UNIVERSITY OF SOUTHAMPTON

FACULTY OF LAW, ARTS & SOCIAL SCIENCES

School of Management

Low-Technology Innovation in a Sectoral System: A Critical Realist Perspective

By

Muhammad Nouman

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ABSTRACT

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LOW-TECHNOLOGY INNOVATION IN A SECTORAL SYSTEM: A CRITICAL REALIST PERSPECTIVE

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This research aims to generate an in-depth understanding of the existence or non-existence of low-technology innovation from a sectoral system of innovation (SSI) perspective. Embedded in the critical realist paradigm, this study espouses the notion of a stratified ontology. Moreover, it considers innovation to be systemic and non-sequential influenced by multiple objects and their relations. Deriving from a systematic literature review, this research addresses knowledge gaps including lack of an exclusive and all-encompassing understanding of LT innovation from the critical realist and SSI perspectives. It also addresses the lack of research on the influence of individual within firm, various sectoral elements and sectoral structure on LT innovation through use of a conceptual framework derived from systems thinking, SSI and micro-meso-macro (individual-firm-contextual) framework.

Empirically rooted in the marble industry of north-west Pakistan, this research applies retroduction to explain causal mechanisms by understanding events, objects/entities, necessary and contingent relations and causal powers. Following case study approach a multiple (two) case design (embedded type 4) having two cases/sectors, Peshawar Marble Sectoral System (PeMaS) and Buner Marble Sectoral System (BuMaS) has been chosen. A case study protocol has been applied to increase reliability along with a three-phased data collection, the use of mixed methods and a two-step analysis procedure.

Research outcomes reveal limited occurrences of incremental LT innovation amongst firms (events). The lack of innovation is a result of the systemic interplay of many sectoral elements identified and presented as the causal mechanisms of stasis. Moreover, the causal mechanisms that can result in LT innovation have been provided, a significant contribution that critical realism makes to the work. Seventy factors (causal powers) that explain the lack of LT innovation categorized across elements/objects and micro-meso-macro origins are discovered. These help identify the extant but latent causal powers that underlie the occurrence of LT innovation. The research makes a number of key contributions. It draws influence from critical realism to understand LT innovation and integrates its tenets with empirical work through use of mixed methods, as opposed to the predominant use of positivism and phenomenology found in previous research. It offers a unique and previously non-existent perspective of the SSI that is all-encompassing and exhaustive. Particularly, it addresses the lack of research on the sectoral elements including individual, learning processes and demand as well as the sectoral structure. Moreover, it complements the SSI approach with a first-time use of a micro-meso-macro (individual-firm-contextual) framework to offer a powerful explanation of the complex interplay within a low-tech SSI. Finally, this research addresses the lack of empirical work on LT innovation from a developing country context.

DEDICATION

This thesis is dedicated to my father, Muhammad Ikram (late), the most God-fearing and humble person I have ever known. His love for education and constant encouragement and support are the prime reasons behind my achievements. However, it was during his hard-fought battle with chronic cancer, knowing he had just a few months to live, that he taught me the true meaning of courage, resilience and gratitude towards the Creator despite his acute pain and suffering.

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LIST OF APPENDICES

Declaration of Authorship

I, Muhammad Nouman, declare that the thesis entitled *'Low-Technology Innovation in a Sectoral System: A Critical Realist Perspective'* and the work presented in the thesis are both my own, and have been generated by me as a result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;

- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

- where I have consulted the published work of others, this is always clearly attributed;

- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

- I have acknowledged all main sources of help;

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Chapter One

INTRODUCTION: AN OVERVIEW OF THE THESIS

1.1. Introduction

The purpose of this chapter is to provide a concise overview of the thesis. First, the main idea and overall value of this research study are presented. This is followed by the research aim, objectives and questions developed from findings of the literature review. Presented next is an outline of the research methodology and related methods. Finally the structure of the thesis is provided in the form of list of chapters.

1.2. Main Idea and Overall Value of This Research

Low-technology sectors (characterized by zero or limited R&D intensity) are considered the 'forgotten sectors' in innovation policy (Hirsch-Kreinsen, 2008a). Consequently, low-tech innovation is an under-researched topic. With 90% contribution to growth output of the developed countries, the potential and value of low-tech and low- and medium-tech sectors have been underestimated (Robertson et al. 2009; Hirsch-Kriensen & Jacobson, 2008; Bender, 2004) not to mention their pivotal role in the developing economies. Much greater attention has been paid to high-tech due to the long-held linear view of innovation that tends to overemphasize the influence of R&D and modern technologies. Recognizing that innovation (including LT innovation) is systemic and non-sequential in nature; a conceptual framework derived from the systems thinking, sectoral system of innovation (SSI) approach and micro-meso-macro (individual-firm-contextual) analytical framework guides this research.

A systematic literature review reveals many gaps in terms of our understanding of LT innovation which are addressed by this research. Major ones include;

- Lack of an exclusive and all-encompassing understanding of LT innovation within the context of a developing country

- Lack of a critical realist view (explaining events by identifying and explaining the objects/entities and underlying mechanisms) of low-tech SSI that integrates the conceptual and theoretical aspects of critical realism and SSI with empirical work on LT innovation
- The neglected influence of individual within small firms, various sectoral elements and sectoral structure on LT innovation

The research is empirically rooted in the marble industry of north-west Pakistan that has two subsectors (mining and processing). Characterized by low-technologies, the sector suffers from up to 70% resource wastage with $ 60 – 70 million losses per year in exports only (SMEDA, 2002; IMS, 2007). However, the sector is one of Pakistan's three SME-based industries with 'new potential for growth' (Zia, 2007) where policy or institutional actions can have the greatest positive impact (WB, 2006). Thus, presenting an exclusive and all-encompassing understanding of the nature and causes behind lack of LT innovation is one of the first steps to improving the marble sector. This is in line with a regional development agenda for the north-west regions of Pakistan that seeks to enhance local industries by exploiting the area's natural resources.

1.3. Research Aim, Objectives and Questions

The overall aim of this research is to generate an in-depth understanding of the existence/non-existence of innovation in a low-technology sector by exploring perspectives of all key stakeholders in the context of the sectoral system of innovation (SSI). The relevant research objectives (ROs) and questions (RQs) are;

RO1: To understand the existing phenomenon of innovation within a low-technology sector

RQ1.1: What products, processes, organizational structure and markets do firms within the sector have or deal with?

RQ1.2: What types of innovation exist amongst firms within the sector?

RO2: To explain how a low-technology sectoral system of innovation exists in terms of its elements

RQ2.1: How are the actors or agents (firms including individuals and non-firms) setup in the sector?

RQ2.2: How do knowledgebase & technologies exist in the sector?

RQ2.3: How do learning processes and demand exist in the sector?

RQ2.4: How are institutions placed in the sector?

RO3: To examine why or why not low-technology innovation exists within the LT sector by studying and explaining structure of the sectoral system of innovation

RQ3.1: How do firms interact amongst themselves and with non-firms?

RQ3.2: How do firms interact with institutions (sectoral & national)?

RQ3.3: How do firms interact with knowledge and technologies?

RQ3.4: How do firms interact with learning processes and demand?

RQ3.5: What are the factors (individual, firm and contextual) that influence low-technology innovation amongst firms in the sector?

RQ3.6: How much do these factors influence LT innovation amongst firms in the sector?

1.4. Outline of Research Methodology and Methods

Taking influence from critical realism, especially Sayer's (2004; 2000; 1992) perspectives, this research recognizes the need to separate an objectivist/metaphysical ontology from a subjectivist epistemology in order to understand LT innovation. Thus applying retroduction the focus is on explaining causal mechanisms by understanding events (occurrences of LT innovation), objects/entities (elements of SSI), necessary and contingent relations (structure of SSI), and causal powers (determinants of LT innovation).

Owing to the nature of research questions, case study approach mainly influenced from Yin (2003) has been applied as it connects well with critical realism. The concepts of phenomenon, context and boundary as envisaged in the case study approach can be conceptualized as event, objects/entities along with relations and SSI respectively. A multiple (two) case design (embedded type 4) has been chosen with two cases;

- Peshawar Marble Sectoral System (PeMaS)
- Buner Marble Sectoral System (BuMaS)

Characterized by the largest marble reserves and highest number of firms, both cases/sectors have two embedded units of analysis (mining and processing firms) while owners and managers of these firms are the units of observation. Some data has also been collected from the representatives of non-firms.

In order to increase reliability of case study, a case study protocol has been developed. It serves as a guide during the process of data collection and includes a data collection plan comprising of three phases. These include;

1. Preliminary Phase: Semi-structured In-depth Interviews (Purposive Sampling – Heterogeneous)
2. Build-up Phase: Questionnaires and Structured Interviews (Purposive Sampling – Homogeneous)
3. Closing Phase: Structured Interviews (Purposive Sampling – Heterogeneous)

The protocol also provides a detailed list of case and respondent questions linked to specific research questions that helped in gathering the relevant data from respondents in both cases/sectors.

Data has been analysed in two steps, one placed after the preliminary phase and the second placed after the build-up phase of data collection. Step I includes the creation of case study database, translating and transcribing, creating codes (star list and splitting) and memos and formulating structured interviews and questionnaires. Step II consists of building up the database further, splitting and splicing codes, preparing further memos, within and cross case displays (matrices, networks, others), and categorizing and ordering to prepare the case study report.

1.5. Structure of the Thesis

Apart from the abstract, appendices and list of references, the thesis comprises of twelve chapters with self-explanatory titles. These include;

Chapter 1: *Introduction: An Overview of the Thesis*

Chapter 2: *Paradigmatic Foundations*

Chapter 3: *Placing 'Low-Tech' on the Innovation Landscape*

Chapter 4: *Conceptual Framework*

Chapter 5: *Innovation in LT/LMT Sectors – Disciplinary Debates, Key Insights and Synthesis of Literature*

Chapter 6: *Structuring Research Aim, Objectives and Questions*

Chapter 7: *Research Methodology and Design*

Chapter 8: *Data Collection and Analysis Procedures*

Chapter 9: *LT Innovations in Marble SSI: Events and Related Objects*

Chapter 10: *Elements of Marble SSI: Objects, Underlying Components and Mechanisms*

Chapter 11: *Structure of Marble SSI: Necessary and Contingent Relations, Mechanisms and Causal Powers*

Chapter 12: *Conclusions and Directions for Future Research*

1.6. Conclusion

This chapter provided a brief overview of the thesis focusing on the main idea and overall value of this research. Research aim, objectives and questions were provided followed by an outline of methodology and methods, and structure of the thesis. The next chapter presents an in-depth discussion on critical realism, the paradigm underpinning this research.

Chapter Two

PARADIGMATIC FOUNDATIONS

> *'It is not surprising that most persons asked to define the term paradigm are unable to offer any clear statement of its meaning. I say it is not surprising because Thomas Kuhn, the person most responsible for bringing that concept into our collective awareness, has himself used the term in no fewer than 21 different ways…'*
> (Guba, 1990, pp. 17)

2.1. Introduction

The purpose of this chapter is to lay down the paradigm in light of ontological and epistemological considerations and to demonstrate the importance of the 'belief' system (Bhaskar, 1997) influencing this research. Difficulties are highlighted in deciding among various paradigm choices, particularly the dominant qualitative and quantitative paradigms as well as the futility of 'paradigm wars'. Using this discussion, an argument is constructed for critical realism as the paradigm of choice. Further, while remaining cognizant of some limitations of the original concept (Bhaskar, 1989b), important insights suggested later (Sayer, 2004; 2000; 1992; Johnson & Duberley, 2000) are provided to come up with an interpretation of critical realism that influences this study. The paradigm's distinction between the natural and social worlds (stratified ontology) is used to advocate its suitability and draw interpretations for marble sector and low-tech innovation (focus of this research). Critical realism is revisited in Chapter 4 (linking up with systems thinking), Chapter 6 (linking up with research objectives and questions) and Chapter 7 (linking up with methodology reflecting on the suitability of case study approach to the paradigm).

2.2. Research Paradigms: Ontological, Epistemological and Axiological Considerations

Two questions are of fundamental concern for researchers. The first is about how do we know what reality is? The second is about what is valid knowledge for us? Seeking answers to these questions has led to ontological and epistemological debates amongst the scientific community. Bringing in the ontological perspective, one major dimension is the dichotomy that exists between the 'objective perspectives' and the 'subjective perspectives' (Burrell & Morgan, 1979). 'Objectivisim' is that social objects exist in reality external to social actors. 'Subjectivism' is that social phenomena are ingrained in the perceptions and actions of these actors (Saunders et al., 2006).

Taking into account epistemological considerations, two dominant stances namely positivist (also known as empiricist, logical positivism, logical empiricism, postpositivism) and constructivist (also known as interpretivist, phenomenological, naturalist) emerge. The statement below advocates positivism;

> *'…social research should adopt scientific method…that…consists of the rigorous testing of hypothesis by means of data that take the form of quantitative measurements'*
>
> (Atkinson & Hammersley, 1994 pp. 251)

While supporters of constructivism suggest;

> *'…observation cannot be pure...altogether excluding the interests and values of individuals; investigations must employ emphatic understanding of those being studied; the paradigm supports qualitative methods'*
>
> (Howe, 1988 via Taskakkori & Teddlie, 2003, pp 705)

The term 'paradigm' (Kuhn, 1970) means a set of beliefs, values, assumptions and techniques that are shared by the members of a society. This shared way of thinking enables us to assign unique meanings to objects encountered while dealing with the world (Johnson & Duberley, 2000). Paradigms are 'basic belief systems based on ontological, epistemological and methodological assumptions' (Guba & Lincoln, 1994, pp.107). They serve as frameworks comprising of theories, methods and ways of defining data (Collis & Hussey, 2003) and lay foundations of how a researcher understands things around him. Hussey and Hussey (1997) provide an important classification of paradigms below:

Philosophy of Social Science	Phenomenological Perspective	Positivist Perspective
Ontology: Focus on the nature of reality	Reality is subjective	Reality is objective
Epistemology: Focus on the nature of knowledge	Researcher becomes part of the phenomena being investigated	Researcher remains independent of the phenomena being studied
Axiology: Focus on values	Researcher is influenced by values, induces biasness	Researcher remains free of values and biasness
Corresponding Research Strategy	Case Studies Action Research Grounded Theory Ethnography etc.	Surveys Experiments Cross-sectional studies Longitudinal studies etc.

Table 2.1: Classification of Paradigms Adopted from Hussey and Hussey (1997)

2.3. The 'Paradigm Wars'

Highlighting the debate over epistemological stances Easterby-Smith et al. (2002) suggest that while positivism provides wide coverage of a situation, is economical and potentially more useful for the decision-makers, it lacks deeper understanding from the people's point of view. In praising phenomenology they highlight the paradigm's ability to capture change over time, provide the individual's perspective, understand meaning and contribute to theory. Time consuming data collection process and highly interpretive nature of meaning given to findings are the weaknesses. Elaborating further on the divisions, Tashakkori and Teddlie (2003) point out three broad categories of researchers in social sciences; those with (a) post-positivist orientation, (b) constructivist orientation and (c) mixed methodologists. 'QUANS' and 'QUALS' represent the first two of these categories (Morse, 1991).

The debate over quantitative and qualitative paradigms has resulted in emergence of purists on both sides (Campbell & Stanley, 1963; Lincoln & Guba, 1985). For the quantitative purists social phenomena should be studied like physical phenomena (Ayer, 1959; Popper, 1959). Inquiries conducted in social science should be generalized without restrictions of time and context

(Nagel, 1986). The qualitative purists have been criticized in different ways. For example in qualitative research relativism is used to accommodate the perspective of every individual to demonstrate subjectivity and generate multiple realities (Guba, 1990). However, any such account should be termed ‘subjective reality’ or ‘intersubjective reality’ rather than reality alone (Johnson & Onwuegbuzie, 2004, pp. 16).

On the other hand purists favouring qualitative approaches have argued for the supremacy of constructivism, relativism, humanism, hermeneutics (Guba & Lincoln, 2005; Schwandt, 2000). Some of their criticism concerns ‘context stripping’ that quantitative research applies. This puts into question the study’s generalizability (Guba & Lincoln, 1989). Another argument put forth is that for theories to be valid they should be qualitatively ‘grounded’ in the particular setting/context (Glaser & Strauss, 1977; Strauss & Corbin, 1998). Bringing in axiological concerns, another contention is that just like theory and facts are inseparable, theory and value are linked thus putting into question the objectivity of facts discerned from the theory (Guba & Lincoln 1994). Philosophers like Popper (2002) reject the concept of ‘theory verification’ and favour ‘theory falsification’.

2.4. Commonalities and Philosophical Debates

Social sciences seem more worried than natural sciences about the choice of methodologies for research (Meehl, 1978). The long-prevailing disagreements between the two dominant research philosophies have put forth the notion of ‘incompatibility’ of the two (Howe, 1988). However, many have challenged this assertion since mixed methods are already being used in research (Patton, 2002).

Critics of the ‘purist’ school highlight similarities that exist between the two research philosophies and debate over philosophical issues to counter the epistemology-method link. For example, both methodologies ‘describe their data’, develop ‘explanatory arguments from their data’, and attempt to explain ‘why the outcomes they observed happened as they did’ (Sechrest & Sedani, 1995, pp. 78). Essentially all social sciences research studies human beings in the context of their environments (Biesta & Burbules, 2003). The rapid development of multivariate statistics has also allowed quantitative researchers to address context limitations better (Bednarz, 1985). The following statement supports the non-purist view;

> *'Today's research world is becoming increasingly interdisciplinary…Taking a non-purist or compatibilist...position allows researchers to mix and match design components that offer the best chance of answering...specific research questions.'*
>
> (Johnson & Onwuegbuzie, 2004, pp.15)

The wisdom behind paradigm wars is questioned by suggesting that the 'logic of justification' should not be confused with the choice of research methods (Onwuegbuzie & Teddlie, 2003). The choice of data analysis techniques instead of being influenced by epistemological considerations should stem from the purpose of research (Newman et al., 2003). Onwuegbuzie (2000, pp. 2) stresses the need for epistemological and paradigmatic 'ecumenicalism'.

2.5. Critical Realism: A Paradigm of Choice

No end in sight regarding debate over the two traditional paradigms, in some cases, has led researchers to draw valuable lessons and suggest alternative views. Emerging from these stances another ontological position is of the 'realist'. It argues that what our senses show us as reality is the truth however objects exist regardless of whether we as humans can sense them or not (Saunders et al. 2006). By stressing that reality exists independent of the human mind and that researchers need to adapt scientific approaches in order to create knowledge, realism demonstrates strong characteristics of positivism. However, that is not the case because of the presence of human element in social sciences. Knowledge though socially constructed is the result of human interactions with an independent reality (Johnson & Duberley, 2000).

The confusion over what 'realism' exactly means has remained for quite some time because of a lack of clear, single and agreed upon meaning. Haack (1987) highlighted this ambiguity by reminding us that realism has had many variants. These include 'theoretical realism,' 'cumulative realism,' 'progressive realism', 'optimistic realism', 'minimal realism', 'ambitious absolutism', 'transcendentalism', 'nidealism' and 'scholastic realism'.

Saunders et al. (2006) remind us of two dominant forms of realism namely 'direct realism' and 'critical realism.' Direct realists argue that we sense reality and truth directly and as they exist. Thus researchers should strive to produce narratives that correspond with reality (Hammersley, 1992). Critical realists assert that the natural and social worlds are fundamentally different whereby the latter is socially constructed and dependent on human action. The natural world remains independent of the social world and actions of human beings. The social world however has aspects which human beings have no, limited or mistaken knowledge of. Consequently, critical realism stresses the need to distinguish between ontology and epistemology and avoid 'epistemic fallacy' (Bhaskar, 1991). If not avoided the distinction between nature of reality and our knowledge of reality is so blurred that we think of the two as the same. The paradigm does not assume that reliable knowledge about reality can be developed easily. However, it does imply that while 'epistemic relativism' – the view that knowledge is socially constructed – is acceptable, 'judgemental relativism' – the view that all depictions of the world are equally correct – should be rejected. Rather the focus should be on whether some of these depictions provide us greater knowledge about the world than others or not (Fairclough, 2005).

Elaborating further on Roy Bhaskar, Dobson (2002) asserts that we have 'real objects' on one side and 'value-laden observation of reality' by human beings on the other. The former is non-transitional and relatively enduring while the latter is transitional. The post-modernist view espousing a relativist view of science and knowledge and containing epistemic and judgemental relativism is criticized by Bhaskar for failing to appreciate this difference. Narrating a key difference between objects in social and natural sciences Johnson & Duberley (2000) explain that while our understandings of objects change due to the transitioning nature of human thought, 'intransitive causal mechanisms' that are found in reality external to the human mind will not change unless these causal mechanisms are dependent on the actions of human beings themselves.

Explaining critical realism further, Bhaskar (1989a; 1998) gives the notion of 'stratified ontology'. On one side reality consists of causal mechanisms and events that are the actual truth. On the other side, some and not all of these actual events are conceptually conceived through our empirical observations. Critical realists do not construe causation and reality to mean all that is within the empirical realm of human judgement. Rather, they point out that causation and reality can be identified by further exploring the underlying causal mechanisms that result in actual events. A key to understanding critical realism is recognition of the abstract forms of structures and mechanisms that, although not directly observable, control the events we experience in this world. For this Bhaskar (1997) uses the term 'retroduction' which means describing the underlying structure or mechanism that has resulted in an apparent phenomenon. Sayer (1992, pp. 107) defines retroduction as '…mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them...".

While explaining 'stratified ontology' critical realists like Lawson (2003; 1997) and Sayer (2000) explain three levels. The 'real' includes structures with their related 'causal' mechanisms. The 'actual' includes events and processes. While the 'empirical' includes that part of the real and actual that is experienced by social actors (Fairclough, 2005). In social sciences critical realism claims that there are mediating entities or social practices that account for the relationship between 'real' structures and the processes/events.

1. Critical realism emphasizes a metaphysical ontology meaning that social and natural reality consists of intransitive objects that exist independent of human thought
2. The objects/entities may not be observable and different individuals may formulate different understanding of transitive realities based on their own paradigmatic and metaphorical standards
3. By presenting the concept of epistemic relativism, critical realism rejects the idea of theory of truth
4. Critical realism takes science to mean something more than science and not conventionally derived empirical and observable generalizations about the world
5. The concept of science put forward by positivists has little role in thoroughly explaining actual scientific practice except for helping scientists explain their point of view about the world
6. Critical realism puts forward an epistemological defence of causal explanation by suggesting that we can understand cause and effect better by exploring the underlying mechanisms, otherwise unobservable, using 'retroduction'

Figure 2.1: 'Six key elements of critical realist thought adapted from Johnson and Duberley (2000, pp. 154)

Apart from Bhaskar, critical realism has had significant contributions from many particularly Margaret Archer and Andrew Sayer. Archer (1995) is known for 'elisionism' whereby her morphogenetic theory presents a complex account of the interdependent yet separate nature of structure and agency. People influence structures due to their actions while structures influence people through their contextual influences. However, recognizing the separate nature of structure and agency enables us to understand the causal mechanisms underlying context dependent social phenomena. Compared to Archer, Sayer (1992; 2000; 2004) presents a more useful case for how critical realism can be applied to bridge the gap between theoretical and empirical (a major concern for many researchers). Using actual research examples he eloquently describes the key concepts underlying critical realist thought. These include 'objects' and underlying 'components', 'events', 'necessary and contingent relations', 'mechanisms' and 'causal powers'. Thus Sayer has demonstrated the methodological application of critical realism to the wider social sciences' community. It is for this reason that his work is a major influence on this research (demonstrated in ensuing chapters especially Chapters 6, 7).

2.6. Acknowledging Limitations of a Critical Realist

Critical realism, like other paradigms, also faces some questions that are difficult to answer. For instance, a potentially difficult issue to resolve is the difficulty in knowing whether the intransitive structures (metaphysical ontology) that researchers have constructed are merely their imagination or real and non-empirical depictions of the actual truth. Also, by rejecting the possibility of theory-neutral observation, establishing the truth of our epistemic transitive constructions of reality would be difficult (Johnson & Duberley, 2000).

There have been attempts to address some of these criticisms by bringing in influences from the pragmatic school of thought or pragmatism. According to Rorty (1998) via Johnson and Duberley (2000) in order for knowledge to be considered useful and valid it has to be supported by the pragmatic consensus of people who use a mutually comprehensible language for communicating with each other. Since this language can change from one community to another, truth and reality are changeable according to variations in language.

Sayer (1992) differentiates between 'thought objects' and 'real objects' by pointing out that there indeed is as external reality independent of human mind but it also is resistant to it and thus will remain unknowable. Emphasizing the need to understand the world in terms of our conceptual resources he however points out that these resources;

> *'…do not determine the structure of the world itself. And despite our entrapment within our conceptual schemes, it is still possible to differentiate between more and less practically adequate beliefs about the material world. Observation is neither theory-neutral nor theory-determined but theory-laden. Truth is neither absolute nor purely conventional and relative.'*
>
> (Sayer, 1992, pp. 83)

Bhaskar (1989b) himself implies a more realistic or pragmatic solution to the problem with retroduction pointed out earlier. He suggests that although social theory is influenced by the society and has consequences for it, this cannot be implied to suggest that a social theorist can 'construct' social reality. Further;

‘Realists don’t have to assume that the truth of statements, theories or discourses is an all-or-nothing, absolute matter. The relationship has an emphatically practical character, so that we may infer to talk of degrees of practical adequacy, and of progress in terms of ‘epistemic gain’ rather than establishing absolute truth about some situation once and for all, whatever that might mean.’
(Sayer, 2004, pp. 7 – 8)

2.7. Construing Critical Realism

Figure 2.2 provides an understanding of the paradigmatic influence for this research. In developing this understanding influence has been drawn not just from Bhaskar (1989b; 1991; 1997) and Sayer (1992; 2004) but also Johnson and Duberley (2000) and Collier (1994).

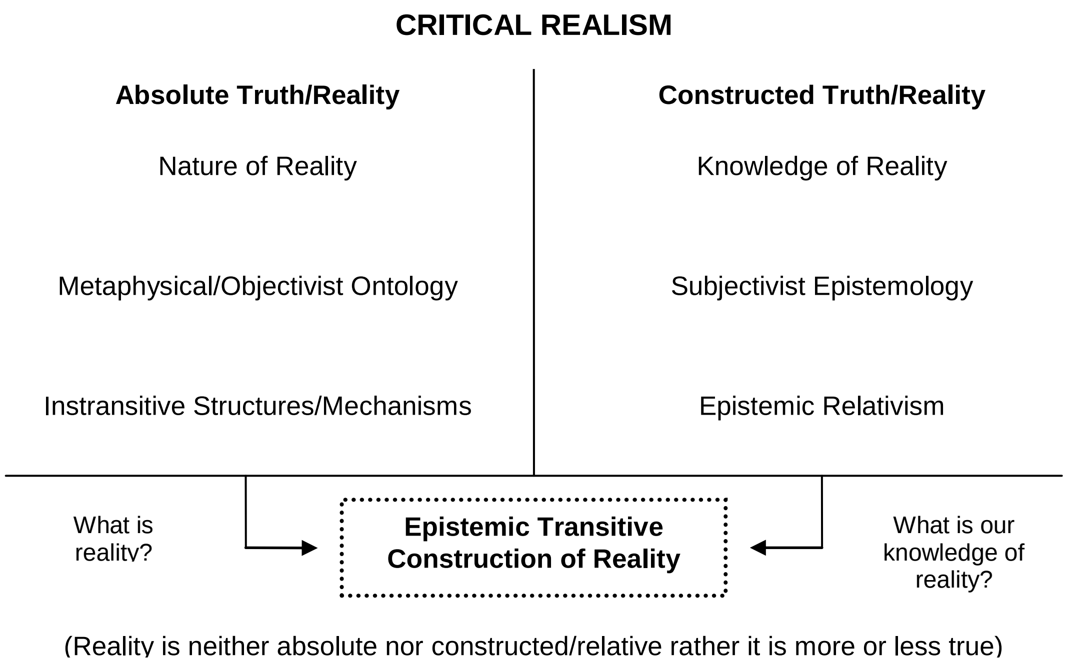


Fig. 2.2: An Interpretation of Critical Realism

2.8. Linking Tenets of Critical Realism with This Research

Three main factors help describe the compatibility of this research study and the paradigmatic influence. They are provided below;

2.8.1. Nature of the Marble Sector

Separating the natural world from the social world, as espoused by critical realists suits this research study in terms of the sector being studied. Marble in essence is a natural resource located in mountainous terrains. It has been lying there for thousands of years till discovered with a beneficial use. Consequently the marble industry presents a relevant scenario where the natural world and social world interact. The stone itself is a natural resource but its conversion into various commercial products is a result of human interactions with this natural world. The products, processes, technologies, equipments and others are objects with a natural existence but it is how the social world comprising of humans interacts with these objects that really results in events (occurences of low-tech innovation). While this research recognizes the difficulty of truly understanding the natural world, it attempts to present this world based on an understanding of the social world. Table 2.2 below provides these interpretations;

Some Examples of Natural World (Metaphysical/Objectivist)	**Some Examples of Social World (Subjectivist – The 'Empirical')**
Marble mountains/mines	People/firms in the marble business especially firm owners/managers
Mining technologies or machineries/equipments	Other individuals and stakeholder organizations
Mining processes	Perceptions of good quality marble vs. bad quality marble
Raw marble	Perceptions of improved/innovative products and processes
Production process technologies or machineries/equipments	Perceptions of low-tech innovation
	'Human' involvement in mining and production processes
Production processes	Marble markets and customer demand
Semi-finished and finished marble products (shapes, sizes, colours)	Marble firms' organizational structure made up of people
	Knowledge, learning processes having human characteristic

Table 2.2: Interpretations of the Natural and Social World for Marble Sector

Table 2.2 suggests the presence of many factors in the marble industry that can influence low-tech innovation. These include technologies, knowledge, learning processes, demand, customers, stakeholder organizations, individuals present in marble firms, different production processes, different product forms and others. Thus it suggests the non-linear, interactive and systemic nature of innovation (Heidenreich, 2009; Hirsch-Kreinsen, 2008a; Fagerberg, 2005; Rothwell, 1992; Teece, 1989; Kline & Rosenberg, 1986). This aspect is discussed in more detail in Chapter 3. The system-based view of LT innovation also corresponds well with critical realism (discussed in Chapter 3). Explaining 'stratified ontology' critical realists like Lawson (2003) and Sayer (2000) argue that reality is like a structured open system where the 'real', the 'actual' and the 'empirical' are interrelated. Like critical realism, objects in a system can also be conceptualized as having causal relationships whereby events are the 'empirical' aspect of the system (Mingers, 2000).

2.8.2. Neither Deduction nor Induction

As pointed out in Chapter 1, this research focuses on understanding the event or phenomenon of LT innovation in marble sector of north-west Pakistan. Case study approach is being applied influenced from Yin (2003) (Chapters 7 and 8). Research outcomes will not be generalized to other LT sectors in the region or countries by applying deduction as perspectives of specific key stakeholders are being sought including marble firm owners and managers. Thus taking a positivist stance is irrelevant here. Similarly, the research does not propose to generate new theory. Even though it seeks to develop an in-depth understanding of LT innovation guided by respondent data, it does not argue that the reality of LT innovation interpreted by respondents is the 'absolute truth' about LT innovation itself. Consequently induction is not being applied either. Rather, retroduction (the approach underlying criticism) is found to be more suitable since it focuses on describing the mechanisms that cause the event of LT innovation in marble firms or whose absence explains the lack of it. Applying mixed methods (explained in Chapter 8), that are iterative in nature data has been collected and analyzed to gather 'epistemic gain' rather than the absolute truth about LT innovation.

2.8.3. Nature of Research Aim, Objectives and Questions

The overall research aim, objectives and questions (Chapter 1) focus on objects like system, sector, firms, other organizations, products, processes, technologies, institutions and others in order to understand their influence on events (occurrences of low-tech innovation). Words like 'how' and 'why' dominate research objectives and questions. This suggests the study's focus on explaining the mechanisms underlying events due to the causal powers of these objects. Thus critical realism and the purpose of research complement each other.

2.9. Conclusion

This chapter introduced the paradigmatic foundations for the research. In doing so ontological and epistemological considerations and ensuing 'paradigm wars' were discussed to highlight the difficulties a researcher faces in choosing a particular philosophical perspective. While discussing critical realism, key works of Roy Bhaskar, Andrew Sayer and others have been reviewed and interpreted. In light of critical realism's basic tenets interpretations are drawn for this research, the marble sector and low-tech innovation to demonstrate why this paradigm has been chosen.

Chapter Three

PLACING 'LOW-TECH' ON THE INNOVATION LANDSCAPE

'There seems to be something inherently "human" about the tendency to think about new and better ways of doing things and to try them out in practice. Without it, the world in which we live would look very, very different.'
(Fagerberg, 2005, pp. 1)

3.1. Introduction

In order to understand innovation questions like what it means, how it manifests itself and what are its different levels have been given considerable attention in research. However, other fundamental questions concerning how innovation occurs, what are its determinants and how it can or should be managed have been more difficult to answer. Provided below is Rothwell's (1992) chronology of our attempts to address these questions;

ROTHWELL'S FIVE GENERATIONS OF INNOVATION MODELS/PROCESSES	
Generation	**Key Features**
First *(1950s to mid 60s)*	Simple linear model based on 'technology push' and R&D
Second *(mid 60s to early 70s)*	Simple linear model based on 'needs pull' or 'market pull'
Third *(early 70s to mid 80s)*	Coupling model that underscores interaction & feedback loops (technology push and market pull)
Fourth *(early 80s to early 90s)*	Parallel model with emphasis on linkages & alliances through upstream & downstream integration
Fifth *(early 90s and onwards)*	Systems integration & extensive networking, focus on continuous innovation with flexible & customized response

Table 3.1: Adopted from Rothwell, R. (1992) and Tidd, J. & Bessant, J. (2009)

Influenced from Schumpeter Mark I and II (Nelson & Winter, 1982; Kamien & Schwartz, 1982), the first three generations viewed innovation as a linear process whereby R&D was considered the key determinant. This popular view led to a 'high-tech myopia' (Von Tunzelmann & Acha, 2005). Consequently, low-tech industries characterized by limited or no R&D remained 'the forgotten sectors in innovation policy' (Hirsch-Kreinsen, 2008a) resulting in lesser research on low-tech innovation.

This chapter emphasizes that innovation (including low-technology innovation) is a non-linear process with many dimensions in management literature (fourth and fifth generations in Table 3.1). Different meanings assigned to innovation, different interpretations of its manifestation, levels and determinants have been presented through the literature review. Using this discussion a model has been developed that helps place low-technology innovation on a wider innovation landscape and emphasizes its systemic nature and relevance with regards to the more popular high-tech innovation. Moreover, deriving from the fifth generation (Rothwell, 1992), this chapter argues for the systemic nature of innovation, why 'systems' thinking is the appropriate choice for understanding low-technology innovation and how critical realism (Chapter 2) and systems thinking are interrelated..

3.2. Nature of Innovation

The pioneering works of Joseph Schumpeter in earlier 20th century played a crucial role in understanding innovation. Initial work – Schumpeter Mark I – describes innovation in terms of the technological ease with which a firm enters an industry and the crucial role played by new and small businesses to challenge the incumbents (Schumpeter, 1934). However, Schumpeter Mark II suggests that large firms with greater resources to conduct R&D form the driving force for innovation and also serve as barriers to new and small firms (Schumpeter, 1942). It is obvious from these opposing stances that there was a lack of agreement at the very outset about what innovation means and how it occurs.

To understand innovation it is important to differentiate it from invention, another closely associated concept. Fagerberg (2005) describes invention as the first occurrence of an idea. Innovation is the attempt to put this idea to commercial use. Thus invention and innovation have a time lag sometimes of several decades (Rogers, 1995). Both are continuous processes whereby it is not the invention per se but the subsequent improvements that are vastly important (Kline & Rosenberg, 1986). Supporting the process view Fagerberg (2005) suggests that innovation is a 'series of changes' whereby various factors influence each other resulting in a 'systems perspective'. This is associated with Rothwell's (1992) fifth generation model discussed later in this chapter.

3.3. Manifestation of Innovation

Schumpeter (1939) via Reisman (2004) describes innovation as setting up a new production function. This offers a simple classification including product, process, marketing and organizational innovations (Tidd et al., 1997). Product and process innovation are two dominant forms (Kirner et al. 2009; Fagerberg, 2005) whereby product innovation is the commercialization of a technologically distinct product (Dougherty, 1992), 'new products or services introduced to meet an external market need' (Damanpour and Gopaiakrishnan, 2001, p. 47) and the most natural force driving continuous change in an organization (Nonaka, 1994; Danneels 2002). It helps firms integrate their dispersed knowledge in innovative ways (Kogat & Zander, 1996) that leads to new knowledge creation (Helfat & Raubitschak, 2000). Product innovation is critical for sustaining the firms' competitive advantage (Li et al., 2009), a critical success factor especially for manufacturing enterprises (March-Chorda` et al., 2002) and a key influence on a firm's long-term performance (Lemon & Sahota 2004; Montalvo 2006). Factors influencing product innovation include a firm linking technical opportunities with customer needs (Karlsson & Olsson, 1998; Dougherty, 1992), firm's dynamic capabilities including knowledge creation and absorption (Verona & Ravasi, 2003) and its organizational learning capabilities (Alegre & Chiva, 2008).

Process innovation is the second key contributor to a firm's growth (Cohen & Klepper, 1996), a 'catalyst' for dynamic cost reduction (Hatch & Mowery, 1998), vital for a firm's long-term profitability (Furnsinn et al., 2007), productivity (Parisi et al. 2006) and competitive advantage (Cefis & Marsili, 2005). Other interpretations include technical innovation (Chiesa et al., 1996; Santos-Vijande & Alvarez-Gonzalez, 2007) and administrative innovation (Zajac, 1991; Kim et al., 2006). The former relates to an organization's primary work activity (Damanpour, 1988 via Ibarra, 1993) while the latter is concerned with improvements in administrative techniques and the organization of economic activity (Teece, 1980). Both forms of innovation are influenced by a number of individual, organizational and contextual factors (Kimberley & Evanisko, 1981) including supportive leadership and teamwork cohesion (Montes et al., 2005). Two other forms of innovation identified in the literature are component innovation and architectural innovation. Used for technological products the former concerns product improvements through its components while the latter is related to the way the product is integrated into the system (Henderson & Clark, 1990; Mikkola, 2003). Other versions of architectural innovation relate to dynamic capabilities used by multi-business corporations to reconfigure divisional resources (Galunic & Eisenhardt, 2001) and how firms adopt innovations at different stages of the innovation life cycle (Westerman et al., 2006).

3.4. Levels of Innovation

Considerable literature focuses on the levels of innovation. Tidd and Bessant (pp. 21, 2009) highlight four dimensions of innovation space, 'product', 'process', 'position', and 'paradigm'. Moreover, there are three extents of innovation, incremental, radical and transformational or disruptive (Tidd et al., 1997; 2001). Incremental innovation is progress made in small steps (Schwery et al., 2004), 'marginal' or continuous in nature, while 'radical' is completely new or the 'technological revolutions' (Freeman & Soete, 1997). Also, radical is a 'breakthrough which creates a new trajectory' (Tidd and Bessant (2009, pp. 253), adapted by larger firms (Dewar and Dutton, 1986) and small entrepreneurial firms (Leifer et al., 2000). However, many times realization of benefits from radical innovation has resulted from the incremental improvements (Fagerberg, 2005; Lundvall, 1992). Literature reveals different research perspectives on radical innovation. For example, cannibalization of a firm's own investments (Chandy & Tellis, 1998), dynamics within pharmaceutical industry (Cardinal, 2001) and telecommunications sector (Grover et al., 2007), influence of firm's tacit knowledge and project teams (Mascitelli, 2000), strategic market orientation (Zhou et al., 2005) and external knowledge (Phene et al., 2006).

Capturing another aspect of the degree of novelty is disruptive, discontinuous or transformational innovation. Such innovations are directed towards the low-end of a market and offer simpler solutions to customers compared to mainstream products (Vuola & Hameri, 2006; Chritensen, 1997; Bower & Christensen, 1995). Examples of different research perspectives on disruptive innovation include for example, how established firms should respond to them (Gilbert & Bower, 2002), small firms' advantage in commercializing them (Kassicieh et al., 2002) and challenges firms face in adapting them (Birkinshaw, 2007). Other perspectives include understanding such innovations through the comparison between private and public sectors (Bessant, 2005); through a theoretical model for new product development (Reid & Brentani, 2004) and marketing process (Lynn et al., 1996). However, the need for more research (Daneels, 2004) and differentiation among different types of disruptive innovations Markides (2006) are stressed.

3.5. Determinants of Innovation

As emphasized in Section 3.1, even though a plenty of academic literature on innovation has been developed, a precise prescription concerning factors influencing it has been difficult to find. As competition intensified in the mid-80s and product life-cycles shortened attention in developed economies shifted to the integrated nature of innovation processes. Consequently, the fourth generation integrated perspecive and fifth generation system/network perspective view innovation as essentially a non-linear, cross-functional and multi-actor process (Rothwell, 1992). The system perspective (increasingly studied since the early 1990s) emphasizes the vertical linkages with suppliers and customers and horizontal linkages amongst firms to realize innovation. Consequently R&D, 'technology-push' and 'market-pull', traditionally perceived as key influencers, are just a few of the many other innovation determinants.

3.6. The Case for LT Innovation

Deriving from the long-held linear view, developed countries of the post-industrial revolution mainly invested in R&D-intensive high-technologies (HT) to achieve innovation success and economic growth. However, as the realization came that innovation is a much more complex and multidimensional process that should be viewed in the context of a system (Rothwell, 1992), attention also shifted to other forms including low-tech (LT) and low- and medium-tech (LMT) innovation. Influenced from the OECD, industries have been classified into three types; HT sectors (R&D intensity of above 5 percent), LMT sectors (R&D intensity between 0.9 and 5 percent) and LT (R&D intensity between zero and 0.9 percent) (Hirsch-Kreinsen, 2008b).

Of late there has been an increasing focus in literature on how innovation occurs in the LT and LMT sectors. Evidence of a reviving interest is the special issue (April, 2009) of the Research Policy journal on 'Innovation in Low- and Medium-Technology Industries'. This is noteworthy because LT has been the 'forgotten sector in innovation policy' (Hirsch-Kreinsen, 2008a). The increasing attention derives from growing criticism of the 'high-tech myopia' which assumes that economic growth primarily results from innovation in the HT sectors driven by R&D (Von Tunzelmann & Acha, 2005). Identifying reasons for this HT bias Radauer and Streicher (2007) suggest that these industries grow faster strengthening the belief that they contribute more to economic growth. However, the argument favouring HT is relatively weak because even in the developed economies LT and LMT sectors comprise a dominant portion of national economies (Bender, 2004; Hirsch-Kriensen & Jacobson, 2008). They contribute more than 90% of growth output in highly developed economies (Robertson et al., 2009) as well as dominate developing countries.

3.7. The Systemic Nature of LT Innovation

As discussed in Section 3.5, Rothwell's (1992) fifth generation of innovation models that emerged in the 1990s stress that innovation is a non-sequential process that is part of an overall innovation system comprising many factors. Alluding to complexities, Teece (1989, pp. 35) points out the 'extremely variegated' institutional structure of innovation that 'involves a complex network of backward, forward, horizontal, lateral relationships and linkages within, among and between firms and other organizations'. Opposing the 'linear process' view, Kline and Rosenberg (1986, 275) observe that innovation is 'complex, uncertain, somewhat disorderly, and subject to changes'. It is 'a series of changes in a complete system of hardware, market environment, production facilities and knowledge, and the social contexts of the innovation organization.' The social context underscores importance of the human influence on innovation.

Underscoring its systemic nature Hirsch-Kreinsen (2008a) argues that instead of relying on intensive R&D LT innovation can result from many other factors including incremental product improvements, customer-focus and 'optimisation' of processing technologies. Additionally, it can also occur as a result of tacit and experiential knowledge as well as formal/informal diffusion of knowledge and learning amongst LT firms (Jacobson & Heanue, 2005 via Heidenreich, 2009). Using evidence from case studies of 43 LT/LMT sectors in 9 EU countries Hirsch-Kreinsen (2008a, pp. 38) concludes that these sectors are 'innovative in a very specific way' especially when compared to high-tech. Provided below is an analysis of LT innovation;

Factors	'Innovation modes' in LT sectors
'Key drivers'	New technologies, market demand
Strategies	Broad, mainly incremental & architectural
Firm size	Predominantly SMEs
'Knowledge-base'	'Internal:' reliance on practical knowledge, [possibly implicit] 'External: codified'
Firm capabilities/competences	Reliance on management & unskilled workers
Links with institutions	'Loose coupling with most institutional conditions other than industrial structure' [sectoral structure]

Table 3.2: Analysis of LT Innovation Adopted from Hirsch-Kreinsen (2008a, pp, 39)

Table 3.2 underscores the systemic nature of LT innovation that is characterized by the interplay of many factors (including human/social aspects) internal and external to a firm.

3.8. Placing 'LT' on the Innovation Landscape

Deriving from discussions (Sections 3.3 to 3.7) the diagram below places LT innovation on the innovation landscape.

Figure 3.1: Placing Low-Tech on the Innovation Landscape

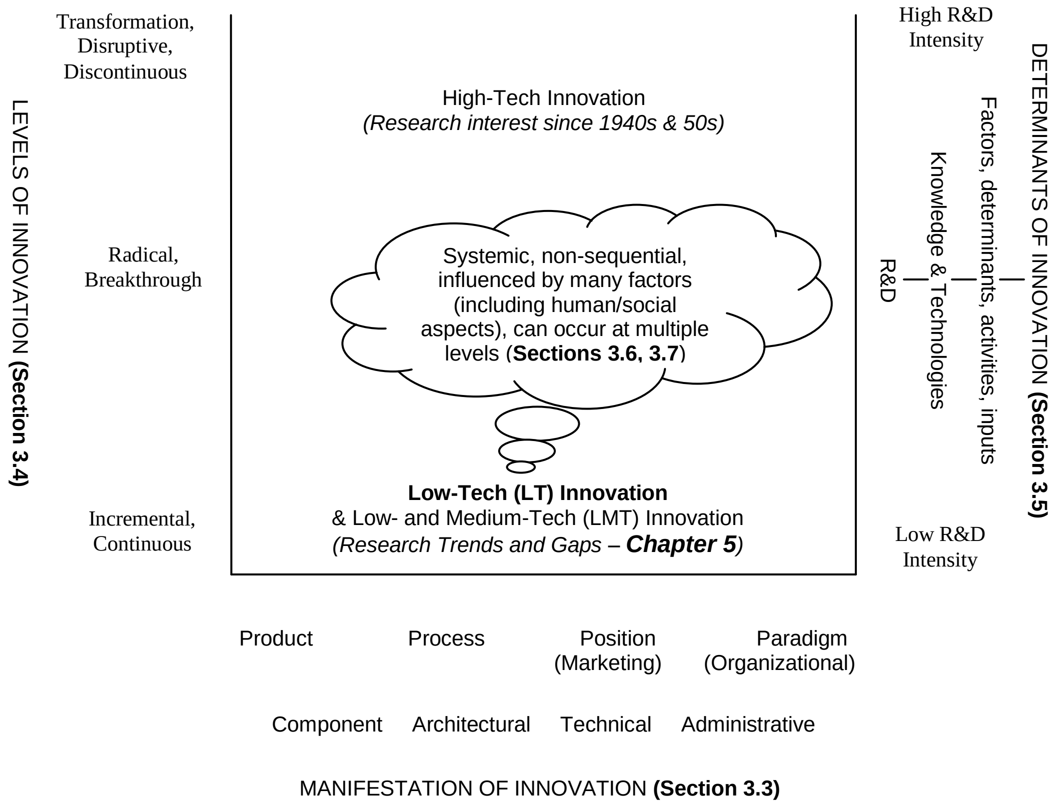


Figure 3.1 shows that like other forms of innovation LT innovation can occur at multiple levels, is non-linear in nature, and influenced by many factors whereby R&D is not the key determinant. It further illustrates the key differences between LT innovation and the more researched HT innovation as well as their relative placement across a wider innovation landscape. This further underscores the systemic nature of LT innovation.

