify the source of information, as shown in Fig.4.The Federal Ministry of Education and Research in Germany has published a report titled"High-Tech Strategy 2025"[6]. It has identified certain areas of research and innovation that benefit the people of Germany.

Similarly, NITI Aayog in India has also published a report titled "Strategy for New India@75", in context with the needs of our country [7].These two reports form the basis of our search for areas of mutual interest in S&T cooperation. The annual reports and newsletters published by IGSTC is a rich source of data about its various kind of activitiesfrom 2010 to 2019[8, 9].

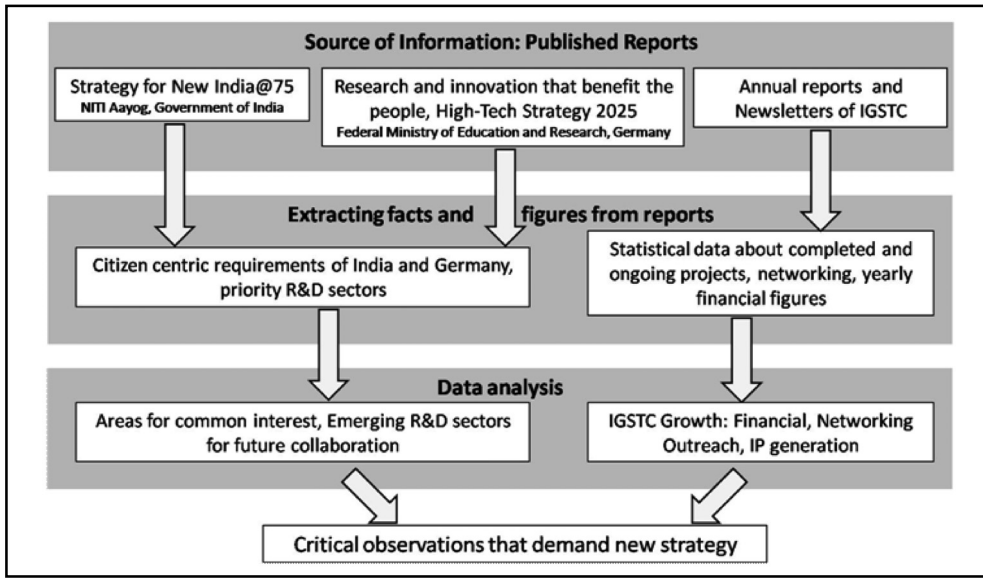

Fig.4: Extracting facts and figures from published reports

Extracting facts and figures from the reports mentioned above is the next step. The R&D priority areas as identified by the Indian and German governments in their reports are listed separately.The citizen-centric requirements of the two countries are given high priority here. The information related to areas of R&D projects, number of ongoing projects each year, institutions and industries involved, co-investigators and the amount of R&D investment each year is gathered from the IGSTC published reports.

Data analysis involves looking at the information gathered from various perspectives. The first analysis is to identifyareas of mutual interest that fit within the IGSTC mandate framework. Information given in the High-Tech Strategy 2025 and Strategy for New India@75 is screened carefully for mutual interest areas. Health care, Mobility and Energy are all citizen centric sectors that are on the R&D priorities list of both governments. We call these areas of strong mutual interest, as shown in

Fig.5.In addition, Agriculture, Sustainability, Water & wastewater management, Climate protection, Solid waste management are areas of similar interest with varying needs. R&D funding in these identified areas is expected to fulfil the overall objectives of IGSTC.

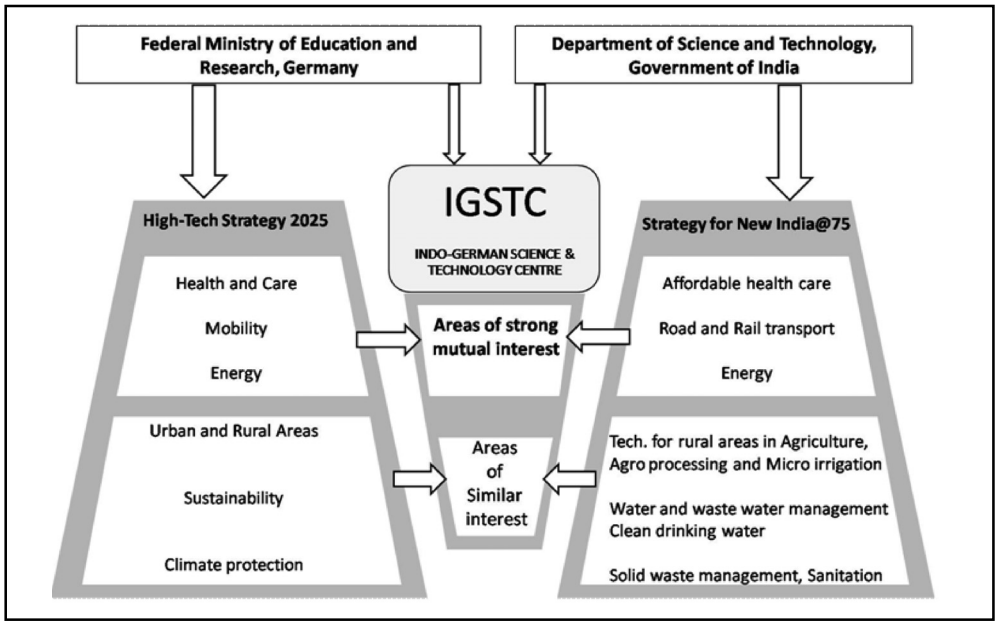

Fig.5: Areas of mutual interest based on documents High-Tech Strategy 2025 and Strategy for New India @75

The second part of data analysis is more rigorous. It involves looking at the growth pattern of IGSTC since its inception in terms of financial investment, the number of funded projects each year, research outreach, diversification of active research areas etc.Indian and German governments financially support the activities of IGSTC with assured yearly funding of 2 million Euros by either side. This provides a sufficientinflow of funds for the organisation to grow. The annual project investment by IGSTC is given in its annual reports. The project investment data plotted yearlyin Fig.6show a clear upward trend.However, the yearly bilateral commitment of 4 million Euros during 2010-16 andenhanced bilateral commitment of 8 million Euros per year during 2016-19 makes it net 48 million Euros (24 for first six years + 24 for next three years duration). The total spending of 15 million Euros out of 48 million Euros committed fundamounts to roughly 31 percent spending. The positive financial growth pattern with surplus unspent committed funds indicates two factors responsible for this trend. There is a possibility that the organisation has not publicised its programme to attract a good number of project proposals to give thrust to its activities. An over-cautious approach adopted by IGSTC in considering new project proposalsfor funding may also be a reason for limited spending.

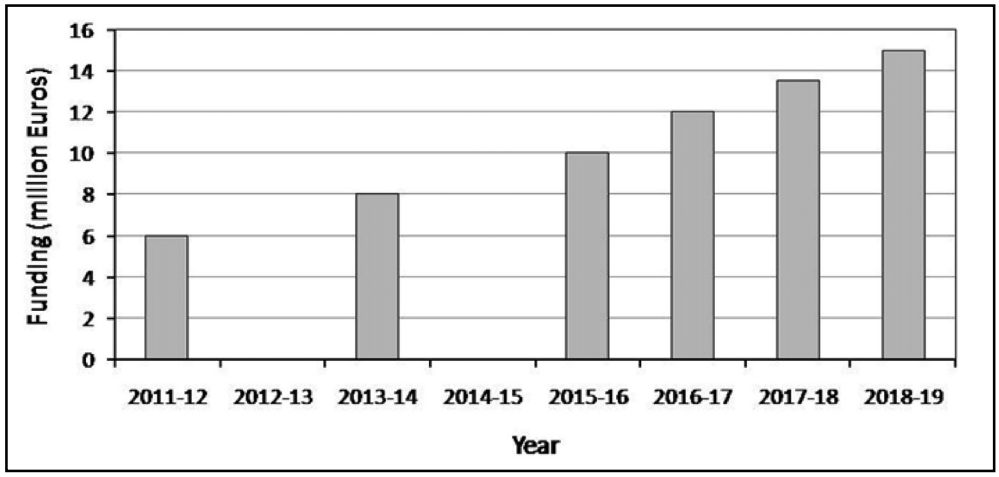

Fig. 6: Indo-German joint project investment

A list of 36 ongoing and completed 2+2 projects from 2011-2019 has been prepared from the IGSTC annual reports. Theseproject details are listed in table 2. The projects are classified under seven categories and shown in Fig.7.