3.9. The Appropriateness of Systems Thinking for LT Innovation

Linking with Rothwell's (1992) work cited earlier, 'systems' perspective is one of the key approaches in management sciences. The concept of socio-technical system emerges from the two dominant perspectives of systems methodology; hard systems and soft systems. Hard systems are characterized by pre-specified 'objectives' and 'ends' (Jackson, 1991). However, many critics of hard systems (Rosenhead, 1989; Checkland, 1983; Ackoff, 1979) argue that determining objectives in social and managerial scenarios characterized by humans is part of the problem. Different social actors have different understandings of problems and define objectives accordingly. Hard systems are ‘highly selective’ due to ‘quantification’ and ‘optimization’ resulting in biases that fail to provide a true picture of reality especially in complex systems involving humans. To help account for multiple perceptions of reality and deal with complex phenomena/problems soft systems approach is considered more appropriate. Because of hard systems’ failure to tackle with the human element, the concept of socio-technical systems is put forth that conceives organizations within open systems. Such systems achieve desired ends through optimization of social, technological and economic elements (Jackson, 1991, pp. 80-81). They have both hard and soft dimensions including human interactions in the form of social groups. Deriving from Table 3.2 and Figure 3.1, it is evident that LT innovation involves many factors (including multiple social actors and their perceptions of reality). This adds to the complex nature of LT innovation whereby systems thinking is an appropriate way to try and understand it better.

Despite differences, two commonalities amongst all systems perspectives exist; (a) their focus on ‘holism’ or looking at the world in ‘wholes’ and (b) acknowledging the ‘cognitive’ nature of systems (Jackson, 1991, pp. 07). The overall aim of this research is to generate an in-depth understanding of the existence/non-existence of low-technology innovation by explaining all the elements and structure of low-tech sectoral system of innovation (SSI). This requires taking a holistic and non-‘reductionist’ view of the world (the marble industry). Moreover, human beings organize their knowledge of the world into ‘cognitive systems’ that are ‘structured frameworks linking various elements of this knowledge into cohesive wholes’ (Jackson, 1991, pp. 07). Shown in Figure 3.1, our understanding of low-tech innovation is structured around our concept of innovation, its manifestation and levels. Moreover, the realization that multiple determinants/factors influence LT innovation leads to a cognitive view of LT innovation’s systemic nature.

Two other tenets of systems thinking are interconnectedness and emergence. Emergence is the way in which systems manifest themselves in the form of structures or patterns and have properties while interconnectedness refers to the interactions and linkages among various components that result in forming a system (Corning, 2002). These characteristics of systems approach are important because they help offer better insights into this research. As evident from the research objectives (Chapter 1), this study focuses on understanding low-technology innovation in marble sector of north-west Pakistan whereby the sector manifests itself as a system of innovation comprising of interconnected elements (marble firms, other organizations, products, technologies, knowledge, others) that form the structure of the system due to their interactions. Fagerberg et al. (2005) point out that a central finding of innovation research is that firms do not innovate in isolation. Interactions with customers, suppliers, distributors, competitors and various other organizations (public and/or private) play a key role. Thus a 'system' approach is more appropriate and useful in understanding these interactions.

3.10. Critical Realism as an Underpinning Philosophy of Systems Thinking

Chapter 2 has argued for critical realism as the paradigm underpinning this research whereby reality is intransitive and stratified (the real, the actual and the empirical) (Fairclough, 2005). Although 'objects' have an intransitive character our knowledge of these objects is subjectivist and involves the work of humans (Bhaskar, 1997). Here the systems based view corresponds well with critical realism's view of stratified reality. The events we experience (the actual) are 'causally generated by the structure of underlying systems'. Within a system, various objects or components having causal relationships interact with each other (the real). These interactions within the system result in events (the actual) while some of these events within the system, if not all, are observable (the empirical) (Mingers, 2000, pp. 1264). Explaining this notion of 'stratified ontology' critical realists like Lawson (2003) and Sayer (2000) reject the concept that the society, economy and social systems are closed systems. Rather they argue that reality is like a structured open system where the 'real', the 'actual' and the 'empirical' are interrelated. Moreover, referring to the notion of 'cognitive systems' common among most systems thinkers (Jackson, 1991), it can be argued that our knowledge of the world and systems is a result of our cognitions related to our ability to identify and observe the 'empirical'. Also, critical realism is more suited to systems thinking as it deals with the natural and social sciences thus catering to both hard and soft systems perspectives. Critical realism while cognizant of the ‘real’ (natural) recognizes meaningfulness of social interaction (social) (Mingers, 2000).

3.11. Conclusion

This chapter reviewed literature to help place low-technology innovation – an important but lesser researched concept and the focus of this study – on a broad innovation landscape. Taking influence from Rothwell’s (1992) five generations of innovation models the chapter emphasizes the non-linear and systemic nature of LT innovation. Further it espouses the appropriateness of systems thinking for studying LT innovation and links it up with critical realism.

Chapter Four

CONCEPTUAL FRAMEWORK

> *'[Having an] instrumental view of theory is particularly useful because it treats theory as a tool to structure inquiry.'*
> (Shields & Tajalli, 2006, pp. 314)

4.1. Introduction

This chapter presents the conceptual framework that helps structure the research idea to give greater relevance to research objectives and questions. Four major approaches to studying innovation are discussed to highlight differences. Advocating the use of system of innovation (SI), strengths of the approach are highlighted to demonstrate appropriateness for this research. Then weaknesses (theoretical gaps) of the SI are pointed out to suggest how this research can improve our understanding of SI. The focus then shifts to sectoral systems of innovation (SSI) – a key variant of SI. The discussion includes SSI's theoretical underpinnings, three building blocks of SSI, and benefits SSI offers to a researcher studying low-tech innovation. Further, influenced from the micro-meso-macro framework applied as an analytic structure to understand an evolutionary economic system, the same is interpreted for marble-SSI by underscoring the relationship between the framework and SSI. The chapter concludes with a conceptual framework diagram that takes influence from critical realism (Chapter 2 and 3), systems thinking (Chapter 3), SSI, and micro-meso-macro analytical framework.

4.2. Approaches Used to Study Innovation

Derived from Rothwell (1992) (Chapter 3), the broadly accepted view among researchers is that innovation is a non-linear multi-factor process that is systemic in nature and takes place within a system having hard and soft dimensions (Kline & Rosenberg, 1986). However, within this broadly accepted view there are various approaches to studying innovation. Table 4.1 below provides four major ones with the key differences amongst them;

Approach	Differences based on conceptualization of actor/factors/relationships
Innovative Milieu	Underscores the importance of informal relationships amongst local firms including 'protagonists' as well as soft factors such as common understandings of behaviours/attitudes towards innovation
Innovation Networks	Based on specific relationships amongst actors both in a region and beyond contributing to innovation. It underlines the motives for cooperation amongst firms such as technological complementarities and access to particular resources and knowledge
Clusters & Knowledge Spill-overs	Argues that the spatial concentration of firms and supporting organizations in particular industries can contribute to knowledge spill-overs and innovation. However, knowledge flow is considered an externality with unclear mechanisms
Systems of Innovation (SI)	Argues that it is the institutions relevant to a nation, sector or region and their relationships that influence innovation. These include regulatory frameworks, organizations generating and diffusing innovation and the firms that commercialize such knowledge

Table 4.1: Innovation Approaches Adopted from Todtling et al. (2009, pp. 60)

'Innovative Milieu' approach combines three paradigms (1) the technological paradigm focusing on innovation, know-how and learning, (2) the organizational paradigm stressing the importance of networks, cooperation amongst firms and competition and (3) the territorial paradigm emphasizing proximity and region-based competition (Crevoisier, 2004; Maillat, 1998; Shefer & Frenkel, 1998). Innovation 'network' is a 'complex, interconnected group or system' that can be conceptualized as a hybrid organization consisting of firms and markets (Tidd & Bessant, 2009). Networks include formal contractual relations amongst firms as well as informal ties (Powell & Grodal, 2005) and are characterized by firms' collaborative access to relevant external competencies (Katzy & Crowston, 2008). The 'cluster' concept considers geographic concentrations of interconnected companies, specialized suppliers, service providers and associated institutions in a particular field or area (Porter, 2003). Clusters have advantages such as shared infrastructure cost, development of skilled labour, transaction efficiency and knowledge spillovers contributing to a firm's innovation Malmberg and Maskel (2002) however, clustering alone cannot create conducive conditions for innovation (Beaudry & Breschi, 2003). 'Systems of Innovation' or SI approach focuses on interactions and relationships between technological development and the institutional embeddedness of innovative firms (Freeman, 1987; Lundvall, 1992; Nelson, 1993). While Lundvall (1992) opines that the 'structure of production' and 'institutional set-up' form the two dimensions of SI, Edquist (2005) describes the system as consisting of economic, social, political, organizational, institutional and other factors influencing innovation.

4.3. System of Innovation (SI) Approach

The system of innovation (SI) concept influenced from systems thinking was first presented by Freeman (1987) and later developed by Lundvall (1992) and Nelson (1993). It encapsulates the systemic nature of innovation (Chapter 3). Three major variants of the SI approach are national system of innovation (NSI) (Edquist, 2005; Nelson, 1993; Lundvall, 1992), regional system of innovation (Asheim & Gertler, 2005; Doloreux, 2002; Cooke, 2001; 1998; Asheim, 1995) and sectoral system of innovation (Malerba, 2005; 2004; 2002; Breschi & Malerba, 1997). For NSI Lundvall (1992) lays greater emphasis on theory development based on learning and interactions amongst various objects. Nelson (1993) on the other hand emphasizes empirical case studies focusing on a nation's R&D systems. Studies like Brackzyk (1998), Cooke (1998; 2001) and De la Mothe & Paquet (1998) explain the SI concept not just at the national level but also local, regional and in some cases global levels. Other variants include Technological SI (Montresor, 2001) with technologies at the centre and Distributed SI (Andersen *et al.*, 2002 via Malerba, 2005) with innovation at the centre of a spread-out system. Table 4.2 below adopted from Edquist (1997; 2005, pp. 181-208) helps provide a simple understanding of the SI concept.

Concept	Description
Constituents of SIs	Components + relations amongst components
Main Components in SIs	Organizations and institutions
Organizations	Formal structures (actors) with an explicit purpose
Institutions	Sets of common habits, norms, routines, established practices, rules/laws that regulate relations between individuals, groups and organizations and form incentives or obstacles to innovation
Function of SI	To develop, diffuse and use innovations
Activities in SI	Factors/determinants that influence the development, diffusion and use of innovations

Table 4.2: Understanding SI Concept Adopted from Edquist (2005, pp. 182)

Like other approaches Edquist (2005) points out strengths and weaknesses of the SI approach. The strengths underscore the appropriateness of using SI approach for this research while outcomes from this study can help address some of the weaknesses. Table 4.3 below illustrates this;

Strengths of SI approach (Edquist, 2005)	**Appropriateness for this research**
Innovation is at the centre of the system contrary to other approaches which consider it externally derived	Understanding dynamics of low-tech innovation remains the primary focus
More holistic – includes a wider array of determinants and factors that influence innovation	Providing an all-encompassing understanding that includes all interconnected components of the system influencing low-tech innovation is a priority
Innovation is considered to be evolutionary thus there is focus on real systems rather than determining/describing ideal systems	This research focuses on low-tech innovation in a real system that is marble sector(s) of north-west Pakistan
Innovation is considered to be non-linear influenced by relations and interactions amongst firms and other organizations in the system	This research focuses on understanding low-tech innovation (essentially non-linear in nature) from firm's perspective by focusing on the roles of and interactions between marble mining and processing firms, sector support organizations, government, suppliers, middlemen and other components of the system
The SI lays greater emphasis on studying and understanding the role of institutions.	This research offers empirical evidence on the role of institutions in SI for low-tech innovation
Weaknesses of SI approach (theoretical gaps) -- needs for improving our understanding of SI	**Addressing weaknesses through this research**
'Conceptual diffuseness' in terms of defining boundaries of the system	This research takes influence from sectoral systems approach (discussed later in this chapter) to address this concern
Greater need to understand how organizations (especially firms) and institutions are set-up in SI	This research explores how agents (marble firms and non-firms) and institutions are setup in marble SI
Greater need to understand determinants of innovation in SI and relations among organizations, institutions and determinants	This research answers question like how firms interact with institutions, knowledge, technologies, learning processes, demand (interconnected components of a system)
Greater need to understand which determinants are relevant to which categories of innovation and develop case studies to enhance our systematic knowledge about innovation determinants	This research helps identify determinants (individual, firm and contextual) specific to low-tech innovation by developing a case study of Pakistan's marble industry
Greater need to integrate conceptual and theoretical aspects of SI (organizations, institutions, activities) with empirical studies to help identify determinants of innovation.	This research not only offers empirical evidence regarding determinants of low-tech innovation but also their relative influence thus linking with theoretical aspects of SI

Table 4.3: Appropriateness of SI Approach: to this Research

4.4. Sectoral System of Innovation (SSI)

As pointed out in section 4.3, SSI is one of the key variants of SI approach. The main aspect of SSI is the concept of sector and the benefits it offers to a researcher studying innovation. Malerba (2005) describes a sector as;

> *'...a set of activities that are unified by some linked product groups for a given or emerging demand and which share some common knowledge. Firms in a sector have commonalities and at the same time are heterogeneous.'*
>
> (Malerba, 2005, pp. 385)

The SSI does not place limitations in terms of a location or region (focus of RSI), national (focus of NSI) or international boundaries. Rather it is characterized by having one or all of the above boundaries included in the concept of a sector and focuses on 'linked product groups'. Greater emphasis is laid on understanding the sectoral system in the context of its three building blocks (Malerba (2002; 2005) to be discussed later.

4.4.1. Theoretical Underpinnings: Linking SSI, Systems Thinking and Evolutionary Economics

System of innovation approaches including SSI mostly focus on understanding production or generation of innovation. However, in order for innovation to be truly beneficial it has to be not only produced but diffused and utilized as well. Geels (2004) stresses the need for SSI to take influence from the socio-technical system (a key approach under systems thinking pointed out in Chapter 3, section 3.9). This approach emphasizes the importance of the human actors within a system in addition to technologies and infrastructure. These human actors form interrelated social groups (including firms, non-firms, customers), apply technologies and are influenced by institutions (a key focus of SSI) resulting in the generation, diffusion and use of innovation.

Socio-technical systems approach is useful because it treats a system as open rather than closed. While a closed system by definition does not exchange anything with the environment and acquires equilibrium, the open system behaves in essentially the opposite manner. It exchanges information, energy and matter with the environment and the more these exchanges occur the greater the open system moves away from equilibrium (Jackson, 1991, pp. 48). Thus such systems are characterized by qualitative and structural fluctuations (Saviotti, 1997, pp. 182). The evolutionary theory of economics, that is a key influence on the SSI approach (Malerba 2004) also considers a system to be open, dynamic, undergoing transformation (Banathy, 2000) and having innovation processes. Agents (having humans at their core) with the ability to learn and gain further knowledge demonstrate 'rational' behaviour influenced by their past experiences and cognitions (also a characteristic of systems discussed in Chapter 3, Section 3.9). They operate in this changing environment thus contributing to transformation (Breschi & Malerba, 1997).

Deriving from Nelson (1995) and Dosi (1997), Malerba (2005, pp. 386) states that 'for evolutionary theory, aggregate phenomena are emergent properties of far-from-equilibrium interactions'. This 'far-from-equilibrium' nature of interactions is also a characteristic of open systems under systems thinking (Saviotti, 1997). Similarly the concept of 'emergent properties' refers to emergence, a key characteristic of systems approach highlighted in Chapter 3. Dosi (1997, pp. 1531) elaborates on 'aggregate phenomena' and 'far-from-equilibrium interactions' by pointing out that economic systems are characterized by the presence of agents, their 'imperfect understanding' of the environment and the resultant 'persistent heterogeneity' among agents even though they have access to similar information and opportunities. As a result even though agents use their past experiences, cognitions and capabilities, gain new knowledge and take advantage of opportunities, they contribute to the 'continuous appearance of various forms of novelty' in the economic system. Elaborating on SSI Malerba (2002, pp. 250-251) points out the elements of SSI including (1) products, (2) agents, (3) knowledge and learning processes, (4) basic technologies, inputs, demand and related links and complementarities, (5) mechanisms of interactions both within firms and outside firms, (6) processes of competition and selection and (7) institutions. The SSI structure refers to interactions between these elements. These characteristics are in line with the systems thinking whereby elements come together to develop the ‘whole’ or ‘holistic’ character of the system. Also, technologies, knowledge and other elements transform through improvements leading to transformation of sectoral elements as well as the SSI itself.

Additionally, a key issue that needs to be addressed with regards to any study taking influence from SSI approach is how broadly or narrowly the concept of the system is defined. Malerba (2004) offers the notion of ‘aggregation’ to answer this. Taking a smaller set of product groups and/or agents with specific levels of aggregation (such as individual firms, departments within firms, groups of firms together) would influence whether a sectoral system is being considered narrowly or vice versa. Also, a narrower definition would focus on only specific relationships in a sector while a broader definition would include all linkages amongst various components. Linking the purpose of a research study with how narrowly or broadly the sectoral system is conceptualized Malerba (2005) makes a key point;

> *‘The choice of the level of aggregation depends on the goal of the analysis.’*
> (Malerba, 2005, pp. 387)

Table 4.4 provided later addresses the issue of sectoral system boundaries for this research.

4.4.2. ‘Building Blocks’ of SSI

Deriving from Malerba (2002), Figure 4.1 provides three dimensions of the SSI to help understand them better;

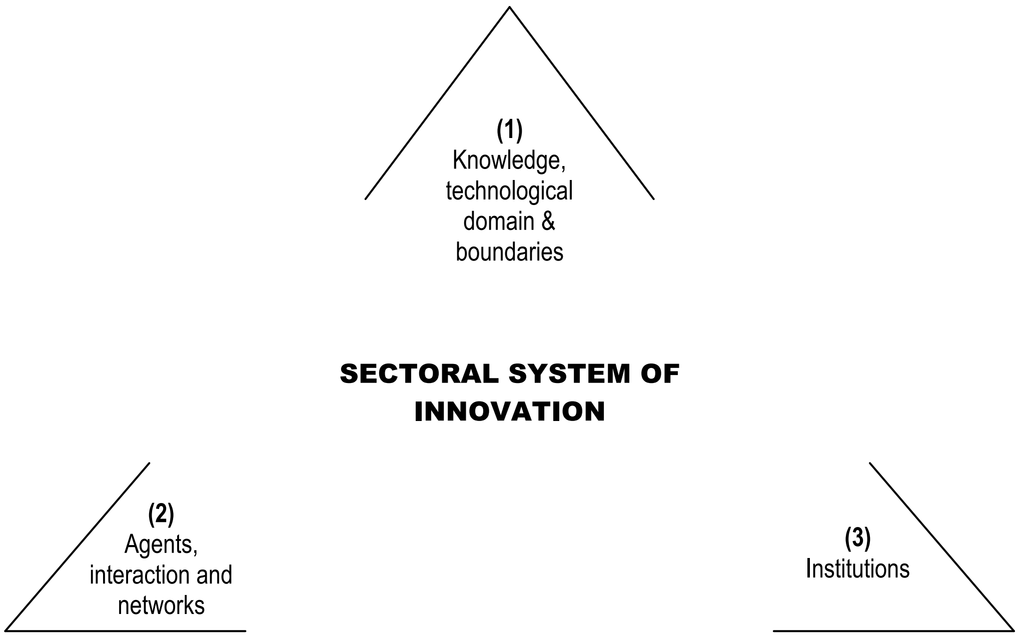


Fig. 4.1: Building blocks of SSI, adapted from Malerba (2004, pp. 17)

Taking the first dimension, innovation is primarily the collective creation of new knowledge or blending existing knowledge in new ways (Freel, 2003). Thus it becomes concerned with learning, a social process, especially when one deals with transferring and accumulating tacit knowledge (Howells, 1996) and is a result of interaction amongst agents. Sectors and their technologies differ from each other in terms of the knowledgebase and learning related to innovation. Also, firms because of their differential capabilities absorb and utilize knowledge at varying degrees (Malerba, 2005) suggesting that knowledge holds peculiar characteristics at the firm level. Two key characteristics of knowledge are (a) accessibility and opportunity and (b) cumulativeness (Nelson & Winter, 1982). Knowledge external to firms may be accessible at varying degrees (Malerba & Orsenigo, 2000). Sectors differ from each other in terms of knowledge and technological opportunities (Freeman & Soete, 1997; Rosenberg, 1982). Knowledge relies on cognition and is shaped by past experience and learning process. In addition to groups of similar products, knowledgebase and technologies also influence sectoral boundaries (Malerba, 2005). However, as Breschi and Malerba (1997) and Malerba (2004) suggest that a sector undergoes co-evolution and transformation mainly influenced by the type and dynamics of demand as well as links and complementarities among sectoral activities.

The second dimension is actors/agents, relationships/interactions and networks. Actors within the SSI include firms, users, suppliers and non-firm organizations. Firms are central to the creation, adoption and usage of knowledge and technologies which in turn is influenced by their beliefs, competences and organization (Teece & Pisano, 1994; Dosi *et al.*1998). Firms are essentially heterogeneous because of their differential capabilities (Nelson, 1995) while users and suppliers have their own capabilities (Lundvall, 1992). Non-firm organizations may include financial institutions, universities and research organizations, government agencies, local authorities, and sectoral business associations (Malerba, 2005). Sectoral agents do not operate in isolation and are interconnected (Lundvall, 1992; Edquist, 1997). Innovations have been triggered in sectors as a result of interactions among firms and non-firms (Nelson & Rosenberg, 1993). These interactions and relationships form the structure of SSI (Malerba, 2005).

Institutions are the third key dimension. While discussing various 'taxonomies' of institutions Edquist and Johnson (1997, pp. 50) point out two broad types; 'formal' institutions having a more 'visible' and 'codified' existence; and 'informal' institutions that can be 'indirectly observed through the behaviour of people and organizations.' Sectors differ from each other because of the different sets of institutions and the differing balance of formal and informal institutions. Institutions provide incentives for innovation but can also act as obstacles due to their stabilising effect in a system (Edquist & Johnson, 1997). Institutions generally tend to be national in terms of orientation (Edquist, 1997) but can also be sectoral whereby studying the relationships between national and sectoral institutions is very helpful in understanding SSI (Malerba, 2005; 2002).

4.5. The Benefits of Using SSI Approach in This Research

In addition to the appropriateness of applying the SI approach argued through the strengths and weaknesses of SI in Table 3.3, using the SSI approach in this research also offers major benefits. Table 4.4 below underscores this;

Benefits of SSI approach (Evangelista & Mastrostefano, 2006)	Concerns addressed for this research
Suitable for studying innovation within a sector or industry	Understanding dynamics of low-tech innovation within marble industry/sector of north-west Pakistan is the overall aim
Focus on 'product groups' and the firm	The central characteristic of marble industry is production of a variety of linked products during mining and processing phases (two distinctly different sub-sectors within the sector) The research is concerned with firm-specific low-tech innovation
More flexible – 'level of aggregation' concept can be used to determine sector boundaries and level of analysis	In line with the research objectives and questions (Chapter 1), boundaries of marble-SSI are being determined through; • The product group that includes all major products produced during mining and processing phases • Marble firms (mining and processing) that are also being used as the units of analysis • Specific relationships that is marble firms' interactions (structure of SSI) with non-firms, knowledge, learning processes, demand and institutions (elements of SSI)
Focus on industry/sector-specific nature of technological regimes	Marble sector is characterised by technological regimes and low-technologies specific to the sector.
Offers descriptive analysis of a sector and a thorough understanding of its working	Generating an in-depth understanding of the existence or non-existence of innovation in marble low-tech sectoral system remains the overall aim of this research
Enables us to better understand elements of a system that are localized and sector-specific	Marble firms (mining and processing), technologies (such as machineries), demand and many institutions have a localized existence peculiar to north-west Pakistan and the marble industry/sector.

Table 4.4: Concerns of SSI Approach Addressed by This Research

4.6. The Analytic Structure of SSI: Applying Micro-Meso-Macro Framework

As evident from theoretical underpinnings, a sectoral system of innovation is socio-technical in nature characterized by multiple levels of innovation and transformation. Agents (with humans and social groups at their core) and other elements interact with each other whereby learning and new knowledge contribute to evolution of the innovation system. It has also been pointed out that SSI take influence from the evolutionary theory of economics. In order to better understand the evolutionary nature of an economic system Dopfer et al. (2004) provide a general analytic structure called the micro-meso-macro framework. Advocating for a wider applicability of this framework, Kastelle et al. (2009) argue that just as one can study real economy in terms of micro, meso and macro perspectives, systems of innovation including SSI that are also evolutionary in nature can be analyzed using a micro-meso-macro framework too. However, in order to understand the applicability of this framework to SSI, it is important to address two aspects;

1. What do the terms ‘micro’, ‘meso’ and ‘macro’ mean from the perspective of an evolutionary economic system
2. How are these terms related or can be interpreted to an innovation system particularly the SSI

The framework originates from the premise that we cannot directly link up ‘micro’ with ‘macro’ from evolutionary perspective of economics and that there exists an intermediate ‘meso’ layer. Dopfer et al. (2004, pp. 263) suggest that an economic system can be understood as a ‘population of rules, a structure of rules and a process of rules’. The economic system is conceptualized as a set of meso units whereby each meso consists of a rule and the collection of its manifestations. The micro consists of individual carriers of rules while the macro is the overall population of all the meso units. While favouring the application of the framework to understand evolution of an economic system Dopfer and Potts (2008) stress that the SI is a component of the overall economic system. Consequently, Kastelle et al., (2009) suggest that while an evolutionary economic system can be analyzed using the micro-meso-macro framework, the same can be done for a system of innovation including SSI. This is because a system of innovation (including national, regional or sectoral) not only contributes to evolution of the economic system but also evolves or changes due to new rules and knowledge generated through interactions between agents within the economic system and those present within the innovation system.

Translating the micro-meso-macro framework to SSI, a micro unit in the system can be a carrier of the innovation such as agents (individual, firm, other organization). A meso unit is the analytic core of the system and consists of the knowledge, idea or innovation and population of all carriers of that innovation (firms and other organizations. A macro unit is a complex system of multiple meso units that altogether form the knowledge-base of the system. Examples of macro unit are a sector, a market or an industry (Kastelle et al., 2009). Because this research studies low-tech innovation in the marble-SSI characterized by very small firms, it is important to account for the influence of the individual (owner, manager of a business) on innovation while taking influence from the socio-technical nature of SSI (Geels, 2004). Table 4.5 elaborates the three levels considered for this research.

Analytical Level	Translation to this research
Micro-individual level	Individuals: owner/manager of marble firm (mining and processing units); key individuals in non-firm organizations (e.g. public or private organizations such as government, distributors, suppliers of technologies, know-how, expertise)
	Activities/determinants of innovation
Meso-firm level	Firms, Non-firms (mining units, processing units, suppliers, distributors, public/private organizations related to marble sector)
	Activities/determinants of innovation, types of products and innovations, interactions among agents (firms and non-firms)
Macro-contextual level	Marble sector of north-west Pakistan
	Activities/determinants of innovation, institutions and their setup, influences of national institutions on sectoral institutions, interactions between firms and knowledge, learning processes, technologies, demand and institutions

Table 4.5: Applying micro-meso-macro framework to marble SSI

4.7. Conceptual Framework Diagram

Based on the discussion about systems thinking and the relationship between critical realism and systems thinking (Chapter 3), SI, SSI and micro-meso-macro framework, the following conceptual framework has been developed that influences this research study.

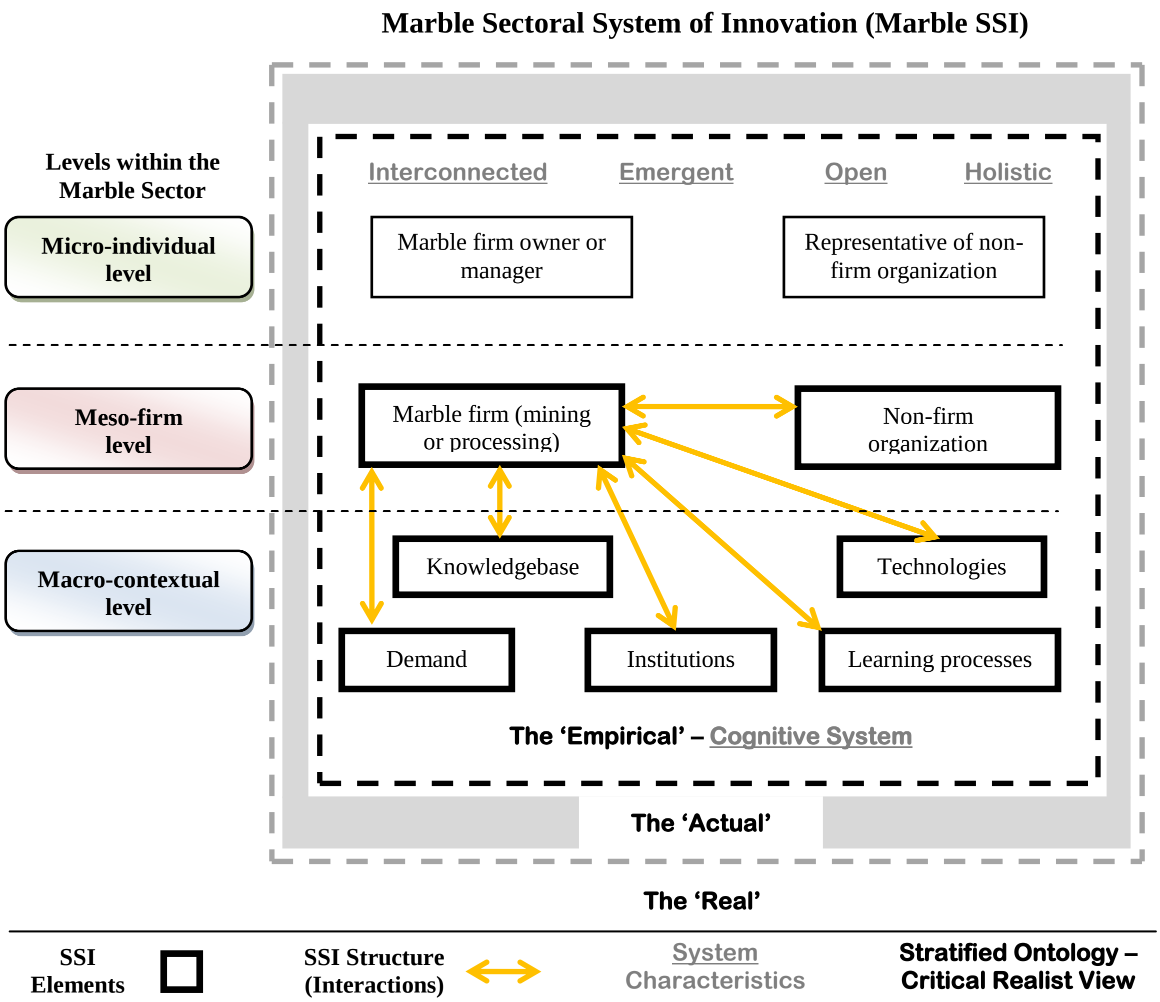


Figure 4.2: Conceptual Framework Diagram

4.8. Conclusion

Chapter 4 helped illustrate the conceptual framework for this research study. This was done by incorporating the influence of systems thinking, critical realism's role in helping us understand systems thinking, the SI particularly SSI approach and the micro-meso-macro analytical framework. Chapter 5 develops a detailed review of literature on low-tech and low- and medium-tech innovation while Chapter 6 helps structure the research aim, objectives and questions. Both chapters take influence from this conceptual framework also.

Chapter Five

INNOVATION IN LT/LMT SECTORS – DISCIPLINARY DEBATES, KEY INSIGHTS AND SYNTHESIS OF LITERATURE

'Knowledge does not exist in a vacuum, and your work only has value in relation to other people's'

(Jankowicz, 2000 via Saunders et al., 2006)

5.1. Introduction

This chapter provides a detailed and systematic review of literature on innovation in low-tech/low- and medium-tech (LT/LMT) sectors particularly that published from 1999 to 2010-11. Existing disciplinary debates on the subject have been assessed, a total of 269 key insights have been identified and empirical work has been synthesized using various techniques. The purpose is to provide an updated account about our understanding of LT/LMT innovation and identify gaps in terms of our existing knowledge as a research community. It helps build the case for structuring research objectives and questions later (Chapter 6).

The current chapter has been structured taking influence from the conceptual framework (Chapter 4) especially the sectoral system of innovation (SSI) including its elements and structure or interactions. This forms the basis for categorization and evaluation of the cited work and relevant critiques. Predetermined criteria were used to select relevant publications. While reviewing literature and writing up the main text of the chapter the focus has been on presenting key findings of research studies. This helps provide a perspective on ongoing debates and point out key insights about various aspects of LT/LMT innovation. Later, the reviewed literature has been evaluated from various dimensions revealing interesting findings. An emerging trend in terms of number of publications per year is found suggesting a possible realization among the research community of the importance of studying innovation in LT/LMT sectors along with high-tech. The reviewed literature has been further subjected to synthesis by highlighting each study's use of methodology/methods, country context, sectors/industries studied and main focus or topic of research. Outcomes suggest a dominant use of quantitative methods – 67% studies (influenced from positivist paradigm) followed by use of qualitative methods – 20% publications (phenomenological perspective). However, very few instances of the use of mixed methods (3%) and a lack of critical realist influence have been found. Most of the studies (83%) focus on developed country and sector contexts with little attention to poor economies and their constituent sectors. The main topics of research studies are found to be diverse and scattered across a wide spectrum making it difficult to identify themes that are interconnected or suggest a sense of direction amongst the research community. The chapter concludes by identifying the specific gaps in terms of our existing knowledge and insights about LT/LMT innovation.

5.2. Structuring Literature Review

In order to have a more objective and transparent synthesis of existing research work, a number of factors have been kept in mind to make the review more logical, understandable, organized and systematic. Greater emphasis is laid on works published from 1999 till present to try and capture more recent perspectives on our understanding of LT/LMT innovation. Wherever found, studies have also been included that take up the systems of innovation especially sectoral perspective in to account. The key sources reviewed include relevant books, journals and any other published and online resources. Online databases accessed include Wiley, InterScience, Elsevier, JStor and others. The list of journals mainly includes the following;

- Technovation
- Research Policy
- R&D Management
- Journal of Product Innovation Management
- Enterprise and Innovation Management Studies
- European Journal of Innovation Management
- Economics of Innovation and New Technology
- Creativity and Innovation Management

- Journal of Business Venturing
- Technology in Society
- Journal of Manufacturing Technology Management
- Others

Most searches in online databases were carried out using the key words 'systems of innovation', 'innovation systems', 'sectoral systems of innovation', 'developing countries', 'LT', 'LMT', 'low technology innovation' and 'low and medium technology innovation'. The main focus during the search process was to find out empirical work that studies some aspect of innovation in an industrial sector or sectors that are characterized by usage of low-technologies or low- and medium-technologies.

In order to keep the literature review focused and systematic, research studies have been categorized in line with the elements of SSI including elements and structure or interactions (Conceptual Framework – Chapter 4). Figure 5.1 illustrates this point;

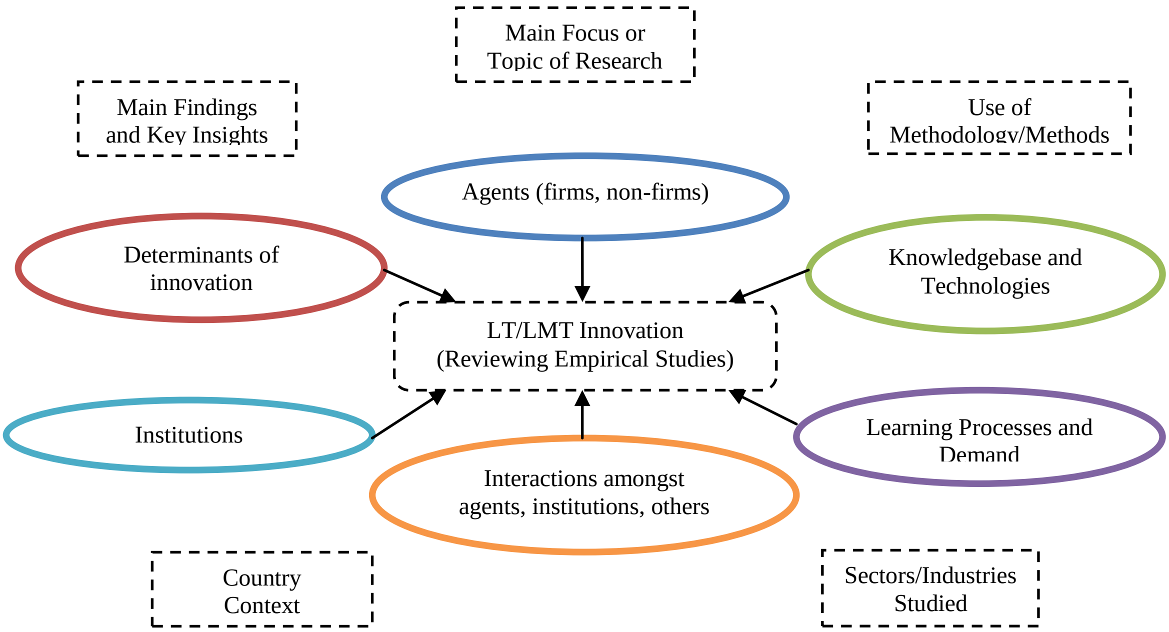


Figure 5.1: Structure of the Literature Review

5.2.1. Criteria for Selecting Empirical Work and Basis of the Critiques

While each study reviewed for this chapter did not possess equal level of relevance in terms of the criteria/factors, they were strong on at least a majority of them.

Criteria or factors used to include or exclude empirical studies in this chapter are;

- LT, LMT and/or SSI focus
- Purpose/objectives of research work and their relevance to the main theme of current research
- Industrial sector/sectors included in empirical work
- Focus on manufacturing firms
- Country/countries where sectors included in the study are located
- Main findings/results
- Use of methodology, it's possible strengths/weaknesses and relevance of findings

The critiques of relevant literature offered in this chapter take influence from the conceptual framework mainly derived from the sectoral system of innovation (SSI) approach and micro-meso-macro framework. Consequently, all relevant findings relating to the purpose/objectives of referenced empirical studies have been categorized, compared to and evaluated on their relevance to the concepts underlying the conceptual framework (as shown in Figure 5.1). These concepts include determinants of innovation (meso-firm level, micro-individual level and macro-contextual level including non-firms), other SSI elements including knowledgebase and technologies, demand, learning processes and institutions, and sectoral structure (referring to interactions among sectoral elements).

5.3. Determinants of Innovation in LT/LMT Sectors

The limits, objectives and performance of a system of innovation that involves a natural resource as a key input for firms should be studied keeping the natural resource as a major influence on the way the system exists (Belis-Bergouignan & Levy, 2010). This research while focusing on marble (a natural resource) remains aware of the limits to different types of innovation and influence of determinants when the major input is a natural resource. In his landmark work Pavitt (1984) presents sectoral patterns of technical change by examining 2000 innovations since 1945. By grouping sectors taking into account their technological characteristics he offers a three part taxonomical classification consisting of four categories of sectoral patterns of innovation. These include (1) 'supplier-dominated' sectors, (2) 'production intensive' sectors including (2a) 'large scale producers' or 'scale intensive', (2b) 'specialized suppliers' and (3) 'science-based' sectors. Later reviewing 4000 of such innovations in UK between 1945 and 1983 Pavitt et al. (1989 pp. 81) point out 'size of firms' and their 'principal activity' or 'core business' as two major factors that influence innovation behaviour of firms. This taxonomy explains the similarities and differences among sectors in the sources, nature and organizational modes of innovative activities.

While most taxonomical classifications are dominated by large firms, De Jong and Marsili (2006) propose one using 1234 small firms. It has greater diversity because of the inclusion of manufacturing and service firms. Determinants of innovation are influenced by a number of 'moderating conditions that include (1) firm size, (2) industrial sector the firm belongs to and (3) the environment of the country where the sector and its constituent firm exists. Focusing on quantitative methodologies, 'methodological differences' are also responsible for variation in results for innovation determinants (Souitaris, 1999). Pavitt's work proposing sectoral taxonomies is one of the most highlighted and used by researchers focusing on sectoral systems. Thus it is natural to highlight some of the key aspects of his work in the beginning of discussion about activities/determinants of LT/LMT innovations from a sectoral perspective. Table 5.1 provides an understanding of Pavitt's taxonomy;

Category of firm	**Type of core sectors**	**Determinants of technological trajectories**		
		Sources of technology	**User type**	**Means of appropriation**
Supplier-dominated	Agriculture; housing; traditional manufacturing	Suppliers; research extension services incl. government; big users	Price sensitive	Non-technical (trademark, marketing advertising, aesthetic design)
Scale intensive	Bulk material (steel, glass); assembly	PE suppliers; R&D	Price sensitive	Process secrecy & know-how; technical lags; patents;

	(consumer durables, autos)			dynamic learning economies
Specialized suppliers	Machinery; instruments	Design & development users	Performance sensitive	Design know-how; knowledge of users; patents
Science-based	Electronics; chemical	Mixed	Mixed	R&D know-how; patents; process secrecy and know-how; dynamic learning economies
Category of firm	**Technological trajectories**	**Measured characteristics**		
		Source of process technology	**Relative balance between product & process innovation**	**Relative size of innovating firm**
Supplier-dominated	Cost-cutting	Suppliers	Process	Small
Scale intensive	Cost-cutting (product design)	In-house; suppliers	Process	Large
Specialized suppliers	Product design	In-house; customers	Product	Small
Science-based	Mixed	In-house; suppliers	Mixed	Large

Table 5.1: Sectoral Taxonomy Derived from Pavitt (1984) and Souitaris (2002)

From the perspective of management literature a long-debated issue regarding innovation is the lack of consensus about determinants of innovation. Rothwell (1992) highlights these debates by providing five generations of innovation thought. Becheikh et al. (2006) review empirical innovation studies on manufacturing sectors from 1993-2003 and provide a list of 'internal' and 'external' determinants or 'variables' influencing innovation. Interestingly, they also admit;

> *'…our results show that the relationship linking several of these variables with innovation is often moderated by an interaction with other variables. This fact, coupled with the diversity of the measurements and methodologies used by researchers, makes analyzing and understanding this phenomenon challenging and any attempt to compare and generalize the results difficult.'*
>
> Becheikh et al. (2006, pp. 659)

Additionally, from a 'systems of innovation' perspective, more empirical works are needed to further enhance our knowledge about activities/determinants

(Edquist, 2005). Souitaris (2002) explains the variations we observe and the ensuing difficulties with regards to determinants of innovation by pointing out three 'sources of instability' or variation. These include;

(1) Type of innovation

(2) Industrial sector

(3) Size of firm

The table below interprets these factors for the current research;**Souitaris (2002) three major 'sources' affecting innovation determinants**	**This research study**
Type of Innovation	Low-tech, incremental, product, process, marketing, organizational
Industrial sector	Marble sector (mining & processing sub-sectors) after applying 'level of aggregation' from SSI approach
Size of firm	SMEs (based on SMEDA, Government of Pakistan's definition of SMEs)

Table 5.2: Linking Souitaris' (2002) three 'sources' with this research

Regarding innovation determinants especially from a systems perspective, the work of Edquist (2005) is very relevant (as demonstrated in Chapter 4) whereby a generic list of ten determinants (firm-specific with others present within the system) is provided. Becheikh et al. (2006) provide a firm-specific and more detailed list breaking down determinants into categories, sub-categories and variables. Edquist's list however, does not take into account size of firm, type of innovation, and industrial sector (three of Souitaris' 'sources of instability'). Similarly Becheikh's list does not focus on size of firm, however it does take into account innovation type (technological innovation) and sector (manufacturing). The table below provides a list of 'generic' determinants offered by Equist (2005) and a more formal and categorized list provided by Becheikh et al. (2006).

Tentative list of activities/determinants of innovation using SI approach (Equist, 2005)	**Determinants of technological product/process innovations in manufacturing sector firms Becheikh et al. (2006)**	
Research and Development Forming new product	**INTERNAL DETERMINANTS**	**EXTERNAL DETERMINANTS**
	Category Firm's general characteristics **Subcategory** -	**Category** Firm's industry-related variables **Variables** Sector

markets Networking among organizations by integrating new knowledge coming from within SI and outside with that available to innovating firms Creating & changing institutions (that provide incentives or obstacles to innovation) Financial support for innovation processes Building competence (human capital - education, training, skill development) Demand-oriented quality improvements in products Creating & changing organizations to enhance innovations (entrepreneurship & intrapreneurship amongst firms, new support institutions) Support through incubation (access to facilities etc.) Consultancy services e.g. for technology transfer, commercial information etc.	**Variables** Firm size Age of firm Ownership structure Past performance	Demand growth in industry Industry concentration
	Category Firm's global strategies **Subcategory** Strategy definition Corporate strategy Business strategy **Variables** Defined strategic orientation Diversification strategy External vs. internal growth Differentiation strategy Cost reduction strategy Protection mechanisms	**Category** Firm's regional variables **Variables** Geographic location of firm Proximity advantage
	Category Firm's structure **Subcategory** Formalization Centralization Interaction **Variables** Formal structure Flexible structure Centralization of decision-making Employees' empowerment Interaction between firm's units	**Category** Networking **Variables** Interaction with universities, research centres, competitors, industrial & professional associations, consultants and service providers, suppliers, customers
	Category Control activities **Subcategory** **-** **Variables** Financial vs. strategic control	**Category** Knowledge/technology acquistion **Variables** Formal & informal knowledge & technology acquisition
	Category Firm's culture **Subcategory** - **Variables** Resistance to change TQM/continuous improvement Culture of support for innovation	**Category** Government & public policies **Variables** Government policies
	Category Management team **Subcategory** Leadership variables Manager-related variables **Variables** Presence of project leader CEO characteristics CEO change Manager qualification/experience Perception of innovation's cost/risk Perception of innovation return	**Category** Surrounding culture **Variables** External financial support Power distance, risk avoidance, feminity-masculinity, collectivism-individualism, temporal orientation
	Category Functional assets & strategies **Subcategory** R&D HR Operation & production Marketing	

	Finance **Variables** R&D assets & strategies Personnel qualification/experience HR strategies Advanced equipment/technologies Degree of capacity utilization Marketing strategies Monitoring of competitors Financial autonomy Turnover/profit Budget/funds availability	

Table 5.3: Determinants of Innovation Adapted from Equist (2005, pp. 190-191) and Becheikh et al. (2006, pp. 651, 657)

Evangelista and Mastrostefano (2006) investigate differences in innovation processes across different countries and sectors by identifying determinants of these differences that are sector-specific, context-specific and firm-size-specific. The authors support the use of SSI since it stresses the industry-specific nature of technological regimes and the vital role played by institutions, networks and 'systematic interactions' that enable the generation and dissemination of knowledge. Findings reveal that innovation performance varies considerably across sectors and countries due to varying levels of resources (especially technological sources) devoted to innovation. Results confirm that R&D is not the only measure to define a firm's innovation strategy. Activities such as design and acquisition of know-how and training are important factors differentiating innovative behaviour of firms and technological profiles of sectors.

Amongst small firms factors influencing innovation include innovation budget, innovation capacity (time to implement innovation), innovation specialists, suppliers, customers, scientific development, innovative orientation of managers, documented planning for innovation, consultation with external organizations (non-firms) and collaboration with other firms and non-firms (De Jong & Marsili, 2006). Customer demand and competitive pressure are the main drivers to open innovations while organizational and cultural issues arising out of managing external contacts are major challenges amongst sectors like food and beverages, chemical, machinery and equipment (Van de Vrande et al., 2009). However, a possible problem with both the works of De Jong and Marsili (2006) and Van de Vrande et al. (2009) is that they rely on a survey-based database developed 3 years earlier in the case of the former and 4 years in the case of latter. Further, a lack of in-depth qualitative focus whereby SMEs are investigated on the ground and reliance on data that had been collected using computer assisted telephone interviewing (CATI) are some of the other issues of concern.

Technological competence derived from internal R&D drives product innovation in manufacturing firms (Vega-Jurado et al., 2008). The authors also agree with the assertion made earlier that variations in their results regarding innovation determinants are attributed to different industrial sectors the firms included in the survey belong to. In addition to internal R&D, design (including ergonomics, simplified manufacturing, user friendliness and efficient material use), advanced machinery and training play key roles in innovation amongst LMT firms. Factors external to firms including hiring of relevant personnel, collaborations/alliances and external R&D drive process innovations. While consultants influence product and process innovation (Santamaria et al., 2009). It is pertinent to point out that while the studies by Vega-Jurado et al. (2008) and Santamaria et al. (2009) are based in Spain, both rely on survey databases. The former analyses data collected 8 years earlier in 2000 while the latter focuses on data collected 7 years earlier in 2002.

5.3.1. Focusing on Firm-Level Determinants

The discussion in the above section portrays a picture of innovation in which determinants can be present at the firm (macro) level and/or at the contextual (macro) level. This makes it difficult to ascertain which determinants at which level are more influential than others and under what circumstances. It is important to avoid debating these issues. Rather focus should be on finding the most relevant determinants peculiar to a particular sector within its context be it at the meso, macro or even micro (individual – to be discussed later) level. An important aspect to consider is that not all authors favour using a sector-oriented perspective to study patterns and types of innovation. For example, Kirner et al. (2009) stress the importance of studying low-technology innovation at the level of firm. They opine that all sectors regardless of what products they deal with have a mix of low, medium and high technology firms.

Innovative process designs are found to be the main reason for LT firm's better performance on process innovations. However, while innovation is more a firm-specific phenomenon, it is important that we study this phenomenon within the sectoral context within which the firm is operating. Apart from process design, design activities in themselves are a major aspect of LT/LMT firms. Filippetti (2011) finds that design activities are complementary to R&D activities in supporting innovation. The more a firm interacts with the external environment the greater the importance of design activities for innovation. Related to R&D, Raymond and St-Pierre (2010) find for SMEs the influence of R&D on product innovation is mediated by process innovation.

Marketing and organizational innovations add to firm's capacity to innovate. However, the influence of these innovations on the firm's innovation performance (firms actually innovating and profiting from innovation) was not found (Mothe & Thi, 2010). However, Evangelista and Vezzani (2010) have a different conclusion. They find that firms with an overall focus on product, process and organizational (technological and non-technological innovation) have a competitive advantage over non-innovative firms or those with partial innovation focus. LMT firms have five internal capabilities that impact their innovativeness. These include 'technological, marketing, integrative, R&D, cultural and emotional capabilities' (Akgun et al., 2009, pp. 103-104). However, these findings cannot be generalized due to the particular country context of Turkey. According to Huang and Chen (2010) firms can innovate better at a certain level of diversity in their technology base. However, beyond that limit technology diversity has a negative relationship with innovation. The constraining affect of innovation budgets at times may discourage firms from investments to speed up innovation process (Dunk, 2007). The study has its limitations due to focus on the perspectives of functional managers within firms only. According to O'Regan and Kling (2011) small firms have lower R&D investment and tend to outsource it. Findings suggest that outsourcing does not bring 'inferior' results on product innovation however as firm size increases benefits of outsourcing decrease.

Innovation performance amongst firms with low R&D intensity is influenced more by production-based innovation factors and strategies that include gaining market access and maintaining customer connections. These firms focus on competitiveness, marketing, and distribution channels (Hall & Bagchi-Sen, 2007). The greater a firm engages with the market and transforms accordingly the more likely it will innovate resulting in improving firm performance (Liao & Rice, 2010). With regards to strategies, firms that have a diversification focus in terms of seeking collaborations with other partner firms and a product oriented innovation strategy perform have better results from their collaborations (Lokshin et al., 2011). Most SME firms are less likely to access finance from banks resulting in lack of product innovations (Freel, 1999). However, the study is unclear as to what other factors within the firm may contribute to low innovation. Moreover, it does not suggest any particular sectoral spread or categorization of firms selected for empirical work. Investigating the influence of firm-level decisions (internal versus external product and process technology development decisions) Swan and Allred (2003) found them to be associated negatively with differentiation strategy and positively with product dynamism. Also, acquiring product technologies from external sources was associated negatively with low cost goal and positively with increasing distance between primary marketing and R&D operations. LMT sectors where competitive intensity is high were more likely to acquire process technology externally in order to innovate. With regards to firm decisions and choices Talke et al. (2010) find that diversity in the top management team of a firm has a strong positive influence on firm's strategic choices that lead to innovation. Presenting a different perspective Buech et al. (2010) argue that employees can also contribute to firm innovation through their ideas and suggestion when their wellbeing is a priority for the firm.

Amongst LMT firms working of teams to solve problems, intra-firm transfer of knowledge, more extensive and effective workflow and production scheduling contribute to improvements in manufacturing process innovations (Macher & Mowery, 2003). Firms that better utilize sources of information present in their environment perform better on innovation due to the development of their technological innovation capabilities (Yam et al., 2010). Firms should invest in product innovation particularly when competition is intense and be cautious otherwise. Also, firms with a market orientation performed well with respect to product innovation (Hernandez-Espallardo & Delgado-Ballester, 2009).

Innovation is influenced by acquisition and utilization of knowledge about customers, competitors as well as knowledge generated within the firm (Jimenez-Jimenez et al. (2008). Additionally, it is suggested that organizational learning plays a more influential role compared to market orientation in encouraging innovation amongst firms. A potential weakness of the research is its reliance on only one respondent group (firm CEOs) for collecting data and not taking a more holistic perspective of other stakeholders. A similar study carried by Keskin (2006) finds that a firm's learning orientation influences its ability to innovate positively while learning orientation in turn is positively influenced by market orientation. Thus learning orientation serves as a mediator between a firm's market orientation and its innovativeness. Again, like the work of Jimenez-Jimenez et al. (2008), the findings from this study are also weakened by the fact that it has only incorporated the perspective of one stakeholder group that is the managing directors of sample firms. An earlier work by Aldas-Manzano et al. (2005) does not conform to Keskin's conclusions. Results suggest that market orientation is not statistically related to innovativeness. Need for further research is suggested to help elaborate the relationship between the two.

In line with a firm-specific focus on innovation determinants, certain studies propose models to enhance our understanding of these determinants. For example, Dobni (2008) uses literature review and mixed methods (a strong aspect) to present a seven-factors-model that influences an organization's innovation culture. These include innovation propensity, organizational constituency, organizational learning, creativity and empowerment, market orientation, value orientation and implementation context. However, the study only focuses on innovation in service-oriented firms. According to Morone and Testa (2008) firms remain competitive as a result of innovation by applying strategies such as specialization in quality products and creation of well-integrated social and institutional clusters.

In a study that uses a small group of firms, McAdam et al. (1998) highlight the greater influence of organizational learning and human capital on innovation rather that a firm's total quality focus which is based more on mechanistic process based continuous improvement. Pullen et al. (2009, pp. 219-220) investigate patterns of internal firm characteristics that lead to high innovation performance. Firms with high innovation performance as a result of incremental innovations had a similar 'configuration of internal organization'. This configuration focused on an 'analyser or prospector' business strategy combined with the culture of 'adhocracy' (as opposed to hierarchy culture suggested in theory). Additionally, these firms were characterized by having no formal processes (as opposed to theory which suggests that best performing incremental SMEs have formal processes), a functional team structure and an internal climate that is entrepreneurial in nature. The authors point out that one possible explanation for difference between empirical results of the study and relevant theoretical concepts is that most innovation research has traditionally focused on large firms rather than small ones. According to Choi et al. (2011) firms with foreign ownership tend to innovate more while firms with insider ownership (owners and managers are relatives or the same) perform poorly on innovation. However, a weakness of the study in terms of relevance to this research is its focus on large firms while ignoring small firms.

5.3.2. Focusing on Individual-Level Determinants

Interestingly, very few studies were found that focus on the role of individual (micro-level) within an LT/LMT firm in terms of innovation. This suggests a possible gap in literature regarding out understanding of LT or LMT innovation. However, one example is an empirical study by Entrialgo et al. (2000). Evidence suggests that a manager's psychological traits influence a firm's innovativeness and success through the mediating role of entrepreneurial processes within firms. Consequently, it is suggested that a manager's psychological characteristics have little direct influence on a firm's innovativeness and success. A study by Akgun et al. (2009) for LMT firms cited earlier reveals that a firm's 'emotional capability involving the dynamics of encouragement, displaying freedom, playfulness, experiencing, reconciliation and identification' and ultimately involving individuals will have positive effects on a firm's product and process innovation. It is important to mention here that while many studies reviewed for this chapter focus on firm-level or sectoral-level determinants of innovations in LT/LMT sectors, a genuine dearth of studies that focus on individual-level determinants was observed. Woodcock et al. (2000) find that while managers may strongly feel the need for new product development (NPD) they generally fail at implementation due to shifting of priorities arising from other short-term considerations. Data suggests little involvement of manufacturing managers within SMEs in the NPD process. A genuine lack of record keeping regarding NPD efforts results in shortage of information. This means firms are unable to streamline their NPD activities and improve performance by learning from past experience and knowledge. Two important limitations of Woodcock's work are lack of generalizable results and limited scope of the study whereby only NPD has been focused upon. Additionally, data has been collected using interviews and company records. However, the authors themselves admit that they encountered problems with company records due to differences in the way these historical records were collected and arranged.

5.3.3. Comparing LT/LMT with HT to Understand Determinants

Another aspect to understanding innovation determinants in LT or LMT sectors is through comparisons with HT sectors. In one such study investments in firm-level knowledge and training and responsiveness to markets are found to have the greatest impact on innovation among low-tech firms. While industry level dynamism and R&D intensity contribute to innovation in high-tech (Thornhill, 2006). Comparing HT and LT sectors from a different perspective Carbonell and Rodriguez-Escudero (2009) reveal that in low-tech sectors characterized by lower level of uncertainty the clarity of organizational goals and incentives in terms of speed-based rewards contribute to innovations. While top management support has a greater role in high-tech sectors since they are characterized by greater uncertainties. For new product forecasting low-technology firms rely more on quantitative marketing techniques such as customer surveys which is external to the firm while high-tech firms rely more on qualitative methods using internal data (Lynn et al., 1999). A limitation of the study is reliance on a relatively small sample size while applying the survey approach.

Further, there are studies applying survey-based research to compared high-tech, medium-tech, low-tech firms. For LT firm factors influencing innovation include human capital (employee skills influence firm's ability to engage in R&D), path dependency (firms with no R&D experience are less likely to engage in it), technological opportunity (sectors with no/limited opportunities are less likely to engage in R&D), firm size (smaller firms with less ability to afford sunk cost of R&D will less likely participate), financing constraints, domestic ownership (firms with international or foreign ownership can take advantage of parent company's research, not so with domestically owned firms) (Blanes & Busom, 2004). Departing from the survey-based approach Vonortas (2002) indicates that more than technological support it is policy consistency, involvement of all stakeholders at the local level, assistance in locating and approaching customers, training employees, accessing finance that can help low-tech firms innovate and enhance their competitiveness. A potential problem with Vonortas' work is that it reviews innovation policy initiatives in different countries relying only on previous literature and archival data. No new empirical evidence has been offered to substantiate conclusions. Marsili and Salter (2005) conclude that LT sectors have greater performance diversity among innovators compared to HT sectors. This suggests that since HT sectors are more competitive and selective, firms within them tend to follow similar strategies and are constrained by sectoral pressures. On the other hand a firm innovating in LT sector is more likely to derive benefits from it. As opposed to novel innovations the more incremental an innovation is, the lesser is the concentration of innovation returns. The study however has two limitations. One, some of the indicators used to determine innovation returns rely on subjective criteria. Two, it relies on two databases formulated at least 8 years prior to this work. In another study findings suggest that technology diffusion reduces the distance between a firm-specific technology and technologies available in the market thus encouraging firms to outsource and access skilled workers externally. While HT firms use R&D investments to expand their technological frontiers, LT firms focus on assimilation of existing technologies and outsourcing in order to innovate (Magnani, 2006).

5.3.4. Focusing on Sector-Level Determinants

Studies on innovation in firms cannot ignore the contexts within which these firms operate. Factors like science-push, spread of wage labour, urbanization process, changing lifestyles, interactions of knowledge and technologies from various industries contribute to innovation in LT sectors (Hansen & Serin, 1999). Using systems approach Albuquerque (2000) highlights system weaknesses such as lack of innovation and consistent patent activities, declining role of machinery sector in terms of patents and existence of adaptive technological innovations. Innovation determinants related to the regional environment have a stronger influence as compared to national environment (Buesa et al., 2010). For March-Chorda et al. (2002) barriers to innovation in LMT sectors include costs associated with the development process, uncertainty about market acceptance, lack of top management support, technical uncertainty, fear of failure, conservative attitude of market and problems ensuing failure of product innovation. However, the study is limited in terms of its scope by focusing only on product innovations.

Departing from a focus on firm there are studies that focus on the role of other actors within a sector. Adapting a qualitative approach Jones-Evans et al. (1999) study the role of industrial liaison offices (ILOs) in technology transfer from universities to industries that can contribute to innovation. Findings reveal that cultural differences between universities and industry, lack of financial resources and property for expanding liaison activities, lack of ‘academic-entrepreneurial role models’, lack of incentives for industry to work with universities and vice versa are serving as barriers to better collaboration between the two. In another study Bigliardi and Dormio (2009) suggest that universities and research centres are key sources of information influencing firm’s ability to innovate. Also, firms with an efficiency as well as market focus perform better on process innovations. Financial and information constraints serve as innovation barriers.

Some interesting differences regarding sectoral influences on innovation within two regions of the same country emerge from the work of Kirbach and Schmiedeberg (2008). Findings suggest a strong relationship between product innovation and export performance but not the same case for process innovations. Firms in one region with less competitive sectors demonstrate less export success due to low labor productivity and low propensity to innovate products. This is partially explained by the fact that these firms specialize towards low-price markets compared to the other region. A problem with this study is use of ten-year old data.

Sectors characterized by less technology turbulence (mostly LT/LMT) have a positive relationship between presence of key individuals championing product innovation and firm's performance on new product (Fernandez et al., 2010). An important aspect of innovation amongst firms is related to their absorptive capacity which in turn has contextual dimensions. It is not just a firm's knowledge stock but also knowledge flows and utilization that influence its innovation capabilities (Jantunen, 2005). Advocating a broader view of innovation in order to observe innovation in LMT sectors, Avermaete et al. (2003) find that almost 90 % firms in their sample have innovated in terms of products. Geographical location influences innovation however, firms located in economically prosperous regions are less innovative than those located in regions lagging behind. Explaining the high percentage the authors clarify that most of the innovations are new products from the company's perspective – as proposed by Nelson and Rosenberg (1993) – and not first-time introductions to the industry. One limitation of the study is its reliance on only one respondent group for collection of survey data.

Rather than focusing exclusively on innovation determinants some studies focus on innovation outcomes and in the process explain role of determinants. Gu and Tang (2004) find that both technology generation and technology adoption are important sources of innovation. Firms must invest in R&D or purchase machinery and equipment that embody latest technology. Additionally, skilled workers play a crucial role in conducting R&D or adopting new technology. The authors also point out that in the past most studies focused on R&D as a source of innovation resulting in their inability to provide a relationship between innovation and productivity. It is suggested that a more comprehensive view of innovation needs to be adopted whereby other factors are considered. Presenting a different perspective firms applying various instruments of intellectual property protection tend to innovate more. However, for small firms and those in LT sectors the costs associated with learning and effectively using protection of intellectual property discourages them from using them as regularly as large and HT firms. Technological opportunities within a sector and progress in science reduces the costs of innovation for a firm using internal R&D. Factors such as availability of specialised manpower and natural resources also influence innovation within a sector (Hanel, 2008). In one study Guerzoni (2010) establishes market size and user sophistication as innovation determinants. Comparing radical and incremental innovations Duguet (2006) find that incremental innovations depend more on adoption of equipment goods provided by suppliers and informal research. While having a very large sample size with results that can be generalized, a limitation of Duguet's work is the reliance of the study on a very old set of data collected in 1991.

5.4. Other Elements of LT/LMT Sectors

An important aspect of the discussion so far on sectoral determinants of innovation is that these determinants can be multifaceted and difficult to categorize in a particular format. The write-up in the sections below looks at various elements of a sector. Influence is drawn from conceptual framework to organize reviewed empirical work according to sectoral elements and structure.

5.4.1. Knowledgebase and Technologies

Applying the sectoral perspective Von Tunzelmann and Acha (2005) opine that LMT sectors are generally mature industries where technologies and market conditions change more slowly. As opposed to R&D or basic research, knowledge search, identification and proof are the main activities. Different LMT sectors vary in terms of labour and capital intensity while most are characterized by presence of technologies that spill-over from HT sectors. This underscores the importance of absorptive capacities amongst firms to take advantage of knowledge and technology spill-overs. Focusing on technology spill over, Schmidt (2009) suggests that radical-disruptive innovation has the potential to disrupt competition in traditional LMT industry and also affect other sectors. Hauknes and Knell (2009) observe that technology flows are mostly from high-tech to low-tech. However, certain studies add to confusion by finding similarities between LT and HT sectors in terms of innovation performance. For example, Yang and Kang (2008) observe that the effect of innovation capital (firm's innovation capabilities and knowledge) and customer capital on a firm's performance is positive and similar in both sectors. Studying the relationship between HT and non-HT through sectoral case studies, Robertson and Patel (2007) demonstrate that LMT sectors are significant purchasers of embodied technologies from other sectors. Thus, benefits of innovations in HT sectors are truly realized when LMT sectors utilize them. According to Buesa et al. (2010) universities and public support for R&D play a complimentary role in creating knowledge (especially patents) and supporting innovation. A weakness of the study is use of subjective criteria to filter data for analysis from the databases.

With regards to sources of knowledge, Grimpe and Sofka (2009) conclude that search patterns for external sources of knowledge rely on market knowledge in low-technology firms. These external sources include competitor knowledge (more comparable) and customer knowledge (more tacit and difficult to understand). Firms use knowledge access, reliability and transferability as trade-offs thus affecting their search patterns. According to Varis and Littunen (2010) product and marketing innovation are related more to the use of more or less freely accessible knowledge sources. Another important consideration is how knowledge flows in LT/LMT sectors. Using patent data Waguespack and Birnir (2005) suggest that knowledge flow usually has geographical characteristics resulting in innovations spreading less widely and rapidly. However, innovations that result from knowledge flows across different knowledge clusters and under similar legal institutions tend to be more novel and diffuse faster. Limitations of Grimpe and Sofka (2009) and Waguespack and Birnir (2005) are that both rely on databases developed a long time before publication of these studies (18 years old data for the former and 11 years for the latter). Technologies available for LMT sector through public funded research needs to have a match with local firms and be accessible. Otherwise firms and the sector cannot realize their potential for innovation (Kroll & Schiller, 2010).

Apart from knowledge/technology flow and sources of knowledge another research concern is management of knowledge in LT/LMT sectors. External knowledge sourcing is positively related to innovation however, firms with higher levels of vertical integration face barriers to acquiring external knowledge (Li & Tang, 2010). Similarly knowledge management and personnel policy contribute to development of a firm's transformative capabilities. LMT firms are characterized by incremental knowledge accumulation and informal on-job training (Schmierl & Kohler, 2005). Presenting a different perspective by linking use of knowledge with outsourcing, Rundquist and Halila (2010) reveal two groups of firms. The first performs better at NPD by giving greater importance to knowledge integration and development of knowledge about outsourcing NPD. The second does not perform well on NPD because of focus on geographical proximity and cost. A limitation of this study is that only medium-sized firms have been analyzed without considering the small-firm perspectives. Presenting a different perspective on NPD Lindman (2002) presents a case study to suggest that SMEs rely on in-house knowledge-base generated as a result of close understanding of user conditions. Using case study approach, Pederson (2005) attempts to understand links among production techniques, product development and skills. Findings reveal that companies with higher formal knowledge manufacture value added products with better finishing. Also, origin and control of product design was found to be better amongst firms with greater formal knowledge. The study recommends that companies with low formal knowledge should develop product design in line with varying customer specifications. Companies with higher formal knowledge have greater collaboration with technology infrastructure (technical service suppliers). Product innovation is an explicit objective in companies with high formal knowledge while the same was not consistently observed amongst firms with low formal knowledge.

As evident from discussion so far, knowledge accumulated and applied by LT/LMT firms can have multiple dimensions. For example, in an in-depth case study Chiva-Gomez et al. (2004, pp. 159) suggest that product design management (PDM) has a positive effect on a firm's innovation performance. A limitation of this study is that it only offers insights on four cases/companies. However, the use of mixed methods and replication logic are some of the strong points. Presenting a different scenario and supporting use of sectoral systems approach Vale and Caldeira (2008) suggest that knowledge acquired from one sector speeds up innovation processes and innovation cycles in another sector. Firm competencies that include combinations of tacit and codified knowledge also play a key role. A strong aspect of the study is its in-depth focus on one sector whereby perspectives from all elements of the sectoral system have been incorporated. Tether and Tajar (2008) use survey data on firms' innovation orientations. They conclude that low-technology manufacturers are most likely to adapt 'process-technologies mode' of innovation. This mode is orientated to the flexibility and efficiency of production by relying on acquisition of advanced machinery and equipment.

Start-up firms resulting from university research projects rely on specific knowledge inputs in order to innovate. While 'unsponsored spin-offs' rely on generic knowledgebase to achieve the same (Balthelt et al., 2010). A key aspect to LT/LMT firms' use of technologies is where from and how they acquire them. Veugelers and Cassiman (1999) indicate that small firms are more likely to source technology externally. Also stronger the appropriation regimes in a sector and a firm's internal resistance to change the less likely firms will exclusively rely on external technology sourcing. Stressing the importance of technologies as a key input to innovation in LT/LMT firms Bergek et al. (2008) suggest that one of the variants of SI concept that is technological innovation system (TIS) can be considered as a 'sub-system' of sectoral systems. Another influencer on knowledge within a sector is uncertainty and its influence on knowledge boundaries between two groups of firms. Lee and Veloso (2008) conclude that in times of uncertainty firms from one group adjust their knowledge boundaries to create overlaps with the other.

5.4.2. Learning Processes

Most learning processes in LT/LMT firms are informal at the firm level. Innovation and adoption-related activities tend to be based more in the real world whereby learning by doing is the norm (Von Tunzelmann & Acha, 2005). Another dimension is learning orientation it relationship with innovativeness. Keskin (2006) studies the relationships among market orientation, learning orientation and innovativeness. Results indicate that a firm's learning orientation influences its ability to innovate positively while learning orientation in turn is positively influenced by market orientation. Thus learning orientation serves as a mediator between a firm's market orientation and its innovativeness. In another study Guo and Guo (2011) find that learning processes and learning opportunities for firms are influenced by four factors; complexity of technology in the sector, 'interconnectedness between product and process', 'path dependency of knowledge searching' and incremental technological development within the sector. Use of mixed methods is a strong aspect of this research. While arguing for the need to further understand learning processes amongst firms in system of innovation Van Mierlo (2010) finds that differences in learning can be explained by the presence or absence of conditions for learning

5.4.3. Demand

While in most LT/LMT sectors demand changes relatively slowly there are situations where it may fluctuate more rapidly resulting in turbulence. A common strategy to overcome stagnant demand is for LMT firms to go for new markets. Also, since most LMT products cater to consumer 'necessities', demands tends to be inelastic. Here the role of new technologies becomes crucial because it can help these firms improve quality of products (quality innovation) and change demand conditions. Demand patterns may also be changed by offering new characteristics in the existing products (Von

Tunzelmann & Acha, 2005). Four sectoral patterns of demand (inspired from Pavitt's (1984) taxonomies and Malerba and Orsenigo (1995) exist (Guerzoni, 2010). These patterns include;

(1) Passive markets – small market size and low user sophistication means firms not encouraged to innovate

(2) Mass markets – common for LT/LMT sectors. Standard goods used by many consumers. Market size is large but since these goods are mostly commodities there is low user sophistication. This pushes firms to go for cost reducing process innovation.

(3) Niche markets – small market size because of niche customers discourages firms from investing in process innovations. There is high user sophistication and greater user involvement in helping the firm develop product innovation.

(4) Dual markets – large market size and higher user sophistication means there will be two types of firms. The first ones focus on process innovations and produce products for large number of users. While the second ones focus on niches by providing product innovations for sophisticated consumers.

5.5. Institutions

Institutions can be understood in terms of 'three pillars' (1) 'regulative', (2) 'normative' and (3) 'cognitive' (Scott, 2001, pp. 52). Geels (2004) gives examples of each. Provided below is combination of the two's concepts;

THREE TYPES OF INSTITUTIONS			
	Regulative institutions	**Normative institutions**	**Cognitive institutions**
Compliance depends upon	Expedience	Social obligation, expectations of society	Shared understanding, taken as is
Procedures or mechanisms for compliance	Coercive i.e. formal penalties placed	Normative (social pressures of disgrace or shame)	Imitation, following others
Reason or logic	Provide stability and 'rules of the game'	Appropriateness, becoming part of the group	Orthodoxy i.e. shared ideas
Legitimacy depends upon	Imposition by law	Social morality	Culturally supported & conceptualized
Examples	Formal rules, laws, incentive structures, standards, procedures	Norms, values, role expectations, duty, authority, codes of conduct	Common beliefs, shared logic of action, priorities, beliefs

Table 5.4: Types of Institutions Adapted from Scott (2001, pp. 51) and Geels (2004, pp. 905)

The role of institutions in a system is not just to maintain inertia or stability. An essential component of the system, institutions explain the interactions between actors and other elements of the system (Geels, 2004). However for both Scott and Geels it is important to consider that their work is mainly theoretical or conceptual in nature and not supported by empirical evidence analyzed by the researchers themselves.

An important aspect to understanding the role of institutions in the context of LT/LMT sectors is to establish the relationship between institutions at the national/regional level (NSI and RSI) and sectoral level (SSI). From NSI perspective a system consists of sub-systems including SSI. Thus national institutions have the ability to influence the structure of SSI through their sectoral effects (Storz, 2008). In the case of large firms, national institutions may be more influential however for small businesses sub-national institutions including sectoral ones may play a greater role (Carlsson, 2006). Countries may demonstrate similarities across NSI however differences would emerge amongst them across sectoral components of NSI (Lee & von Tunzelmann, 2005; Malerba, 2004)

Using mixed methods Radosevic and Myrzakhmet (2009) indicate that LMT firms in technology parks do not innovate more than others and have a focus on local markets. Lower rents and the possibility of accessing finance are the main drivers for firms to move to such technology parks however these parks alone are found to be lacking in terms of supporting innovation. Fisher-Vanden and Terry (2009) suggest that governments put pressure on firms to improve product quality and counter the import of better products. Latest technologies alone are not enough for firms to innovate and improve quality. Technology acquisition factors and technology absorptive capacity factors need to be in place for firms to achieve success.

Formal institutions like ‘technology-forcing regulation’ influence technological innovation amongst firms (Lee et al., 2010). Sources and uses of knowledge amongst HT and LMT firms are highly diversified that require a similar effort in government policy to effectively manage this variation. These policies should focus on both innovation and diffusion not just for HT but also LMT sectors. However, as decisions regarding use of technologies are mostly taken by individual managers at the firm level in line with their peculiar contexts, the diffusion policies should not be commanding and rather be facilitating. Governments should focus on provision of technological knowledge that is quick, inexpensive and is not barred by delay-inducing official procedures (Robertson & Patel, 2007). Describing the transformation of Chinese national innovation system, it is found that government plays an important role in a system of innovation. However, the system has transformed from government-centric and firm-research organization focus to firm-centric and firm-led. Government remains the leading force in reforming the system (Sun & Liu, 2010).

Utilizing archival records and comparing institutions in three countries Casper and Whitley (2004) suggest that differences in institutional frameworks among countries and sectors including those that influence organization of labour markets influence determinants' relative influence on innovation. In another study Czarnitzki et al. (2011) finds that government implemented tax credits on R&D lead to improvement in innovation performance of firms. A potential weakness of the research is lack of clarity on which firms and sectors have been studied.

5.6. Interactions and Relationships (Structure of LT/LMT Sectors)

The underlying notion of interactions and networks within sectoral systems of innovation is that firms do not innovate in isolation. Rather, they collaborate and develop relationships with different elements of the system. Because this research takes influence from SSI approach, it would be appropriate to focus on sectoral structure explained through the concept of interactions. It is important to note that attempts to understand the role of interactions within SSI does not reveal conclusive evidence that points in a particular direction. However, it enables us to understand how interactions influence the dynamics within SSI no matter how divergent the results of different studies might be. Provided below are reviews of relevant empirical works.

5.6.1. Interactions among Agents (firms and non-firms)

Sectors characterized by strong contacts among firms and non-firms have higher capability to diffuse technology leading to innovation (Soofi & Ghazinoory, 2010). However, existence of firm-level product and process innovations is not a sufficient condition to support collaboration for innovation within a sector. Results vary considerably when compared against Pavitt's (1984) sectoral taxonomy. This suggests lack of conclusive evidence that sectors belonging to a particular taxonomy will demonstrate a particular level of collaboration to influence sectoral innovations (Freel, 2003). However, vertical chains of production collaborations among agents have a strong influence on innovation (Tomlinson, 2010). Compared to HT firms, small and less R&D intensive firms (LT/LMT firms) rely more on cooperation with supplier, a limited number of agents (firms, non-firms) and national partners in order to innovate. One problem in terms of relevance is that the sample of firms only includes those that have internal R&D. However, firms with no R&D focus may also cooperate with partners in order to innovate (Barge-Gil, 2010). Firm interactions with non-firms (vertical and horizontal cooperation with suppliers, customers, other non-firms) have a stronger influence on SME innovation. Firm-intermediary interactions, firm-research organization interactions and firm-government interactions (three horizontal cooperation modes) have a lesser influence (Zeng et al., 2010). Continuing with firm-supplier interactions Schiele (2010) suggests that early supplier integration helps firms in product innovation especially through new product development.

Most firms perform poorly on product innovation whereby one of the underlying causes is weak access to finance from banks (firm-non-firm interaction) that can help them invest in technologies (Freel, 1999). Investigating the role of 'bridging' non-firm organizations Sapsed et al. (2007) suggest that these organizations can support incremental and disruptive innovations. A small sample size coupled with lack of clarity about which of sample firms are LMTs and which are not weaken the relevance of results. Similarly, research centres can contribute more effectively only if technology intermediaries (another set of non-firms) play their due role. This can include knowledge intelligence services (gate keeping, technology watch, road mapping), knowledge agency functions (transferring knowledge) and knowledge repository (technical libraries, study days) (Spithoven et al, 2010). In order for firms to successfully commercialize their innovation the role of intermediary non-firm is crucial (SMEs have limited abilities to search for partners) as it can help bring together agents to collaborate (Lee et al., 2010). The last two studies suggest the importance of interactions that involve firms and more than one group of non-firms in order for innovation to occur within the system. Another study by Jones-Evans et al. (1999) finds that collaboration between universities and industries can prove more beneficial and result-oriented through the mediating effect of industrial liaison offices (ILOs). A possible limitation of this research is the reliance on only the representatives of ILOs for data collection through interviews.

Focusing on systems of innovation perspectives, research offers comparisons between different types of systems with respect to interactions. For example, Ronde and Hussler (2005) compare regional and sectoral systems. For RSI they stress that intra-regional links (geographical proximity) between actors are a more important influence on innovation than inter-regional links. While for SSI they suggest that intra-industry links (sectoral proximity) between actors are more crucial compared to inter-industry links. Giving further credence to the intra-industry argument, Vale and Caldeira (2008) find that linkages between two industries (fashion and footwear) result in innovations amongst firms in footwear. An interesting dimension about the works of Ronde and Hussler (2005) and Vale and Caldeira (2008) is that both derive similar conclusion regarding interactions in LT/LMT sectors while applying different methodologies (quantitative for former, qualitative for latter) in two different country contexts and addressing a very different set of research questions. Keeping focus on proximity and taking the discussion further Tsai and Wang (2009) observe that sources of external technological knowledge include collaborations with research organizations, suppliers, clients and competitors. A limitation of the work is that it relies on a selective data from a dataset developed seven years earlier. Investigating the relationships between machinery manufacturers and their sub-contractors (suppliers) findings suggest that subcontractors performing better than their competitors had better trained employees with technical skills, retention of exclusive know-how and existence of competitive pressure on the firm. However, dependence of supplier on buying firm inhibits development of skills, knowledge and competencies amongst suppliers rather than stimulate it (Petroni, 2000). With regards to firm interactions with transnational corporations Kumar and Subrahmanya (2010) find that the more such interactions SMEs have the greater the likelihood of technological innovation among them.

An important aspect to agent interactions is differences among them in terms of knowledge and its influence on innovation. Contrary to recent theory that considers a positive relation between cognitive distance (difference in the knowledge and perceptions of partner firms from two separate sectors) and innovation, findings suggest no correlation (Enkel & Gassmann, 2010). Presenting the link between R&D organizations and firms that utilize their offerings Douthwaite et al. (2001) find that research organizations should engage with firms to facilitate technology adoption taking into account user (firm) innovation. A key question that needs to be addressed is how different research studies conceptualize interactions and collaborations before conducting research on them, something the study by Douthwaite et al. (2001) does not address satisfactorily. In this regard Abramovsky et al. (2004) conceptualize collaboration in the context of knowledge flows, cost and risk-sharing and public financial support. A positive relationship is found between external information flows (incoming spillovers) and likelihood of collaboration among firms for innovation.

Interactions typically characterized as being firm-firm and firm-non-firm can also take the form of firm-customer. Firms responding more to customer needs offer more incremental innovations rather than radical (Salavou, 2002). Throwing in a different perspective Debruyne et al. (2002) reveal that price changes are the most frequent response of competitors to product innovations.

5.6.2. Interactions among Firms and Institutions

Malerba (1999) via Faulkner (2009) highlights the need for further research to understand influence of institutions on sectoral systems' innovation and diffusion processes. Faulkner (2009, pp. 645) points out that transnational policy institutions in Europe may support innovation through 'constructive processes of regulatory ordering'. This is contrary to the common notion that the role of regulations (a type of formal institutions) is restrictive and limited mostly to monitoring innovation patterns within sectors. However, Boymal et al. (2007) indicate that institutional setup in a country can be a major hindering factor to innovation when it is influenced more by 'ideo-political than socio-economic realism'. It is recommended that the government should relinquish control and let competition take its own course. While Boymal reviews the influence of innovation policy in one context Vonortas (2002) does that in another. It is found that more than technological support it is policy consistency and involvement of all stakeholders at the local level that can help LT/LMT firms innovate and enhance their competitiveness.

A key aspect to understanding institutions is through the concept of institutional infrastructure. Presenting this infrastructure as the interplay among firms, government and non-government organizations, Cetindamar (2001) find that regulations and public pressure are the main determinants of the transfer and diffusion of environment technologies. This suggests the crucial role of institutional infrastructure. However, results suggest that these regulations have a limited effect on innovativeness and competitiveness because they are not innovation-oriented. Thus it becomes vital to understand the orientation of institutions as this affects their influence on innovation. Also, the local social context such as sub-community and its social structuring have a stronger relationship with adoption of the new technology amongst LT firms as compared to individual or farm level variables (Moxley & Lang, 2006).

5.6.3. Interactions among Sectoral Elements (knowledge as the dominant element of discussion)

Apart from research work which focuses more on interactions amongst any two elements, there has been empirical work which highlights interactions amongst more than two. However, commonalities and patterns are difficult to identify and comparisons difficult to draw from literature. One way to organize the discussion is to identify at least one element apart from firms that has dominated the researcher's discussions.

Knowledge exchanges can occur among different sectors and firms within them due to sectoral proximity. This means that regional SI demonstrate sectoral patterns of innovation (Ronde & Hussler, 2005, pp. 1155). This suggests the difficulty in conceptually separating RSI from SSI. Small firms and those that operate in traditional sectors lack 'absorptive capacity' to internalize knowledge from external sources especially in the case of open innovations. The role of technology intermediaries (non-firm organizations) is a key in this regard as they can help organise absorptive capacity at a collective level (Spithoven et al., 2010). However the authors stress the need for further research to understand how firms utilize this knowledge to generate innovations. According to De Faria et al. (2010) firms with greater absorptive capacity and priority for managing spillovers cooperate more with other firms and non-firms for innovation. A potential weakness in terms of relevance to this research is that the analysis uses firm-oriented data without focusing on industry or sector context. 'Trend-setters' are able to innovate successfully by putting forward new interpretations of existing combinations of product inputs. Such firms have capabilities to access and interpret tacit and distributed knowledge by means of interactions and dialogues with other stakeholders (Dell'Era & Verganti, 2010). Additionally, collaborations on knowledge and information between various departments of a firm lead to process innovations (Cuijpers et al., 2010). A potential weakness of the research is lack of clarity on which firms and sectors have been studied.

Presenting a different perspective on how collaborators' mindset influences innovation, Andersen and Munksgaard (2009) suggest that situated knowledge contexts influence the scope and organization of new product development activities amongst various collaborating firms. Cetindamar and Ulusoy (2008) reveal that despite high levels of partnerships between firms and companies and firms and universities, there is little impact of these partnerships on the firms' innovation performance. Weak collaborations are described as the underlying cause. Firm collaborations for R&D with different non-firms differ from each other in terms of breadth of new knowledge provided to the firm and ease of knowledge access (Un et al., 2010).

5.6.4. Interactions among Sectoral Elements (technologies as the dominant element of discussion)

New technologies bring incremental or substantial changes to a sectoral system in terms of its structure and the set-up of institutions. Similarly sectors can also respond to new technologies as a result of 'social patterns' such as ones exhibited by firms resulting in sectoral transformations (Dolata, 2009). Christensen et al. (2005) observe that the way firms manage new technologies is influenced by their relative position within the sector (small firms initiate the new technologies but large firms take over later improving and maturing the technology) and the nature and level of maturity of technological regime. In addition to technological improvements, a related aspect is the nature of this improvement and how it can become a problem for some firms. In this context Ahman and Nilsson (2008) point out that accumulated experience and path dependent nature of technological developments creates technology lock-in. They underscore the greater role of the public sector that is government in helping companies get out of the lock-in. Firms' adoption of advanced technologies combined with investment in employee skills especially through training leads to innovation and productivity gains (Boothby et al., 2010).

Laying emphasis on technology infrastructure (TI) in supporting innovation in small low-tech firms Laranja (2009) advocates demand stimulation in place of supply-side 'technology push'. It is suggested that SMEs should be encouraged to hire trained technical staff by providing short-term subsidies to overcome higher personnel costs and new schemes of 'proactive intermediation' should be launched to help SMEs make better use of available TIs. As pointed out in earlier discussions, firms in LMT sectors generally rely on technology acquisitions to facilitate innovation. Fisher-Vanden and Terry (2009) reveal that latest technologies alone do not suffice for firms to innovate and improve quality. Technology acquisition factors and technology absorptive capacity factors need to be in place for firms to achieve success.

5.6.5. Interactions among Sectoral Elements (institutions as the dominant element of discussion)

Countries and sectors that suffer from weak markets, ‘low retention of value-added function’, limited professional capacities and ‘limited institutional thickness and networks’ need to have a more ‘expansive’ government role in funding industrial R&D (Breznitz & Zehavi, 2010, pp. 301). Taking into account the role of governments in influencing innovation amongst firms (Fisher-Vanden & Terry, 2009), there are studies which point out different forms of interactions amongst sectoral elements with a greater focus on institutions. For example, focusing on the interactions among firms, institutions and technologies Hall and Soskice (2001) observe that institutions in ‘liberal market economies’ provide greater support to firm competences encouraging innovation in emerging technologies (more radical innovations). On the other hand institutions in ‘co-ordinated market economies’ encourage incremental innovations. In another study Lee et al. (2010) observe that innovating firms strategically manage their architectural and component knowledge while remaining cognizant of uncertainties with their technological capacity to meet formal institutions.

Subrahmanya (2005) focus on comparisons of policy structure between a developed and developing economy. Findings suggest that incremental product innovations in both countries mainly come from external sources. However, due to low R&D intensity and a different policy structure extent of innovations in developing country is lesser than the developed economy. A weakness of the work is that sample selection procedures have also not be clearly elaborated. Presenting a different perspective Metcalfe et al. (2006, pp. 1283) suggest that innovation is influenced by key individuals within organizations as well as a ‘correlated understanding among heterogeneous agents whose rules of interaction are contingently instituted in socio-economic systems along unfolding scientific and technological trajectories’. Pointing out the important role of policy in influencing innovation Teubal (1997) argue for a horizontal perspective. It is suggested that policy should be oriented to all industries and sectors of the economy to achieve a wider economic impact rather than focused only on high technology sectors alone. However, Teubal’s work is conceptual and theoretical in nature. Focusing on primary data and empirical evidence Santamaria et al. (2009) demonstrate that for LMT firms the traditional focus on R&D needs to be revised because such firms are influenced by other determinants of innovation also.

5.6.6. Studies with a Mixed Discussion on Interactions

One aspect of firm innovation is collaboration with international partners. In this regard Li and Zhou (2008) find that over-reliance of firms on their MNC partner results in reduction of innovation capabilities. It is also observed that the greater the ‘technology gap’ between MNC and the firm, the greater the importance of absorptive capacity of LMT firms to overcome gap quickly. The authors have used subjective criteria to filter out relevant data which puts to question the objectivity of results derived using quantitative means. Kafouros and Buckley (2008) investigate LT firms to find that small firms characterized by incremental innovations from external technologies derive greater benefits from R&D spillovers as compared to large ones. However, factors like technological opportunities, firm size and competitive pressure play an influential role in this regard. Bengtsson et al. (2009) compare two outsourcing strategies (low cost and innovation). Findings reveal that innovation outsourcing is correlated with a firm’s innovation capability. Another aspect of innovation-oriented outsourcing revealed is that it is characterized by presence of greater manufacturing and supplier integration in the product design processes and is prevalent in situations where products and manufacturing processes are complex.

5.7. Research on Innovation in LT/LMT Sectors – Possible Emerging Trend

A key aspect of the systematic literature review was to assess nature and current focus of research with regards to low-tech innovation. The reviewed journals and papers suggest an emerging trend (figure 5.2 given below). Between 1999 and 2007, there are an average 8 to 9 papers per year that cover some aspect of LT/LMT innovation. However for 2008 the number of articles increases by twofold to reach 17. For 2009 the number of articles increases almost threefold to reach 26. For 2010 the number reaches 35. The graph below captures this aspect. It is important to mention that all of the studies shown in the graph do not exclusively focus on LT/LMT sectors. As a result some had to be discarded from the discussions in this chapter because of their low relevance to the ‘Criteria/Factors’ (Section 5.2.1) established for screening purposes.

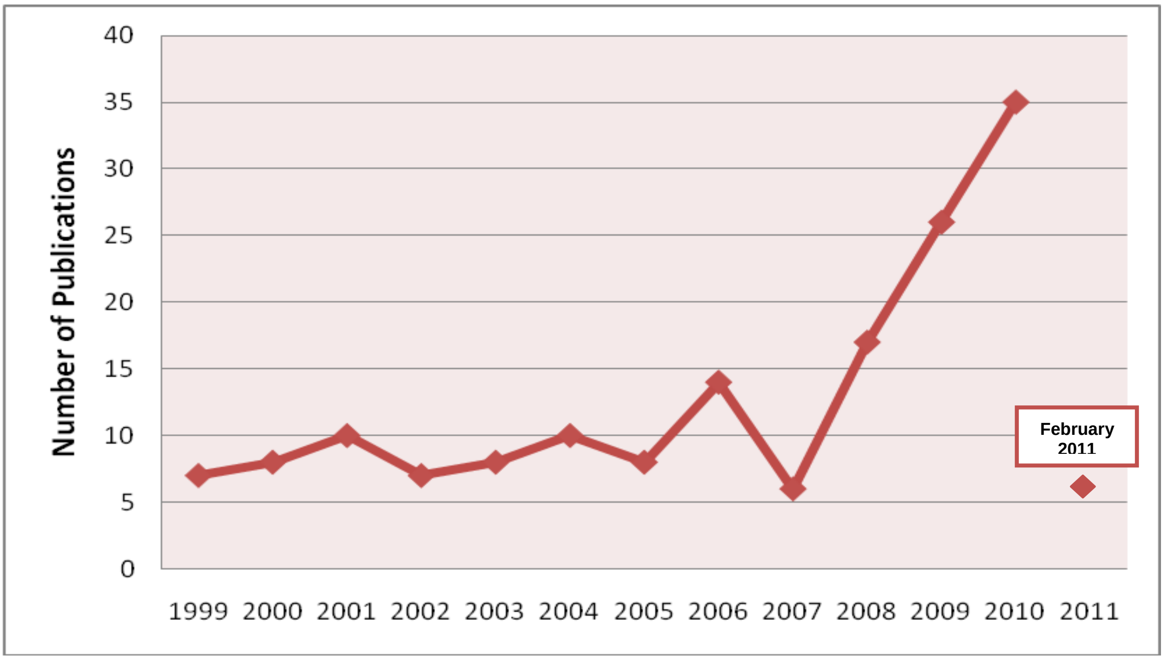


Figure 5.2: Emerging Research Trend – Publications on Innovation in LT/LMT Sectors (1999 – 2010)

Although the sharp increase evident for 2009 is partly explained by the special issue of Research Policy in April 2009, evidence from other journals mentioned in the introduction of this chapter also suggests an emerging trend. The top six journals in terms of maximum number of publications (1999 – 2010) are mentioned in the table below;

Journal Title	Number of Papers
Research Policy	37
Technovation	24
European Journal of Innovation Management	23
Technology Forecasting and Social Change	14
Economics of Innovation and New Technology	13
Journal of Product Innovation Management	05

Table 5.5: Top Six Journals in terms of Number of Publicaions

5.8. Synthesizing Empirical Studies

The reviewed publications were further subjected to some analysis to derive results and conclusions. Following information was extracted in this regard;

(1) Author(s) and year of publication

(2) Approach/methodology/methods

(3) Country or region and sector/industry focus

(4) Main focus or topic of research within LT/LMT context

Table 5.6 provides a sample of this categorization.