Table-2: List of 2+2 mode projects during 2011-2019 (36 no.)

Area	Project title
Agriculture/ Biotechnology & Food Security	Imparting drought stress tolerance to crop plants by the heterologous transfer of high altitude plant protection mechanisms.
	Biotechnological approaches to improve the chickpea crop productivity for farming community and industry.
	Developing sustainable transgenic crop plants tolerant for a combination of drought or drought and heat stress by manipulating ABA signalling and Ascorbate-Glutathione pathways.
Medical Technology	Micro fluidic based detection of microbial communities and the antibiotic responses in management of diabetic foot ulcers.
	Next generation dynamic scheimpflug imaging and biomechanical analytics for quantification of corneal viscoelasticity.
	Re-engineering high-end audiometric devices for robust and affordable audiological testing.
Solar Energy/ Energy & Sustainability	Compact Linear Fresnel Reflector (CLFR) for solar thermal power generation and process heat.
	Reduction of earth metals in chalkopyrite-based solar cells (Remsolar).
	Flexible printed integrated disposable electronics (Flexipride).
	Resource and energy reliability by co-digestion of slaughterhouse and veg-market waste.
	Nanostructured hybrid transparent network electrodes for large area visible transparent solar cells.
	Low-cost emergency power system based on printed smart supercaps.

Nanotechnology	Development, characterisation and validation of nanoparticles for the adsorption of hydrophobic uremic toxins in renal failure patients (NPORE).
	Chemoenzymatic synthesis and development of biodegradable core-shell, structurally persistent nano-architecture for drug delivery applications.
Materials & Manufacturing/ Advanced Manufacturing	Architecture-aware timing analysis and optimization of safety-critical automotive software (Autosafe).
	Visualization of automated multi-sensor NDT assessment of concrete structures (NDT Data Fusion).
	Integration of non-destructive evaluation based ultrasonic simulation (INDEUS).
	Combined process and alloy design of the micro alloyed dp forging steel based on integrative and computational materials engineering.
	Advanced manufacturing process monitoring using in-line laser thermography – AMPLAST.
	Design and development of hollow crankshaft for automobiles.
	Design of selective nanoporous membrane bioreactor for the efficient production of bio-butanol from lignocellulosic sugars.
	Roll-to-roll printed electronic labels for the temperature, humidity and tampering detections.
	Robot skill transfer from simulation to real world deployment in manufacturing industries and warehouses.
	Design & development of near-net-shape manufacturing process for the lightweight high strength aluminium composite and engineering components by using squeeze infiltration technique for automotive and aerospace applications.
	High strength spring steels with the reduced low temperature creep for light weight designs.
	Metal powder production for additive manufacturing.
	Advanced lithium ion transporting solid electrolytes for the solid-state lithium batteries.
Water & Wastewater Technology	Online-indication of pathogen-like pollution in water by fecal pigment (FP) analysis.
	Cluster-composite nanofibre membranes for the rapid, ultra-trace detection of waterborne contaminants.
	Multiplexed, label-free fiber optic biosensor array system for waterborne pathogen detection.
	DNA biochip for on-site water pathogen detection, including the viability and antibiotic resistance testing.
Smart Cities	Efficient coupling of water and energy technologies for the smart sustainable cities.
	Smart and reliable water/wastewater infrastructure system for our future cities in India & Germany.
	Integrated diagnostics of the contaminants in water supply and management system.
	Biotechnology for the recovery of germanium, copper and indium from industrial copper dust waste.
	Smart Cities integrated energy supply, carbon sequestration and, urban organic waste treatment through the combined solar sludge drying and pyrolysis.