Table 5.6: Sample Table: Synthesizing the Empirical Studies on LT/LMT Innovation

Author(s) and Year	Approach/Methodology/Methods	Country/Region & Sector	Main Focus of Research within LT/LMT Context
		FIRM-LEVEL DETERMINANTS	
De Jong and Marsili (2006)	Computer Assisted Telephone Survey (database of 1234 small & micro firms) Data collected in 2003	Netherlands, different sectors	Empirical taxonomy of small innovative firms
Evangelista and Mastrostefano (2006)	Survey (10 European countries)	Europe, 22 different sectors	Influence of firm size, sector and country on variety in determinants of innovation
Vega-Jurado et al. (2008)	Survey (6094 manufacturing firms)) Data collected in 2000	Spain, different sectors	Effect of external and internal factors on firm's product innovation
Santamaria et al. (2009)	Survey (1300 SMEs) Data collected in 2002	Spain, different sectors	Factors/determinants of innovation other than R&D
Kirner et al. (2009)	Postal survey (1663 manufacturing firms) Data collected in 2006	Germany, different sectors	Comparison among LT, LMT and HT firms in terms of Innovation paths and innovation performance
		INDIVIDUAL-LEVEL DETERMINANTS	
Entrialgo et al. (2000)	Survey – database (233 SMEs)	Spain, fifteen sectors	Influence of individual/psychological characteristics on innovation in a firm
		COMPARING LT/LMT WITH HT TO UNDERSTAND DETERMINANTS	
Thornhill (2006)	Survey (sample of 845 observations)	Canada, different HT and LT sectors	Comparison of LT and HT with regards to knowledge, innovation and firm performance
Blanes and Busom (2004)	Survey – database (2000 manufacturing firms), data for the time period 1990 – 1996 analyzed	Spain, different sectors	Effect of R&D subsidy programs on innovation in HT, MT and LT sectors
Vonortas (2002)	Literature review, archival	Miscellaneous Latin American Countries, different sectors	Technology and innovation policy initiatives; comparisons for different HT and LT sectors
		SECTORAL DETERMINANTS OF INNOVATION	
Jones-Evans et al. (1999)	Qualitative – face-to-face semi-structured interviews (representatives of ILOs)	Ireland and Sweden	Role of industrial liaison office in influencing innovation as a result of university-industry collaboration

Bigliardi and Dormio (2009)	Survey (98 firms)	Northern Italy, food machinery sector	Determinants of technological innovation
Kirbach and Schmiedeberg (2008)	Survey (sample of 12600 manufacturing firms, up to 47 % LT & LMT firms) Database (1993 – 2003)	Germany (East & West), different sectors	Comparison of two geographical regions in terms of relationship between innovation and export performance and factors influencing innovation
Avermaete et al. (2003)	Survey (top manager or owner of 55 micro and small enterprises)	Belgium (two regions – north & south), food sector (foods and drinks)	Determinants of innovation, comparison of two regions with two different sectors
KNOWLEDGEBASE, TECHNOLOGIES, OTHER INPUTS			
Schmidt (2009)	Case Study (archival records and publications)	USA, bedding mattress sector	Technology spillover from HT to LT/LMT sector
Waguespack and Birnir (2005)	Archival records (patent database 1990 – 1994)	USA, different sectors	Geographical characteristics of knowledge flows
Schmierl and Kohler (2005)	Firm case studies	Not specified	Knowledge management and training in LT and LMT firms
LEARNING PROCESS AND DEMAND			
Von Tunzelmann and Acha (2005)	Literature Review	-	Perspectives on innovation in LT sectors
Guerzoni (2010)	Literature review	-	Impact of demand (market size, user sophistication) on innovation
Keskin (2006)	Survey (managers of 157 SMEs)	Turkey, eleven different sectors	Relationship among market orientation, learning orientation and innovativeness
INSTITUTIONS (SECTORAL AND NATIONAL INFLUENCES)			
Storz (2008)	Mixed methods (documents and interviews)	Japan, games software sector	Institutional setting and competence of actors: Dynamics of innovation system
Fisher-Vanden and Terry (2009)	Four different datasets for manufacturing firms (archives), quantitative analysis	China, steel sector	Influence of technology acquisition factors and technology absorptive capacity factors on a firm's ability to utilize technology and improve product quality

Casper and Whitley (2004)	Archival research	Germany, Sweden and UK, five different sectors	Comparing institutions across different countries
INTERACTIONS AMONG AGENTS (FIRMS & NON-FIRMS)			
Freel (2003)	Survey (5200 manufacturing SMEs, 597 responses), database developed in 2001	Scotland & Northern England, ten different sectors	Relationship of cooperation for innovation and interactions with firms' product/process 'innovativeness'
Douthwaite et al. (2001)	Case Study (archival records)	Asia (countries not specified) Focus on four different technologies	Analysis of innovation history of four technologies with high and low levels of complexity
Abramovsky et al. (2004)	Survey – database developed in 2001	France, Germany, Spain, UK, sectors not specified	Innovation through cooperation and collaboration: Comparing four countries
INTERACTIONS AMONG AGENTS & INSTITUTIONS			
Faulkner (2009)	Mixed methods (secondary data, interviews, observations)	Europe, tissue engineering sector	Role of regulation with regards to innovation in technology sectors
Boymal et al. (2007)	Archival records, qualitative	Vietnam, internet-based sector	The influence of innovation policy on a sector
INTERACTIONS AMONG SECTORAL ELEMENTS			
Andersen and Munksgaard (2009)	Qualitative (3 cases), interviews and observations	Denmark, food industry	Collaborative product development and knowledge contexts
Cetindamar and Ulusoy (2008)	Survey (135 manufacturing firms), face-to-face structured interviews	Turkey, textile, chemical, food & machinery sector	Impact of collaboration and partnership on innovation performance of firms
Bengtsson et al. (2009)	Survey (267 manufacturing firms), questionnaire	Sweden, eight different sectors	Comparing low cost strategy vs. innovation strategy in the context of outsourcing

The categorization of literature (as shown in the sample Table 5.6) has been used to arrive at a number of conclusions regarding nature of research work on LT/LMT innovation. Figures 5.3 and 5.4.below provide geographical spread of empirical work on LT/LMT innovations over the time period 1999-2010.

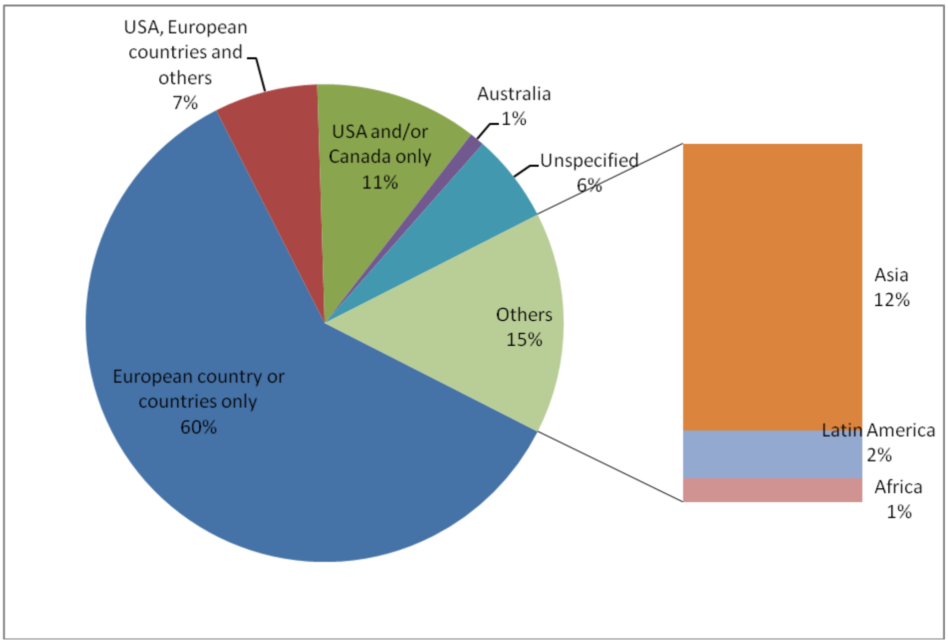
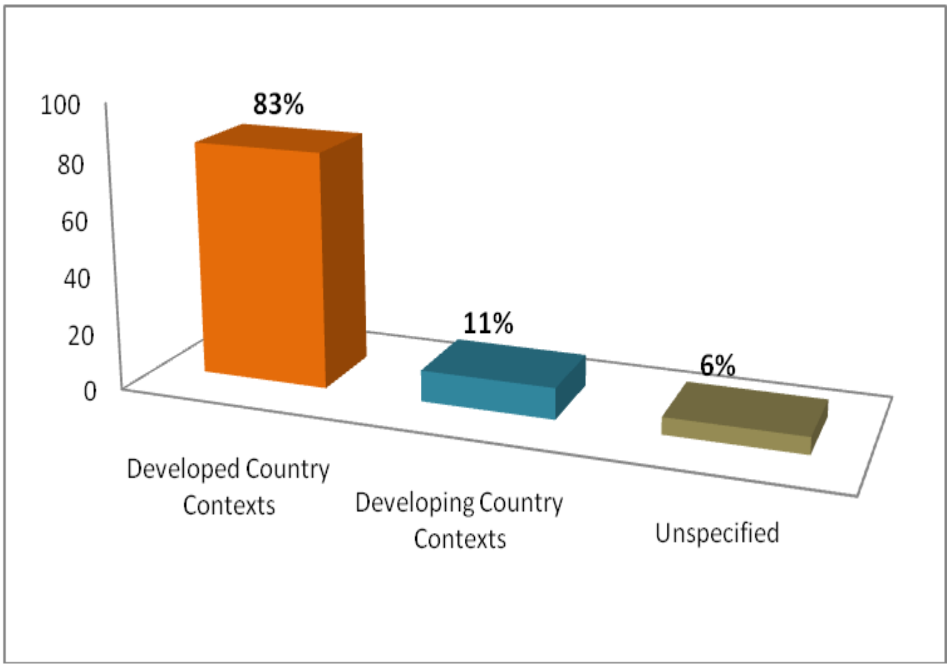


Figure 5.3: Region-wise Geographical Spread of Publications on LT/LMT Innovation (1999 – 2010)



Figures 5.4: Three-Category Spread of Literature on LT/LMT Innovation (1999 – 2010)

Table 5.7 below further provides information about the types of LT/LMT sectors and countries the literature focuses on;

MAJOR LT/LMT SECTORS STUDIED (Predominantly Manufacturing)	MAJOR COUNTRY-CONTEXTS
Agriculture, Mineral (Metallic), Mineral (Non-Metallic), Food, Beverages, Chemical, Machinery and Equipment, Pharmaceuticals, Building Materials, Biotechnology, Semiconductor, Steel, Metal Packaging, Wood, Medical Equipment, Rubber, Leather, Plastic, Paper, Food Machinery, Construction, Textile, Electronics, Tobacco, Housing, Furniture, Ferrous Ore mining, Non-Ferrous Ore Mining, Glass, Footwear, Printing/Publishing, By-Products, Graphic Arts, Bedding Mattress, Mechanical Engineering, Ceramic, Electronic Games, Games Software, Integrated Circuit, Vehicles Equipment, Transport, Fertilizer, Office Equipment	United Kingdom, Germany, France, Belgium, Portugal, Austria, Italy, Norway, Sweden, the Netherlands, Spain, Denmark, Finland, Ireland, Greece, Australia, USA, Canada, Brazil, Chile, Mexico, China, Japan, Korea, Taiwan, Turkey, India, Kazakhstan, Vietnam, Jamaica

Table 5.7: Sectors and Countries included in Empirical Work (1999 – 2010)

As evident from Figures 5.3 and 5.4, there is a dominant focus on various European countries and USA which are developed economies (83% studies). However, only 11% research papers focus on developing countries mainly located in Asia, Latin America and Africa. This points to a gap in our knowledge about LT/LMT innovation because developing country contexts for innovation and systems of innovation are different from developed country contexts. Thus attention needs to be paid to conduct research on LT/LMT innovation in less developed parts of the world including Pakistan (for which no empirical work was found).

Another purpose of categorizing literature (as shown in the sample Table 5.6) was to help find out methodologies/methods applied by researchers to study LT/LMT innovation. Figure 5.5 below provide information in this regard;

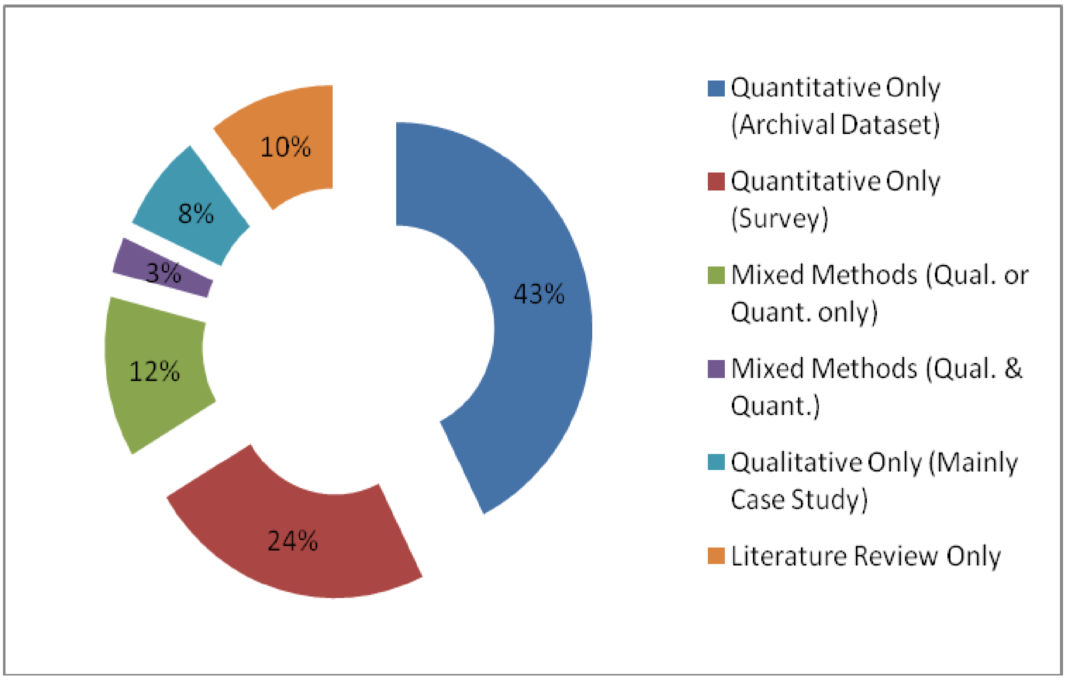


Figure 5.5: Methodology/Methods Applied by Researchers (Percentage of Articles)

Findings suggest that most research relies on using quantitative methods (67% papers) influenced from positivist paradigm to illustrate some aspect of LT/LMT innovations while 20% apply qualitative methods (phenomenological approach). However, studies that employ a mix of quantitative and qualitative methods are far less (3% of publications with mainly case study approach) while the influence of critical realism as a paradigm seems non-existent. In order to fill the gap this research applies case study and mixed methods approach underpinned by critical realist view of reality and knowledge to address research objectives and questions regarding LT/LMT innovation in the marble sector of north-west Pakistan.

All information contained in column 4 titled 'Main Focus of Research in LT/LMT Context' (as shown in sample Table 5.6) was further subjected to analysis. In this regard a software tool named Leximancer 2.25 was used. Leximancer is software used to extract themes and concepts contained within electronic documents. These themes and concepts are displayed visually on interactive maps that provide the researcher with a unique perspective on text-based data. Additionally, the software also allows for automatically searching for instances of the text that contains given concepts. The interactive maps help understand the contents of a large body of text or information. Provided below are figures 5.6, 5.7 and 5.8.

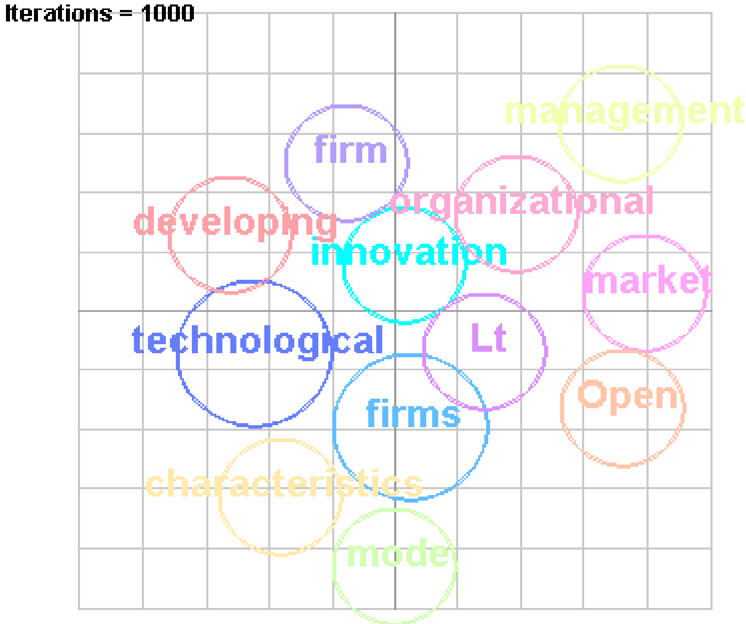


Figure 5.6: Key Themes: Main Focus of Research in LT/LMT Context

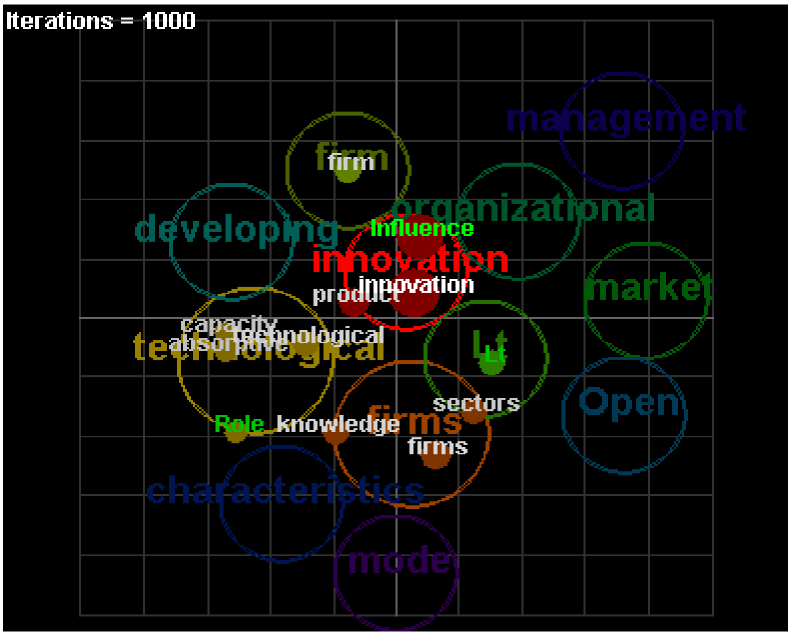


Figure 5.7: Concepts: Main Focus of Research in LT/LMT Context

Entities

Concept	Absolute Count	Relative Count
innovation	49	100%
Influence	48	97.9%
firms	17	34.6%
knowledge	15	30.6%
product	15	30.6%
technological	14	28.5%
firm	13	26.5%
sectors	11	22.4%
LT	9	18.3%
Role	9	18.3%
capacity	8	16.3%
absorptive	8	16.3%
market	8	16.3%
organizational	5	10.2%
developing	4	8.1%
formal	3	6.1%
Open	3	6.1%
size	3	6.1%
characteristics	3	6.1%
sophistication	3	6.1%
Understanding	3	6.1%
management	2	4%
economy	2	4%
mode	1	2%

Figure 5.8: Concept Ranking: Main Focus of Research in LT/LMT Context

In Figure 5.6 the circles highlight the key themes identified among the main focus or topics of research in LT/LMT context. The dots in Figure 5.7 point out the key concepts within the themes. It is important to point out that the brighter and larger a theme and concept in the two figures are, the more central they are in terms of the list of 'main focus of research'. As can be observed none of the themes have a circle significantly large compared to others. Also, none of the circles (except 'LT' and 'Firms') intersect to suggest a conceptual relationship. This leads to the conclusion that the main focus or topics of research on LT/LMT innovation are very diverse and scattered across a wide spectrum suggesting a lack of direction or focus among the research community.

Figure 5.8 reveals the frequency of a concept within the 'main focus of research'. 'Innovation', 'firms', 'firm' and 'product' emerge as the most frequent concepts (as expected because most research has been about innovation from firm perspective with products occupying centre-stage). However, an interesting dimension is the appearance of 'influence' as the second most frequent concept. This suggests that the main focus of research on LT/LMT innovation (1999 to 2010) has been on understanding influence with regards to some aspect of LT/LMT innovation.

5.9. Key Insights from Literature Review

A total of 269 key insights about LT/LMT innovation are derived from literature review. All of these have been organized in categories. Table 5.8 provides a sample in this regard.

Table 5.8: Sample of categorized key insights obtained from literature review about LT/LMT Innovation

RELEVANCE TO SSI CONCEPT	KEY INSIGHTS ABOUT INNOVATION IN LT/LMT SECTORS	SELECTED REFERENCES
Firm-Level Determinants	Process and product design; innovation budget; advanced machinery and equipment; technological and market access, integrative and internal R&D capabilities; customer-focus; employee/worker skills and training; innovation capacity (time to implement innovation); innovation specialists; documented planning for innovation; collaboration with firms and non-firms; internal vs. external technology development decisions; organizational practices such as teamwork, intra-firm knowledge transfer, extensive workflows and production scheduling; organizational culture including innovation propensity, market-orientation, value-orientation, organizational constituency, organizational learning; creativity and empowerment and innovation implementation context; top management support; learning orientation; export intensity or orientation	Kirner et al. (2009), Akgun et al. (2009), Hernandez-Espallardo and Delgado-Ballester (2009), Dobni (2008), Morone and Testa (2008), Dunk (2007), Hall and Bagchi-Sen (2007), Swan and Allred (2003), Macher and Mowery (2003), Freel (1999), McAdam et al. (1998), Pullen et al. (2009)
Sectoral-Level Determinants	Competitive intensity; customer demand; external R&D; science and technology push e.g. availability of R&D funds, informal and formal research; spread of wage labour; urbanization and changing lifestyles; interactions of knowledge and technologies; usage of intellectual property rights (IPRs), costs of learning usage of IPRs, patent activities; costs of innovation development process; market uncertainty in terms of innovation acceptance; technology uncertainty; market attitude (conservative vs. liberal); technology transfer network (comprising of non-firms e.g. industrial liaison office); existence of academic-entrepreneurial role-models; cultural differences between research organization (university) and industry; incentives for collaboration among actors within a sector; nature of price (low or high) within the market; knowledge flows and utilization within sector; sectoral environment (fast-changing vs. stable, less innovation in case of latter); level of regional economic progress (firms in better-off regions less innovative); human capital within sector; technology generation and adoption trends; availability of modern equipment from suppliers; market size; user sophistication	Guerzoni (2010), Bigliardi and Dormio (2009), , Hanel (2008), Schmiedeberg (2008), Jimenez-Jimenez et al. (2008), Duguet (2006), Keskin (2006), Aldas-Manzano et al. (2005), Kirbach and Jantunen (2005), Gu and Tang (2004), Avermaete et al. (2003), March-Chorda et al. (2002),Albuquerque (2000), Woodcock et al. (2000), Jones-Evans et al. (1999), Hansen and Serin (1999),
Individual-Level Determinants	➢ **Insight 1:** Owner/managers' innovation orientation, risk-taking behaviour, proactive behaviour and other psychological characteristics have indirect influence on innovation through mediating role of entrepreneurial processes within the firm ➢ **Insight 2:** Owner/manager's emotional capabilities including encouragement, displaying freedom, playfulness, experiencing, reconciliation and identification influence product/process innovations	Akgun et al. (2009), Entrialgo et al. (2000)
Knowledgebase,	➢ LMT sectors generally mature, technologies and market conditions change more slowly, knowledge	Rundquist and Halila

Technologies, Other Inputs	search and identification are more common than R&D or basic research; technologies used are mostly spill-overs from HT sectors thus increasing significance of firms' absorptive capacities ➢ Three categories of knowledge utilized by LT/LMT (1) Original HT inventions/discoveries, (2) knowledge of technologies available elsewhere, (3) knowledge of how to adapt technologies developed in other sectors ➢ Technology flows are mostly from HT to LT/LMT sectors and not vice versa ➢ True benefits of innovations/technologies in HT sectors realized when LT/LMT sectors utilize them, quick diffusion of knowledge vital for ensuring economic growth ➢ Sometimes radical innovations/technologies in HT sectors spilling over to LMT sectors can disrupt competition in them ➢ Market knowledge (competitor and customer knowledge) is the main source of external knowledge for LT/LMT firms ➢ Knowledge flow in LT/LMT sectors has geographical characteristics thus spreads less widely & quickly. However innovations resulting from knowledge flows across different knowledge clusters diffuse faster ➢ Incremental knowledge accumulation and on-job training more common in LT/LMT firms ➢ LT/LMT firms focusing on knowledge integration and outsourcing perform better on new product development. Small size and internal knowledge-base makes firms flexible in responding to market requirements. However, firms tend to be more reactive than proactive in this regard ➢ Firms with more formal knowledge better able to produce value-added products, have an explicit product innovation objective and greater interaction with technology infrastructure (technical service providers) ➢ A firm's knowledge stock, knowledge flows and knowledge utilization influence innovation positively ➢ Product design management influences innovation positively ➢ LT/LMT sectors have low-levels of knowledge appropriability and low cumulativeness, knowledge from one LT/LMT sector can also influence innovation in another LT/LMT sector ➢ Process technologies mode with focus on efficiency of production more common on LT manufacturers ➢ External technology sourcing more common. However, strong appropriation regimes in a sector and firm's resistance to change decrease a firm's reliance on external technology sourcing ➢ Uncertainties within a sector force firms to adjust knowledge boundaries with non-firms such as suppliers	(2010), Schmidt (2009), Hauknes and Knell (2009), Grimpe and Sofka (2009), Yang and Kang (2008), Vale and Caldeira (2008), Tether and Tajar (2008), Bergek et al. (2008), Lee and Veloso (2008), Robertson and Patel (2007), Von Tunzelmann and Acha (2005), Waguespack and Birnir (2005), Schmierl and Kohler (2005), Pederson (2005), Jantunen (2005), Chiva-Gomez et al. (2004), Lindman (2002), Veugelers and Cassiman (1999)
Learning Processes and Demand	➢ Learning processes in LT/LMT sectors mostly informal at firm level, 'learning by doing' is the norm ➢ A firm's market orientation influences its learning orientation which in turn influences the firm's ability to innovate, ➢ Demand changes occur slowly but not always the case in all LT/LMT sectors, firms seek new markets to address slow demand changes ➢ Demand tends to be inelastic since most LMT products cater to consumer 'necessities'. New technologies can help firms improve product quality and change demand conditions ➢ Four sectoral patterns of demand (influenced from Pavitt (1984)) proposed; passive markets, mass markets, niche markets and dual markets	Guerzoni (2010), Keskin (2006), Von Tunzelmann and Acha (2005)

Institutions (National and Sectoral Influences)	➢ Institutions within SI can be divided into three broad types; regulative, normative and cognitive ➢ Role of institutions within a system is not just to maintain inertia, they help us understand interactions between sectoral elements ➢ Role of institutions within LMT sectors can be better understood by establishing their link with national (NSI) and/or regional (RSI) institutions. National institutions have the ability to influence structure of SSI through their sectoral effects ➢ Sectoral institutions play a more influential role in the case of small firms as compared to national institutions which are more influential in the case of large firms ➢ The influence of technology parks (mostly having small LMT firms) on innovation is questionable. Lower rents and ease of access to finance are main reasons for LMT firms to move to tech. parks ➢ Governments can put pressures through regulations on firms to improve products and ward of competition from imported products ➢ Governments should devise and implement policies that not only support innovations but also their diffusion. These policies should account for environment within which managers of firms operate and should be facilitative rather than commanding ➢ Government policies should facilitate provision of technological knowledge that is quickly available, affordable and not hindered by complicated official procedures ➢ Differences among countries and sectors in terms of institutional frameworks influence organization of labour markets. This in turn influences the relative affect of determinants on innovation.	Radosevic and Myrzakhmet (2009), Fisher-Vanden and Terry (2009), Storz (2008), Robertson and Patel (2007), Carlsson (2006), Lee and Von Tunzalmann (2005), Geels (2004), Malerba (2004), Casper and Whitley (2004), Scott (2001)

Putting data about key insights regarding determinants of LT/LMT innovation (firm-level, sector-level, individual-level, LT/LMT-HT comparison) into Leximancer identifies key themes shown in the figure below;

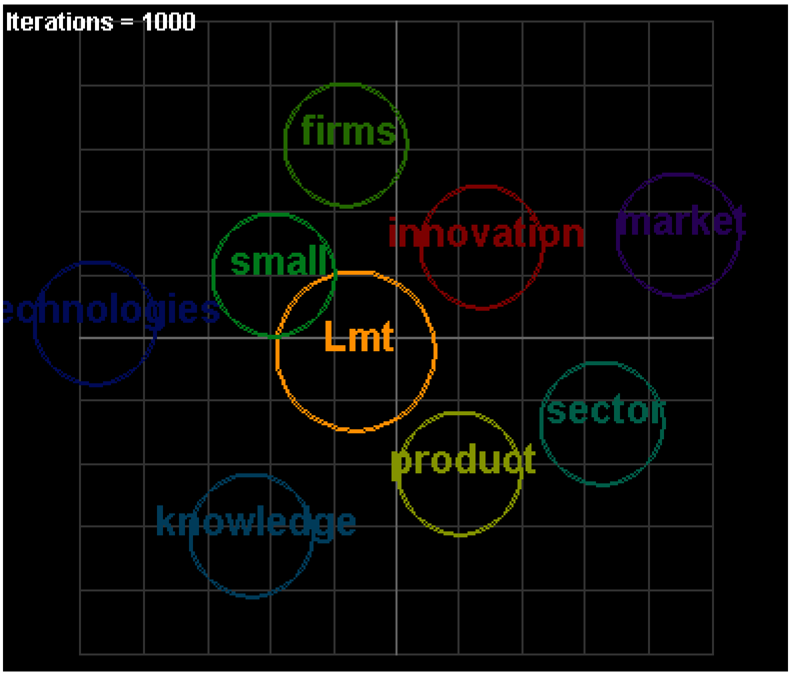


Figure 5.9: Themes: Key Insights on Determinants of LT/LMT Innovation

Figure 5.9 reveals that 'LMT' (largest circle) is the more central theme as far as research on innovation determinants is concerned. Apart from this, innovation determinants are found to be mainly related to themes like 'product', 'sector', 'firms', 'small' (LMT sectors are generally characterized by small firms), 'technologies', 'knowledge' and 'market'. The intersection between 'LMT' and 'small' confirms the assertion in various studies that LT/LMT sectors are mostly characterized by small firms.

5.10. Identifying Gaps

In addition to the key insights about LT/LMT innovation (sample provided in Table 5.8, some interesting outcomes emerge in terms of number of insights and references related to innovations in LT/LMT sectors. Figure 5.10 below displays the outcomes.

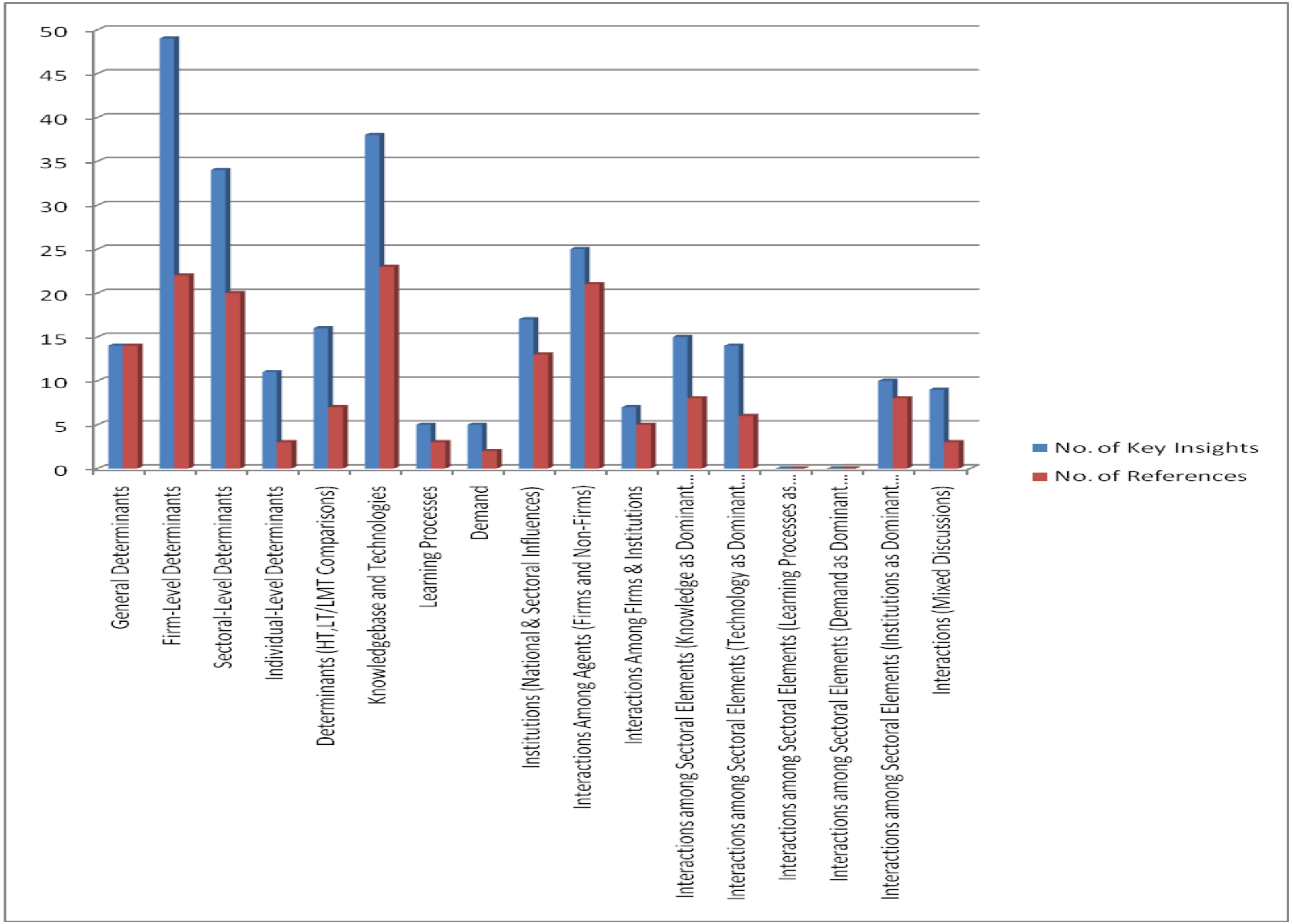


Figure 5.10: Graphical Representation of No. of Key Insights and No. of References from Literature on LT/LMT Innovation

Based on review of empirical work conducted between 1999 and 2010 and the subsequent summarization of information in the tables and charts shown above, following key observations emerge;

1. Studies on LT/LMT sectors have focused on aspects of innovation that are extremely diverse as a result of having varying research focus, objectives, methodologies/methods, findings and contexts (geographical and sectoral).

2. Many studies focus on LT/LMT sectors characterized by small firms. This suggests a possible similarity with Pavitt's (1984) taxonomical characteristics whereby supplier-dominated sectors are characterised by greater presence of small firms.

3. Many of the studies reviewed for this chapter do not exclusively cover LT and rather focus on LMT only or both LT and LMT together or HT making comparisons with LT/LMT.

4. Most studies do not take influence from the SSI-based approach to study innovation. Even though many authors use the word 'sector' at various junctures during their discussions, the usage cannot be termed as being synonymous with the word 'sectoral' as mentioned in SSI concept.

5. A dearth of studies is observed that present an all-encompassing SSI-based perspective of LT innovations that includes all of SSI's elements and structure.

6. Some studies use the terms LT and LMT together or synonymously without drawing the distinction suggested by the OECD classification.

7. More clarity is required to draw the distinction between LT and LMT. Studies are needed that focus exclusively on LT sectors especially those with zero or negligible R&D intensity in order to truly understand the nature of innovation that is not driven by R&D at all.

8. Another aspect that emerges from the review is that most research on LT/LMT focuses on activities or determinants that drive innovation with little attention being paid to those that serve as barriers. This is particularly a relevant aspect in developing countries' context where LT sectors in particular and others in general are affected more by barriers to innovation (Nouman, 2009).

9. A lack of empirical work was observed especially in the context of individual-level (micro) determinants, role of institutions, learning processes, demand, and interactions (especially firm-learning process, firm-demand and firm-institutions). More work is needed in this regard to enhance our understanding of innovation systems.

10. Most empirical work reviewed has been carried out in developed countries including many EU nations, USA and Far-Eastern states. No research, except for a few for Turkey, India, Kazakhstan and Jamaica were found that study LT innovations in developing countries' industrial sectors. Also, no studies were found for Pakistan.

11. None of the studies reviewed for this chapter focus on innovation within marble sector. A few empirical works focus on mineral sectors in different countries but in all cases either the particular mineral sector is not mentioned or the research is focused on 5 to 10 different industries with mineral sector being one of them.

12. No studies could be found that investigate the existence and nature of sub-sectoral interactions (like Pakistan's marble sector) within a LT or LMT sector and the influence of these interactions on innovations.

13. Most of the research work seems not to use a combination of inductive and deductive approaches to analyze innovation within LT/LMT sectors. Greater emphasis was found to be on use of quantitative methods (databases and surveys – 67% studies), thus drawing influence from positivist paradigm. For studies based in European countries, Community Innovation Survey (CIS) with its different versions was found to be the most commonly used database. A smaller number of

studies (20%) apply qualitative approaches and are influenced by phenomenological paradigm. Very few studies use case study approach and mixed methods (3%). While the influence of critical realism as the ontological and epistemological influence on researchers was found to be almost non-existent.

5.11. Conclusion

This chapter provided a detailed and systematic review of literature on innovation in LT/LMT sectors published between 1999 and 2010-11. Apart from identifying 269 key insights, empirical work was synthesized using various techniques to update our understanding of LT/LMT innovation and identify gaps in terms of our existing knowledge. It also helps provide the basis for the next chapter (Chapter 6) which presents this research study's aim, objectives and questions in a structured format taking influence from this chapter's outcomes as well as the Conceptual Framework (Chapter 3).

Chapter Six

STRUCTURING RESEARCH AIM, OBJECTIVES AND QUESTIONS

> *'Compared to positivism and interpretivism, critical realism endorses...a relatively wide range of research methods, but it implies that the particular choices should depend on the nature of the object of study and what one wants to learn about it'*
> (Sayer, 2000, pp. 19)

6.1. Introduction

This chapter presents the overall research aim, objectives and questions (provided in Chapter 1) in a logical and structured format. Influence is mainly drawn from the gaps identified in Chapters 4 and 5 with regards to our understanding of low-tech innovation, paradigmatic influence (Chapter 2) and the Conceptual Framework (Chapter 4). As a result this chapter guides the development of Research Methodology and Design (Chapter 7) and Data Collection and Analysis Procedures (Chapter 8).

6.2. Linking Research Objectives and Questions with Gaps

The overall aim of this research is *to generate an in-depth understanding of the existence/non-existence of innovation in a low-technology sector by exploring the perspectives of all key stakeholders in the context of sectoral system of innovation (SSI).* As mentioned in Chapter 1 and now more evident after presenting Chapters 2, 3, 4 and 5, taking up this research study is justified mainly because;

- It provides a much needed exclusive and all-encompassing focus on low-technology innovation within the context of a developing country.
- It addresses the lack of a critical realist view (explaining events by identifying and explaining the underlying mechanisms) of sectoral system of innovation or SSI (sectoral elements & structure) by integrating conceptual and theoretical aspects of critical realism and SSI with empirical work on LT innovation.
- Bringing in the micro-meso-macro framework it puts to the forefront not only the role of firms and their context but more importantly the role of

individual within firm, sectoral elements and sectoral structure which have been an ignored area within research on LT innovation.

Table 6.1 provides a translation of research aim to research objectives (ROs) and questions (RQs) along with the specific issues and gaps (highlighted through Chapters 3, 4 and 5) that provide the justification for these questions.

Research Objectives	Research Questions	Gaps (Chapters 4 and 5) To Be Addressed
RO1: To understand the existing phenomenon of innovation within a low-technology sector	**RQ1.1:** What products, processes, organizational structure and markets do firms within the sector have or deal with?	Lack of exclusive LT focus (especially zero R&D intensity) from the firm perspective; Lack of developing country (especially Pakistan) & sector context with regard to innovation; Lack of mineral sector especially marble context with regard to innovation
	RQ1.2: What types of innovation exist amongst firms within the sector?	
RO2: To explain how a low-technology sectoral system of innovation exists in terms of its elements	**RQ2.1:** How are the actors or agents (firms including individuals and non-firms) setup in the sector?	Lack of empirical work that studies role of agents within SSI in developing country contexts; Extremely limited understanding of the role of individual within LT firm
	RQ2.2: How do knowledge-base & technologies exist in the sector?	Very limited empirical work on role of knowledge and technologies within SSI & LT sectors especially in developing country context
	RQ2.3: How do learning processes and demand exist in the sector?	A clear lack of empirical work on the role of learning processes & demand within SSI & LT sectors
	RQ2.4: How are institutions placed in the sector?	Few studies that focus on institutions (formal, informal) and their influence on interactions within SSI; No studies on institutions in developing country context
RO3: To examine why or why not low-technology innovation exists within the LT sector by studying and explaining structure of the sectoral system of innovation	**RQ3.1:** How do firms interact amongst themselves and with non-firms?	Lack of research that focuses on interactions among agents; No studies found that focus on sub-sectoral interactions; same as **RQ2.1**
	RQ3.2: How do firms interact with institutions (sectoral & national)?	Very few insights found from literature review that focus on interactions between firms & institutions; same as **RQ2.4**
	RQ3.3: How do firms interact with knowledge and technologies?	Need for studies that focus on interactions between firms & knowledge; same as **RQ2.2**
	RQ3.4: How do firms interact with learning processes and demand?	No studies and insights found from literature review that focus on interactions between firms and learning processes and firms and demand to influence LT innovation; same as **RQ2.3**
	RQ3.5: What are the factors (individual, firm and contextual) that influence low-technology innovation amongst firms in the sector?	No studies found that present a critical realist view of LT innovation using SSI approach; No studies found that apply micro-meso-macro framework to SSI approach; Almost non-existent research on individual-level determinants; Need to understand which determinants relevant to LT innovation (a particular type of innovation) and how much is their influence on LT innovation within SSI
	RQ3.6: How much do these factors influence LT innovation amongst firms in the sector?	

Table 6.1: Linking Research Objectives and Questions with Gaps

6.3. Interpreting Research Questions in Light of the Paradigmatic Influence and Conceptual Framework

Chapter 4 focused on developing the conceptual framework guiding this research. The framework not only takes influence from the basic tenets of critical realism (Chapter 2) but also the systemic nature of innovation (system of innovation particularly sectoral system of innovation approach). Also, it applies a micro-meso-macro analytical framework to the SSI approach. It is important to point out that since individuals (including marble firm owners and managers and other key individuals in non-firms) remain the primary respondents in terms of primary data collection the micro-individual level remains the key influence in analysis (covered in greater detail in Chapter 8). Recognizing the role of individuals is particularly important in the case of small businesses where they essentially influence the firm (meso-level) as well as how it behaves with regards to the sectoral environment or context (macro-level). Thus the analysis of the meso and macro levels will be influenced by the micro-level.

Table 6.2 presents research questions in light of the paradigm and the conceptual framework.

Research Questions	Critical Realist Interpretation	Micro-Meso-Macro Analytical Framework: Data Collection	Micro-Meso-Macro Analytical Framework: Data Analysis	SSI	Translation To This Research
RQ1.1: What products, processes, organizational structure and markets do firms have or deal with?	**Objects**	**Micro-individual level** Mining and Processing Firm owner and/or manager Owner or manager of non-firm such as supplier, distributor Key individual in non-firm such as government department, other support or stakeholder organization	**Meso-firm level**		Nature of existing products, production processes, markets, organizational structure that mining and processing firms in low-tech marble sector of north-west Pakistan have
RQ1.2: What types of innovations exist amongst firms	**Events**				Nature and types of LT innovation (product, process, incremental, low-tech and others) amongst marble firms
RQ2.1: How are the actors or agents (firms including individuals and non-firms) setup in the sector?	**Objects**		**Micro-individual level** **Meso-firm level**	**Elements**	Roles of individuals and firms within marble sector Roles of non-firms within low-tech marble sector
RQ2.2: How do knowledge-base & technologies exist in the sector?	**Underlying Components**		**Macro-contextual level**		Dimensions of knowledge and technologies present or available within low-tech marble sector
RQ2.3: How do learning processes and demand exist in the sector?	**Mechanisms**				Dimensions of learning processes and demand within low-tech marble sector
RQ2.4: How are institutions placed in the sector?					Types and roles of institutions (formal, informal), influence on interactions, institutional framework for low-tech marble sector
RQ3.1: How do firms interact amongst themselves and with non-firms?	**Necessary and Contingent Relations (Context)**		**Meso-firm level**	**Structure**	Nature of interactions between mining firm and non-firms Nature of interactions between processing firm and non-firms Nature of interactions between mining firm and processing firm
RQ3.2: How do firms interact with institutions? **RQ3.3:** How do firms interact with knowledge and technologies? **RQ3.4:** How do firms interact with learning processes and demand?	**Mechanisms**		**Macro-contextual level**		Nature of interactions between firms and institutions, firms and knowledge/technologies, firms and learning processes, firms and demand Influence of different types of interactions on innovation
RQ3.5: What are the factors (individual, firm and contextual) that influence low-technology innovation amongst firms in the sector? **RQ3.6:** How much do these factors influence innovation amongst firms in the low-tech sector?	**Causal Powers**		**Micro-individual level** **Meso-firm level** **Macro-contextual level**	**Elements and Structure**	Individual, firm and contextual factors influencing existence/non-existence of low-technology innovation in the marble sector Relative and quantifiable importance of each factor influencing existence/non-existence of low-technology innovation amongst marble firms in the sector

Table 6.2: Interpreting Research Questions in light of Paradigm and Conceptual Framework

6.4. Conclusion

This chapter presented the research aim, objectives and questions in a structured format taking influence from the gaps identified in Chapters 4 and 5. Moreover, it presented research questions in light of the paradigmatic influence and conceptual framework. Issues concerning choice of research methodology and design (Chapter 7) and data collection and analysis procedures (Chapter 8) have been decided taking influence from the structured presentation of research objectives and questions provided in this chapter.

Chapter Seven

RESEARCH METHODOLOGY AND DESIGN

> *'Empirical research advances only when it is accompanied by logical thinking, and not when it is treated as a mechanistic endeavour'*
> Yin (1984)

7.1. Introduction

The purpose of this chapter is threefold. First, it revisits critical realism, the paradigm underpinning this research (introduced in Chapter 2). The basic tenets of critical realism like objects/entities, events, mechanisms, causal powers, structure of causal explanation and others are translated for this research. This is made possible as a result of discussions in previous chapters regarding; contextual background (the marble industry of north-west Pakistan) in Chapter1; the paradigmatic foundation in Chapter 2; the basic concept and dimensions of low-tech innovation (focus of this research) in Chapter 3; the conceptual framework including the SSI approach (Chapter 4) pointing out that the marble sector is being treated as a sectoral system; and structuring of research objectives and questions (Chapter 6) resulting from identified gaps and outcomes in Chapters 4 and 5.

Second, the chapter presents a case for use of case study by highlighting some of its key characteristics (type of research questions, extent of control over behavioural events and focus on contemporary phenomena) appropriate for this research. Further, it links up the key aspects of critical realist thought with case study in order to demonstrate the appropriateness of using case study as the methodology. These include phenomenon, context, boundary, nature of research questions, flexibility in choosing data collection tools (that link up paradigmatic assumptions with research methods – Table 7.2) and the use of retroduction.

Third, the chapter introduces a multiple (two) case design (embedded – type 4) and the justification (including 'replication logic') for its use along with unit of analysis and definition of case for this research. The case is the marble sectoral system. In this regard two separate, yet identical in many aspects, sectoral systems – Peshawar Marble Sectoral System (PeMaS) and Buner Marble Sectoral System (BuMaS) have been presented. Each case is characterized by context, units of analysis (marble firms) and units of observation (firm owner/manager). Chapter 8 provides a more detailed account of the two-case-design by providing details of data collection and analysis procedures including case study protocol applied in this research.

7.2. Revisiting Critical Realist Thought

Chapter 2 built the case for critical realism as the philosophy underpinning this research. The fundamental idea behind critical realism is that reality and objects exist independent of the human mind however reality and truth for us are what our senses show us. This brings in the notion of 'epistemic fallacy' whereby the notion that ontological and epistemological considerations are interconnected is challenged. Critical realists assert that the natural and social worlds are fundamentally different whereby the social world is constructed based on human interpretation and actions. Bhaskar (1989a; 1998) presents the notion of 'stratified ontology' whereby reality or truth has two dimensions. On one hand it consists of the 'transcendental', metaphysical or objectivist ontology (the real or actual truth) that is intransitive and has its underlying causal mechanisms. On the other it consists of our subjectivist, interpretivist or relativist epistemological construction of that reality which is transitive since human thought and interpretations change.

Although critical realism advocates developing a construction of the intransitive transcendental reality and its underlying causal mechanisms it is limited in terms of its ability to provide that understanding since it is difficult for humans to judge whether these constructions are merely imagination or real and non-empirical depiction of the actual truth. Keeping this limitation Sayer (2004) underscores the need for critical realists not to engage too much in attempts to discover the absolute truth. Fairclough (2005) draws a distinction among the 'real, the 'actual' and the 'empirical.' The 'real' includes structures with their related 'causal' mechanisms. The 'actual' includes events and processes. While the 'empirical' includes that part of the real and actual that is experienced by social actors. In social sciences critical realism claims that there are mediating entities or social practices that account for the relationship between the 'real' structures and the processes/events. Bringing in the notions underlying pragmatism that espouse usefulness of truth that is context-specific it is possible to develop an epistemic transitive construction of reality in line with the philosophical thought that reality is more true or less true rather than whether it is absolute or constructed/relative. That is why Sayer (1992, pp. 83) emphasizes the need to understand the limitations of our conceptual resources. Thus, 'truth is neither absolute nor purely conventional and relative'. Bhaskar (1989b) himself implies a more realistic or pragmatic solution to the problem with retroduction that attempts to explain events by identifying and explaining the mechanisms underlying these events.

7.3. The Critical Realist View of Low-Tech Marble Sectoral System of Innovation (LT-Marble-SSI)

Taking influence from discussions in Chapter 1 to 6, it is possible to develop a more detailed critical realist interpretation of low-technology marble sectoral system of innovation or LT-Marble-SSI.

Table 7.1 provides Sayer's (2004; 1992) perspectives of critical realist thought and an interpretation of these thoughts to LT-Marble-SSI.

Sayer's (2004; 1992) components of critical realist thought	Interpretations for this research
Objects/Entities Building blocks for critical realist explanations such as organizations, people, resources, attitudes	Sectoral system of innovation (SSI), organizations (marble firms, non-firms such as support organizations, suppliers, distributors, government departments, others), sectoral institutions (including sectoral influences of national institutions), knowledge, technologies, marble products
Events/Outcomes What critical realists investigate, they are external and visible outcomes of behaviours of people, organizations, systems	Existence of innovations in low-tech sector in various forms such as product, process, organizational, marketing, incremental and others
Causal powers Objects/entities have causal powers, they make things happen	Firms, non-firms, institutions, technologies and their interactions cause events (innovation in different forms). Within SSI causal powers exhibit themselves as determinants of LT innovation
Structure of entities Entities comprise of components or objects which are internally related. In other words structures exist within structures	Firms comprise of individuals/people (manager/owner, skilled/semi-skilled/unskilled staff or workers, departments, production processes, resources such as machinery, finance). Similarly other objects such as non-firms, institutions have their own components
Emergence Objects/entities analyzed at different aggregation levels. Properties of entities understood better at low aggregation level. Choosing level influenced by which one can be accessed	SSI can be analyzed using level of aggregation (micro-meso-macro) influenced by product types (marble – raw & processed forms), firms can be analyzed using level of aggregation influenced by key individuals within firms, institutions can be analyzed using level of aggregation influenced by whether institutions are formal/informal, sector-specific, regional or national
Necessary and contingent relations Critical realism argues for two types of relationships among entities. Necessary – when one entity is dependent on another. Contingent – when one entity may be influenced by another. Events are explained by using a combination of necessary and contingent relations	Relations/interactions between mining firms and processing firms or mining/processing technologies and firms are necessary Relations between knowledge/technologies and firms are necessary Relations between institutions and firms may be necessary or contingent Relations between firms and non-firms may be necessary or contingent
Context Generalized perspective of contingent relations, includes all 'relevant circumstances'	Ways in which objects/entities act within the context of SSI resulting in generation of low-tech innovations or their lack there off
Mechanisms Ways in which objects/entities cause events to occur. Mechanisms do not need to be linear (requiring statistical models). They can be linguistic and descriptive in nature	Firms produce marble products using production technologies and worker expertise. Poor technologies and lack of worker skills may result in lack of LT innovation. Improved technologies and trained/experienced workers may result in LT innovation. However technologies and worker skills may have institutional and non-firm influences as well
Structure of causal explanation and research process Central concern of critical realism is explanation of what caused events. Rather than induction or deduction (moving at the level of events from general to particular and vice versa), critical realism is concerned with retroduction – explaining events by explaining mechanisms which produce them	Objects having structures and causal powers will, under certain conditions result in event 1 or under other conditions will result in event 2. For example, firms with owner/manager as a structural component and having causal powers will under certain conditions (e.g. institutional, non-firm support and interactions) result in incremental LT innovation. Or under other conditions will not result in low-tech incremental innovations. Actual explanations will of course not be as simple because they deal with complex real situations

Table 7.1: Interpreting the Components of Critical Realist Thought for This Research

Chapters 9, 10 and 11 take influences from the components of critical realism provided in Table 7.1. These chapters focus on events (occurrences of LT innovation), objects (sectoral elements), necessary and contingent relations (sectoral structure), mechanisms that influence events, and causal powers (determinants of LT innovation).

7.4. The Case for Case Study Research

As pointed out in Chapter 1 the research strategy applied in this research is case study. It is one of the main methods in organizational and management studies. Yin (2003) describes case study as;

> *'…an empirical inquiry that investigates a contemporary phenomenon within its real-life context especially when the boundaries between the phenomenon and context are not clearly evident.'*
>
> Yin (2003, pp. 13)

A key component of the case study approach is that it provides a context-rich understanding of a phenomenon thus influencing data collection and analysis procedures. Yin (2003, pp. 3-4) suggests that a case study inquiry will;

(1) Have 'many more variables'

(2) Depend 'on multiple sources of evidence' whereby data needs to be triangulated so as to converge it

Pointed out by Yin (2003), three main reasons for using Case Study interpreted for this research are provided below;

7.4.1. Type of Research Questions

The influence of research questions on choice of strategy is foremost (Hedrick, et al., 1993). The current research is characterized by a dominant presence of 'why' and 'how' questions (Chapters 1 and 6) whereby explanations of the possible mechanisms underlying the phenomenon/event (occurrence of LT innovation) is sought.

7.4.2.. Extent of Control over Behavioural Events

Histories are characterized by the researcher having no control over behavioural events (since they have already occurred). Experiments are more suitable when a researcher can manipulate behavioural events. However, a case study is more appropriate for events whereby the behavioural component cannot be manipulated by the researcher. In the case of this research the focus is on a firm-oriented existence/non-existence of LT innovation in the marble sector. Here events are influenced by causal powers of objects and not influenced by the researcher.

7.4.3. Focus on Contemporary as Opposed to Historical Events

As opposed to histories, the case study and experiment focus on contemporary events. This research focuses on LT innovation in the present times rather than treating it as some historical occurrence of the past.

Three key applications of case study approach in research as pointed by Yin (2003) include;

(1) Explaining 'causal links' in real-life interventions which otherwise might be too complicated to elaborate on using other strategies like survey or experiment.

(2) Describing real-life context in which the intervention has taken place

(3) Describing the intervention itself

Revisiting the research aim, objectives and questions it is clear that this study addresses all of the above. This research describes the phenomenon of low-technology innovation, investigates the real-life context in which low-technology innovation occurs or does not occur and explains the causal mechanisms that underlie the existence of low-technology innovation.

As evident from the discussion in this section, Robert Yin's work is greatly influencing this research. It is important to point out that Kathleen Eisenhardt is another key contributor to our understanding of case study. Eisenhardt (1989) stresses the use of case study to induct theory whereby the process is highly iterative and closely linked to data. However, as illustrated in Chapter 2, section 2.8.2, this study's main aim is not to generate new theory. Thus Yin's work remains the major influence on this research as it offers greater flexibility by espousing use of mixed methods whereby retroduction is possible and research questions are at the core of inquiry.

7.5. Linking Case Study Methodology with Critical Realism

In addition to the three reasons for choosing case study, another important aspect is to appreciate the suitability of case study to underlying components of critical realism. Six relevant points are discussed below.

7.5.1. Perspective on Phenomenon

Innovation (product, process, marketing and/or organizational) within a low-technology sector is the phenomenon under investigation. Sayer (2004) points out that the events are external and visible outcomes of the behaviour of objects/entities (marble mining and processing firms). Thus the phenomenon of innovation within the context of marble SSI is under investigation. This phenomenon manifests itself in the form of product, process, marketing and/or organizational innovations resulting from the behaviour or actions of marble firms that are influenced by the internal and external context within which they operate.

7.5.2. Perspective on Context

Critical realism provides a complex view of contexts and appreciates the interwoven nature of the epistemic transitive construction of reality. It leads us to conceptualize frameworks that focus on the interactions between context and phenomenon in question (Layder, 1993). This is particularly useful because this research applies the micro-meso-macro analytical framework (Chapter 4) to look at firm-specific LT innovations within the context of SSI while also appreciating the key role of individuals within firms. The SSI consists of elements and interactions among them (structure).

7.5.3. Perspective on Boundary

Easton (2009) suggests that a critical realist approach is more suited for clearly bounded phenomena that are essentially very complex in nature.

However, it is less suitable to phenomena that are highly qualitative in nature for instance human behaviours and phenomena that are highly quantitative in nature such as sales trends in industry. Suitable phenomena may include organizations or inter-organizational relationships. However, the boundaries between the phenomena and context may be flexible and subject to change in line with the nature of research or the questions it seeks to answer. This is particularly important because critical realism focuses on determining the causal mechanisms underlying the objectivist ontological world which in turn might require imposing certain limitations on the boundaries to determine causality.

Low-tech innovation cannot be characterized as a highly qualitative or quantitative phenomenon. It manifests itself in tangible forms like product or process innovation thus not having qualitative characteristics in the real sense. On the other hand it is not really a quantitative phenomenon characterized by highly number-oriented data. However, innovation is a complex and systemic phenomenon (Chapter 3) influenced by a variety of factors. Also, this research applies certain boundaries to the phenomenon of firm-specific low-tech innovation by bringing in the 'level of aggregation' concept derived from SSI approach. Under this, boundaries of the phenomenon under investigation are influenced by product groups (marble of different shapes, sizes and colours excavated from mines plus different types of products in processing units), technologies and sets of activities. However, a case study is useful particularly when boundaries between the phenomena and context are not clearly drawn. This stands true in this research because sometimes it is difficult to determine that which aspect of LT innovation has been influenced by the firm-specific factors and which one is affected by the contexts of non-firms, institutions, knowledge-base, technologies and interactions.

7.5.4. Nature of Research Questions

A central tenet of critical realism is that it attempts to identify underlying causal mechanisms that can explain phenomena (Table 7.1). This means asking questions like what caused events or how and why they occurred. The case study approach is particularly useful for an in-depth study of social phenomena to explain the events that resulted from the action of entities or objects (human and non-human). The questions posed for this research study essentially ask how and why LT innovation occurs or does not occur thus helping to explain the causal mechanisms that need to be present for LT innovation to take place.

7.5.5. Flexibility in Choosing Data Collection Tools

Case study provides the flexibility of collecting data using multiple sources of evidence (quantitative, qualitative, through interviews, questionnaires and others). The use of methodological triangulation (Denzin, 2006) enhances validation of research data and research outcomes. Triangulation is a method of cross-checking data from multiple sources to search for regularities (O'Donoghue and Punch, 2003). Since critical realism focuses on establishing causal mechanisms, the choice of data collection tools and types of collected data will be influenced by the kind of causal mechanisms that need to be studied in light of research questions. Limitations of collecting data or data availability within the context of research also need to be kept in mind. This research uses literature, interviews (semi-structured in-depth and structured) and questionnaires through a multi-phased approach (discussed in Chapter 8) to help explain the existence or lack of LT innovation in the marble sector. For example, LT innovation amongst marble processing firms may be a result of certain interactions between the firms and technologies. In order to explain how these causal mechanisms exist and work to influence the event of LT innovation, interviews and questionnaires with firm owners and managers, suppliers of technologies and non-firms having a supportive role regarding technologies will be useful.

Before going into a detailed explanation of the case study design implemented in this study it is important to provide a sense of the interrelationships among key components of the research discussed so far. Table 7.2 provides the paradigmatic assumptions leading to research methods. These methods have been explained in greater detail in Chapter 8.

Paradigmatic assumptions (PA) (Chapter 2)	Research concern (Chapters 4 and 5)	Research questions (Chapters 1 and 6)	Themes/Concepts (Chapters 4 and 5)	Research Methods (Details in Chapter 8)
PA1: Ontology Transcendental, metaphysical or objectivist ontology (the real or actual truth) that is intransitive and has its underlying causal mechanisms.	Existing situation in terms of workings of a low-technology sector in a developing country (objects) Existing phenomenon of innovation in the low-technology sector (events)	**RQ1.1:** What products, processes, organizational structure and markets do firms within the sector have or deal with? **RQ1.2:** What types of innovation exist amongst firms within the sector?	Meso-firm level products, processes, organizational structure & marketing practices Meso-firm level manifestations of innovation	Semi-structured in-depth interviews with owners/managers of mining firms within marble sector Semi-structured in-depth interviews with owners/managers of processing firms within marble sector
PA2: Epistemology Epistemic relativist, transitive construction of reality that is subjectivist/interpretivist	Focus on understanding the SSI in term of its elements (objects/entities) Building understanding of a low-tech SSI within a developing country (mechanisms)	**RQ2.1:** How are the actors or agents (firms including individuals and non-firms) setup in the sector? **RQ2.2:** How do knowledge-base & technologies exist in the sector? **RQ2.3:** How do learning processes and demand exist in the sector? **RQ2.4:** How are institutions placed in the sector?	Micro-individual level role of owners/managers of firms within the low-tech sector Meso level role of firms within the low-tech sector Macro level role of non-firms, technologies, knowledgebase, learning processes, demand and institutions within the low-tech sector	Semi-structured in-depth interviews with owners/managers of mining firms & processing firms within marble sector Semi-structured in-depth interviews with supplier, distributor, sector expert and representative of sector support organization Structured interviews with owners/managers of mining firms Questionnaires with owners//managers of processing firms
PA3: Pragmatist Influence Reality is neither absolute nor constructed, rather it is more or less true **PA4: Retroduction** Events/phenomena can be explained in terms of causal mechanisms; Iterative data collection and analysis till epistemological closure, no matter how flawed and temporary is obtained	Explaining why or why not innovation in a low-tech sector is occurring (mechanisms) Focus on understanding the SSI in terms of its structure (necessary and contingent relations) Determinants of low-tech innovation and their relative influence within SSI (causal powers of objects/entities)	**RQ3.1:** How do firms interact amongst themselves and with non-firms? **RQ3.2:** How do firms interact with institutions (sectoral & national)? **RQ3.3:** How do firms interact with knowledge and technologies? **RQ3.4:** How do firms interact with learning processes and demand? **RQ3.5:** What are the factors (individual, firm and contextual) that influence low-technology innovation amongst firms in the sector? **RQ3.6:** How much do these factors influence innovation amongst firms in the low-technology sector?	Meso-firm level interactions with non-firms Meso-firm level interactions with institutions Meso-firm level interactions with knowledgebase & technologies Meso-firm level interactions with learning processes & demand Determinants of innovation in a low-tech sector from SSI perspective including micro, meso and macro level determinants	Structured interviews with owners/managers of mining firms Questionnaires with owners//managers of processing firms Structured interviews with owners/managers and representatives of non-firms during closing phase of data collection

Table 7.2: Critical Realist Paradigm Leading to Research Methods

7.5.6. Analyzing/Interpreting Data: The Use of Retroduction

Critical realism distinguishes itself from other paradigms by using retroduction instead of relying on induction (common in qualitative/interpretivist approaches) or deduction (common in quantitative/positivist approaches). Sayer (1992, pp. 107) describes retroduction as a '…mode of inference in which events are explained by postulating mechanisms which are capable of producing them…'

Lawson (1997) points out that while deduction tries to understand an event by moving from the particular to the general and vice versa for induction; retroduction approaches events from a different perspective. The main concern here is to understand an event or phenomenon in terms of the mechanisms that caused it. Critical realism acknowledges that explanations resulting from the analysis of collected data are essentially interpretivist (especially true for this research study where all primary data comes from interviews and questionnaires involving respondents and analysis as a result of interpretations of their interpretations/responses). Woodside et al. (2005) term this double interpretation as the problem of 'double hermeneutic'. However, critical realism does not consider the discourse resulting from this form of data analysis to be enough in itself. Rather 'reference to referents of the discourse need to be made' and the researcher needs to repeat data collection (done through a multi-phased approach in this research – Chapter 8) 'until epistemological closure, however flawed and temporary, is obtained' (Easton, 2009, pp. 7). As mentioned earlier, retroduction is the key epistemological process that is iterative in nature (Dubois & Gadde, 2002). Case studies are suitable in this regard because they can employ inductive as well as deductive cycles of data collection. Easton (2009) explains this by stating that;

> *'Deduction helps to identify the phenomenon of interest, suggests what mechanism may be at play and provide links with previous research and literature. Induction provides event data to be explained and tests the explanations… (Both) invoke causal language and the identification of mechanisms and offer the data collected as evidence.'*
>
> (Easton, 2009, pp. 7)

This study also uses retroduction in a similar manner. It applies deductive approaches by using previous theory/concepts about LT innovation through literature review to highlight mechanisms that influence it. Further, it uses data collected from questionnaires and applies the conceptual framework (Chapter 4) to further explain mechanisms specific to the marble sector. However, it also applies inductive approaches by starting the data collection process through semi-structured in-depth interviews in a completely new context of north-west Pakistan's marble sector with no similar study conducted previously. Outcomes from these interviews also inform the development and design of structured interview and questionnaire and help identify possible explanations of why or why not LT innovation occurs. Another set of interviews is carried out in the closing phase after analyzing first set of interview data as well as questionnaires thus ensuring the iterative nature of retroduction process. This helps offer further explanations of the causal mechanisms.

7.6. Case Study Design

Nachmias and Nachmias (2000) describe research design as a plan that directs the researcher in the process of data collection, analysis and interpretations. Two key components of a case study design are (a) the research questions especially those containing 'how' and 'why' questions and (b) the unit of analysis along with definition of the case Yin (2003). The former have already been discussed in Chapters 1 and 6. The sections below focus on the units of analysis along with defining the case for this research. This is followed by the case design being employed in this research. It also helps in laying the basis for detailed discussions in Chapter 8 regarding data collection and analysis procedures.

7.6.1. Determining Unit of Analysis and Defining the Case

Yin (2003) suggests that for a case study the case itself can be conceptualized as an individual, a firm, a group of firms (industry), a process, or a project. Babbie (2009) suggests that the unit of analysis is the entity being analyzed in a study. However, it should not be confused with the unit of observation which is the unit on which data is collected. Yin (2003) points out that determining the unit of analysis is primarily influenced by the way the research questions of a study have been put. Revisiting the research objectives and questions it is evident that the purpose of this study is to understand firm-oriented innovation in low-technology sectors within the context of a sectoral system of innovation.

This research collects and analyzes data for two sectors within Pakistan's marble industry which in turn have been conceptualized as sectoral systems of innovation (SS). These include Buner Marble Sectoral System (BuMaS) and Peshawar Marble Sectoral System (PeMaS). Each is characterized by its own elements and structure thus each marble SSI forms a single case for this study. Going back to Babbie (2009) it is important to remind ourselves of the difference between the unit of analysis and the unit of observation. While a sector remains the case, the unit of analysis is the firm (processing and mining units) that exists within the sector. The firms in turn are represented by key individuals such as owners/managers from whom data has been collected. Thus these individuals are the units of observation along with individuals from non-firms who have been contacted mainly during the initial semi-structured interview phase.

A more important issue is defining the case itself. Platt (1992) reminds us that the earliest or classic case studies take an individual as a case. While an individual, a group of individuals, a program or project, a firm or a group of firms can be a case, Stake (1995) does not agree with having a wide view of the case. For example, relationships or interactions among individuals or firms will be more difficult to assign case status because they are weak in terms of 'specificity' and 'boundedness'. As evident from the research questions and subsequent discussions emanating from detailed literature review, this study takes influence from the sectoral system of innovation characterized by low-technology innovation within system boundaries. These boundaries are characterized by similar sets of marble products the sector deals with as well as the particular elements and structure of the system. Firms (the unit of analysis) remain the most important element with regards to low-technology innovation.

7.6.2. Choosing the Design: Multiple (Two) Case Design (Embedded – Type 4)

Yin (2003) offers a '2x2 Matrix' of case study design. It includes the 'Single Case Designs (Types1 & 2)' and the 'Multiple Case Designs (Types 3 & 4)'. As pointed out earlier, the two sectoral systems namely 'BuMaS' and 'PeMaS' form the basis for case study research. Each case is characterized by embedded units of analysis in the form of mining and processing firms (elements of the sectoral system). The use of two cases in this research that are mostly similar to each other is primarily influenced by two factors. The first relates to practical conditions or actual situation on the ground. The marble industry of north-west region of Pakistan is characterized by three dominant sectors namely Peshawar, Buner and Mohmand Agency. Each of these has a significant number of marble processing units that acquire raw marble from the adjoining marble mines. Buner has a presence of both mining and processing units suggesting a 'within-sector' utilization of marble. Similar is the case with Mohmand Agency. However, Peshawar despite having a strong presence of processing units does not have mining units. Raw marble is mostly supplied from the adjoining area of Mohmand Agency. The main reason for discarding Mohmand Agency as a separate case is because of the bad law and order situation prevalent in the tribal regions of Pakistan since the last 5 to 6 years. Even at this point during write-up of the chapter, a military operation is underway in these areas making access to firms impossible. More importantly, most marble processing units in Mohmand Agency have closed down their operations either temporarily or permanently. Thus only Peshawar and Buner have been included. However, PeMaS is taken to include processing units in Peshawar and mining units in Mohmand.

The second factor influencing use of two or more cases relates to the imperative of increasing robustness of the study (Herriott & Firestone, 1983). Applying the 'replication logic' (Hersen & Barlow, 1976) also used in experiments helps build our confidence in the research outcomes. Yin (2003) points out that the use of 2 – 3 cases that provide similar results is a 'literal replication'. Both BuMaS and PeMaS are similar in terms of their sectoral characteristics (similar products, technologies, knowledgebase, learning processes, demand, institutions, firms that is processing and mining units, non-firms and interactions/relationships). A possible difference between the two cases is that PeMaS is characterized by being located in the provincial capital of the province (North-West Frontier Province) with better access to markets, knowledge and technologies. However, it is only through cross-case comparisons that we can determine the influence of these differences on innovation within the two selected cases.

As a result this research study applies a multiple case study design (embedded – type 4). Use of the multiple cases is justified not just through replication logic but also because neither of the two cases represents a critical case, a unique case, a revelatory case, a typical case or a longitudinal case (Yin, 2003) that are the criteria used to justify selection of one case in single case study designs. Figure 7.1 provides a visual representation of the multiple case study designs (embedded – type 4):

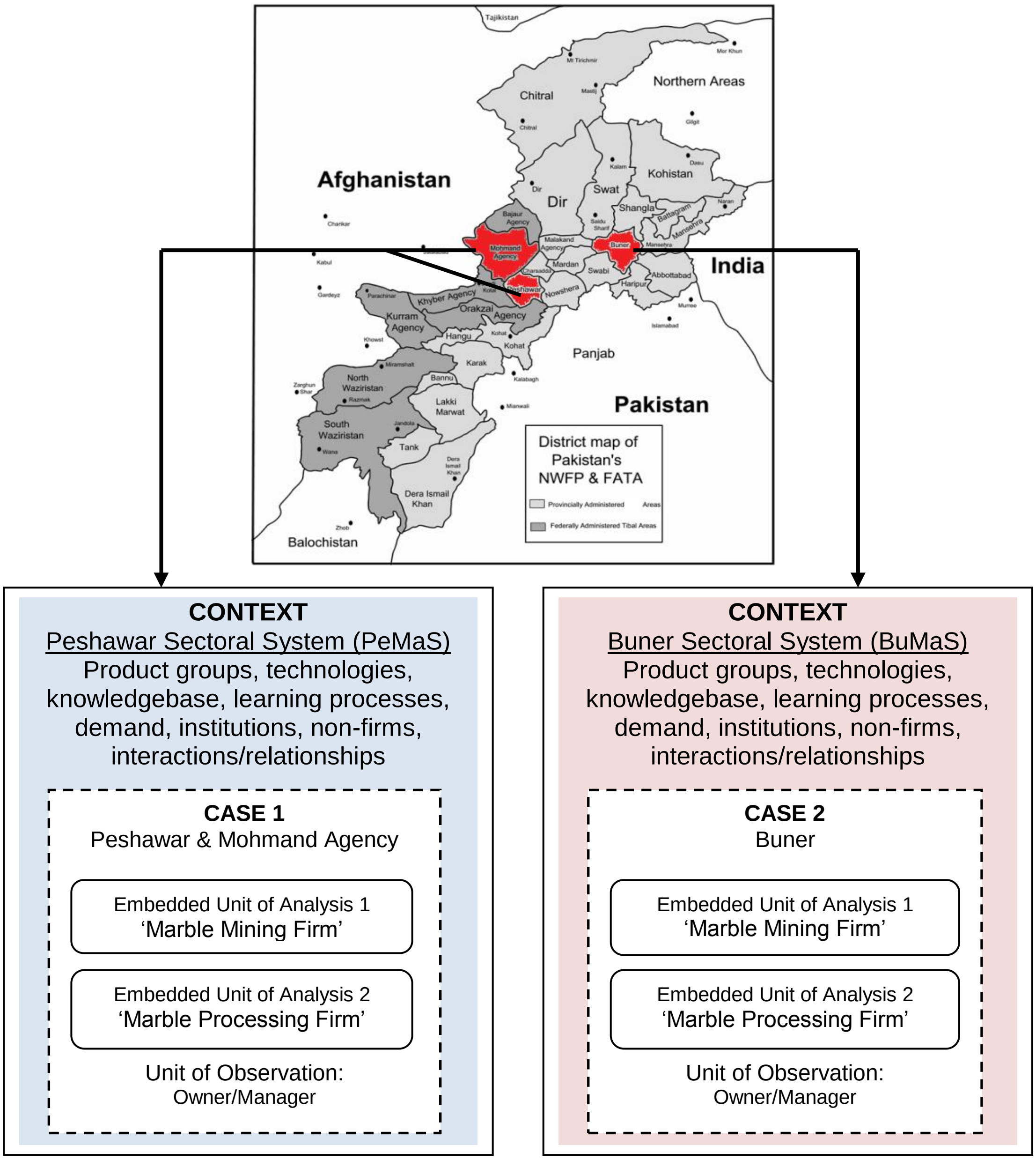


Figure 7.1: Multiple (Two) Case Design (Embedded – Type 4)

7.7. Conclusion

This chapter has introduced the research methodology and design. The suitability of case study as a strategy is presented in light of the components of critical realism and interpretations to this research. The concept of 'case' applied in this research is presented along with the units of analysis. Multiple case design (embedded – type 4) is chosen while providing the background and reasons for this choice. The ensuing Chapter 8 presents the procedures used for data collection and analysis thus elaborating in greater detail on the research methodology and design applied in this research.

Chapter Eight

DATA COLLECTION AND ANALYSIS PROCEDURES

'As researchers, we need to keep sharing our craft – that is, the explicit, systematic methods we use to draw conclusions and to test them carefully. We need methods that are credible, dependable, and replicable.'
Miles & Huberman, 1994, pp. 2)

8.1. Introduction

The purpose of this chapter is to provide details of the data collection and analysis procedures employed in this research. Influence is drawn from critical realism (Chapters 2, 4 and 7) that stresses the need for retroduction in order to explain events through their underlying causal mechanisms. Further, research objectives and questions (Chapter 6) and research methodology and the case study design (Chapter 7) also influence the development of data collection and analysis procedures. Case study protocol is presented along with its components. It includes the all important Data Collection Plan – Three Phase Approach. A detailed set of case and respondent questions aligned with research objectives (ROs) and questions (RQs) follows that will help develop explanation of causal mechanisms from a critical realist perspective in analysis chapters (Chapters 9, 10, 11). Apart from format of case study report, justifications for choosing data collection tools and sampling procedures are provided. Different steps of data analysis are explained. The chapter concludes by pointing out the steps taken in this research to address research quality issues.

8.2. Preparing for Data Collection: The Case Study Protocol

As mentioned in Chapter 7 this research applies multiple case study design (embedded - type 4). Consequently, it is imperative to develop case study protocol to ensure that both cases are investigated in the same manner to achieve the purpose behind replication logic. This also increases reliability of the research. Provided below are various sections of the protocol and their descriptions.

8.2.1. Overview of Case Study

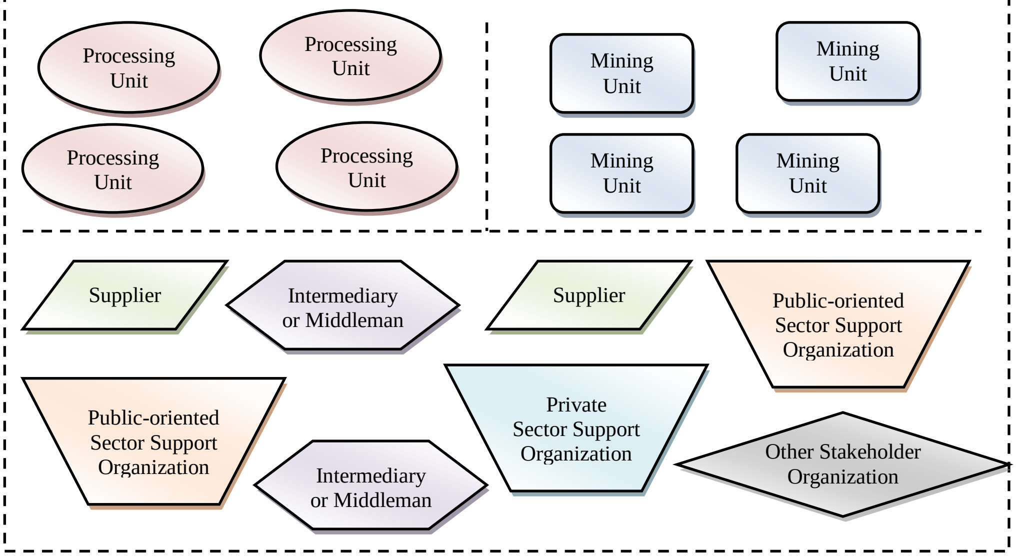
This case study offers insights into the phenomenon of innovation in low-technology sectors and offers explanations regarding its existence or non-existence. The study has been undertaken as part of doctoral research for a PhD in Management from University of Southampton, United Kingdom. Two low-technology sectors or cases have been selected that are located in the north-west region of Pakistan. These are Peshawar Marble Sectoral System (PeMaS and Buner Marble Sectoral System (BuMaS). Apart from low-technology characteristic (zero or negligible R&D), the reasons for choosing the two cases are that both produce similar marble products. Additionally, both cases have a presence of only small business that use similar technologies and knowledge, cater to similar markets/customers, influenced by similar institutional frameworks and interactions/relationships amongst various elements within each sector/case. However, minor differences might exist that may be revealed as a result of in-depth investigations. Another reason for choosing the two cases is because marble industry in north-west Pakistan holds more than 90% of the country's marble reserves (SMEDA, 2002). Within the industry three regions have a dominant presence of marble businesses. These include;

1. Peshawar – a predominantly urban/semi-urban district with the Federally Administered Tribal Area (FATA) of Mohmand Agency on its geographical boundaries. The region can be accessed through Warsak and Nasirbagh areas of Peshawar. Mohmand Agency is the major source of raw marble to Peshawar's marble businesses. However the distances between processing and mining units are considerable further aggravated by poor condition of roads.
2. Buner – a predominantly rural district with a large number of marble processing units. The unique characteristic of the region is high marble reserves within Buner thus suggesting presence of both mining and processing units within the same region.
3. Mohmand Agency – a Federally Administered Tribal Area with its peculiar tribal culture and customs and a strong presence of both marble mining and processing units. However, the region has been severely affected by poor law and order situation since the last 4-5 years adversely affecting marble businesses.

Amongst the three regions two cases have been selected in such a way that Case 1 – PeMaS consists of both Peshawar and Mohmand Agency while Case 2 –

BuMaS consists of Buner. The reasons for excluding Mohmand Agency as a separate case for this research stems from a choice between the ideal and the practical. The poor law and order situation resulting in closure of many marble businesses and the risks associated with the researcher or enumerators' travel to the area (mostly located in far-flung mountains) made it almost impossible to effectively collect data. Thus Case 1 comprises of mining units in Mohmand and processing units in Peshawar since they are the main users of marble from Mohmand. Figure 8.1 provides a visual representation of a sector.

Figure 8.1: A Marble Sector



The above diagram does not presume interactions taking place amongst various firms and non-firms within the sector. The linkages if present are presumed to be very weak at this stage. This presumably contributes to poor status of marble industry in general and innovation performance in particular.

8.2.2. Relevant Readings and Researcher's Prior Experience

In order to develop a better understanding of the marble industry in north-west Pakistan, a number of relevant organizations were approached. The purpose was to get access to published material including different reports prepared at various times. Two organizations accessed included;

a. Small and Medium Enterprise Development Authority (SMEDA), Government of Pakistan
b. Pakistan Stone Development Company (PASDEC)

The researcher being an academic himself with prior contacts inside the two organizations was able to gain access to concerned individuals and gather material.

The reports and published material provided by these organizations and studied prior to undertaking data collection included;

1. Marble and Granite Sector Brief (2002)
2. PASDEC Mainstream Projects Brief
3. Pre-feasibility Study – Marble and Granite Warehouse (2005)
4. Pre-feasibility Study – Marble Mosaic Development Centre (2008)
5. Pre-feasibility Study – Marble and Onyx Products Manufacturing (2007)
6. Pre-feasibility Study – Marble Processing Plant (2007)
7. Pre-feasibility Study – Marble Tiles (2007)
8. Cluster Diagnostic Study Marble Processing in Rawalpindi/Islamabad, a SMEDA-UNIDO Project

Other reports collected through miscellaneous sources include;

9. Economic Impact Assessment of Pakistan Initiative for Strategic Development and Competitiveness (PISDAC) and Final Report (2008)
10. PISDAC II Closeout Report (2006)
11. Pakistan Growth and Export Competitiveness (2006)
12. Cluster Mapping of Pakistan's Marble Sector (N-WFP) 2007, A Pakistan Financial Services Sector Reform Programme (PFSSRP), European Union
13. Report on Evaluation of the Competitiveness Support Fund (CSF), Pakistan (2008)

Additionally, to gain further understanding related to LT innovation, a detailed and systematic literature review (Chapters 3, 4 and 5) has been conducted. The review in Chapter 5 mainly focuses on empirical studies on different sectors conducted in different countries. This review has resulted in a total of 269 key insights into different perspectives of LT/LMT innovation. Also, the systematic nature of literature review resulting in identification of knowledge gaps has influenced the development of research aims, objectives and questions (Chapter 6).

8.2.3. Research Objectives and Questions

This research attempts to address the research objectives (RO) and related research questions (RQ) as provided in Chapters 1 and 6)

8.2.4. Conceptual Framework

This research applies a conceptual framework discussed in detail in Chapter 4. In this regard Figure 8.2 provides the conceptual framework diagram.

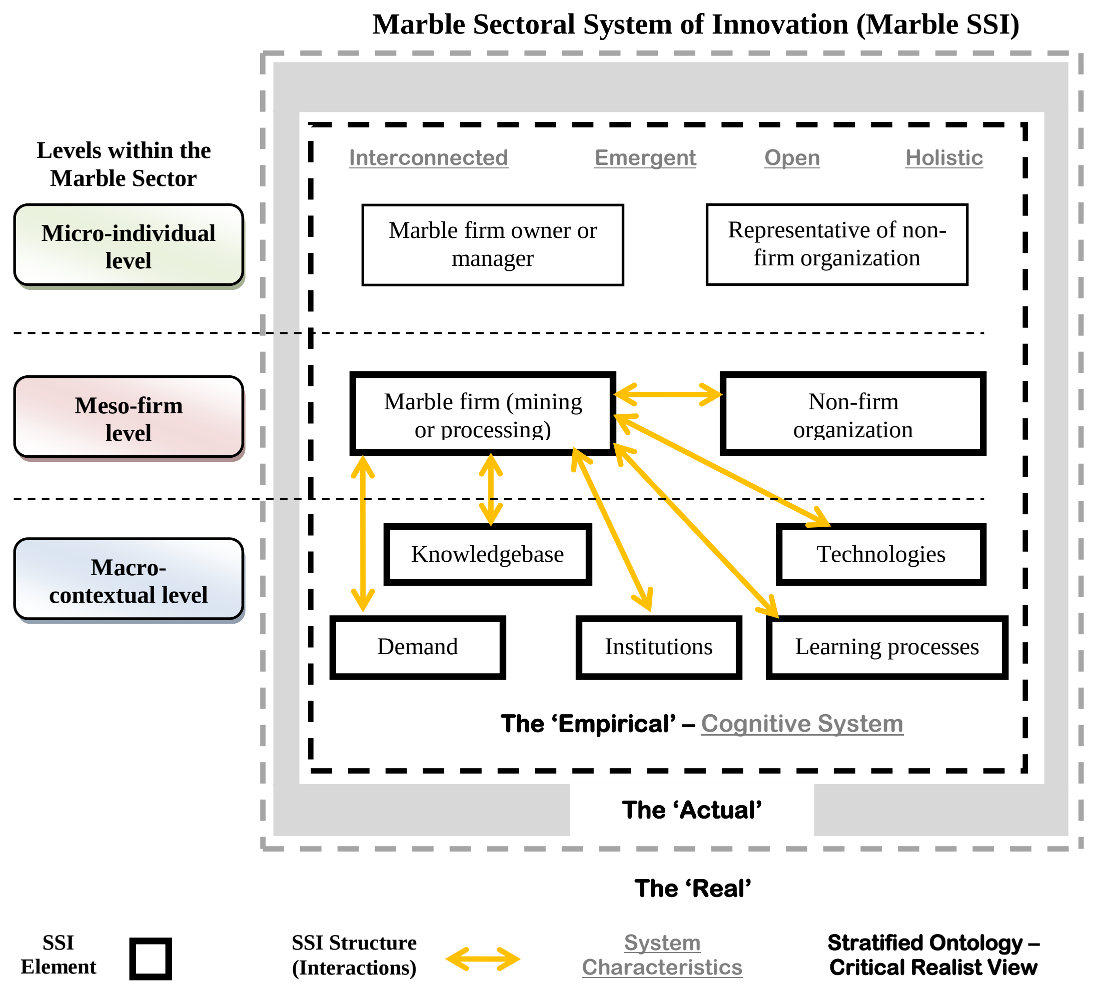


Figure 8.2: Conceptual Framework Diagram

8.2.5. Role of Protocol

The main purpose of this protocol is to increase reliability of the case study. The protocol is being applied to two cases selected for this research and attempts to ensure that the data collection procedures are implemented in exactly the same manner for both cases. The protocol also serves as a guide during the process of data collection so that all criteria and procedures are adhered to and the data collection process remains on target.

8.2.6. Field and Data Collection Procedures:

Data Collection Plan (Three-Phase Approach)

A significant amount of time during the overall period of research (2008-2011) was spent planning for and collecting primary data from various sources. As pointed out in Chapter 7, three tools for data collection have been employed. These include;

a. Semi-structured in-depth interviews
b. Structured Interviews

c. Questionnaires

Individual respondents representing firms and non-firms have been selected as units of observation using purposive sampling – heterogeneous and homogenous. Table 8.1 on the next page provides the data collection plan for executing data collection procedures that applies a ‘Three-Phase Approach’.

Table 8.1: Data Collection Plan (Three-Phase Approach)

PRELIMINARY PHASE: Semi-structured In-depth Interviews (Purposive Sampling – Heterogeneous) **(April - May 2009)**			
Type and Number of Respondents	**Procedural Issues Prior to Data Collection and Establishing Contacts**	**Location For & Time Per Interview**	**Procedural Reminders During Data Collection**
Owner/Manager of Processing Unit (4 respondents – 2 each from Case1: Peshawar and Case2: Buner) Owner/Manager of Mining Unit (3 respondents –1 from Case1: Peshawar/Mohmand and 2 from Case 2: Buner) Supplier and Middleman (2 respondents – 1 machinery expert/supplier, 1 middleman or wholesaler) Sector Expert (1 respondent, consultant academician) Representative of Sector Support	○ Owners/managers of processing and mining units and supplier/middleman identified through contact persons who are in the marble business, have travelled to the areas or are locals, know the respondents and can provide assurance and information regarding safety/security situation prior to researcher's travel to the area ○ Owners/managers of processing and mining units approached formally after placing phone calls and establishing a mutually convenient time and day for interview ○ All interviews from processing unit respondents, suppliers/middlemen conducted on-site i.e. at factory or business location ○ All interviews from sector support organization representatives and sector expert conducted at their respective offices ○ All interviews from mine owners from Buner and Mohmand Agency conducted in Peshawar during their visit to the city due to serious security concerns at areas where mines are located ○ Sector expert and representative of sector support organization contacted through formal channel including office email and official letters. Emails/letters followed up with phone calls and interviews scheduled	Peshawar (Warsak Road, Industrial Estate, G.T. Road, Cantonment, Hayatabad) Buner (main city) Islamabad (main city) (1 – 1.5 hours)	• Processing units being the main potential source of different types of innovation accessed for interviews first • Mining units being the second main source to find possible innovations and primary suppliers of raw marble (the main sector product) to processing units accessed for interviews next • Supplier/middleman, sector expert and representatives of support organization accessed afterwards once an initial understanding of marble industry had been established from firm owners'/managers' perspectives • All interviews initiated with formal introductions and ice-breaking in the form of greetings in local language (Pushto or Urdu) • Interviewer/researcher dressed in traditional clothes/attire when meeting mine or processing unit owners to help assimilate more quickly. Cultural sensitivities remain a primary concern • Interviewer/researcher dressed more formally when meeting sector expert or support organization representatives • Interviews conducted in Pushto (regional language), Urdu (national language) and English depending on respondents' ability to communicate effectively • Interviews kept informal and semi-structured allowing the respondents to discuss things openly • A 'List of Reminders' used to help interviewer/researcher stay on course during an interview and avoid wastage of time

Organization (2 respondents – 1 each from SMEDA and PASDEC)	○ Sector expert and support organization representative contacted after establishing their credentials in terms of experience/relevance to marble industry		• All interviews conducted by the researcher himself and recorded using a digital recorder
Data Analysis – Step I: Create Case Study Database, Translate & Transcribe Interviews, Conduct Initial Analysis, Inform & Formulate Structured Interviews and Questionnaires (June – December 2009)			
BUILD-UP PHASE: Questionnaires and Structured Interviews (Purposive Sampling – Homogeneous within each sub-sector) **(January – March 2010)**			
Type and Number of Respondents	**Procedural Issues Prior to Data Collection and Establishing Contacts**	**Location & Time Per Interview or Questionnaire**	**Procedural Reminders During Data Collection**
<u>QUESTIONNAIRE</u> Owner/Manager of Processing Unit in Case 1: Peshawar (35 respondents) Owner/Manager of Processing Unit in Case 2: Buner (35 respondents) <u>STRUCTURED INTERVIEW</u> Owner/Manager of Mining Unit in Case 1: Peshawar/Mohmand (6 respondents) Owner/Manager of Mining Unit in Case 2: Buner (12 respondents)	○ A team of two trained enumerators hired for the questionnaires and interviews. ○ One enumerator belongs to Peshawar and has participated in similar surveys for various projects. The enumerator has contacts in the local marble sector ○ Second enumerator belongs to Mardan, an area close to Buner and has also participated in similar surveys. He knows the Buner area, is well-travelled and has local contacts. Services of local guide were also acquired to access mining areas ○ Three meetings held amongst the researcher and enumerators at the researcher's office in Peshawar. ○ Meetings focus on making enumerators understand data collection tools, how they are structured and what purposes do they want to achieve. Broad background of study provided and timelines set. Compensation issues also resolved. ○ Most respondents contacted informally by direct visit to business with the exception of	Peshawar (Warsak Road, Industrial Estate, G.T. Road) Buner (main city, Chamla, Sunigaram, Dewanbaba, Karakar) (35 – 45 minutes)	• Pilot survey (6 questionnaires/interviews) conducted to test the questionnaire and address possible issues • One meeting held with enumerators after pilot to gather feedback and make amendments to questionnaire and interview format where required • Regular contact with enumerators maintained via telephone to get constant feedback on progress and assess security situation in target areas • Questionnaire in both Peshawar and Buner completed first followed by interviews • Interviews and questionnaires conducted in Pushto (regional language) and Urdu (national language) • All interviews and questionnaires kept formal and structured to help elicit focused and relevant responses • All interviews and questionnaires conducted using printed sheets with questions • None of the questionnaires filled by the respondents themselves primarily because of a lack of education in the areas. To ensure consistency enumerators wrote the responses even if a respondent was educated/literate • All data collected by enumerators except 5 questionnaires and 3 interviews conducted by researcher

	a few phone calls prior to visit ○ All questionnaires and interviews conducted at mine or factory locations		
Data Analysis – Step II: Further Build Case Study Database, Conduct Data Analysis and Write-up of Analysis (May – July 2010)			
CLOSING PHASE: Structured Interviews (Purposive Sampling – Heterogeneous) **(August – September 2010)**			
Type and Number of Respondents	**Procedural Issues Prior to Data Collection and Establishing Contacts**	**Location For & Time Per Interview**	**Procedural Reminders During Data Collection**
Owner/Manager of Processing Unit (2 respondents – 1 each from Case 1: Peshawar and Case 2: Buner) Owner/Manager of Mining Unit (1 respondent from Case 2: Buner) Supplier/Middleman (1 respondent) Sector Expert (1 respondent, consultant academician) Representative of Sector Support Organization (1 respondent)	○ All respondents have been selected from the same group interviewed during Preliminary Phase ○ Screening of respondents has been conducted in light of their responsiveness, usefulness of information provided, depth of understanding the marble sector and experience relevant to the industry as observed by the researcher during the Preliminary Phase ○ All other procedural issues followed in the same manner as implemented during the Preliminary Phase	Peshawar (Warsak Road, Industrial Estate, G.T. Road, Cantonment, Hayatbad) Buner (main city) (35 – 45 minutes)	• All relevant procedural reminders followed during Preliminary Phase being adhered to during the Closing Phase

(black)	Data Collection Phase
(grey)	Intermediary Analysis

8.2.7. Case and Respondent Questions:

Preliminary Phase (Semi-Structured In-Depth Interviews)

Because this research focuses on offering explanation of the event of low-tech innovation specific questions (along with their levels within the case study) have been relied on in order to generate explanations of the causal mechanisms (the critical realist view). Yin (2003) suggests two levels of questions that are of primary concern here. One, questions pertinent to the case. These have been termed as Case Questions (Case-Qs) in this section. Second, questions posed to particular respondents. These have been termed as Respondent Questions (Res-Qs) in this section. Additionally, Case-Qs and Res-Qs have been linked to the particular research objectives (ROs) and research questions (RQs) they help address.

RO1-RQ1.1

Case-Qs:

- Develop an understanding of the sector in terms of different products, production processes, marketing practices being implemented by firms and the firms' organizational characteristics
- Develop a general sense of various problems and issues relevant to the sector. What is 'good', what is 'bad'?

Res-Qs:

Mining and Processing Unit Owners/Managers

- *Different products, shapes, sizes, colours, forms, quality. How does final product look like?*
- *Phases of production process, equipments/machineries/technologies used*
- *Workers' skills, experience and training, respondent's business orientation, experience and knowledge*
- *Markets for products. Domestic/national/international, types of customers and nature of relationship with them, nature of demand, supply issues related to raw material, equipment/machinery and its components/parts*
- *Nature of business (small or medium sized firm), organizational structure (owner and manager same or different), roles of workers/staff*
- *Sharing of experiences that shed light on any other issues and problems prevalent in the sector especially with reference to processing business*

Supplier and Middleman

- *Technical details about equipment/machinery/technologies currently being used. Where from are they available? Where are the problems and in what form do they exist in the machinery? How they affect product quality and production efficiency*
- *Different kinds of products (mining and processing phase), machinery/equipment used*
- *Workers' skills/experience and training, processing/mining unit owner/manager's business orientation, experience and knowledge, respondent's own experience/knowledge*
- *Markets for products. Domestic/national/international, types of customers and nature of relationship with them, nature of demand, supply issues related to equipment/machinery*
- *Marble firms' organizational structure*
- *Sharing of experiences that shed light on any other issues and problems prevalent in the sector especially with reference to role of 'middleman' and supplier of equipment/machinery/components*

Sector Expert

- *Nature of product and processes both in the mining and processing phases*
- *Technologies and machinery/equipment being used by firms in the sector*
- *Nature of knowledge and learning process prevalent in the sector*
- *Marketing practices, nature of demand, supply issues and firms' organizational structure prevalent in the sector*
- *Sharing of experiences with respect to respondent's interaction with the sector and different stakeholders*

Representative of Support Organization

- *Sharing of experiences with respect to respondent's interaction with the sector, marble firms and different stakeholders*

RO1-RQ1.2

Case-Qs:

- Find out whether firms in the sector innovate or not. If yes, in what forms do these innovations manifest themselves and what are the respondents' perceptions about innovation itself.