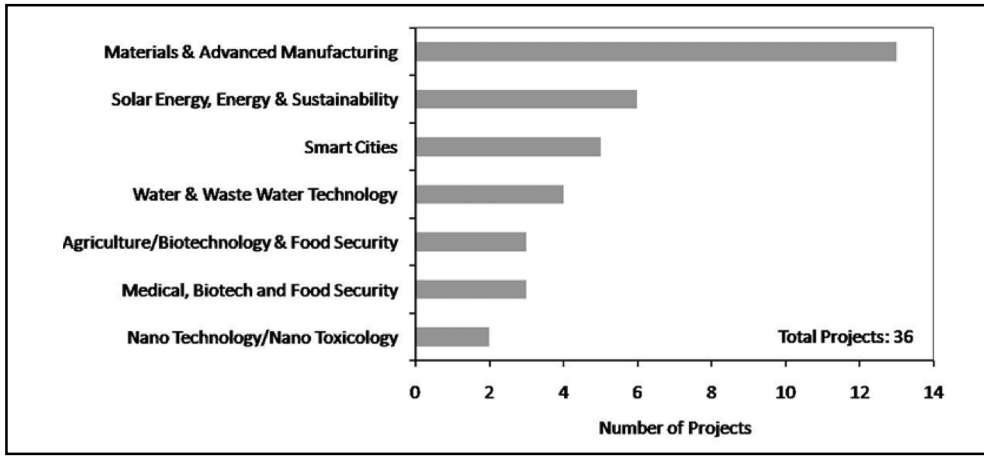

Fig. 7: Area wise classification of IGSTC projects

The above mentioned 36 projects executed during 2011-2019 contain 15 completed and 21 ongoing projects. The IGSTC activities started with 11 funded projects in 2011, and it has grown to 21 live projects in the year 2019. Thebreak-up of ongoing projects every year is shown in Fig.8.The project-related data indicates a period of stabilisation during 2011-14 for the organisation. This was followed by a sudden spurt of activities in 2014-15. However, the subsequent years during 2015-18 show a dull phase in new project initiatives. Since the assured inter-governmental funding is available yearly, the only reason for this dull phase is thelack of publicity oran over-cautious approach in initiating new projects. The project activities again show an upward trend during 2018-19 compared to the previous year.

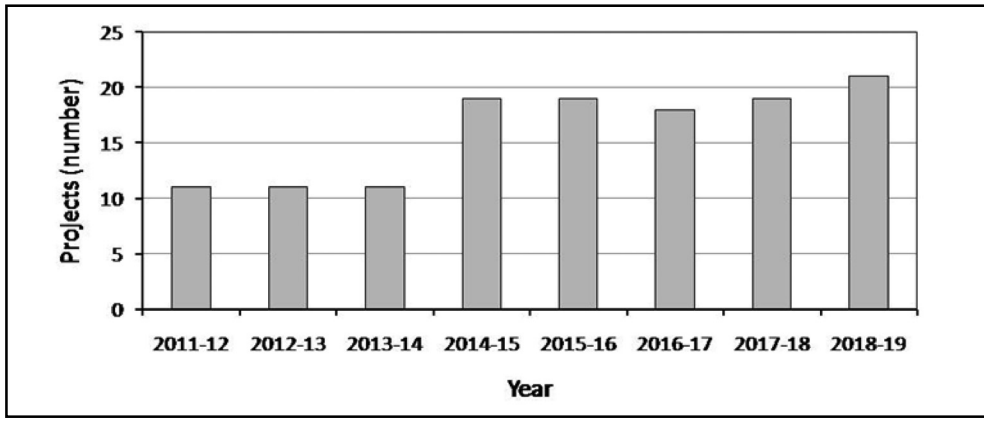

Fig. 8: Projects in 2+2 mode

The academic/researchinstitutes involved in these projects are listed separately, table-3 for India and table-4 for Germany. Total 26 Indian academic/research institutes located in 16 cities and 30 German academic/research institutes located

in 23 cities participating in 2+2 projects. These are then mapped based on their geographic location, as shown in Fig.9. The map brings out the localised nature of project execution in India compared to Germany. It appears as though the large pool of scientists and engineers in India is unaware of IGSTC activities, restricting its visibility at a few academic/research institutes and cities. It also limits the growth of the intergovernmental programme as resources available elsewhere in the country remain utilised.