- Begin to focus on factors (internal and external to the firm) that influenced or can influence the owner/manager to innovate or not to innovate.

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- *Was there an attempt by the firm to innovate in terms of products and/or processes? In what form (new and/or improved products, new and/or improved processes e.g. machinery/technologies, production techniques)? What happened as a result?*
- *Did the firm search for new markets/customers for its products? What happened with the search? Did the firm attempt to increase sales in existing market? What happened?*
- *Did the firm introduce any change to its organizational structure, improved worker skills through formal/informal training, hired/removed workers? What happened?*

Supplier, Middleman, Sector Expert, Representative of Support Organization

- *What kind of product, process, marketing or organizational improvements/innovations has the respondent observed in the sector*
- *Highlight key factors that influenced or can influence firms to improve/innovate or not to improve/innovate? Let the respondent elaborate on these issues.*

8.2.8. Case and Respondent Questions: Preliminary Phase (Semi-Structured In-Depth Interviews) and Build-Up Phase (Structured Interviews and Questionnaires)

RO2-RQ2.1

Case-Qs:

- Develop a more in-depth understanding of SSI in terms of its key element, the agents (firms including individuals and non-firms) and their role within the sector

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- What and how important is the role of firm and individual (owner/manager) within the firm and the sector with regards to innovation

- What is the role of government and other support organizations with regards to innovation by a firm
- What is the role of suppliers and middlemen with regards to innovation in a firm

Supplier, Middleman, Sector Expert, Representative of Support Organization

- What is the role of Small and Medium Enterprise Development Authority (SMEDA) in promoting innovation amongst firms in the sector
- What is the role of Pakistan Stone Development Company (PASDEC)
- What is the role of government with regards to innovation by a firm
- What is the role of suppliers, middlemen and sector experts
- What is the role of firm and individual within firm

RO2-RQ2.2

Case-Qs:

- Develop an in-depth understanding of nature of knowledge and technologies within the sector

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- Are technologies changing/improving in the sector? Is the change slow, fast or non-existent?
- What knowledge is structured/unstructured, technical/non-technical
- Do firms generate internal knowledge; do they rely on external knowledge only or have a combination of both?

RO2-RQ2.3

Case-Qs:

- Develop a more in-depth understanding of nature of learning processes and demand in the sector

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- Is learning process in the sector formal in nature or informal? How does learning occur?

- What is firm's learning orientation?
- Does demand change occur in the sector? What does it appear like? Do firms seek new markets?
- What factors influence demand?

RO2-RQ2.4

Case-Qs:

- Develop a more in-depth understanding of nature of institutions in the sector

Res-Qs:

<u>Processing Unit and Mining Unit Owner/Manager, Supplier, Middleman, Sector Expert, Representative of Support Organization</u>

- What are the different forms of institutions in the sector? Are they regulative, normative and/or cognitive institutions? What role do they play?
- Do institutions help stabilize the sector or play a role otherwise?
- Do institutions in the sector have a national and/or regional character/origin as well? Are there institutions that are sector specific?

RO3-RQ3.1

Case-Qs:

- What is the nature of interaction amongst firms and amongst firms and non-firms?
- Does the interaction facilitate innovation amongst firms or otherwise? Why or why not?

Res-Qs:

<u>Processing Unit and Mining Unit Owner/Manager</u>

- Do firms in the sector collaborate and interact amongst themselves and with non-firms? Are these interactions strong or weak? What are these interactions about?
- Do the interactions have a particular pattern and are they formalized?
- What is the nature of dependence of one type of agent on another? Who is dependent on whom? Does that support or hinder innovation?
- Are non-firms able to play a facilitative role in innovation or otherwise?

RO3-RQ3.2

Case-Qs:

- What is the nature of interaction amongst firms and institutions?
- Does the interaction facilitate innovation amongst firms or otherwise? Why or why not?

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- Do firms interact with formal institutions? How does the interaction occur?
- Do firms interact with informal institutions? How does the interaction occur?
- Do formal institutions have a facilitative or restrictive role with regards to innovation? How?
- Do informal institutions have a facilitative or restrictive role with regards to innovation? How?

RO3-RQ3.3

Case-Qs:

- What is the nature of interaction amongst firms and knowledge and technologies?
- Does the interaction facilitate innovation amongst firms or otherwise? Why or why not?

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- How often do firms interact with knowledge/technologies?
- Can they internalize knowledge from external sources?
- What is the role of technology intermediaries (non-firms present between firms and technology producer) and other non-firms in facilitating interactions?
- Does the interaction facilitate innovation amongst firms or otherwise? Why or why not?

RO3-RQ3.4

Case-Qs:

- What is the nature of interaction amongst firms and learning processes?
- What is the nature of interaction amongst firms and demand?
- Do the interactions facilitate innovation amongst firms or otherwise? Why or

why not?

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- How often do firms interact with learning processes and demand?
- How do workers learn? Is it 'learning by doing' or formal process? Is learning a collective process from the firm's perspective?
- How do firms interact with market/customers? Is the firm proactive? Do firms respond to market demand? Do the actively lead to triggering new demand or address stagnant demand?
- Do the interactions facilitate innovation amongst firms or otherwise? Why or why not?

RO3-RQ3.5

Case-Qs:

- Has a list of factors that influence low-tech innovation been developed?
- Are these categorized into internal (within firm) and contextual (outside firm) factors?
- Have the internal factors been further categorized into individual-level and firm-level factors?

Res-Qs:

- Not required

RO3-RQ3.6

Case-Qs:

- Has a list allowing the respondent to relatively rank all factors influencing innovation been prepared?
- Does it enable to find out how much each factor influences innovation?

Res-Qs:

Processing Unit and Mining Unit Owner/Manager

- Has the respondent completed the ranking of all factors?

8.2.9. Format/Outline of Case Study Report

The case study is spread over three chapters (9, 10, 11) addressing the three research objectives. The outline includes;

1. General Scenario in the Sector (Objects): Firm and non-firm context (RQ1.1)
    i. Nature and types of products
    ii. Nature of production processes
    iii. Nature of marketing practices
    iv. Nature of organizational structure
    v. Organizational structures

2. Existing Innovation Scenario in the Sector (Events) – Firm Context (RQ1.2)
    i. Innovation from product perspective
    ii. Innovation from process perspective
    iii. Innovation from marketing perspective
    iv. Innovation from organizational perspective

3. The Sectoral System of Innovation: Elements (Objects and Mechanisms)
    i. Role of Agents (RQ2.1)
        a. Individuals and Firms
            1. Mining Units
            2. Processing Units
        b. Non-Firms
            1. Suppliers
            2. Middlemen/Distributors
            3. Sector Support Organization
    ii. Knowledge and Technologies (RQ2.2)
    iii. Learning Processes (RQ2.3)
    iv. Demand (RQ2.3)
    v. Institutions and their role (RQ2.4)

4. The Sectoral System of Innovation: Structure (Relations, Mechanisms, Causal Powers)
    i. Interactions amongst Firms and Firm and Non-Firms (RQ3.1)
    ii. Interactions amongst Firms & Institutions (RQ3.2)
    iii. Interactions amongst Firms & Knowledge/Technologies (RQ3.3)
    iv. Interactions amongst Firms & Learning Processes (RQ3.4)
    v. Interactions amongst Firms & Demand (RQ3.4)

5. Factors Influencing Innovation in the LT Sector: Categorization (RQ3.5) and Relative Importance (RQ3.6)
    i. Lists of Factors and Discussions (RQ3.5 – 3.6)

8.3. Choice of Data Collection Tools and Accompanying Sampling Procedures

As shown in the Data Collection Plan (Case Study Protocol), all primary data has been collected using a ‘Three-Phase Approach’.

8.3.1. Semi-Structured In-Depth Interview and Purposive Sampling – Heterogeneous

The Preliminary Phase whereby the purpose was to develop an initial in-depth understanding of the marble sector and help address RO1 and RO2 relied more on detailed probing. Developing a deeper and more comprehensive understanding of the working of marble sector required that for each of the two cases (PeMaS and BuMaS), all possible stakeholders are identified and their perspectives are explored in detail. Burgess (1986) highlights benefits of using interviews by suggesting that they enable the researcher to probe deeply and open up new dimensions to a problem under investigation as a result of respondent sharing his/her experiences. However, it is important to remind ourselves that this research study is influenced by a pre-developed conceptual framework that also guides the research questions. Consequently, the interview questions were kept semi-structured allowing respondents to express themselves openly. Yet the interviewer ensured that discussions remained focused. A total of 12 semi-structured in-depth interviews were conducted by the researcher himself.

As the purpose during preliminary phase was to have an all-encompassing view of the marble sector, purposive sampling – heterogeneous or maximum variation was employed for selecting the sample members. This type of sampling is especially useful when the purpose is to identify, describe and explain key themes (Saunders et al., 2006). The difference and variation in findings resulting from this sampling procedure is its key strength (Patton, 2002).

8.3.2. Structured Interview, Questionnaire and Purposive Sampling – Homogeneous:

During the Build-up Phase of data collection, the purpose was to further enhance the understanding of low-tech innovation and focus on the elements and structure of marble SSI (RO2 and RO3). Again, taking influence from the conceptual framework and research questions, the researcher used structured interviews and questionnaires for collecting data. The purpose was to generate a more focused and relevant understanding of the role of individual, the firm and the context within which these firms operate. And how the elements and structure of the SSI come together to shape into determinants of LT innovation.

The fundamental reason for using structured interviews was the inherent problem associated with accessing owners/managers of mining units. The mines are located in hard-to-access far-flung areas of Pakistan's north-west regions. Coupled with this is the additional problem of security crisis in the region making travel a high-risk option. Consequently, a smaller number of mine owners within each of the two cases were interviewed. The structured interviews were designed to meet two objectives simultaneously.

1. Keep the conversation focused
2. Allow for more detailed discussion to address the possible weakness associated with having a smaller sample of mine owners/managers

12 structured interviews were conducted in BuMaS (Buner) and 6 in PeMaS (Peshawar) resulting in a total of 18 structured interviews. The smaller number for PeMaS stemmed from the severe security crisis prevalent in Mohmand Agency making access to mine owners extremely difficult.

Questionnaires were used for owners/managers of processing units. The processing units located mostly in urban and semi-urban areas were easier to access compared to mining units. A larger sample consisting of 70 firms (35 within each case) enabled the researcher to have an in-depth understanding of each sub-group. Purposive sampling – homogeneous was used for both mining and processing firms. This type of sampling is considered useful when one wants to focus on a sub-group in which all sample members are similar. This enables the researcher to study each group in greater depth (Saunders et al., 2006).

8.3.3. Structured Interview and Purposive Sampling – Heterogeneous

The Closing Phase of data collection was conducted after completion of data analysis. Structured interviews were used applying Purposive Sampling – Heterogeneous. The purpose was to seek closure, reiterate some of the research outcomes and help address any ambiguities still left after completion of the data analysis process.

While deciding on the choice of data collection tools, an important question encountered was whether observations particularly participant observations should be used or not. The decision not to use this tool was primarily influenced from practical concerns. Two factors played a significant role.

1. Use of observation required visiting and staying at mining/processing units for extended period of time other than the time spent on interviews and/or questionnaires. Personal security was a key concern. Thus the focus was on striking a balance between getting all detailed data and ensuring personal safety by making data collection process efficient and convenient.
2. The marble enterprises are essentially small firms with very simple organizational structures, products, production processes and limited resources. The simple structure of firms coupled with researcher's prior exposure to these businesses meant there was no additional information that could be acquired through observations.

8.4. Addressing Issues Encountered During Field Visits: Selecting and Employing Enumerators

The Build-up Phase of data collection required accessing a larger respondent group (18 mining units and 70 processing units). Caution was exercised as the researcher was advised not to travel unaccompanied and during late hours of the day to certain locations. To help address this and also ensure timely and quick completion of Build-up Phase, two enumerators were hired. The following three criteria were used to select them;

(1) Education and qualification (minimum Masters degree)
(2) Enumerators' familiarity with area under investigation (local resident of Buner or Peshawar)
(3) Prior experience conducting surveys and data collection activities (participated in at least one similar project)

Three meetings took place between the researcher and enumerators. The purpose of these meetings was to;

- Make enumerators understand the purpose of the research study

- Explain the process of development of data collection tools (interviews and questionnaires) and why they looked the way they looked
- Help them understand the logic and purpose of each question
- Answer any queries that they may have

It is pertinent to mention here that the researcher himself conducted 3 structured interviews and 5 questionnaires. However, enumerators were responsible for collecting a major chunk of data. Initially, each enumerator was required to conduct a maximum of three interviews/questionnaires (total is equal to six) and report to researcher with outcomes and possible problems encountered. Once any ambiguities about questions or their interpretations were clarified, the enumerators embarked on collecting remaining data.

8.5. Analyzing Data

The data analysis conducted for this research adopted Yin (2003, pp. 111 – 115) approaches of case descriptions and case study protocol. A case study database was established comprising of all interview and questionnaire data collected through ‘Three-Phase Approach’. This database was subjected to various analysis techniques. More specifically Miles and Huberman’s (1994) methods including coding (descriptive, interpretive and pattern), memos, matrices and networks (within-case and cross-case displays) have also been used. Dey’s (1993) splitting and splicing codes is used as an intermediate technique especially during initial phases of the coding process.

Data analysis for this research was closely aligned with the ‘Three-Phase Approach’. Consequently, analysis was done in two steps. Figure 8.3 elaborates this;

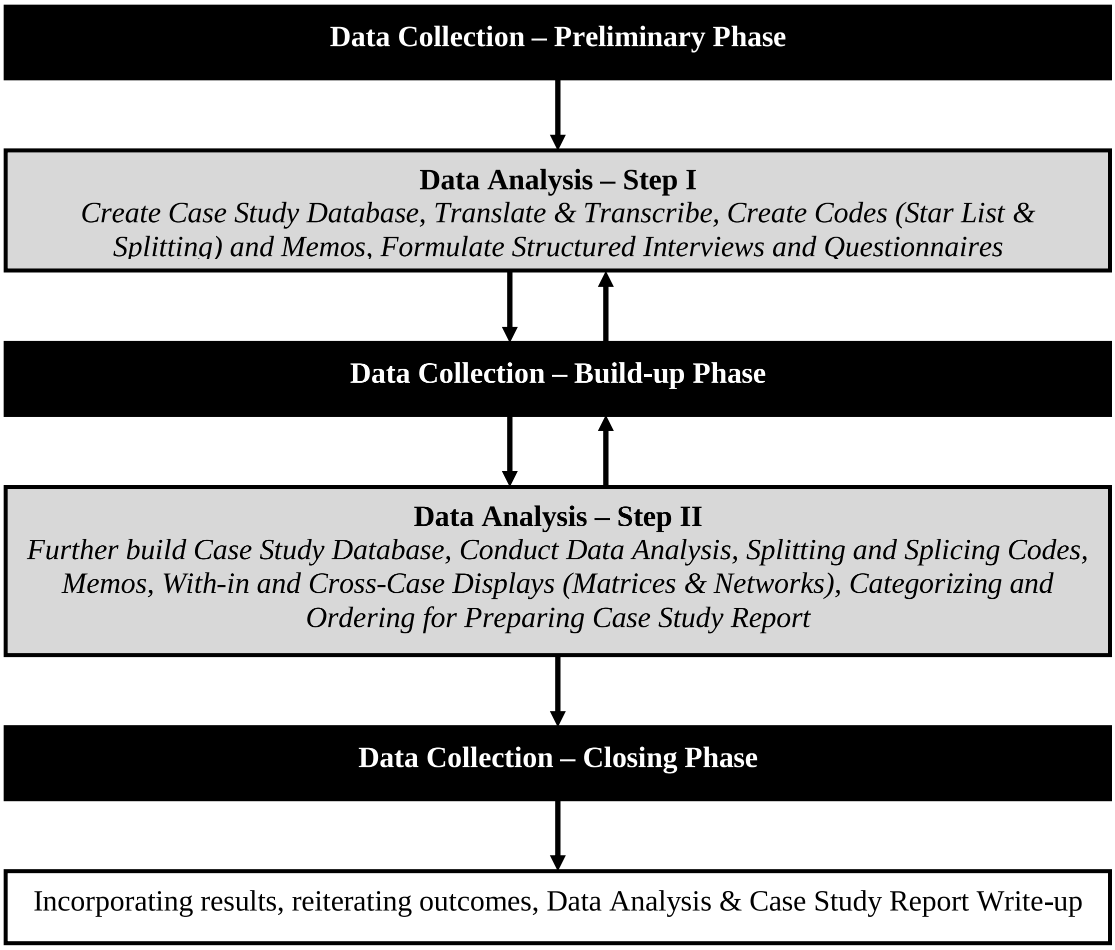


Figure 8.3: Aligning Steps in Data Analysis with 'Three-Phase' Data Collection Process

8.5.1. Data Analysis – Step I: Coding

Codes are 'tags or labels' assigned to units or chunks of descriptive data collected and compiled during a study (Miles & Huberman, 1994). In order to organize data more effectively and help develop initial understanding of large amounts of interview data a 'star-list' of codes was created. This initial set of codes was influenced by the research questions and conceptual framework of the study. Consequently, the interviews were kept semi-structured to allow for some sense of direction to the sequence of questions influenced from the star-list. However, as more data started coming in the list of codes was revised. Most of codes generated initially were descriptive in nature and the researcher chose to do coding manually. However, some of the codes generated during this part of analysis were interpretive as well (Miles & Huberman, 1994). Provided below is an initial list of codes;

Table 8.2: Initial Set of Codes applied during 'Data Analysis – Step I'

Short Description	Code	Research Question
Existing Scenario – Mining Firm Level	**ExMF**	RO1
Existing Marble Product From Mine	ExMF-Prod	RQ1.1
Existing Production Process in Mining	ExMF-Proc	RQ1.1
Existing Marketing Practice at Mining Level	ExMF-Mark	RQ1.1
Existing Organizational Structure at Mine	ExMF-Org	RQ1.1
Problem with Existing Product (Mine)	ExMF-Prob-Prod	RQ1.1
Problem with Production Process (Mine)	ExMF-Prob-Proc	RQ1.1
Problem with Existing Marketing (Mine)	ExMF-Prob-Mark	RQ1.1
Problem with Existing Org. Struc. (Mine)	ExMF-Prob-Org	RQ1.1
Existing Scenario – Processing Firm Level	**ExPF**	RO1
Existing Marble Product (Processing)	ExPF-Prod	RQ1.1
Existing Production Process (Processing)	ExPF-Proc	RQ1.1
Existing Marketing Practice (Processing)	ExPF-Mark	RQ1.1
Existing Organizational Structure (Processing)	ExPF-Org	RQ1.1
Problem with Existing Product (Processing)	ExPF-Prob-Prod	RQ1.1
Problem with Existing Process (Processing)	ExPF-Prob-Proc	RQ1.1
Problem with Existing Marketing (Processing)	ExPF-Prob-Mark	RQ1.1
Problem with Existing Org. Struc. (Processing)	ExPF-Prob-Org	RQ1.1
Manifestation of Innovation	**Man-Inn**	RO1
Product Innovation	Man-Inn-Prod	RQ1.2
Process Innovation	Man-Inn-Proc	RQ1.2
Marketing Innovation	Man-Inn-Mark	RQ1.2
Organizational Innovation	Man-Inn-Org	RQ1.2
Level of Innovation	**L-Inn**	RO1
Incremental Innovation	L-Inn-Inc	RQ1.2
Radical Innovation	L-Inn-Rad	RQ1.2
Characteristic of Owner/Manager Mining Firm	**Ch-Ind-M**	RQ2.1
Characteristic of Owner/Manager Processing Firm	**Ch-Ind-P**	RQ2.1
	CT	RO2&3
Context	***NF-CT***	RQ2.1
Non-Firm Context	NF-CT-Supp	RQ2.1
Role of Supplier	NF-CT-Dist	RQ2.1
Role of Distributor	NF-CT-SupOrg	RQ2.1
Role of Support Organization	NF-CT-SecExp	RQ2.1
Role of Sector Expert		
	Tech-CT	RQ2.2
Technology Context	Tech-CT-S	RQ2.2
Source of Technology	Tech-CT-N	RQ2.2
Nature of Technology		
	Know-CT	RQ2.2
Knowledge Context	Know-CT-S	RQ2.2
Source of Knowledge	Know-CT-N-F	RQ2.2

Nature of Knowledge – Formal	Know-CT-N-I	RQ2.2
Nature of Knowledge – Informal		
	LP-CT	RQ2.3
Learning Process Context	LP-CT-F	RQ2.3
Formalized Learning Process	LP-CT-I	RQ2.3
Informal Learning Process		
	D-CT	RQ2.3
Demand Context	D-CT-NM	RQ2.3
Increasing demand through New Market	D-CT-EM	
Increasing demand through Sales in Existing		RQ2.3
Market	D-CT-Res	RQ2.3
Responding to Demand		
	Ins-CT	RQ2.4
Institutional Context	Ins-CT-F	RQ2.4
Formal Institution	Ins-CT-I	RQ2.4
Informal Institution		
Interactions Context	***Int-CT***	RO3
Interaction b/w Mining & Processing Firm	Int-CT-M-P	RQ3.1
Interaction b/w Mining Firms	Int-CT-M-M	RQ3.1
Interaction b/w Processing Firms	Int-CT-P-P	RQ3.1
Interaction b/w Mining Firm & Non-Firm	Int-CT-M-NF	RQ3.1
Interaction b/w Processing Firm & Non-Firm	Int-CT-P-NF	RQ3.1
Interaction b/w Mining Firm & Knowledge/Technology	Int-CT-M-KT	RQ3.3
Interaction b/w Processing Firm & Knowledge/Technology	Int-CT-P-KT	RQ3.3
Interaction b/w Mining Firm & Learning Process	Int-CT-M-LP	RQ3.4
Interaction b/w Processing Firm & Learning Process	Int-CT-P-LP	RQ3.4
Interaction b/w Mining Firm & Demand	Int-CT-M-D	RQ3.4
Interaction b/w Processing Firm & Demand	Int-CT-P-D	RQ3.4
Interaction b/w Mining Firm & Formal Institution	Int-CT-M-FI	RQ3.2
Interaction b/w Mining Firm & Informal Institution	Int-CT-M-II	RQ3.2
Interaction b/w Processing Firm & Formal Institution	Int-CT-P-FI	RQ3.2
Interaction b/w Processing Firm & Informal Institution	Int-CT-P-II	RQ3.2

8.5.2. Data Analysis – Step I: Splitting and Splicing

The data collected as a result of interviews was subjected to splitting and splicing of codes (Dey, 1993). The purpose of splitting is to enable the researcher to dig deeper into bits and pieces of data and discover new information and ideas. As smaller and smaller chunks of data are being assigned to codes, the process of 'recontextualization' (Tesch, 1990) is taking place whereby the researcher can organize data in line with codes formulated as a result of research questions, conceptual framework and the splitting process. As splitting of data continued and ideas expanded, the researcher continued to write memos (discussed next) to identify new themes and ideas. Splicing is a process that works the opposite of splitting (Dey, 1993). The purpose is to integrate data and bring coherence to analysis. Most of splicing took place in Data Analysis – Step II, also reflected in Fig 8.3. The diagram (Fig 8.4) below is one example of how splitting occurred especially during Data Analysis – Step I.

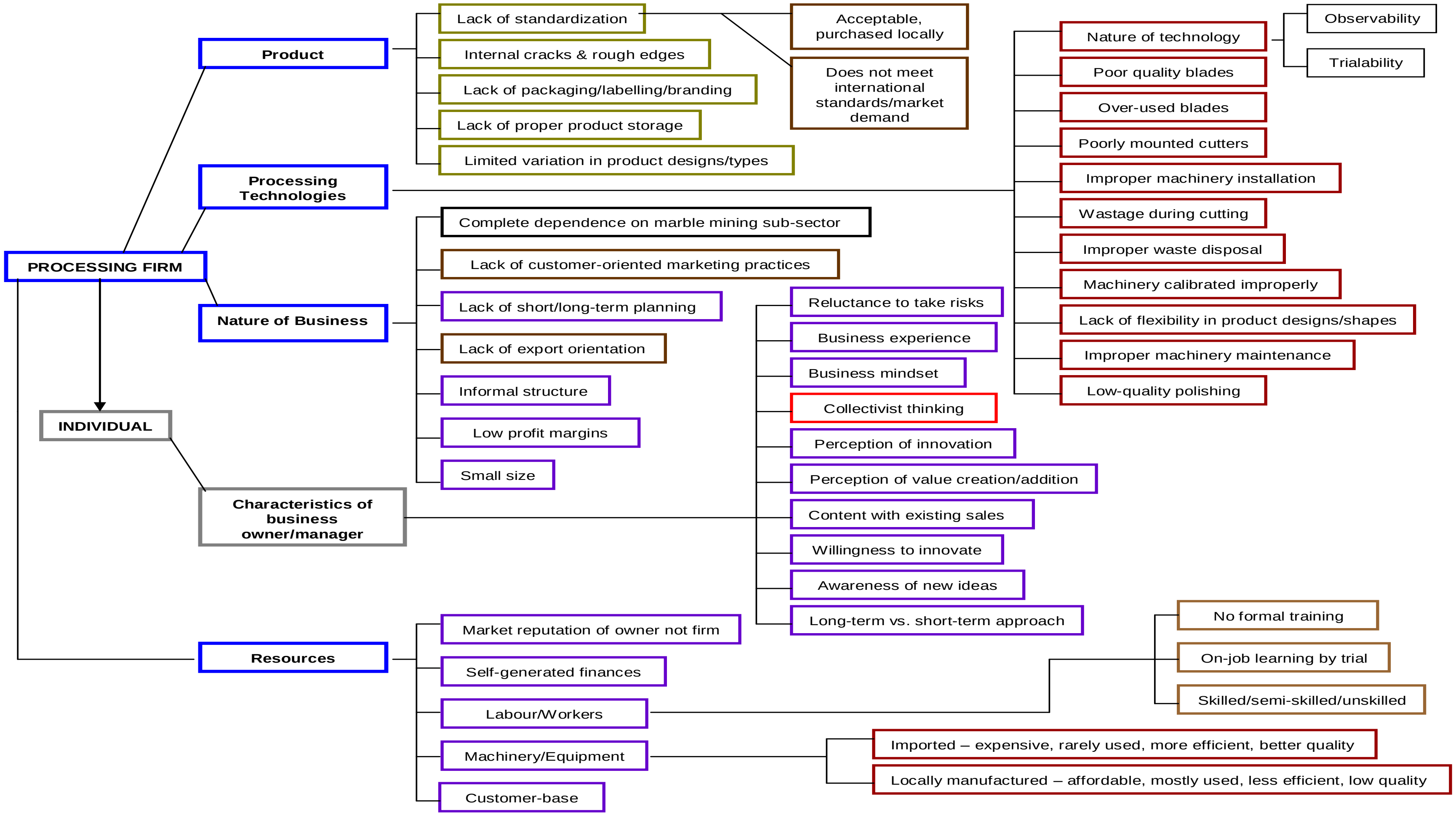


Figure 8.4: An Illustration of Splitting and Splicing Codes and Data

8.5.3. Data Analysis – Step I: Memo

Many memos were used during analysis particularly as the researcher continued with the coding process. The main benefit of memos is that they help the analyst make sense of data as deeper analysis continues (Miles & Huberman, 1994). They help the analyst write down ideas emerging from the analysis process. If not written down in time, these ideas carry the risk of being lost in the analyst's memory. An example is shown in Table 8.3 below;

Memo 11

Date: 20090512
Site: Usman Marbles Ltd. Warsak Road, Peshawar
(Peshawar Marble Sector – PeMaS)
Theme: Interaction between Firm & Institutions (Formal)

There is a strong perception in the processing firm that they are at a disadvantage compared to firms in tribal regions like Mohmand Agency. The electricity department has a fixed billing system for factories in tribal areas regardless of units consumed. On the contrary, the processing units on Warsak Road being part of Peshawar city have to pay bills per units consumed. This is perceived as a clear cost disadvantage when it comes to competing on price. What the processing firm does not realize is that the electricity supplied to tribal regions is far lesser in terms of hours of availability which in a sense cancels out the cost advantage those units seem to have. The processing firm is complaining about inconsistency of regulations and exploitation by Department of Environment and Department of Taxation. The perception is that officials seek to exploit the owner or manager of the factory in terms of meeting criteria set for reduction of pollution. Consequently, the respondent seems to be suggesting (though not admitting openly) that they have to bribe these officials to keep them quiet. There seems to be severe lack of trust amongst processing units as far as government policies and regulations are concerned. They firmly believe the regulations are designed only to exploit them. As a result, there is a strong inclination amongst the processing units to bypass the system or go for the short cut (such as electricity theft) rather than fulfil requirements such as payment of bills and meeting criteria for reduction of environmental pollution. This distorted interaction between the firm and formal institution is creating uncertainty within the industry contributing to short-term approach of owners/managers towards business. The focus seems to be day to day survival and dodging the system if one can get away with it.

Table 8.3: An Example of a Memo

8.5.4. Preliminary Outcomes of Step I

Apart from addressing research objective 1 (RO1) a key outcome of Data Analysis – Step I was development of structured interviews and questionnaires. These were used in Build-up Phase. A total of 87 factors influencing LT innovation were identified. All these factors were included in the subsequent structured interviews (for mining units – 41 factors) and questionnaires (for processing units – 46 factors) to collect further data. Respondents were also allowed to point out factors other than the provided list. Ultimately Step II was designed to help identify all possible determinants of LT innovation (causal powers) and their relative influence on innovation.

8.5.5. Data Analysis – Step II: Coding

The coding initiated in Step I continued while data was being collected using structured interviews and questionnaires. However, a major difference this time was researcher's greater focus on inferential and pattern codes. As Miles and Huberman (1994) suggest pattern codes tend to be explanatory pointing out themes or explanations. The process of splicing codes (discussed earlier) aided significantly during this stage. An important issue that needed to be addressed was how long the coding process will continue and when will it end. In this regard the researcher took influence from Lincoln and Guba (1985) who suggest that the process of coding can continue till the analysis process has achieved its due purpose. Table 8.4 provides a list of some example codes generated during this stage. It is important to mention that the list below is not exhaustive as the original list consists of about 150 codes.

Table 8.4: Example codes generated during Step II

Short Description	Code	Research Question
Internal Factor Influencing Innovation-Mining	**Int-F-InnM**	RQ3.5
Individual-Level Factor Influencing Innovation	***Int-F-InnM-Ind***	RQ3.5
Risk-taking by owner/manager	Int-F-InnM-Ind-R	RQ3.5
Follow example of innovation set by others	Int-F-InnM-Ind-EI	RQ3.5
Business experience of owner	Int-F-InnM-Ind-BE	RQ3.5
Innovation mindset	Int-F-InnM-Ind-IM	RQ3.5
Perception of innovation as being necessary	Int-F-InnM-Ind-PIN	RQ3.5
Perception of innovation as being unnecessary	Int-F-InnM-Ind-PIU	RQ3.5
Perception of profitability from innovation	Int-F-InnM-Ind-PIP	RQ3.5
Mine owner and mine manager the same	Int-F-Inn-Ind-O=M	RQ3.5
Mine owner separate from mine manager	Int-F-Inn-Ind-O≠M	RQ3.5
⋮	⋮	⋮
Firm-Level Factor Influencing Innovation	***Int-F-InnM-Frm***	RQ3.5
Stone wastage due to blasting	Int-F-InnM-Frm-WB	RQ3.5
Presence of cracks within mined stone	Int-F-InnM-Frm-SC	RQ3.5
Lack of finances to invest in upgraded technology	Int-F-InnM-Frm-FinT	RQ3.5
Lack of proper equipment maintenance	Int-F-InnM-Frm-EM	RQ3.5
⋮	⋮	⋮
Contextual Factor Influencing Innovation-	**Con-F-InnM**	RQ3.5

Mining		
Supply-Oriented Factor Influencing Innovation	***Con-F-InnM-Sup***	RQ3.5
Non-availability of imported machinery	Con-F-InnM-Sup-NIM	RQ3.5
Non-availability of leasing facility	Con-F-InnM-Sup-NL	RQ3.5
High cost of fuel used for machinery	Con-F-InnM-Sup-FC	RQ3.5
Non-availability of purer marble varieties	Con-F-InnM-Sup-NPMV	RQ3.5
⋮	⋮	⋮
Demand-Oriented Factor Influencing Innovation	***Con-F-InnM-Dem***	RQ3.5
Limited access to domestic markets	Con-F-InnM-Dem-LDM	RQ3.5
Very Limited access to national markets	Con-F-InnM-Dem-VLNM	RQ3.5
No access to international markets	Con-F-InnM-Dem-NIM	RQ3.5
Stagnant demand in domestic market	Con-F-InnM-Dem-StagDM	RQ3.5
Increasing demand for substitute product	Con-F-InnM-Dem>Sub	RQ3.5
⋮	⋮	⋮
Other Factor Influencing Innovation	***Con-F-InnM-Oth***	RQ3.5
Weak interaction b/w firm and non-firm	Con-F-InnM-Oth-F~NF	RQ3.5
Weak influence of local mining association	Con-F-InnM-Oth~MA	RQ3.5
Inconsistency of formal institutions	Con-F-InnM-Oth-FI!	RQ3.5
Collectivist culture of ‘doing as others’	Con-F-InnM-Oth-Coll-DaO	RQ3.5
⋮	⋮	⋮

8.5.6. Data Analysis – Step II: Within-Case Analysis and Displays

The main influence for conducting within-case analysis was the research questions and conceptual framework of the study. Outcomes from coding and memoing process were organized along the elements and structure of sectoral systems of innovation. Additionally, the micro-meso-macro framework was used to provide an additional layer to the analysis process. Outcomes from Step I were mainly used to address initial part of the analysis including the existing situation within the marble sector of north-west Pakistan with regards to innovation. This helped address RO1 and the subsequent RQ1.1 and 1.2. However, owing to the in-depth nature of the collected data, analysis during Step I was also used to develop a deeper understanding of each of the two cases by investigating the role of agents (firms and non-firms), knowledge, technologies, learning processes, demand and institutions within each case. As the analysis moved to Step II greater focus shifted to addressing not just RO2 (already being addressed partially through Step I outcomes) but also RO3 that focuses on understanding the structure of a low-tech SSI.

In order to provide greater understanding of research outcomes logic models, matrices networks and table were used as the main data display formats. Data display formats including those suggested by Miles and Huberman (1994) were used to represent information systematically. The main argument presented in favour of displays is that 'valid analysis requires…displays that are focused enough to permit a viewing of a full data set in the same location, and are arranged systematically to answer the research questions at hand' (Miles & Huberman, 1994, pp. 91-92). Moreover, qualitative analysis that is usually marred by expanded and unreduced amounts of texts is considered 'a weak and cumbersome form of display' (Miles & Huberman, 1994, pp. 91). For this research study most displays were tailored to answering one question each. Some information especially pertaining to RQ3.6 was also presented using extensive tables.

8.5.7. Data Analysis – Step II: Cross-Case Analysis and Displays

For this research the cross-case analysis was mainly focused on case-oriented strategy. Explaining this approach Noblit and Hare (1988) suggest that the strategy consists of 'reciprocal translations', 'refutational syntheses' and 'lines-of-argument syntheses'. These three types can be used to analyze predictability of one case's results on the second case. Additionally, Yin (2003) points out the concept of 'replication logic' whereby the researcher has used the conceptual framework to analyse Case 1 and identify patterns within the case. Next, Case 2 has been analysed to identify whether a match to patterns identified in Case 1 is found or not. This provides the researcher with more powerful and sophisticated explanations as the two cases are compared. Similar to within-case displays, matrices and networks were also used to illustrate results emerging from the cross-case analysis. The main product of cross-case analysis was the additional discussions and displays that highlight possible differences between Case 1 and Case 2. However, due to a lot of similarities a separate section on cross-case analysis was not included in the discussions.

8.5.8. Outcomes of Step II

The main outcome of Step II is the three analysis chapters (Chapters 9, 10 and 11) influenced from the case study report format (outline provided in Case Study Protocol). Both within-case and cross-case analysis have been incorporated into the three chapters.

8.6. Addressing Quality Issues

A crucial question faced by any research is how good it is. In other words how issues of quality have been addressed? Guba and Lincoln (1994) point out that researches aligning with positivist conventions address quality in light of internal and external validity, objectivity and reliability. However, the same criteria cannot be applied the same way for research studies whereby data is qualitative in nature collected based on people's perceptions of the relevant issues. Since this study uses the case study methodology Yin (2003) argues that the research should be evaluated against criteria of external validity, internal validity, reliability and construct validity. Further, steps should be taken throughout the process of conducting case study in this regard.

8.6.1. Construct Validity

The issue of construct validity is significantly important in any research to ensure the correct measures are taken regarding concepts under investigation. Yin (2003) espouses use of multiple sources of evidence and establishing a chain of evidence to address this. Use of multiple sources of data which is also termed as triangulation of evidence is recommended by many others (for example, Eisenhardt, 1989; Patton, 1990; Stake, 1995). They contend that it is an important means by which findings can be corroborated and credibility of results can be enhanced. Referring to a two-case design Marshall and Rossman (1989, pp. 146) point out that using multiple sources of data strengthens 'the study's usefulness for other settings.' This research uses a process which is somewhat circular in nature. Outcomes through multiple sources have been compared and contrasted with literature as well as outcomes from different data collection tools.

8.6.2. Internal Validity

Yin (2003) contends that internal validity is a greater concern for case studies that are explanatory or causal in nature. This research although predominantly exploratory and descriptive in nature, also focuses on determinants of low-tech innovation to explain why or why not innovation in a low-tech sector manifests itself. The use of multiple sources of evidence and the reiterative nature of data collection and analysis process (a key characteristic of retroduction) helps address the issue of whether inferences drawn by the researcher are correct or not.

8.6.3. External Validity

Influenced by retroduction the case study approach applied in this research does not attempt to generalize results to the population as is the case with quantitative studies. Yin (1994) argues that the concept of external validity cannot be applied the same way in case study research as is the case in quantitative work. Applying critical realist perspective this study focuses on understanding the mechanisms underlying the phenomenon of LT innovation while also taking influence from previous literature for comparison. Thus the appropriate strategy 'analytic generalization' rather than 'statistical generalization' (Yin, 2003). The use of multiple case study design and 'replication logic' helps increase robustness of research outcomes and strengthens 'analytic generalization'. Arguing further, Stake (1995) points out that case study research is primarily not a sampling research whereby one case is being studied to understand other cases. Pointing out that lack of sampling in case study research is not a problem it is suggested that;

'…the validity, meaningfulness and insights generated from qualitative inquiry have more to do with the information richness of the cases selected and the observational/analytical capabilities of the researcher than with sample size.' (Patton, 1990, pp. 185)

8.6.4. Reliability

The main idea behind reliability is the concept of consistency. That is the ability of data collection and analysis procedures to provide the same answers whenever carried out (Kirk & Miller, 1986) and whether another investigator who follows the same procedures achieves similar outcomes. Guba and Lincoln (1989) support the use of multiple data sources and a trail or sequence of actions taken by the researcher to help an outsider understand how decisions were taken during the course of a study. Yin (2003) suggests the use of case study protocol and case study database to address reliability issues. The protocol developed for this research elaborates the context of the study, the questions it addresses, the conceptual framework used, measures taken during the data collection process to ensure procedures were followed and a set of case and respondent questions used to ensure that the data collection processes remained relevant and on target. Table 8.5 presents the discussion on quality concerns.

Table 8.5: Addressing Quality Issues

Design Quality Criteria	Recommended Steps To Meet Criteria	Actions Taken	Research Phase
Construct Validity	a. Use multiple sources of evidence (method triangulation) b. Establish chain of evidence	a. Use of literature review, semi-structured in-depth interviews, structured interviews & questionnaires from multiple stakeholders within marble SSI b. Results of analysis (Chapters 9, 10, 11) take repeated influence from case study database. The database includes all originally collected data that has been collected in line with case study protocol	Data Collection Data Collection
Internal Validity	a. Explanation building, search evidence for 'why' behind relationships b. Use logic models and displays	a. Testing inferences made and conclusions drawn to ensure important variables have not been ignored b. Models/displays used to establish chain of evidence	Data Analysis Data Analysis
External Validity	a. Use replication logic for multiple case studies b. Compare outcomes with literature	a. Two case study design (embedded – type 4) used b. Compare outcomes with literature on LT innovation	Data Collection & Analysis Data Collection & Analysis
Reliability	a. Use case study protocol b. Develop case study database, systematic approach to data collection and analysis	a. Protocol developed. Presented in this chapter b. Data Collection Plan, memos, codes, tabular material, interview and questionnaire transcripts	Data Collection Data Collection & Analysis

8.7. Conclusion

This chapter provided details on data collection and analysis procedures employed in this research. In this regard the case study protocol including the data collection plan applied for the two cases (PeMaS and BuMaS) was provided. This was followed by the justifications for choice of data collection tools and sampling procedures. Different steps of data analysis process were explained including coding, splitting, splicing, memos, within-case analysis, cross-case analysis and others. The chapter concluded with a discussion on measures taken in the research study to address quality concerns including construct validity, internal validity, external validity and reliability. This chapter along with Chapter 7 serve as basis for the three ensuing chapters that present a detailed analysis of data in order to address all research objectives and questions.

Chapter Nine

LT INNOVATIONS IN MARBLE SSI: EVENTS AND RELATED OBJECTS

9.1. Introduction

This chapter presents analysis and discussions to address research objective 1 (RO1) and the related questions (RQ1.1 and RQ1.2) provided in Chapter 6. The focus is on understanding the existing phenomenon of LT innovation in marble SSI. Influenced from critical realist paradigm, existence or non-existence of different LT innovations amongst marble firms have been conceptualized as events. These events are caused as a result of the behaviour of objects or entities characterized by having smaller objects (structures within structures). This chapter focuses on specific entities more directly linked with events. These include product, production process, market and organizational structure (other entities like firms, non-firms, knowledge/technologies, institutions and others have been discussed in Chapter 10). Apart from particular objects, specific events (different forms of LT innovation in marble SSI) have been discussed. Data collected through semi-structured interviews, structured interviews and questionnaires has been analysed using the techniques and procedures highlighted in Chapter 8. It is important to remember that because this research follows the 'replication logic – literal replication' (Yin, 2003), the two cases (PeMaS and BuMaS) have been selected more for the similarities of their sectoral elements and structure as well as geographical proximity rather than dissimilarities. Further, rather than presenting two separate case study reports (structure provided in Case Study Protocol) the insights and results generating from analysis of the two cases are being presented together. However, during the discussions a constant and consistent effort has been made to refer to the particular case and referents/respondents (in line with critical realist perspective) when providing relevant research outcomes. Moreover, influence is drawn from the conceptual framework including the micro-meso-macro framework and SSI approach.

The analysis and discussions that follow are a result of different phases of research provided in the table below;

<table>
<tr><th rowspan="2">Marble Sub-Sector</th><th colspan="2">Case 1 and Case 2</th><th rowspan="2">Data Collection Tool Phase 1</th><th rowspan="2">Data Collection Tool Phase 2</th><th rowspan="2">Analysis</th></tr>
<tr><th>Existing LT Innovation Scenario</th><th>Framework Level</th></tr>
<tr><td rowspan="4">Mining</td><td>Product</td><td>Meso-Firm</td><td rowspan="4">Semi-Structured In-Depth Interview Section 1</td><td rowspan="4">Structured Interview Section: 'Firm Information' and 'Que. 1A, 1B, 1C'</td><td rowspan="4">Step I: Coding, Splitting, Memos</td></tr>
<tr><td>Process</td><td>Meso-Firm</td></tr>
<tr><td>Marketing</td><td>Meso-Firm & Macro-Contextual</td></tr>
<tr><td>Organization</td><td>Meso-Firm</td></tr>
<tr><td rowspan="4">Processing</td><td>Product</td><td>Meso-Firm</td><td rowspan="4">Semi-Structured In-Depth Interview Section 1</td><td rowspan="4">Questionnaire
Section: 'Firm Information' and 'Que. 1A, 1B, 1C'</td><td rowspan="4">Step II: Coding, Splicing Memos Displays</td></tr>
<tr><td>Process</td><td>Meso-Firm</td></tr>
<tr><td>Marketing</td><td>Meso-Firm & Macro-Contextual</td></tr>
<tr><td>Organization</td><td>Meso-Firm</td></tr>
</table>

Table 9.1: Phases of Research to Address RO1 (RQ1.1 and RQ1.2)

9.2. Nature of Products

Any industry or sector is distinguished in terms of the products it produces. Because this research applies the SSI approach the product and product groups remain key influencers in conceptualizing SSI and determining the system's boundaries (Malerba, 2004). In the ensuing discussion the nature of marble products, in light of the concept of 'product groups', is presented to illustrate boundaries of the sectoral system. Like innovation itself, the product remains at the heart of the system as ultimately all innovation efforts and activities performed by firms essentially lead to product improvements. Therefore it becomes imperative that in order to understand low-technology innovation the nature of product in the low-tech sector is understood first.

9.2.1. Product Categories

The respondents contacted for data collection in both PeMaS and BuMaS describe the product as being essentially of three different types. This is dependent upon the sub-sector and phase of production the product has been through. The product as a result of the mining phase is;

a. Raw excavated stone

After the processing phase it takes two further forms depending on firm's choice and available technologies and expertise;

b. Semi-processed (semi-finished) dimensional block

c. Finished or end product

9.2.2. Product Types

The product is described across different dimensions of quality. However, these dimensions do not have similar meanings and interpretations across the three product categories mentioned earlier. For example, manager of a processing unit in PeMaS describes the product as;

> *'The products I produce are in the form of different tiles. Product varieties are in terms of stone type or colour with names given such as Super White, Supreme, Nowshera Pink, Green, Black, Grey, Red & White, Brown and others. Most tiles are of the size 1 square foot (and) are used in flooring. I have smaller size tiles as well'*

For measuring size especially thickness of tiles a unique term 'sutar' is used locally. Upon inquiry it was found that 1 inch = 8 'sutars'. Within the processing sub-sector products are also available in the form/design of slabs (larger tiles in polished or unpolished form used as tabletops, kitchen tops and others), fireplace, decorative items (such as ashtray, vase, candle stand, mug mat and others) and mosaic (design products prepared from small marble stones). Two other products (mainly by-products) are marble 'chips' and marble powder or raw calcium. The marble 'chips' are low-priced marble pebbles mixed with cement and used as a low-cost alternative in flooring. Marble powder is a raw material used by other industries such as ceramics, rubber and drainage pipes. Some factories specialize in producing semi-processed dimensional blocks only. These squared blocks are later used to produce the decorative items already mentioned.

The meaning of form, size and shape changes when taken from the perspective of mining sub-sector. The owner of a marble mine in BuMaS states;

> *'Products at the mining stage are…in the form of irregular shaped stones'*

While explaining nature of the product a mine owner in PeMaS asserts;

'Three types of stones are transported from the mine, blocks, half blocks & boulders. A block can have 10 ft. height and 5 – 6 ft. width. Half Block is 3 – 4 ft. in height and 2 – 2.5 ft. in width while boulders are smaller stones with lesser sale value. The blocks can weigh 8 – 10 tons and half blocks usually weigh 4 – 5 tons'

No specific number of stone varieties was possible to determine in PeMaS and BuMaS. Marble being a natural mineral is found in different colours and pattern/line combinations making a clear classification or categorization difficult. However, some common names include 'Badal, 'Sunny Grey', 'Sunny White', 'Carrara', 'Black', 'Super White', 'Supreme', 'Nowshera Pink', 'Green', 'Red and White', 'Brown' and 'Afghan White'. More than twenty varieties were identified in the two sectors.

For all aspects of product quality the data does not reveal any difference between PeMaS and BuMaS except for stone hardness/softness. Highlighting these differences owner of processing unit in PeMaS who also owns mines in Buner and Mohmand Agency and has 20 years of experience states;

'Yes there are differences. The marble in Mohmand is good quality especially in terms of softness I mean it is not too hard. It is suitable to make designs. In Buner it is also good but has more impurities or sand in it and is comparatively harder…more suitable for tiles'

9.2.3. Product Dimensions

The above-mentioned insights on various aspects of marble products provide a total of eight dimensions which in turn also influence quality and price. However, it is important to note that the interpretations of these dimensions across the two sub-sectors vary in some cases. The product dimensions are;

1. Shape
2. Size
3. Colour
4. Form or design
5. Texture (aesthetics)

6. Purity (level of sand particles)
7. Hardness vs. softness
8. Level of cracks

Figure 9.1 on the next page provides an understanding of the nature of marble products revealed through data analysis.

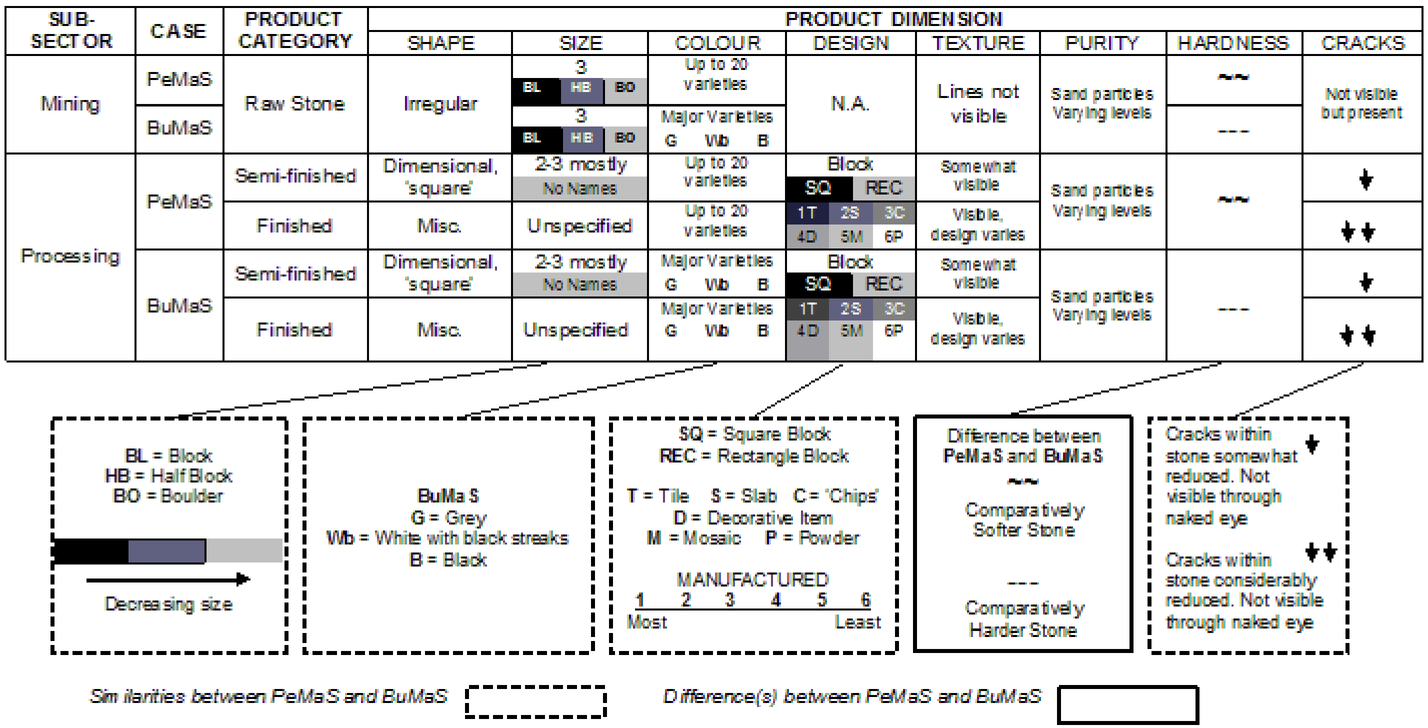


Figure 9.1: Nature of Marble Products in PeMaS and BuMaS

9.3. Nature of Production Processes

Production processes have the most direct and significant impact on the product. In order to develop an understanding of a low-technology SSI, understanding the existing nature of production processes is essential. This section conceptualizes these processes to include all those activities that have a direct relationship with production of the three product categories described in Section 9.2. Outcomes reveal that processes in mining sub-sector are completely different from those in the processing sub-sector. Factors contributing to these differences include;

a. Nature of raw material
b. Technologies applied
c. Equipment/machinery used
d. Nature of manual labour and skills/expertise of workers
e. Characteristics of end-product

Another important aspect to production processes is the complete similarities found between PeMaS and BuMaS. The discussion below has been organized along two dimensions, (1) production processes during the mining phase and (2) production processes during the processing phase.

9.3.1. Production Processes during Mining Phase

The mining phase is characterized by excavation of the stone from the mountains both in Mohmand Agency (PeMaS) and Buner (BuMaS). Describing the initial steps in this regard a mine owner in BuMaS with 15 years of relevant experience stated;

> *'First we develop 'bench' in the mountain that has the marble stone…it is like we remove the lose rocks from the face of the mountain using drill machines and expose the marble. Then we use the drill machine or driller to put holes into the rock in a series pattern that is these holes are dug in the mountain one after the other. After that we use dynamite to conduct blasts'*

A compressor is used to give power to the drilling machine. The compressor itself operates using petrol or diesel. Use of dynamite to conduct indiscriminate and multiple blasting was found to be the only method used in excavation process. Consequently, cracks develop in marble rocks leading to wastage. As one mine manager from PeMaS put it;

> *'I believe about 40 to 50 % of marble becomes useless for us due to blasting because many of the small stones are too tiny to be shipped…there is no buyer…even if there is a buyer it is not cost-effective for us to transport it to processing units which are at a huge distance from our mines. It will not fetch a reasonable price'*

The next step is to extract the loosened stone from the face of the mountain. Mining units use two types of technologies and equipment/machinery for this, bulldozer/excavator or 'mechanical winch'. The type of equipment used depends on ability of the mine manager to purchase given equipment. The 'winch' is comparatively less expensive and more common. A key feature of the 'winch' described by a mine manager in BuMaS is;

> *'The Winch uses the engine of a 1982 model Toyota Corolla and has a trolley at the back. It is like a crane. We put a hook and it pulls the stone to be loaded to the vehicle. For me this is affordable technology. Those who can afford better use a Loader'*

None of the respondents knew when and how the use of 'winch' started. However, all agreed that it was an improvised solution developed indigenously. The second type of equipment/machinery, the excavators and loaders are more original equipments. Further, iron chains are important equipment used with the winch, loader or excavator to wrap a particular stone before applying force to pull it.

The production process during mining phase is also characterized by significant use of human labour. Workers are responsible for installing blasting equipment and triggering dynamite at particular points in the mountain, operating drill machine, winch, loader and excavator. Since most mining units do not have a bulldozer, the workers are remove smaller rocks and debris from the face of a mine to make way for a winch or excavator.

9.3.2. Production Processes during Processing Phase

The processing phase is characterized by arrival of the raw excavated stone at processing units where it undergoes a variety of procedures that result in (a) semi-finished dimensional blocks or (b) finished end products (tiles, slabs, decorative items, mosaic, chips, marble powder and others). For both (a) and (b) the initial steps of the production process are almost the same. Narrating these steps manager of a processing unit in PeMaS stated;

> *'As the stone arrives from mine a crane unloads it. If the stone is large that is a block we use the same crane to place it on the gang saw for initial cutting. If the stone is small for instance half block or boulder the crane is used to place it on vertical cutter'*

Most cranes used in processing units are fixed to the ground positioned near the stone cutting machinery. Cutting of the stone is the first step in the processing phase however this cutting can be of various types and forms depending on three major types of cutting equipment/machinery the processing units in PeMaS and BuMaS have;

a. Gang Saw
b. Vertical Cutter
c. Horizontal Cutter

All three types of machinery use electricity. There is considerable usage of water during the cutting process to reduce the cutter and blades from excessive heating due to high friction. The gang saw has a large metallic or iron platform fixed to the floor with enough space to accommodate a raw marble block. The main feature of the gang saw is 5 – 9 horizontal blades that cut through a block simultaneously. The cutting process starts from the top of the block with blades moving down vertically. This results in 6 – 10 large marble slabs. These slabs undergo further procedures described later in this section. Another type of cutting machinery more common than gang saw is the vertical cutter or 'vertical'. The vertical has either a flexible arm or platform allowing movement mostly in one direction only (forward and backward). The machine operator uses manual handles to move the stone on the platform. The 'vertical' offers lesser efficiency compared to a gang saw. The main feature of the vertical cutter is a single circular blade installed vertically onto a metallic arm which the worker uses to cut the stone vertically. A vertical is more useful for cutting half blocks and boulders but can be used for cutting blocks as well.

The third type of cutting machinery is the horizontal cutter or 'horizontal'. It is very similar to a 'vertical' in terms of basic features. The only difference also evident from the name is that it cuts the stone from left to right or vice versa characterized by horizontal movement of the blade. Vertical cutting takes place prior to horizontal cutting. The 'vertical' and 'horizontal' both perform a similar function termed by the respondents as 'sizing'. An additional feature of 'horizontal' is that it is used for thinning slabs or tiles to pre-determined sizes measured in 'sutar', mentioned in Section 9.2.2. Vertical can be used to straighten the four sides of slabs or tiles. The 'vertical' and 'horizontal are also' used to manufacture semi-finished dimensional blocks. Compared to gang saw which is more suitable for slabs measuring between 3 and 8 feet, the 'vertical' and 'horizontal' are more suited for producing tiles and can cut them in sizes ranging from 1/3 ft to 2 ft. However, there are no standardized sizes for each type of cutting equipment. Describing these processes the owner of a processing unit in PeMaS said;

> *'…at the factory we take out slabs of 9 'sutar' thickness. From that slab we produce tiles of 1 sq. ft., 1 ft. x 2 ft., ½ ft. x 1 ft. and 1/3 ft. x 1 ft. Then we take these tiles to another machine, the Horizontal that cuts each tile from the middle to convert 9 'sutar' thicknesses to two tiles of 4 'sutar' thickness each'*

A key characteristic of the above-mentioned cutting machinery is use of cutting blades termed as 'tips' by respondents. These 'tips' are installed on the circular blades (both vertical and horizontal) or gang saw cutters by experts who specialize in this area. The quality and prices of the tips are mainly influenced by durability. Elaborating on 'tips' a middleman in PeMaS who specializes in 'tip' instalment pointed out;

> *'Most cost in terms of equipment in marble processing is borne on blade tips. These tips are coated with diamond dust or particles to give them the sharp edge. This way they can cut the hard stone…tips are imported and*

manufactured locally…local tips work for one month, Italian can last up to six months but is more expensive'

The slabs and tiles of varying sizes and shapes are put through another process called 'polishing' to enhance the overall appearance of the product. The polishing machine or 'polisher' is used for this purpose. Most processing units in PeMaS and BuMaS have a 'polisher' installed at the factory. This equipment has special kind of 'grinding stones' of varying contours that are abrasive in nature. These stones reduce unevenness of marble's surface. Combined with a special kind of polishing wax or dry soap the last step of the polishing is performed that results in a much cleaner, smoother and shinier end product. Most polishing machines are locally manufactured. Describing this equipment a middleman and sector expert with 20 years of experience stated;

'The Pakistani polishing machine which is manual in nature gives you 100 to 200 sq. ft of polished tiles in 8 hours…these local polishing machines cost about Rupees 0.1 to 0.2 million. It does not give the same value or quality. The imported polishing machine...can give 800 to 1000 sq. ft. in 8 hours…imported machine is Rupees 6.0 to 7.0 million…the price difference is very obvious'

Some processing units also produce decorative items, mosaic, chips and marble powder. The raw material for decorative items is the semi-finished dimensional block and the most common equipment/machinery used for this purpose is called the 'Lathe' machine. The 'Lathe' spins the marble block to perform various operations on it including cutting, sanding, knurling, drilling or deformation. It enables the craftsmen to produce items like ashtray, vase, cups, plates, mosaic and others. For marble chips a special kind of crusher is used in processing units. All small stones that are scrap material resulting from cutting process using gang saw, 'vertical' or 'horizontal' are used in the crusher. However, many processing units approached for data collection did not have a crusher to produce chips. Similarly marble powder also results from the cutting of stones.

The processing phase also involves significant involvement of workers. They are involved not only in manually supporting the cranes to place stones on cutting machinery but also operate these machineries as well as polishers. However, the level of skills and craftsmanship required for producing decorative items is higher than producing slabs, tiles and chips

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Deriving from these discussions Figure 9.2 provides different phases of production processes.

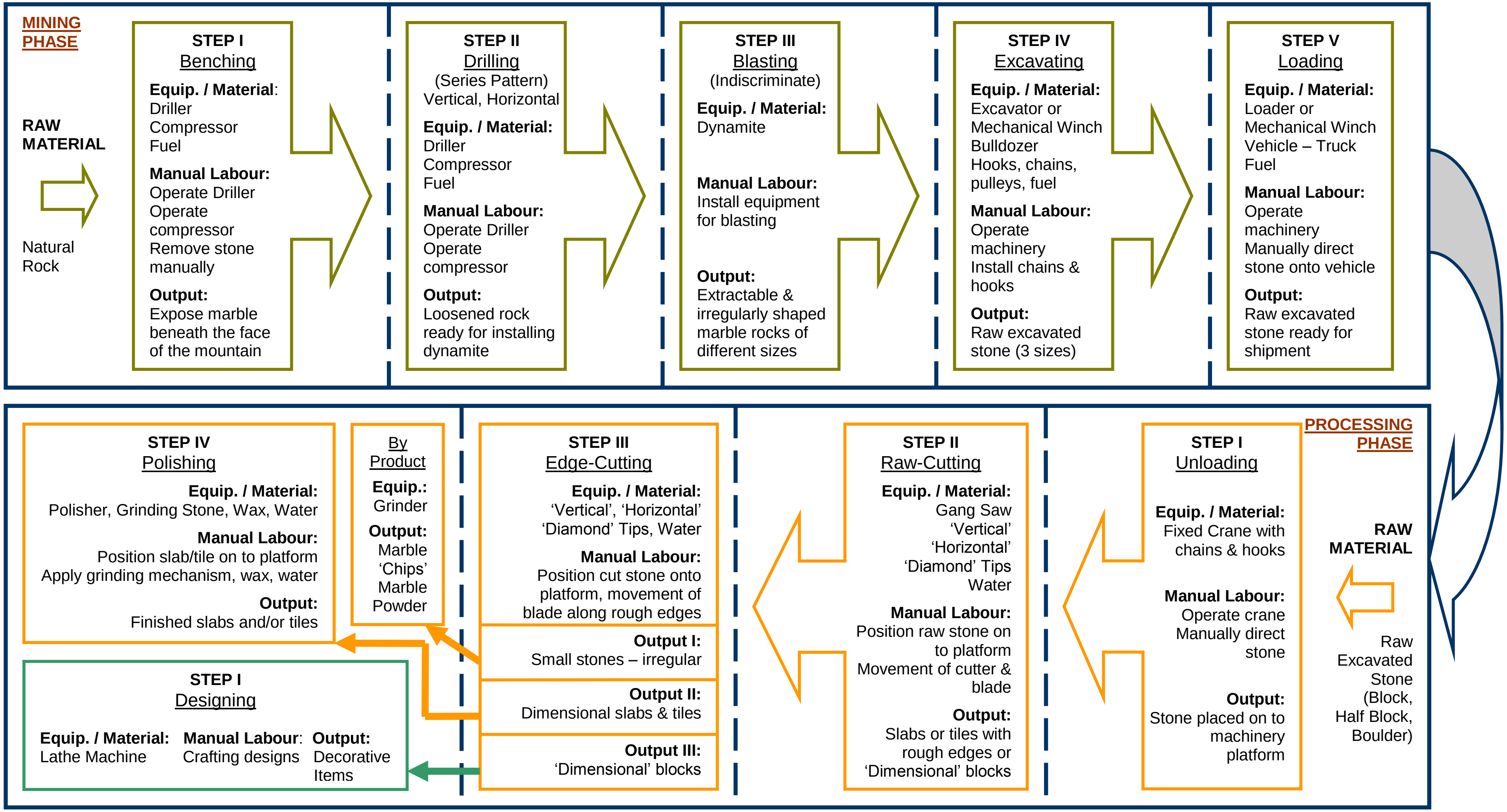


Figure 9.2: Illustration of Production Processes during Mining and Processing Phases in PeMaS and BuMaS

9.4. Nature of the Market and Marketing Practices

Focused on market-related issues the discussions in this section lay the foundations for developing insights in to the elements and structure of marble SSI later in Chapters 10 and 11. Data analysis reveals various dimensions of market and marketing practices within PeMaS and BuMaS. There is a lack of standardized practices as different businesses follow different procedures. The analysis also reveals certain differences between PeMaS and BuMaS with regards to the above-mentioned dimensions. Discussed below are four dimensions of market and marketing practices emerging from data.

9.4.1. Markets for Products and Nature of the Competition

The markets for marble products can be put into three categories. These include;

- Domestic/local
- National and
- International

The mining sub-sectors in both PeMaS and BuMaS are geographically located at a large distance from most processing firms which are the main market for their products. The products in mining sub-sector are essentially for the domestic/local market only. Data does not reveal any evidence of blocks, half blocks and boulders being sold in the national or international market. Citing reasons for this a sector expert with more than fifteen years of experience pointed out;

> *'First of all the cost of transporting such huge and heavy stones that weigh in tons is too high from the mine owner's perspective…travelling over huge distances to reach the markets in the south or southeast of the country like Karachi, Lahore or Rawalpindi is not feasible. Secondly, the stone is irregular in shape and a lot of wastage occurs during processing activity. The product does not fetch a price high enough to cover the costs incurred over huge distances…processing factories within the region are less difficult to access and the only reasonable choice'*

PeMaS's Mohmand Agency has greater law and order problems associated with travelling/transportation on the roads. It was found that a truckload of raw stones on its way from the mine to a processing unit that is located in Peshawar has to pay levies or 'tawan', a kind of informal tax charged by the local tribes guarding different key points on the road. This unregulated and unlawful practice is prevalent more in PeMaS compared to BuMaS and adds to cost of transportation. This forces mining units, especially in PeMaS, to focus on domestic markets only.

The processing sub-sectors in both PeMaS and BuMaS were found to be targeting local as well as national markets with local markets and customers buying most of the products. However, analysis of data did not reveal any focus on international markets. No differences between the two cases were identified in terms of preferred regions within the national market. However, firms that had a national market orientation were mainly focusing on the province of Punjab with areas such as Lahore, Gujranwala, Faisalabad and Rawalpindi. Products mainly included tiles and slabs but some firms offer decorative items and mosaic also. Marble 'chips' and powder are almost exclusively sold only in the domestic market because of the low price they capture.

The concept of competition amongst firms does not prevail in the traditional sense. Particularly mining units in both sectors do not treat each other as competitors. Contributing factors are;

- Mature market with no major fluctuations in customer orders
- Products, essentially raw, not differentiated from one another at all to generate a sense of competition
- People working in the mining industry know each other and are related via tribal lineage

For processing units the market dominated by production of similar products (tiles and slabs) is competition-oriented. However, there is evidence of firms copying each other in terms of technologies and equipments to produce better quality products. Narrating this manager of a processing unit in PeMaS said;

'Yes we influence each other. I was the first one to install a gang saw in the Industrial Estate about 15 years ago. That gave me a unique advantage over other firms in the area. But I found that within a year the owner of another firm also purchased the same machinery because he realized I was making more money out of it. Now quite a few firms here have this technology'

9.4.2. Pricing Practices

The marble industry is characterized by lack of standardized pricing. This stems from the nature of the product which itself lacks consistency in terms of form and quality. The key factors influencing price in the mining sub-sectors are;

- Size of the raw stone – price decreases as size decreases
- Marble variety – certain varieties are in greater demand due to better quality once converted to finished products
- Transportation costs and freight charges – can vary and lack consistency

Analysis of data on pricing practices in both processing sub-sectors revealed inconclusive results. Factors contributing to the lack of clarity include;

- Different types of finished products
- Variation and inconsistency in quality of finished products
- Wide variety of raw marble stone
- Different processes put in place to manufacture products
- Dissimilarities in market/customer needs and preferences

The above factors make it difficult to determine whether the processing sub-sectors have standardized pricing or not. To illustrate this, provided below are contrasting views from two respondents.

When asked to describe how price of marble products is regulated by members of the local association of marble businessmen, the owner of a processing unit in BuMaS stated;

'…there is considerable unity among the members in terms of keeping the prices of products fixed or keeping the rents or transport costs fixed. However, there might be instances where one factory owner might sell the product at a higher rate than the agreed price level'

On the contrary a middleman (distributor) pointed out;

'…there is no cooperation among factory owners. Mostly they work against each other. Prices are not fixed. Although they claim that prices are listed. But no one really implements listed prices'

9.4.3. Nature of Promotion and Relationships with Customers

In both PeMaS and BuMaS no firms engage in formal promotional activities. In the mining subsector, a product is promoted in a very informal way. The mine owner or manager has direct business contacts mostly with middlemen/transporter (mainly responsible for distribution of raw stone). If a new source of marble is discovered in the mining area, the owner or manager will;

- Give the sample to the distributor for onward promotion
- Show it at different processing units in person
- Contact the processing unit via phone

No promotional materials are used nor do formal brands exist. However, certain marble varieties, recognized by their names for example 'Ziarat White' and 'Afghan White', carry a better quality reputation and priced higher. Others such as 'Badal' and 'Grey' are priced lower due to poor quality (impurities/sand in stone) and texture.

The customer in the mining sub-sector can essentially be categorized as a business customer (processing units). Most mining units rely more on personal relationships with business customers that are based on trust and reputation and can last for years. In most instances the distributor responsible for shipment of raw stone from the mine forms the link between the two acting as a go-between.

Product promotion is somewhat formalized in processing units. However, limitations prevail. Some businesses in both PeMaS and BuMaS own showrooms for their finished products. These showrooms are a source of product promotion and customer order acquisition. The showrooms are mainly of two types;

1. Located at the factory
2. Located other than the factory

In the case of PeMaS the showrooms within the sector are located in Peshawar, the provincial capital, with better demand conditions due to customer accessibility. For BuMaS the showrooms are located in the main market in Buner city. A number of showrooms not owned neither run by processing units are located in cities outside PeMaS and BuMaS such as Islamabad, Rawalpindi, Lahore and Karachi. Most processing units however do not have showrooms to showcase and display products and rely on direct customer order at factory location. These customers can be owners of showrooms, commercial buyers (for example, construction companies) and consumers. Products are prepared according to quantity and quality/design requirements of customers.

The semi-finished dimensional blocks are only purchased by business customers (processing units that specialize in decorative items). However, data reveals that a greater number of customers of this product type is located in the national and not domestic market. The semi-finished block produced in PeMaS is in greater demand in the southern port city of Karachi but competes against another good quality product known as Onyx (a softer marble stone) from the province of Baluchistan. The block produced in BuMaS is sold more in the areas of Punjab province to the south-west of the country. Like dimensional blocks, finished products are bought by business customers (showroom owners, construction firms). Buyers also include middlemen or wholesalers who purchase the product for onward sale to another business. Consumers such as people constructing a house for themselves are also buyers.

9.4.4. Supply and Demand Issues

The supply and demand issues in mining sub-sectors of PeMaS and BuMaS mostly relate to equipments, materials, machine components and raw stone. Materials like fuel, dynamite and components are mostly available in Ghalanai bazaar of Mohmand Agency and other adjoining areas in the case of PeMaS. For BuMaS, the same inputs are brought from the district headquarters in Buner named Daggar and also available in Chagharzai. An important issue raised by a few mine owners in BuMaS related to difficulties in purchasing dynamite. Narrating the implications for business a mine owner pointed out;

> *'To purchase dynamite we are issued licenses or permits by the district administration or the district coordination officer's (DCO) office. The seller of dynamite also has a specific license in this regard that has to be renewed periodically. Due to bad law and order situation, there have been restrictions on us…dynamite has not been available easily, the army keeps an eye on us through checkpoints and its price has also gone up'*

For supply issues pertaining to the raw excavated stone, results suggest that mining units do not follow any pre-determined targets regarding how much stone to excavate. The two main product demand factors during the mining phase were found to be stone size (larger blocks and half blocks are in greater demand and fetch higher price) and stone variety. However, the preference of a particular processing unit for specific varieties was influenced by customer orders and sale performance. Thus some processing units demand low priced varieties like 'Black' that has grey streaks.

Outcomes for the two processing subsectors suggest that continuous supply of electricity for cutting machineries and polishers is a major concern. While for BuMaS almost all respondents agreed that frequent power shutdowns seriously hampered their production schedules and the ability to fulfil customer orders adequately, conflicting views were expressed in PeMaS. Owners/managers of processing units located in Peshawar's Warsak Road area complained about a price disadvantage compared to units located a few miles down the road in Mohmand's tribal region. Describing the scenario, one owner of a processing unit in the area stated;

'I have to pay bills based on commercial rates of electricity…the more I consume the more I pay. But these guys (units in adjoining Mohmand) pay a fixed bill. Many units have installed more machinery to produce more and faster with fixed costs. How can I compete with them on price?'

Disagreeing with this perspective, manager of a processing unit located in Peshawar's Industrial Estate suggested;

'I'd say we are lucky because power supply disruptions are much less in Peshawar…yes, the guys in Mohmand pay a fixed bill but power shutdowns over there are five times more. You might think they have a cost advantage but that is lost when I produce more and thus sell more in the market'

The major production of processing units' machinery such as gang saw, vertical and horizontal cutting machines, polishers, lathe machines and grinders does not take place within PeMaS and BuMaS. The manufacturers specializing in this area are located in the Punjab province especially cities like Gujranwala, Faisalabad and Gujrat which are hubs of small industrial manufacturing in Pakistan. However, there is a separate group of 'experts' in both PeMaS and BuMaS that specializes in the installation and maintenance of these machineries at the processing unit premises. Most units in both sectors have machinery made locally in Pakistan. There were few examples of imported technologies from Italy. The most frequently used input in the processing sub-sectors was found to be the blade 'tips' installed on cutters. The market for this product does not have any standardized mechanisms with suppliers varying in terms of the product quality they provide and prices they charge. No evidence of locally manufactured tips was found and all are imported from countries like China, Ukraine and Central Asian Republics.

Semi-finished blocks are mostly in demand by factories in the southern city of Karachi where there is a large number of small firms specializing in producing decorative items. The most commonly sold product within PeMaS and BuMaS is the tile followed by slab. These two products are also sold in large quantities to business customers in Punjab province. A large number of middlemen-oriented firms and individuals are also present within the two sectors. Their mode of operation relies on searching for potential customers not just within the local area but also across Pakistan. Processing units being small firms do not have a formal distribution channel of their own and rely on these distributors (including wholesalers) for sale of products.

The above discussion about nature of marketing within the two marble sectors underscores the inseparability of firm from its context. In order to illustrate this aspect further Figure 9.3 provides a context chart (Miles & Huberman, 1994, pp. 102-105).

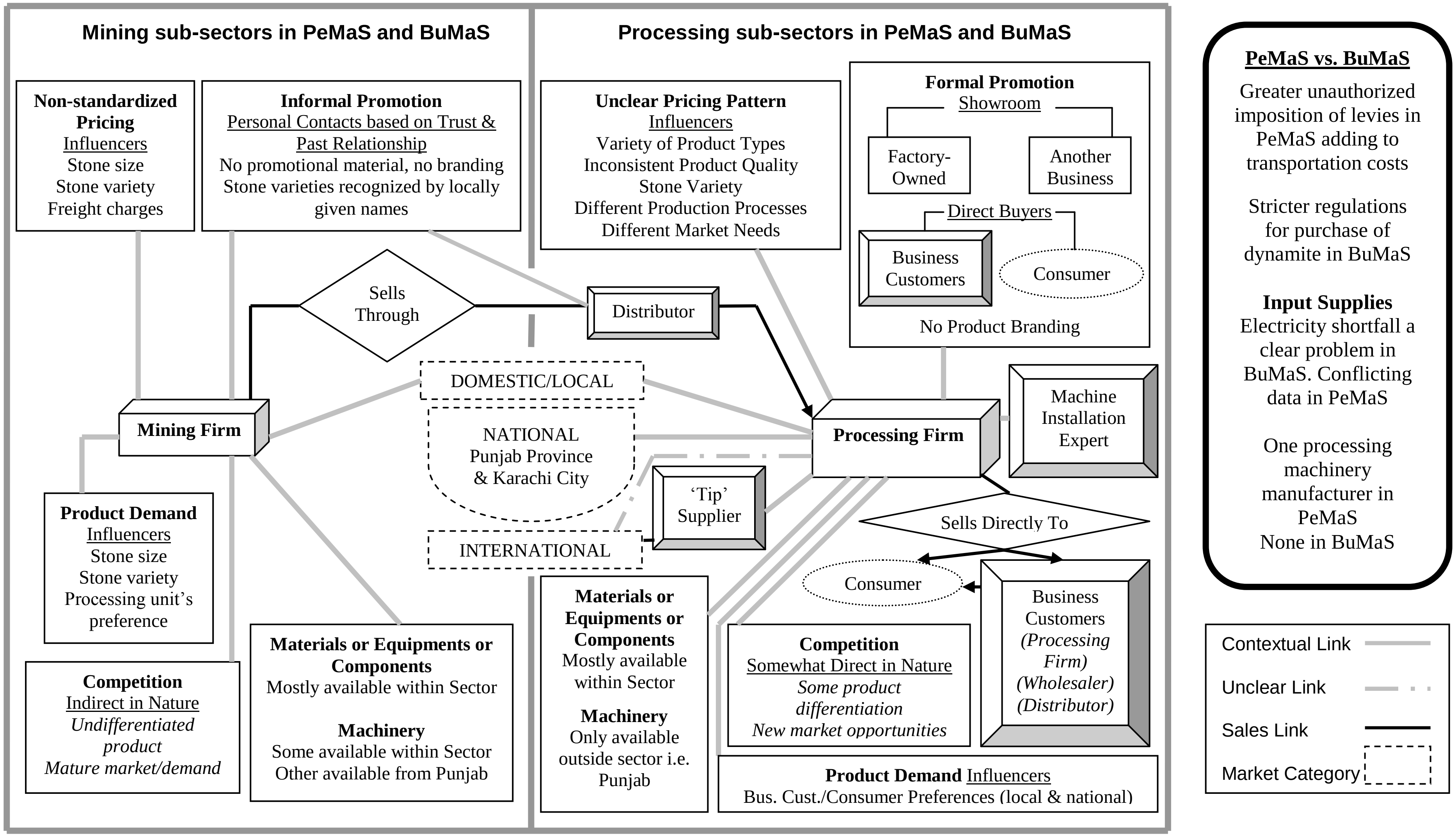


Figure 9.3: Context Chart: Nature of Market and Marketing Practices in PeMaS and BuMaS

9.5. Organizational Structures

Data suggests specific nature of organizational structures within mining and processing firms whereby important differences are found.

9.5.1. The Mining Unit as an Organization

A peculiar feature of the mining unit is the difficulty of determining organizational structure and boundaries. The office of the Director General Mines and Minerals (DGMM) which comes under the aegis of Industries Department of the provincial government issues licenses for mining rights after charging prescribed fees. A similar function is performed by Department of Minerals (DoM) under federal government's FATA Governor's Secretariat. Additionally a certain amount of money that can be termed as royalty is paid to the elders of the tribe. Leasing is a common practice whereby a license holding mine owner allocates a particular section of the mountain to another individual, the mine manager for a pre-specified number of years. An agreement or deed prepared by the local notary public is the contract. Two forms of payment mechanisms prevail between the owner and manager;

a. The manager of mining unit directly pays a pre-agreed fixed amount to the owner for every truckload of raw excavated stone
b. The manager of mining unit directly pays a pre-agreed fixed amount to the owner per month regardless of quantity produced
c. The owner appoints a supervisor or 'munshi' to collect fees from manager on owner's behalf

None of the mining units contacted for data collection had a formal business name or title. This stems from the nature of mining operations. For a single mountain multiple mines (mostly 3 – 4) can be operational. Each face of the mountain where one group of miners with their equipment is operating is termed as 'Darang' in local language. Each 'Darang' managed by a single manager is by definition a mining unit. Results from the data suggest that a single 'Darang' can have 6 – 15 workers. There is no formal training before a worker joins a mining unit. The new worker mostly learns by observing others and directly performing the tasks assigned to him.

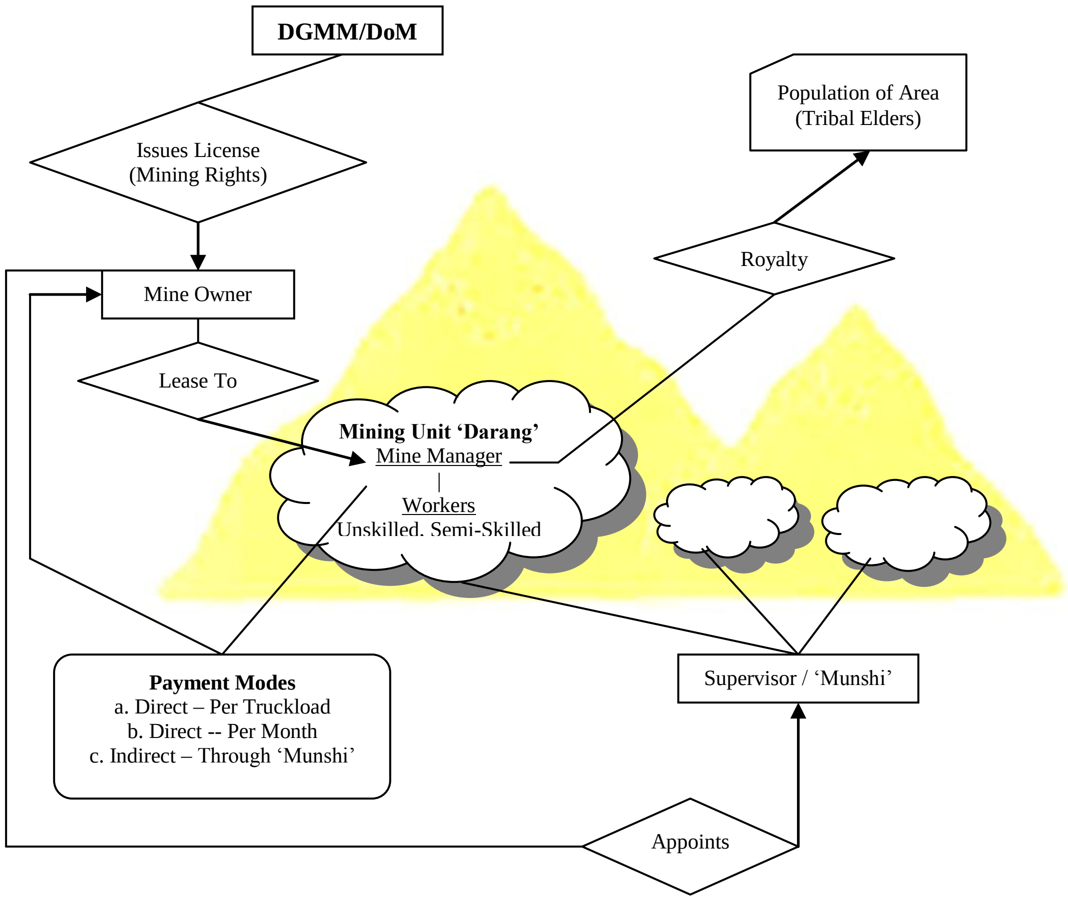


Figure 9.4: Structure of Mining Unit in PeMaS and BuMaS

9.5.2. The Processing Unit as an Organization

The processing units in both sectors are characterized by a somewhat formal organizational structure where tasks and responsibilities are assigned but no formal job titles exist. Each processing unit has a formal business name. Three types of arrangements were identified;

a. The owner and manager is the same individual
b. The owner and manager are two separate individuals
c. The owner and manager both run the business together

Some processing units included in the sample also had a supervisor or 'Munshi' who supervises the workers directly but all financial matters, raw material procurement, customer orders and other operational issues are dealt with by the manager himself. Number of workers can range from 6 – 12 to 12 – 20 workers. Like mining units, there is no formal training of workers who join a processing unit. Learning is characterized by on-job training observing seniors and hand-on performance of tasks.

In mining as well as processing units workers can be broadly categorized in to two types;

a. Semi-skilled workers – operate the equipment and machineries and responsible for maintenance

b. Un-skilled workers – perform the support functions and provide more manual labour

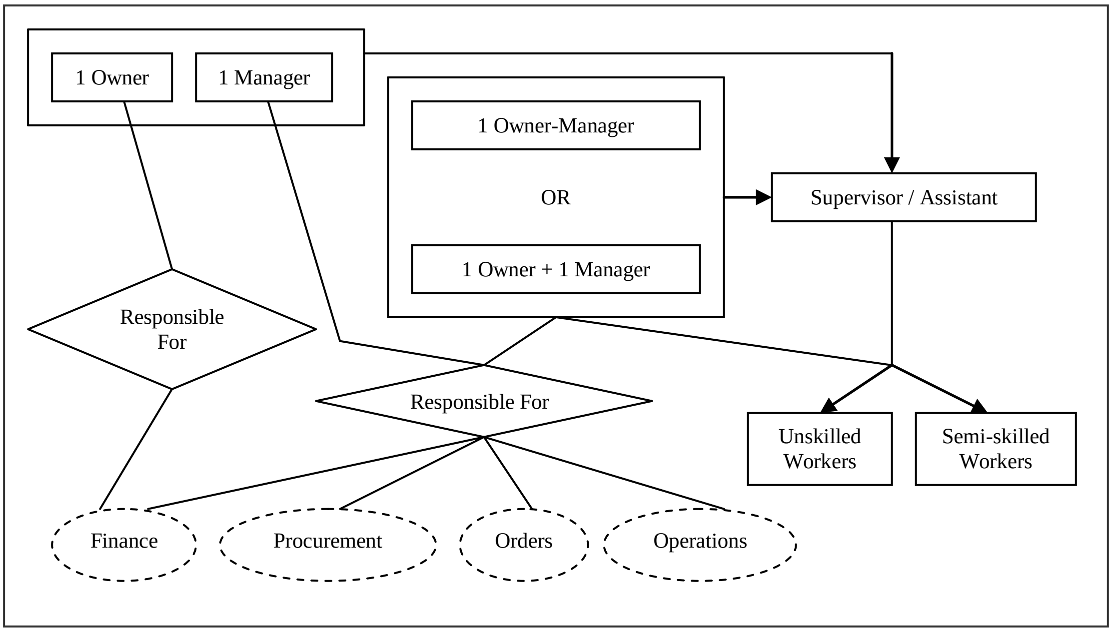


Figure 9.5: Structure of Processing Unit in PeMaS and BuMaS

9.6. Nature and Types of Innovation

One underlying point emerging from the discussion in this chapter so far about objects/entities is that innovation, if present within the two marble sectors (PeMaS and BuMaS) can manifest itself in many forms. An important outcome from data analysis is that none of the firms in the mining and processing sub-sectors have any research and development or R&D focus thus suggesting the low-tech characteristic of the industry. R&D intensity is zero whereby the main underlying cause suggested by respondents is the small size of business with very limited resources.

In order to capture data on nature of innovation certain limitations were in place affecting the nature of collected data and the process of collecting it.

1. No prior research work that studies innovation in Pakistan’s marble industry was identified
2. No previous measurement criteria used to identify innovation and its extent at firm-level and in the marble industry were found

The above factors contributed to how data regarding innovation was collected by essentially relying on respondents’ understandings and perceptions of innovation.

Phase-I of data collection explored the event/phenomenon of LT innovation by requiring respondents to describe their understanding of improved or new products, processes and others activities within mining and processing firms. During Phase-II, respondents were asked specific questions in the structured interview and questionnaire to describe these innovations. Questions were phrased along following lines;

a. Did the mining firm discover and subsequently introduce a new or rare variety of raw excavated stone and production process
b. Did the processing firm improve the existing product in terms of design and/or quality and production process
c. Did the processing firm introduce a completely new product never manufactured before by the firm and production process
d. If yes to (a), (b) or (c), describe the firm’s product and process innovation
e. Did the mining and processing firms sell their products in a completely new market where they did not sell before
f. If yes to (e), describe the firm’s marketing innovation
g. Did the mining and processing firms make any changes to their organizational structure, for example hire better employees, lay off old ones, improve accounting/financial or other procedures and so on
h. If yes to (g), describe the firm’s organizational innovation

9.6.1. Innovation from the Product Perspective

Figure 9.1 reveals that there is no single describable form of product in the two marble sectors. Contributing factors include two-stage or two-phase production activities (mining and processing) and extreme variation in the natural resource itself (marble stone).

Deriving from data, Table 9.2 below shows that product innovation is almost non-existent amongst mining firms. Some processing units have introduced product improvements or new products although it is not a common event amongst the sample firms either. Both sectors are characterized by limited incremental product innovation during the processing phase. This is because even the new products are not radical in the actual sense and are not the first-time introductions to the whole industry. The new products are termed 'new' mainly from the respondent firm's perspective. Influence is taken from the definition given by Nelson and Rosenberg (1993, pp. 4) whereby innovation is 'the processes by which firms master...product designs and manufacturing processes that are new to them, whether or not they are new to the universe'.

Subsector	**Innovation Scenario**	**Total Response (%age) – Phase II**	***PeMaS (%age)***	***BuMaS (%age)***
Mining Firms	Introduced new or rare variety of marble	6	17	0
	Excavating the same product since business started	94	83	100
Processing Firms	Introduced completely new product not manufactured before	6	6	6
	Improved existing product (design, quality)	16	17	14
	Producing the same product since business started	78	77	80

Table 9.2: Product Innovation in PeMaS and BuMaS

9.6.2. Innovation from the Process Perspective

Section 9.3 in this chapter reveals the complete difference between production processes during the mining and processing phases. Contributing factors include the differing nature of raw materials, technologies/machineries, worker expertise/skills and desired end-products. It is also found that innovation can occur at any given 'Step' or 'Steps' of production highlighted in Figure 9.2.

Table 9.3 given below demonstrates that process innovation is very limited in the mining sub-sectors. Some processing units have introduced improvements to production processes such as installing new machine components like better quality blade ‘tips’. Both sectors are characterized by limited incremental process innovation.

Subsector	Innovation Scenario	Total Response (%age) – Phase II	*PeMaS (%age)*	*BuMaS (%age)*
Mining Firms	Introduced completely new process (machinery, technologies)	0	0	0
	Improved existing process (component replacement)	11	17	8
	Same process since business started	89	83	92
Processing Firms	Introduced completely new process (machinery, technologies)	0	0	0
	Improved existing process (component replacement)	19	20	17
	Same process since business started	81	80	83

Table 9.3: Process Innovation in PeMaS and BuMaS

9.6.3. Innovation from the Marketing Perspective

The discussions in Section 9.4 on marketing practices reveal the differences between mining and processing sub-sectors along with similarities and differences between PeMaS and BuMaS. Also, deriving influence from the mico-meso-macro framework, the analysis not only focuses on the meso-firm level but also the macro-contextual (competition, supply, demand) influences on marketing practices.

Data analysis reveals the presence of some incremental marketing innovation but only for processing firms. Table 9.4 provides relevant information in this regard.

Subsector	Innovation Scenario	Total Response (%age) – Phase II	*PeMaS (%age)*	*BuMaS (%age)*
Mining Firms	Offered product in new market	0	0	0
	Selling in the same market since business started	100	100	100
Processing Firms	Offered product in new market	24	23	26
	Selling in the same market since business started	76	77	74

Table 9.4: Marketing Innovation in PeMaS and BuMaS

It is important to point out that all marketing innovation is concerned with firms targeting new national markets with no focus on international markets.

9.6.4. Innovation from the Organizational Perspective

Section 9.5 underscores the completely different nature of organizational structures in mining and processing firms. Compared to processing unit, the difficulty in determining boundaries of a mining unit means that contextual factors have to be incorporated in order to better understand the organizational structure.

Evidence from data analysis reveals just two instances of organizational innovation in processing firms in total whereby employees were replaced with more experienced workers. Table 9.5 provides relevant information in this regard.

Subsector	Innovation Scenario	Total Response (%age) – Phase II	*PeMaS (%age)*	*BuMaS (%age)*
Mining Firms	Made changes to organizational structure (hired/fired employees, others)	0	0	0
	Same organizational structure since business started	100	100	100
Processing Firms	Made changes to organizational structure (hired/fired employees, others)	3	8	0
	Same organizational structure since business started	97	92	100

Table 9.5: Organizational Innovation in PeMaS and BuMaS

It is important to point out that the small size of firms with simple organizational structure (few workers, few types of jobs and tasks) means there is very limited possibility of firms introducing organizational innovation in the real sense.

9.6.5. Overall Innovation Scenario

In order to provide an overall assessment of the level of innovation within PeMaS and BuMaS respondents were asked to provide their perception of innovation carried out by their firms. A five-level rating scale (1 – 5) was provided. The scale ranged from level 1 (no innovation or improvement) to levels 2 – 3 (improvement to existing product, process, marketing practice, organizational structure) to level 4 – 5 (introduction of new product, process, marketing practice, organizational structure). Table 9.6 provides the relevant outcomes in this regard.

<table>
<tr><th>NEED FOR IMPROVEMENT</th><th colspan="2">Yes</th><th colspan="2">No</th><th>Unsure</th></tr>
<tr><td>Mining phase</td><td colspan="2">100%</td><td colspan="2">0</td><td>0</td></tr>
<tr><td>Processing phase</td><td colspan="2">96%</td><td colspan="2">3%</td><td>1%</td></tr>
<tr><th rowspan="2">LEVEL OF INNOVATION INSIDE FIRM</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>76%</td><td>20%</td><td>3%</td><td>1%</td><td>0</td></tr>
</table>

Table 9.6: Perceived Need for Improvement and Level of Innovation in PeMaS and BuMaS

The table suggests that most respondents (76%) do not perceive their firm to be innovating in any form. The 24% that consider their firm to be innovating categorize it as incremental innovation.

9.7. Conclusion

This chapter presented research outcomes about some key entities/objects in marble SSI. These included products, production processes, markets and organizational structure. The product groups discussed in Section 9.2 help establish boundaries of marble SSI. This was followed by a discussion on events (different types of LT innovation which are at the centre of any SSI). Outcomes suggest that marble products though essentially non-complex in nature are available in many forms with lack of standardization. The production processes in mining firms are completely different from those in processing firms. Marble firms' inseparability from their context or environment comes to the fore with regards to nature of markets and marketing practices. The organizational structures though difficult to identify in mining firms are essentially simple for both firm categories. Marble SSI are characterized by limited incremental product, process and marketing innovations. No real examples of organizational innovation were found.