Table-3: List of 26 Indian academic/research institutes located in 16 cities participating in 2+2 projects

City	**Academic/research institutes**
Ahmedabad	Ahmedabad University
Bangalore	Narayana Nethralaya Foundation,
	Centre for Nano and Soft Matter Sciences (CeNS)
	IISc Bangalore
Chennai	CSIR-CLRI
	CSIR - Structural Engineering Research Centre
	IIT Madras
	CSIR-Central Electrochemical Research Institute
Durgapur	CSIR-CMERI
Gandhinagar	IIT Gandhinagar
Gorakhpur	MMM University of Technology
Hyderabad	ICRISAT
	University of Hyderabad
Kanpur	IIT Kanpur
Kharagpur	IIT Kharagpur
Kolkata	Indian Institute of Science Education and Research
Manipal	Manipal University
Mumbai	IIT Bombay
	Institute of Chemical Technology
New Delhi	International Centre for Genetic Engineering and Biotechnology
	IIT Delhi
	AIIMS
	University of Delhi
Palampur	CSIR-Institute of Himalayan Bioresources Technology
Thiruvananthapuram Technology	CSIR-National Institute for Interdisciplinary Science and
Vellore	VIT University

Table-4: List of 30 German academic/research institutes located in 23 cities participating in collaborative projects

City/ Town	Academic/research institutes
Aachen	RWTH Aachen University
Berlin	Charité, Universitätsmedizin
	Freie Universität Berlin
	BAM-Federal Institute for Materials, Research and Testing
Bayreuth	University of Bayreuth
Braunschweig	TU Braunschweigm
Chemnitz	Fraunhofer ENAS
	TU Chemnitz
	Fraunhofer – IWU
Darmstadt	Technische Universität
Dresden	University of Carl Gustav, Carus
	Technische Universität
	DVGW Technologiezentrum, Wasser
	Helmholtz Zentrum, Dresden Rossendorf
Frankfurt	Goethe-University
Freiburg	Fraunhofer ISE
Geesthacht	Institute of Biomateral Science, Helmholtz-Zentrum Geesthacht
Halle-Wittenberg	Martin-Luther-University
Hannover	Leibniz Universität
Hermsdorf	Fraunhofer IKTS
Jena	Leibniz Institute of Photonic Technology
Kaiserslautern	Heidrun Steinmetz, TU Kaiserslautern
Karlsruhe	Karlsruhe Institute of Technology
Leibniz	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
Lippstadt	Deutsche Saatveredlung AG
Munich	TU Munich
Oberstdorf	Ingenieurbuero Scheer
Potsdam-Golm	Fraunhofer IZI
Saarbrucken	IZFP, FhG
Siegen	Universität Siegen

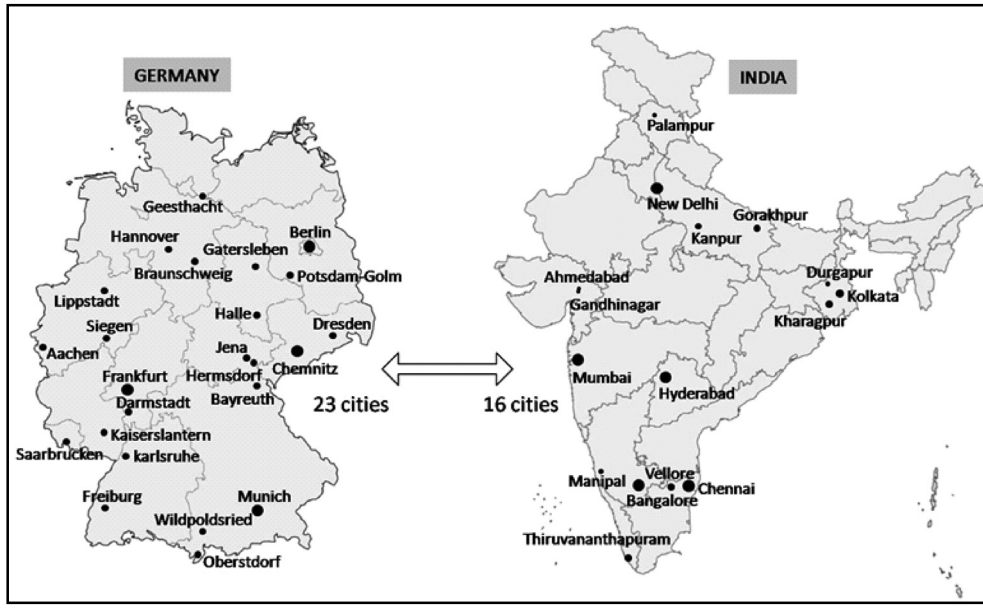

Fig. 9: Location of academic/research institutes from India and Germany participating in 2+2 projects

The list of industrypartners from India and Germany is prepared separately, as shown in table-5 and table-6,respectively. Total 34 Indian industries located in 17 cities and 37 German industries located in 30 cities are participating in 2+2 projects. A network of project investigators involving nearly 160 scientists and engineers from both countries has been created. The mapping of industries as per their geographic location has been omitted as it looksvery similar to Fig.9.Because India has 16.5 times population and 8.4 times area compared to Germany, the spread of these activities within India is comparably weak.

Table-5: List of 34 Indian industries located in 17 cities participating in collaborative projects

City	Industry
Bangalore	Achira Labs Pvt. Ltd.
	Forus Health
	Syngene International Ltd.
	Mahindra Satyam Ltd.
	Fenfe Metallurgicals
	Bigtec Labs Pvt. Ltd.
	SLN Technologies Pvt. Ltd.
Chennai	Ramky Enviro Engineers
	Lucid Software Limited
	Dhvani R & D Solutions
	Inno Nano Research Pvt Ltd
	Tamil Nadu Water Investment Company Ltd
	Ramky Enviro Engineers
Cochin	Ubio Biotechnology Systems Pvt Ltd
Coimbatore	Laksmi Life Sciences
Gandhinagar	GIFTCL
Hyderabad	Nuziveedu Seeds (P) Ltd
Jalna	Krishidhan Research Foundation Pvt. Ltd.
Jamshedpur	Tata Steel Ltd.
Lucknow	ABC Genomics (India) Pvt.
Mumbai	Piramal Life Sciences Ltd.
	Privi Biotechnologies Pvt. Ltd.
	Holographic Security Marking Systems
Nasik	Anil Printers
New Delhi	Tata Consultancy Services (TCS)
	Spectro analytical labs. Ltd.
Noida	Moser Baer India Ltd.
Pune	Thermax Ltd.
	Tata Research Development and Design Centre
	TCS
	Bharat Forge Limited
Salem	JSW Steels Salem Works
Tirupati	Amara Raja Batteries Limited

Table-6: List of 37 German industries located in 30 cities participating in collaborative projects

City/ Town/ Village	Industry
Augsburg	Kuka Deutschland GmbH
Berlin	Nanopartica, GmbH
	Specht, Kalleja + Partner GmbH
	Sifin diagnostics GmbH
Braunschweig	Lionex GmbH
Buch am Erlbach	tandler.com GmbH
Chemnitz	BiFlow Systems GmbH
	Muhr und Bender KG
Darmstadt	SMS group GmbH
Dresden	OCULUS Optikgeräte GmbH
	IMA GmbH
	InfraTec GmbH
	Saralon GmbH
Erbisdorf	Seidel Werekzeugbau GmbH
Frankfurt	GenXPro GmbH
Germering	PATH GmbH
Gladbeck	Atech Innovations GmbH
Gmund am Tegernsee	PapierfabrikLouisenthal GmbH
Grünhainichen	Grunperga Papier GmbH
Halsbrücke	GEOS, Ingenieurgesellschaft, GmbH
Hamburg	Simufact Engineering GmbH
Hovedissen	Saaten-Union Biotech GmbH
Jena	Food GmbH Jena Analytik-Consulting (Food)
Jülich	ForschungszentrumJülich GmbH
Karlsruhe	Daimler AG
	Fader Umwelttechnik (FAD)
Konstanz	Chromasens GmbH
Mainz	SCHOTT Solar
Munich	fortiss GmbH
Obemburg	eXcorLab GmbH
Pöhl	Lehmann GmbH
Potsdam	INCHRON GmbH
Rehburg	Biomacon GmbH
Schwabisch Hall	Manz CIGS technology GmbH
Schwentinental	bbeMoldaenke
Stuttgart	CIKONI GmbH
Wildpoldsried	Sonnen GmbH

The Road Ahead

IGSTC is moving ahead with its mission and vision statement to match the aspirations of the two countries. It has achieved a certain degree of success, as is visible from the data analysis available from its annual reports. There are certain areas where it needs to rework its strategy to derive better results.

R&D+I outreach: The Centremust publicise its activities to attract talented scientists and engineers from both countries to thrust its programme. It can regularly organise brainstorming sessions and virtual conferences in areas of its interest. It can work out its own mechanism to reach a larger scientific and industrial community within India. Creating a network of 1000+ professionals from India and Germany is easily achievable.

Enhanced 2+2 projectsspending: The Centre must aim to utilise the assured funds on a yearly basis. It may like to reformulate its policy on supporting industrially relevant projects by including some projects that may be considered "risky yet promisingtechnological problems".

Covering Indo-German S&T interests: The primary areas of mutual interest are Health care, Mobility and Energy. The list of ongoing and completed projects indicates that the Energy sector has been on the high priority in the past. Health care needs more investment withan even larger investment in the Mobility sector. Similarly, Agriculture, Climate protection, Solid waste management and Sanitation are other areas that need attention.

Geographic spread within India: The biggest concern is the limited penetration of IGSTC supported projects in India. An all-out effort is needed to involve more academic/research institutesfrom diverse parts of the country. The same is true in the case of industry involvement. The Centre can work out its own mechanism to achieve this objective. Based on the previous map (Fig.9), hypothetical projections for 2023 and 2025 are mapped in Fig.10 to demonstrate how the future IGSTC activities in India may look like.

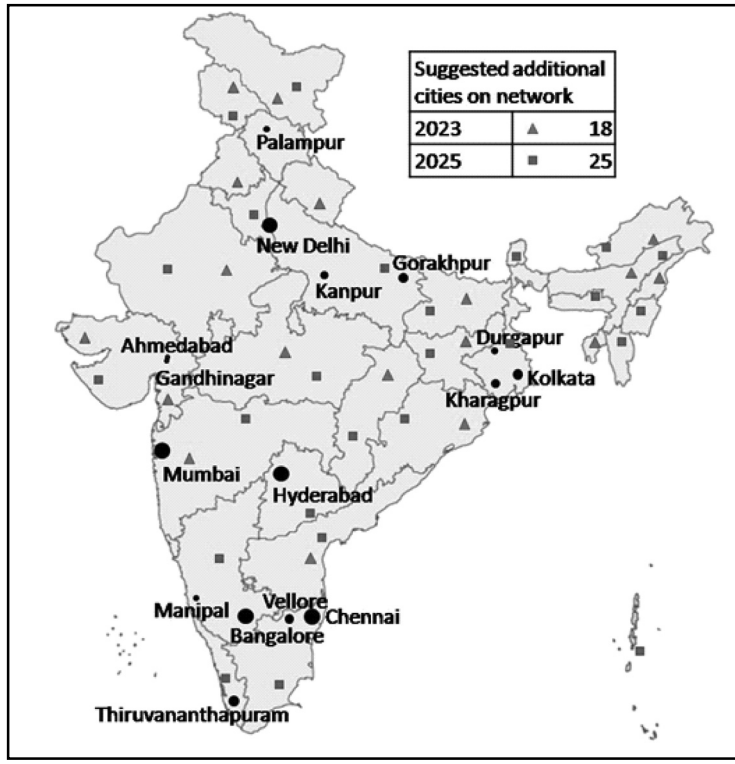

Fig. 10: Suggested geographic expansion of 2+2 projects to involve new academic/research institutes in India

CONCLUSION

Indo-German Science and Technology Centre has completed the first decade in 2020. TheCentre has grown steadilyduring all these years due to the constant support from Indian and German governments. This inter-governmental framework is capable of meeting the aspirations of the people from the two countries by delivering industrially relevant solutions toscience and technology problems of mutual interest. The Centre is now entering its second decade of aspirations and expectations shadowed by new challenges. A holistic analysis of IGSTC activities in the past gives a glimpse of its internal dynamics and challenges before it. The available data suggests limited penetration of IGSTC supported activities in India. There is a definite need to expand its activities across India, both in terms of geographic locations and the number of participating institutions, to exploit its full potential and achieve rapid growth in the coming years. Together, the Indian and German S&T policy documents can serve as a sieve to identify prospective projects of mutual interest forfinancial support. The steady growth of IGSTC during its initial years of existence is attributed to the consistent efforts but the somewhat conservative and over-cautious approach in taking new initiatives.The organisation is well poised to take a rapid growth trajectory by taking corrective policy measures and funding moreindustrially relevant projects.

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Published by Ramshirish Mamidala for Administrative Staff College of India, Hyderabad, India.
Typeset and printed at Balaram Graphics, Hyderabad, India.

ISSN: 0257-8069