Chapter Ten

ELEMENTS OF MARBLE SSI: OBJECTS, UNDERLYING COMPONENTS AND MECHANISMS

10.1. Introduction

This chapter provides analysis and discussions to address research objective 2 (RO2) and related questions RQ2.1 to RQ2.4. The purpose is to explain how a low-technology sectoral system of innovation exists in terms of its elements. Taking influence from critical realism, the elements have been conceptualized as objects with underlying components (objects within objects). The objects covered in this chapter are the SSI elements including firms (including individuals – firm owners and managers), non-firms, knowledgebase and technologies, learning processes, demand and institutions. While elaborating on these objects and their components, discussions also lead into mechanisms or ways in which these objects can cause events (occurrences of LT innovation). Data has been analysed using techniques and procedures highlighted in Chapter 8. Due to application of 'replication logic' (Yin, 2003), the two cases PeMaS and BuMaS have been selected more for their similarities. During the discussions a constant and consistent effort has been made to refer to the particular case and referents (respondents) in line with critical realist perspective. Moreover, influence is drawn from the conceptual framework including the micro-meso-macro framework and SSI approach.

For this chapter the analysis and discussions below are a result of different phases of research provided in the table below;

Marble Sub-Sector	Case 1 and Case 2		Data Collection Tool Phase 1	Data Collection Tool Phase 2	Analysis
	Elements of SSI	**Framework Level**			
Mining	Agents	Micro-Individual, Meso-Firm, Macro-Contextual	Semi-Structured In-Depth Interview **Sections 2, 3 & 4**	Structured Interview **Section: *'Firm Information'*** and ***'Que. 1A, 1B, 1C, 2A & 2B'***	**Step I:** Coding, Splitting, Memos **Step II:** Coding, Splicing Memos Displays
	Knowledgebase	Meso-Firm, Macro-Contextual			
	Technologies				
	Learning Processes				
	Demand	Macro-Contextual			
	Institutions				
Processing	Agents	Micro-Individual, Meso-Firm, Macro-Contextual	Semi-Structured In-Depth Interview **Sections 2, 3 & 4**	Questionnaire **Section: *'Firm Information'*** and ***'Que. 1A, 1B, 1C, 2A & 2B'***	
	Knowledgebase	Meso-Firm, Macro-Contextual			
	Technologies				
	Learning Processes				
	Demand	Macro-Contextual			
	Institutions				

Table 10.1: Phases of Research to Address RO2 (RQ2.1, 2.2, 2.3 and 2.4)

10.2. Role of Individuals (Micro-Elements/Objects) and Firms (Meso-Elements/Objects)

Organizations which are formal structures with an explicit purpose are main components of a system of innovation (Edquist, 1997; 2005). From a critical realist perspective they are the key objects (Easton, 2009) while from SSI approach they are actors or agents (Malerba, 2002; 2005). In this research these actors or objects include firms (mining and processing units) and non-firms (suppliers, distributors, government agencies, financial institutions and others). The marble firms are essentially small businesses where individuals (owner and manager; objects within objects) play hugely important roles. Thus bringing in the micro-meso-macro framework, the crucial influence of the individuals within firms in affecting innovation or lack of it cannot be discarded. Data reveals similarities and differences between mining and processing units however no differences were found between PeMaS and BuMaS for roles of individuals and firms. Discussed below are relevant outcomes.

10.2.1. Individual within Mining Sub-Sector

The mining units in both sectors have a mine owner separate from a mine manager. Data suggests that most mine owners are not the residents of local area where mines are located. These areas which are typically far-flung and hard to access are inhabited by villagers and tribes who are extremely poor and do not have the capacity and know-how to obtain mining rights. As opposed to that the mine managers were found to be residents of the local area along with long-held personal contacts and relationships. These managers mostly have a particular approach towards business which is not long-term in nature and relies on short-term survival.

The mine owner does not have a direct stake in the day-to-day mine operations and profits. His main concern is lease payments from the mine manager managing the business at the face of a particular mountain owned by the owner through mining license. The mediating role of the supervisor or ‘munshi’ appointed by the owner to collect lease payments and supervise mining activity without directly taking part in the operations means a further lack of contact between the manager and owner. Contrary to this, the manager is more concerned about extracting as much raw stone as possible. Payments to the owner are usually fixed according to a pre-agreed amount. Thus product quality, use of improved mining technology, improved worker skills through training and minimized wastage of natural resources are not his priorities. He does not own the reserves. This separation between owner and manager’s business approach and stake emanating from their somewhat contradictory roles is a key reason underlying lack of LT innovation and quality improvement of raw excavated stone.

10.2.2. Individual within Processing Sub-Sector

While the role of individual in a processing unit (also a small firm) remains vital, it is three individual-role variants provided below that underlie the causal mechanisms influencing LT innovation;

1. Variant 1 - one owner-manager (O-M)
2. Variant 2 – one owner and one manager (O&M)
3. Variant 3 – one owner plus one manager (O+M)

For variant 1 all decision-making ranging from managing finances to day-to-day operations and innovation solely rests with one person.

For variant 2 the processing unit is owned (in terms of financial investment) by one person and managed/operated by another. The influence of the individual on firm-oriented innovation is somewhat diluted due to differing roles and priorities of two people (a scenario similar to mining units). Unless the owner has the willingness, capacity and resources to invest in technologies, knowledge and training whereby the manager responds to the owner's initiatives in the same entrepreneurial manner, innovation remains more difficult to achieve. There is also the potential for conflict of interest. Even though the owner would want a good return on his investment he is not directly in-charge of production, quality and sales with limited influence on operational matters. Contrary to this the manager who usually works at a fixed salary and has a greater influence through day-to-day decisions regarding customer orders, operational costs, and utilization of workforce does not have a direct stake or incentive for improving quality and sales.

In variant 3 the owner and manager are two separate individuals but run the processing business together. The unique aspect of this arrangement is the overlapping nature of roles and responsibilities that are not clearly defined or demarcated at times. This lack of clarity can result in an ambiguous focus on business priorities and innovation similar to variant 2. However, compared to the second variant a strong aspect is the direct involvement of owner along with the manager in running the business and attend to quality and sales-related matters. The manager takes a somewhat secondary role in terms of decision-making and acts more as a supervisor in charge of workers, schedules and record maintenance.

10.2.3. Deliberating the Individual's Role (Causal Mechanisms)

Owing to contrasting roles of the owner and manager of a mining unit, the individual's ability to influence LT innovation within firm remains much lower. Same is the case for variant 2 in processing units. On the contrary variant 1 and 3 possess greater potential for influencing firm-level innovation provided the individual(s) has certain personal attitudes. Two expressed attitudes identified include risk taking behaviour and entrepreneurial mindset. Two perspectives emerged from the respondents. A processing unit manager who also owned mines in PeMaS stated;

> *'…of course I'm willing to take risks…if I'm running this business under difficult circumstances don't you think that is enough evidence. I have been constantly searching for unique marble varieties in Mohmand Agency and adjoining locations. This is despite the poor law and order situation. But sir, I am a poor man and do not have sufficient resources'*

However, another processing unit manager in PeMaS elaborated differently;

> *'How can I invest in business or take risk when I have no resources. Only the government can help us if it is serious. Instead they create hurdles for us. Rules and regulations are not implemented across the board and there are a lot of uncertainties. In such a situation I don't have a choice but to be very cautious'*

Two kinds of individual attitudes A1 and A2 (provided in Table 10.2) emerge from such responses. An individual's traits like innovation orientation, risk-taking and proactive behaviour have an indirect influence on a firm's innovativeness through the mediating role of entrepreneurial processes within firm (Entrialgo, 2000). However, the mining and processing units are very small businesses. Thus it is apparent from the data and Table 10.2 that the individual can have a more direct influence on firm's innovativeness not just as a result of risk-taking but also by instigating entrepreneurial processes within firm. The two attitudes (A1 and A2) run contrary to the entrepreneurial mindset that entails independence, self-belief and risk-taking not just at the individual level but also transcending to the firm-level. Focusing on organizational emotional capabilities, Akgun et al. (2009) mention individual attitudes including encouragement, displaying freedom and experiencing having a more direct influence on firm innovation. No evidence of these attitudes was found amongst the respondents which suggest a possible reason for lack of innovation amongst marble firms. Thus the presence of convergent stakes of marble firm owner and manager combined with expressed attitudes of risk-taking and entrepreneurial mindset can lead to occurrence of LT innovation (event). Absence of these causal mechanisms leads to lack of LT innovation amongst firms in the two marble SSI. Table 10.2 presents a role-ordered matrix (Miles & Huberman, 1994, pp. 122-126) that provides ordered information regarding the roles of owners and/or managers.

Individual	Professional Characteristics	Nature of Business Stake	Expressed Attitudes
Mine Owner (MO)	- Better off financially - Basic / higher education - Sound understanding of official or legal procedures - Strong contacts with government authorities including DGMM - Able to acquire mining license - Not a resident of mining area	- Direct stake in receiving lease payments - Indirect stake in costs incurred as a result of operations - No direct stake in product quality and sales/profits - Owner of reserves, unclear stake in their wastage - No direct stake in terms of investment of resources	**IM** – Not relevant due to nature of stake **EA** – Inclined towards understanding the legal/official procedures, maintaining personal contacts with officials **RTB** – Geared towards financial investment for obtaining license **AII** – Present but unapplied **A1?** and **A2?**
Mine Manager (MM)	- Struggling to cope with finances - No / basic education - Does not deal with license acquisition - Strong personal contacts with population of mining area - Does not own mining license - Resident of local mining area and/or member of local tribe	- Direct stake in making lease payments - Direct stake in costs incurred as a result of operations - Direct stake in producing more but not product quality - Reserves not owned, no stake in their wastage - Direct stake in terms of investment in resources	**IM** – Not present due to nature of stake **EA** – Inclined towards maintaining trust of MO and mutual understanding **RTB** – Dealing with uncertain law & order, inconsistent revenues due to uneven sale/demand trends **AII** – Unapplied, influenced more by external factors **A1?** and **A2?**
Supervisor / 'Munshi'	**NK**	- Satisfy MO in terms of trust - Draw monthly salary	**IM** – ~~ **EA** – ~~ **RTB** – ~~ **AII** – ~~
Variant 1 One Owner-Manager (**O**-**M**) of Proc. Unit	- Financial strength – **C?** - No / basic / higher education - Sound business knowledge, high involvement in operations - Direct influence on workers' productivity - Strong and direct influence on types of products, processes, marketing, organizational structure	- Direct stake in revenues and profits generated from operations - Direct stake in minimizing wastage to reduce costs - Direct stake in product quality leading to more sales - Direct stake in terms of investment in resources	**IM** – **T?** **EA** – cost reduction, less focus on quality **RTB** – Investment in resources, dealing with inconsistent revenues due to uneven sale/demand trends **AII** – Strong, demonstrated by some but not all **A1?** and **A2?**
Variant 2 One Owner and One Manager (**O**&**M**) of Proc. Unit	- **O** better off financially - No/basic/higher education - **M** sound business knowledge, high involvement in operations - **M** direct influence on workers' productivity - **O** & **M** unclear influence on types of products, processes, marketing, organizational structure	- **O** direct stake in return on investment - **O** direct stake in costs incurred on operations - **M** indirect stake in return on investment - **M** indirect stake in costs incurred on operations - **M** direct stake in maintaining O's trust - **M** direct stake in salary	**IM** – **T?** for both O & M **EA** – **O** inclined towards financial returns, **M** – inclined towards maintaining trust of **O** **RTB** – **O** financial investment, **M** – ~~ **AII** – Diluted as a result of **O** & **M** having different roles **A1?** and **A2?**
Variant 3 One Owner + One Manager (**O**+**M**) of Proc. Unit	- **O** better off financially - No/basic/higher education - **O+M** sound business knowledge, high involvement in operations - **O+M** direct influence on workers' productivity - **O**+**M** strong influence on types of products, processes, marketing, organizational structure	- **O** direct stake in return on investment - **O** direct stake in costs incurred on operations - **M** indirect stake in return on investment - **M** indirect stake in costs incurred on operations - **M** direct stake in maintaining O's trust - **M** direct stake in salary	**IM** – **T?** for both **O** + **M** **EA** – **O** inclined towards financial returns, **M** – inclined towards maintaining trust of **O** **RTB** – **O** financial investment, **M** – ~~ **AII** – Strong as a result of combined influence of O+M, demonstrated by some not all **A1?** and **A2?**

IM = Innovation Mindset **EA** = Entrepreneurial Approach **RTB** = Risk Taking Behaviour **NK** = Not Known
AII = Ability to Influence Innovation **C?** = Unclear Evidence on Characteristic **T?** = Inconclusive Evidence on Attitude
~~ = Irrelevant Attitude **A1? =** Unclear evidence on 'I-want-to-improve-but-am-helpless' Attitude
A2? = Unclear evidence on 'I-cannot-improve-someone-else-will-do-it' Attitude **=** Sub-sector role boundary
= Complete separation b/w roles within sub-sector = Within sub-sector role boundary

Table 10.2: Role-Ordered Matrix – Role of Individuals within PeMaS and BuMaS

10.2.4. The Mining Unit

The mining unit provides the most important raw material or input (raw excavated stone) for the marble sector especially processing units. Thus it occupies a central position as an element within SSI. Blasting (almost obsolete at the international level) remains the only procedure to extract stone. This is coupled with use of inappropriate equipment (locally improvised versions of mechanical winch that do not meet international standards), poor maintenance of machinery and an unskilled and semi-skilled workforce.

Despite these problems, the role of mining units remains central in influencing LT innovation especially product innovation in the processing sub-sectors. A poor quality excavated stone remains the main problem for the industry. Elaborating on this, a sector expert with fifteen years of relevant experience opined;

> *'The main problem I would say is mining techniques...people don't have a sense of product quality. They don't have the equipment and they don't care much about wastage. An estimated 50% marble reserves are rendered useless at the face of the mountains because the stone is not feasible for processing purposes. You cannot expect things to improve unless we address such limitations'*

In disagreement with the above statement, a strange paradox emerges from data. All owners and/or managers of mining units contacted for data collection agreed that there is a need to improve/innovate (Chapter 9, Table 9.6). However, they fell short of providing a genuine solution to this fundamental problem except citing lack of government help and financial constraints as the main reasons.

10.2.5. The Processing Unit

Within marble SSI a processing unit takes up a dual role. With regards to the ability to have incremental product innovation it has a somewhat secondary status being dependent on raw excavated stone from mining unit. However, for incremental process, marketing and/or organizational innovation it remains more dependent on internal/meso objects (such as owner/manager's innovation orientation, finances, human resource and technologies) and the contextual/macro objects including non-firms and institutional framework. Products are non-standardized (varying levels in design, appearance, quality and complexity). Most units produce tiles and slabs using similar machinery and processes. Thus product differentiation becomes difficult for the same product category except for particular stone variety from which the tile or slab is produced. The product suffers from quality problems because of internal cracks (rooted in mining techniques). These cracks cannot be identified in the finished product through the naked eye thus the product sells relatively easily in the local and national market. However, they emerge as a major constraint when judged for quality at the international level. Innovation though limited/incremental is mostly process-oriented in nature (improved technologies or equipments) thus leading to incremental product innovation.

10.2.6. Deliberating the Firms' Role (Causal Mechanisms)

Data analysis for both PeMaS and BuMaS reveals that process innovation is present amongst some processing firms; a characteristic of LT sectors (Hall & Bagchi-Sen, 2007; Morone & Testa, 2008; Kirner et al. 2009) along with product innovation (Chapter 9). However marble firms have a low-cost focus resulting from low profit margins. Consequently they are less likely to acquire production technologies from external sources in order to innovate (Swan & Allred, 2003) especially when they cannot generate technologies internally. The small size of firm (mostly 6 – 20 employees and limited technological, financial and human resources) also hampers innovation capability (Morone & Testa, 2008). Both types of firms are characterized by unskilled and/or semi-skilled workers. Lack of properly trained human resource also hinders innovation (McAdam et al. 1998). Process innovation present in processing sub-sectors is incremental (Pullen et al. 2009) leading to incremental product innovation. However, unless the excavated stone is improved, improving product within processing subsector will be much more difficult. For mining unit, product innovation can only come through process innovation which in turn is influenced from external sources particularly new mining technologies and knowledge. Thus the availability of better quality excavated stone (with minimal cracks and dimensional shape) resulting from updated mining technologies and mining processes that avoid indiscriminate blasting can lead to LT innovation (especially product innovation). Moreover marble firms' quality-improvement focus which leads them to acquire better technologies from external sources coupled with better trained and skilled human resource, can lead to occurrence of LT innovation. Absence of these causal mechanisms results in lack of LT innovation amongst firms in the two marble SSI. Figure 10.1 illustrates the roles of firms within PeMaS and BuMaS.

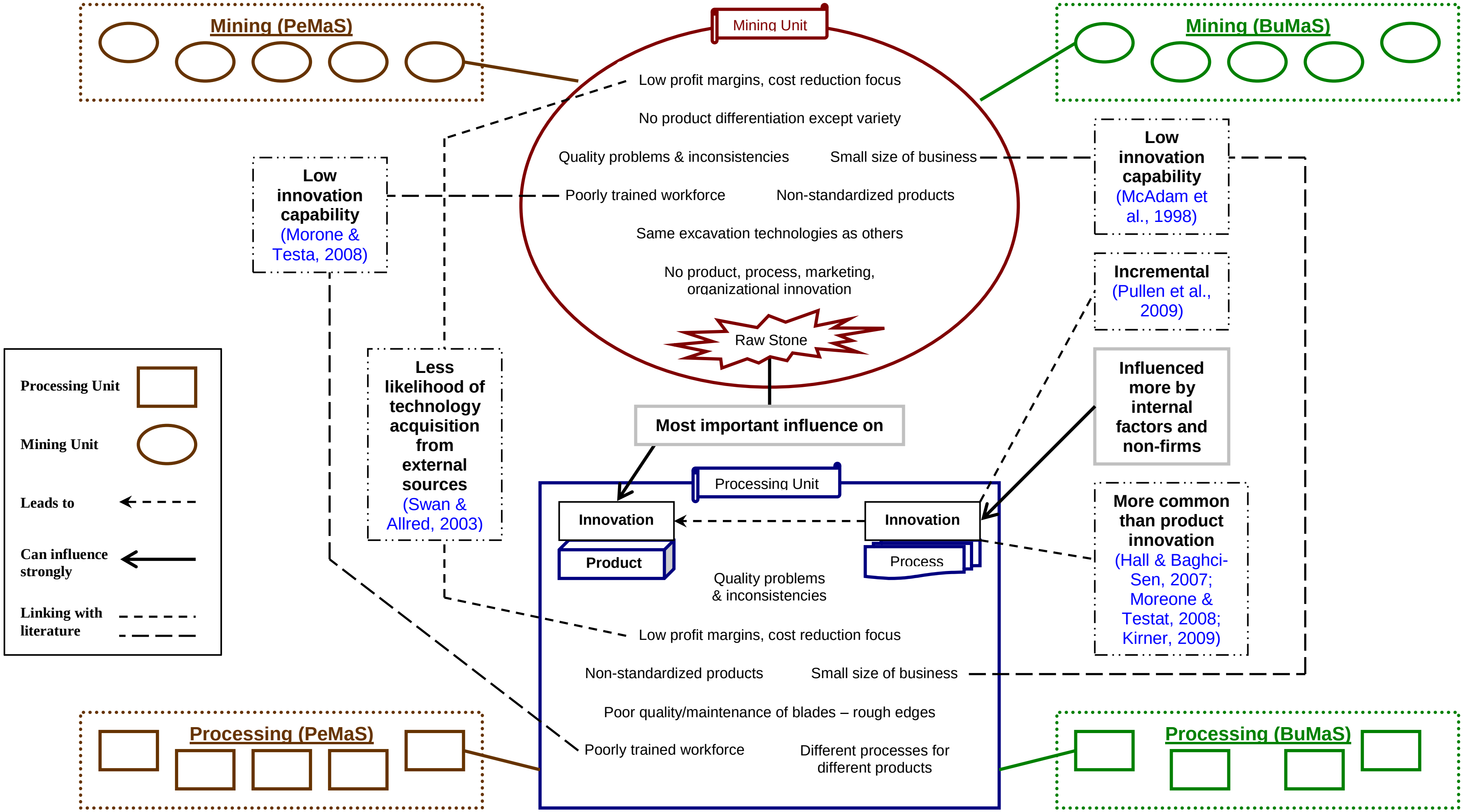


Figure 10.1: Roles of Firms within PeMaS and BuMaS

10.3. Role of Non-Firms (Macro-Elements/Objects)

Three groups of non-firms were identified prior to Phase-I of data collection and contacted through semi-structured in-depth interviews. These included;

a) Suppliers
b) Middlemen/distributors
c) Sector support organizations

Except for (c) the other two categories differ from each other for mining and processing sub-sectors.

10.3.1. Suppliers

For the two mining sub-sectors suppliers mainly include

a) Equipment and component suppliers
b) Machinery manufacturers and suppliers

The first group is present within the sectors especially in cities like Ghalanai and Peshawar for PeMaS and Buner for BuMaS. However, data reveals that most suppliers in this group do not specialize in marble-specific inputs. For example engines used in the mechanical winch were available at shops that are mainly in the vehicle spare-parts business. Similarly most metallic components of the mining equipment like chains, pulleys, handles are manufactured by local blacksmiths who produce products for other types of businesses also. Even suppliers of dynamite (a key input) do not have a full-time business. Group (b) was found to be present outside PeMaS and BuMaS. Machineries like loaders and excavators were mostly available from manufacturers/suppliers in Punjab (especially Gurjat and Lahore). However like group (a), suppliers in this group also do not specialize in mining equipment only. They cater to other industries also specially SME manufacturing sectors in Punjab such as domestic electrical appliances, hospital equipments and others.

Processing sub-sectors have a different set of suppliers including;

c) Mining units for raw excavated stone
d) Transporters for shipment/supply of stone to processing units

e) Equipment and component suppliers
f) Machinery manufacturers and suppliers
g) Machinery installation and maintenance experts (supplying knowledge/expertise)

Except for group (c) all others are not specialized suppliers. For group (e) outcomes suggest presence of price-based competition. A few businesses dominate the market with other individual suppliers trying to create a customer-base for themselves through direct marketing and selling of ‘tips’. There is lesser focus on quality as the low-priced ‘tips’ from China that wear out relatively quickly are more popular with processing units less willing to try a new ‘tip’ from another supplier unless a clear cost advantage is provided. Group (f) remains the same as group (b) for mining units except only one machinery manufacturer also present within PeMaS and based in Peshawar. Group (g) consists of two types of suppliers, blade ‘tip’ installation experts and processing machinery installation and maintenance experts. The ‘tip’ suppliers are unable to consistently provide the same quality ‘tips’ and the ‘tip installation expert relies on non-specialized technology (regular welding equipment) to install these ‘tips’. This results in inconsistencies in the blade’s (‘vertical’ and ‘horizontal’) ability to cut the stone adversely affecting product quality/standardization. Secondly, machinery installation and maintenance experts do not have formal training in their field and have mostly gained expertise by observing and hands-on work with their seniors. Thus, the machinery they install in the processing factory is not mounted by using scientific methods. Thus the platform may not be balanced properly with weight distributed unequally or the blade may be installed improperly resulting in vibrations and wobbliness leading to rough edges of tiles and slabs.

10.3.2. Middlemen/Distributors

Group (d) highlighted in section 10.3.1 remains the only distributors for mining firm linking it with business buyers (the processing units). How much product is produced by a mining firm is influenced by three factors;

- Firm’s production capacity

- Transport company's ability/capacity to ship specific quantity of products per day/week
- Quantity of raw excavated stone demanded by processing units

The above factors highlight the strong dependence of mining unit on distributor for product shipment. However, inconsistencies in shipment schedules implemented by distributors were found resulting from law and order concerns, dilapidated road infrastructure, and poor condition/maintenance of transport vehicles/trucks. These result in supply-demand gaps or inconsistencies sometimes adversely affecting production schedules of processing units.

The distributors for processing units are of three types;

a) Bulk buyers/wholesalers of semi-finished dimensional blocks
b) Bulk buyers/wholesalers of finished end products
c) Bulk buyers/wholesalers of decorative items

Group (a) has some presence within both PeMaS and BuMaS however it is mainly concerned with shipment of products to cities like Karachi where there is greater number of small processing units specializing in lathe-based manufacturing of decorative items. The major activities of group (b) are based within PeMaS and BuMaS as they usually deal with large commercial orders of marble tiles and slabs. Two types of selling arrangements were identified, sales through wholesalers' showroom and direct sales to business clients like construction companies and commercial buyers. Narrating his story, a distributor in PeMaS who sells finished products directly to construction companies stated;

> *'I do not have an office…run my business from home. I worked at a processing firm as manager for 15 years. But later I decided to start my own business due to a lot of contacts I established over the years with construction firms, builders and individual contractors. I survey the market for products required by my client and buy it from wherever it is available…sell it onwards on profit basis'*

10.3.3. Sector Support Organizations

Both marble-SSI have the same sector support organizations with public-sector organizations playing the major role. Provided below is a list identified before and during Phase-I of data collection;

- Small and Medium-sized Enterprise Development Authority (SMEDA), Government of Pakistan
- Pakistan Stone Development Company (PASDEC)
- FATA Development Authority (FDA), Government of Pakistan
- Directorate General Mines and Minerals (DGMM), Government of N-WFP and Department of Minerals (DoM), FATA Governor's Secretariat
- Financial Institutions such as SME Bank, National Bank, Habib Bank
- Higher Education Institutes (N-WFP University of Engineering and Technology, Peshawar, Institute of Management Sciences, Peshawar)
- Consulting Firms like Innovative Marketing Services
- Donor Agencies linked to USAID and European Commission

Data revealed that SMEDA, which comes under the Federal Ministry of Industries and Production, has an all-Pakistan focus on development of many SME sectors. Marble industry is just one of them. It is headquartered in the federal capital Islamabad with one regional office located in Peshawar (PeMaS). It mainly serves as a platform for sharing information and knowledge to help businesses start-up and operate successfully. Two marble-specific initiatives from SMEDA were identified

- Support for mosaic industry in PeMaS
- Establishment of marble city in Mohmand Agency of PeMaS

Only a few training workshops have been held under the first initiative while the second initiative has been in the planning stage since the last three years with progress being very slow. SMEDA has defined its role as a facilitator and not an implementer. For example, it has conducted different feasibility studies concerning establishment of processing plant, marble warehouse and mosaic development centre which are available through its website. However, the organization does not have information on impact of its work nor any evidence of which and how many stakeholders from the marble sectors benefited.

PASDEC is a public-private partnership that also comes under the same federal ministry as SMEDA and is dedicated solely to the development of marble industry. Its role was found to be similar to SMEDA. However the organization is based in Islamabad only with no regional office in PeMaS or BuMaS. Thus many mining and processing unit owners/managers are unable to access its services. A major initiative of PASDEC is the 'machinery pool' located in Risalpur, a city just on the outskirts of Peshawar and located within PeMaS. The 'pool' provides imported mining equipment on rental basis to mining units in PeMaS and BuMaS. However, PASDEC's collaborative effort with SMEDA for establishing marble city in Mohmand Agency has not been successful beyond the planning phase.

The FDA and DoM come under the aegis of the federal government while DGMM is the provincial government's department. All have offices located in the provincial capital Peshawar only. The FDA claims to have a facilitative role similar to SMEDA and PASDEC but its projects have a more direct contribution such as construction of a road in Mohmand Agency to facilitate easy access to markets for the mining units. DGMM and DoM play are greater role in enforcing regulations concerning issuance of mining rights licenses and approval of different projects and initiatives by other sector support organizations. Both FDA and DoM have a FATA-specific mandate (PeMaS). DGMM deals with BuMaS because Buner district is administratively part of the provincial government. Similar to PASDEC-SMEDA relationship, weak collaborations between FDA and DoM were found as each complained of the other infringing upon its administrative domain.

None of the owners/managers contacted for data collection had acquired a loan from banks. No evidence of bank products specifically designed to target firms in the marble industry was found. The initiatives from universities, consulting firms and donor agencies were found to be very few isolated projects with sustainability aspects not addressed properly and no incentives offered for marble firms to collaborate. Once the projects finished, there long-term benefits were never realized as envisaged in the original plans.

10.3.4. Deliberating the Non-Firms' Role (Causal Mechanisms)

Outcomes about the role of non-firms underscore the strong dependence of mining and processing units on suppliers especially for technologies and equipments in order to enable firms to innovate. This suggests that PeMaS and BuMaS adhere to supplier-dominated taxonomy (Pavitt, 1984; 1989; De Jong & Marsilli, 2006). Availability of modern equipment from suppliers remains a key source of innovation (Duguet, 2006). However, suppliers in PeMaS and BuMaS are not providing these modern equipments to marble firms and most do not specialize in industry specific equipments, technologies and services explaining the lack of LT innovation. The roles of sector support organizations especially those representing the government (Souitaris, 2002) are very crucial as they can provide support in technology provision. Despite a number of incentives of sector support organizations the weak incentives for collaboration (Jones-Evans et al., 1999) offered to mining and processing units means that these incentives lack sustainability. As soon as money for a project runs out, the activities envisaged in the project also seize to exist. One example is mosaic training workshops organized by SMEDA. Elaborating on this, a sector expert pointed out;

> *'…although they (SMEDA) launched these courses in 2008 they did not provide any incentive for course participants to take up mosaic production as a business. The training only focused on using lathe machine to produce mosaic designs with no information provided on how and from where to acquire lathe machine itself. Nor there was any financial incentive offered for participants to acquire machinery through bank loans or other means. Consequently, tangible benefits of the training could not be realized'*

The ability of the sector support organizations to get involved at the local level within PeMaS and BuMaS was found to be weak contributing to lack of support that can enable marble firms to innovate. Headquartered in Islamabad and Peshawar no real initiatives were identified where representatives from these organizations have actually worked on-field at mining sites or visited processing units. Moreover, financial institutions like SME Bank do not have loan schemes specifically designed for marble industry. Loan procedures are quite cumbersome and technical from firm owner/manager's perspective resulting in lack of interest/initiative. This lack of stakeholder involvement at the local level (Vonortas, 2002) and lack of access to finance (Blanes & Busom, 2004) also contribute to low levels of LT innovation within PeMaS and BuMaS. Consequently, the presence of specialized suppliers in PeMaS and BuMaS that ensure provision of modern technologies to firms and have related skills and expertise to provide support services associated with these technologies can result in LT innovation. Similarly, the presence of sector support organizations at the local level (where firms are located) that leads to a stronger collaboration with and support for marble firms combined with strong incentives (like cost-sharing, provision of expertise) for firms to cooperate with these organizations can also lead to LT innovation. Moreover, financial institutions need to offer loan schemes that are specifically designed for the marble industry. Lack of LT innovation in PeMaS and BuMaS is due to the absence of these causal mechanisms related to non-firms. Figure 10.2 helps illustrate the roles of non-firms.

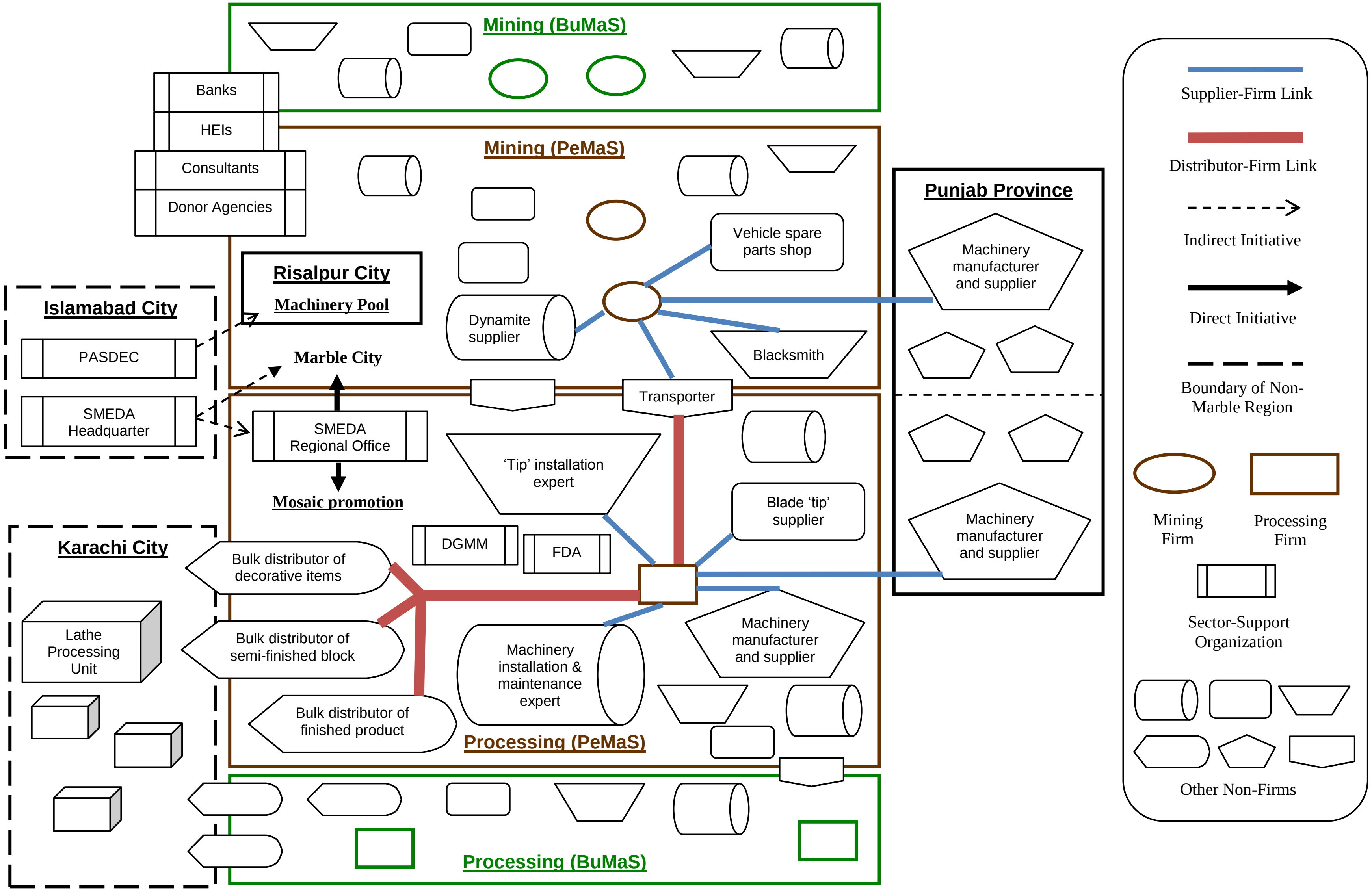


Figure 10.2: Role of Non Firms within PeMaS & BuMaS

10.4. Knowledgebase and Technologies (Meso- and Macro-Elements/Objects)

Knowledgebase as described by Tidd and Bessant (2009, pp. 80) includes knowledge a firm has about its products, the processes it carries out to produce the product and deliver it effectively. It embodies skills and expertise of people and the systems and technologies put in place by the firm to do what it does. Knowledgebase and technologies remain the key elements of sectoral system of innovation (Malerba, 2002). Since this research focuses on knowledgebase and technologies internal to firms (meso), the main respondent group for data collection remains owners/managers of mining and processing units. However, discussions focus not just on internal aspects but external-to-firm (macro-contextual) aspects also.

Discussed below are five dimensions of knowledgebase/technologies. They help in understanding mechanisms underlying the existence of LT innovation.

10.4.1. Formal/Structured versus Informal/Unstructured Knowledge

The knowledgebase in the two sectors was found to be pre-dominantly informal in nature. Except for some examples of formal knowledge (mosaic training workshops, feasibility studies and business plans for processing units) cited by representatives of non-firms (SMEDA and PASDEC) none others were identified especially internal to firms. Formal knowledge is non-existent in the mining sub-sector. This outcome supports the view that LT sectors are characterized by incremental knowledge accumulation that is informal in nature (Schmierl & Kohler, 2005). Absence of formal knowledge suggests a possible reason behind lack of product innovation, value addition and clear product/process innovation objectives (Pederson, 2005). Presence and application of greater formal knowledge inside marble firms can lead to product innovation which is lacking in PeMS and BuMaS as a caual mechanism resulting in lack of LT innovation. Results reveal that some processing units produce product designs influenced more by customer requirements. This adheres to Pederson's (2005) recommendation that firms with low formal knowledge develop designs in line with varying customer specifications.

10.4.2. Technical/Hard versus Non-technical/Soft knowledge

Shown in Figure 10.3 two broad types of knowledgebase are identified within the sectors. One consists of technical or hard knowledge and skills. It deals more with understanding of product shape, design and other specifications. It also involves the use of appropriate processes, technologies and machineries. Technical knowledge was found to be present more amongst workers involved in different production processes. Non-technical or soft knowledge includes understanding of and skills to run a marble business. An important difference for soft knowledge was identified between mine owner and mine manager. The former's soft knowledge consisted of a strong understanding of government procedures and documentation to acquire mining license while the latter's focused more on day-to-day administration of the mining business and activities.

10.4.3. Internal versus External Knowledge

Results reveal that knowledge is more externally-oriented than internally-generated. For example, a few technologies mainly the mechanical winch used in mining is a result of spillovers from another LMT sector (motor vehicle industry). However, knowledge about developing the winch itself generated inside mining firms and still remains within-sector knowledge. Narrating these origins, a mine manager in PeMaS said;

> *'We do not know who developed this winch but it has been in use for many, many years. I guess some help must have been provided by a car mechanic in the beginning'*

All other technologies come from external sources and sectors especially in Punjab province. A key form of soft knowledge is market knowledge (including customer and competitor knowledge) present amongst some processing unit owners/managers and is external in character (Grimpe & Sofka, 2009). Little evidence of internally generated technical knowledge was found because of its informal nature. The senior worker, in both types of marble firms, called 'ustaz' (meaning 'master') in the local language has usually gained experience over the years working for more than one firm. He takes his knowledge to another firm in order to get a better salary and in the process transfers his knowledge informally to junior workers usually called ‘shagirds’ (meaning ‘students’ or ‘pupils’). Thus knowledge transfers this way from one firm to another and essentially remains external in character with regards to the firm. However, flow of knowledge in this manner suggests its geographical characteristics also. For mining sub-sector particularly, knowledge from external sources does not seem to penetrate or spread widely and quickly, a characteristic of LT/LMT sectors (Waguespack & Birnir, 2005). Providing details on this aspect, a mine owner in BuMaS with about 20 years of experience stated;

> *‘I believe I am one of the first persons in Buner to have started use of excavator but that was many years ago…yes I would say that the mining process is really being conducted the same way as twenty years ago when I started off’*

Lack of internal knowledgebase also means firms struggle to respond to market requirements as suggested by Lindman (2002) resulting in lack of LT innovation.

10.4.4. Pace of Knowledge Transformation

The application of same production processes coupled with similar products points to the fourth dimension of knowledgebase, the pace of knowledge transformation/change. Von Tunzelmann and Acha (2005) point out that LMT sectors are generally mature where knowledge and technology changes are slower. The two marble low-tech sectors adhere to the same characteristic where most knowledgebase and technologies have been in place since the last three to four decades when the industry started to flourish in north-west Pakistan.

10.4.5. Knowledge Appropriability

The fifth dimension is appropriability of knowledge from the firms’ perspective. Marble products in PeMaS and BuMaS are simple and a result of non-complex and short sequence of processes. The external nature of knowledge coupled with its simplicity and ease of availability (‘ustaz’ can be hired without much difficulties) means knowledge is not tacit. This results in low levels of appropriability (Teece, 2003), a characteristic of LT/LMT sectors (Vale & Caldeira (2008).

10.5. Learning Processes (Meso- and Macro-Elements/Objects)

According to Malerba (2002; 2005) knowledgebase and technologies present within a sector influence the learning processes amongst sectoral agents. Learning processes in turn are a key source of knowledge cumulativeness. Analysis of data reveals that like knowledgebase and technologies, learning processes can be understood better through four dimensions that also help us understand the causal mechanisms underlying occurrence of LT innovation. As demonstrated in Figure 10.3, because of the inseparable link between knowledgebase and learning, the dimensions discussed below take influence from the discussions provided in section 10.4.

10.5.1. Learning Orientation

Baker and Sinkula (1999, pp. 412) define learning orientation as the 'mechanism that directly affects a firm's ability to challenge old assumptions about market and how a firm should be organized to address it.' Data analysis reveals that due to marble firms' strong dependence on existing knowledgebase and technologies present within the sectors, they do not demonstrate a strong learning orientation. Keskin (2006) points out that a firm's market orientation influences its learning orientation. This in turn influences firm's ability to innovate. Interestingly, the mining firms' market orientation can be described in terms of their focus on customers – the processing units. Similarly the processing units' market orientation is determined mostly by local market followed by national level business customers. Consequently, marble firms' long-held focus on and ability to sell to these markets means they are not willing to challenge their 'old assumptions' and target international customers. The marble firms' market orientation towards international market will positively influence their learning orientation. This will result in occurrence of LT innovation. Non-existence of this causal mechanism leads to lack of LT innovation.

10.5.2. Formal vs. Informal Learning Processes

As pointed out in section 10.4.1, PeMaS and BuMaS are characterized by informal knowledgebase. This suggests that knowledgebase is predominantly a result of informal learning processes. Elaborating on the nature of learning within the marble firms respondents used terms like 'learning by observing others', 'learning on our own' and 'learning by hit and trial'. Manager of processing unit in BuMaS stated;

> *'There is no formal training or information manual available to us. Most businesses are being run by people who worked at a factory as a worker or manager prior to starting own business. There they gained knowledge about products and processes by interacting with seniors, observing things and directly working on machinery or conducting day-to-day operations'*

The informal nature of learning processes is in agreement with Macher and Mowery (2003) and Von Tunzelmann and Acha (2005) who point out that 'learning by doing' is the norm in LT/LMT sectors. Additionally marble firms are mostly being run by individuals who do not have any 'formal qualifications' and are 'non-professionals'. A mine owner from PeMaS pointed out;

> *'…many people in Mohmand Agency started their business merely after getting influenced from others and with no proper training or understanding of business. They tell themselves, 'if he could do it, so can I'. This attitude means they do not consider formal learning and training something beneficial…besides where would they acquire such training even if they wanted to…there are no institutes to go to'*

10.5.3. Learning about Products and Processes vs. Learning about Business

Two types of knowledge (technical/hard and non-technical/soft) are a result of two types of learning processes

a) Learning about products and processes
b) Learning about business

'Learning by observing' and 'learning by doing' remain the norm for (a). This type of learning is more relevant to workers who rely on gaining hands-on experience about production processes. Non-technical knowledge results from (b) and includes a firm's learning about markets, customers, suppliers, distributors, regulations and procedures, accounting, procurement, resource acquisition and utilization, innovation and others. Learning type (a) is characterized by greater knowledge tangibility whereby 'learning by observing' and 'learning by doing' remain plausible. However, learning type (b) deals more with the soft skills that is difficult to learn informally as well as through formal learning processes.

10.5.4. Influence of Technology Source on Learning Process

Technologies being utilized by mining and processing units have been mostly developed outside the firms by non-firms. Lack of internal technology development and learning from the firm's perspective mean that firm's learning processes are not geared towards improving technologies that can lead to product and process innovation. The strong dependence on non-firms for technology sources inhibits learning orientation amongst marble firms. Low knowledge cumulativeness is a characteristic of LT sectors (Vale & Caldeira, 2008). A weak learning orientation coupled with informal nature of learning processes means knowledge in the two marble sectors has low cumulativeness also. Strong evidence is the application of the same production processes and technologies by marble firms since the last many years with no real improvements.

Figure 10.3 below illustrates a variant of context chart (Miles & Hubermann, 1994, pp 102 & 104). Even though context charts are considered more suitable for presenting individuals' roles within the relationships and organizational context, the figure takes liberty to present an understanding of SSI elements (knowledgbase, technologies and learning processes) and also illustrates mechanisms that influence LT innovation. The figure also points to lack of differences between PeMaS and BuMaS for these elements/objects.

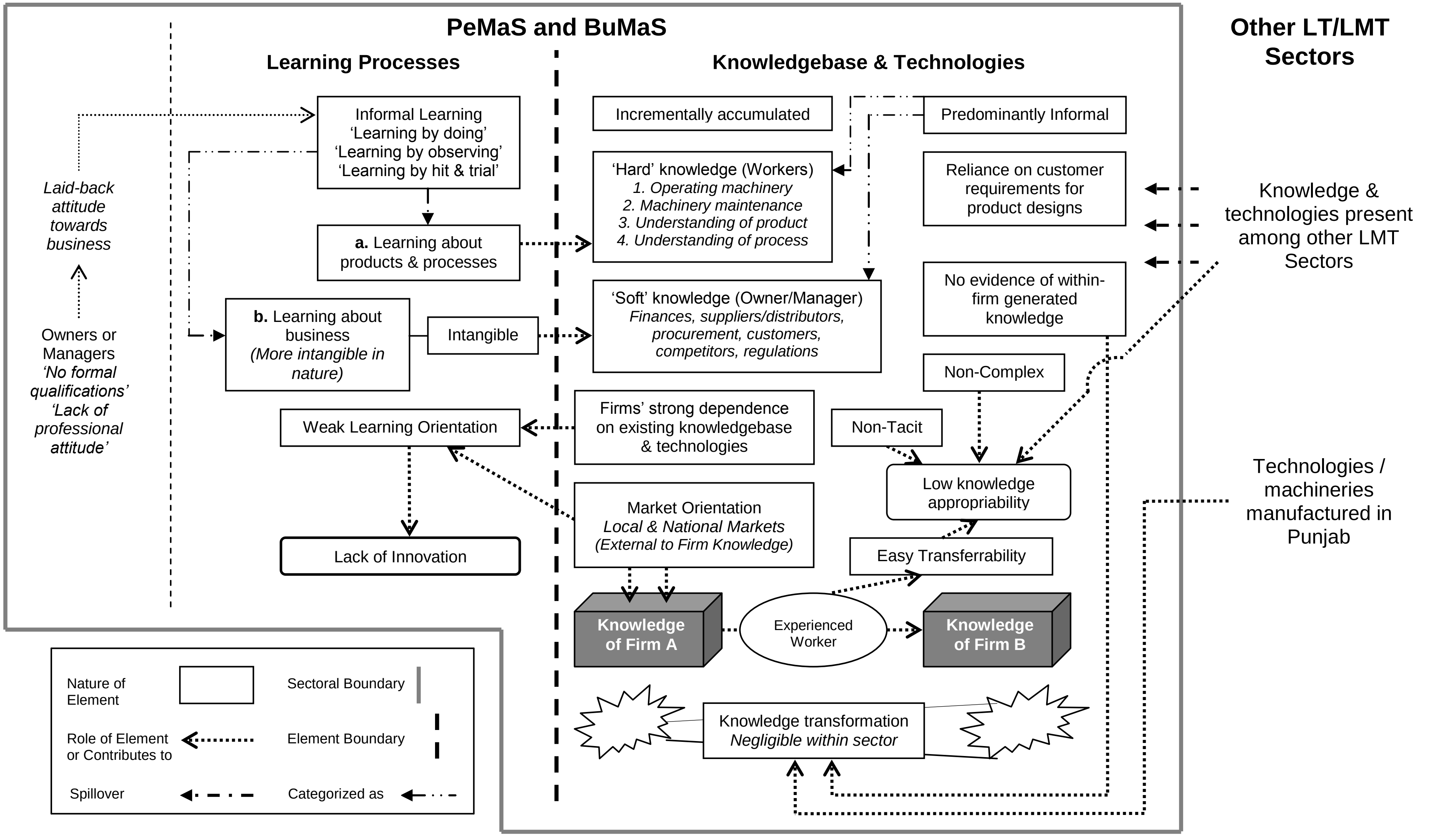


Figure 10.3: Context Chart (Nature and Role of Knowledgebase, Technologies and Learning Processes)

Table 10.3 below provides a brief thematic conceptual matrix (Miles & Hubermann, 1994, pp. 131-132) about knowledgebase and learning processes.

Sector	Characteristics	Mining Sub-Sector	Processing Sub-Sector
PeMaS And **BuMaS**	Examples of formal knowledge and learning processes	***None***	***Few*** Formal knowledge from formal learning processes (trainings, manuals)
	Forms of soft knowledge	***Two*** *Emanate from two individual roles* **Owner** – knowledge about mining regulations, licensing procedures **Manager** – knowledge about mining operations	***One*** *For the two individual roles* **Owner** and/or **Manager** – knowledge about processing operations, finances, markets, suppliers, distributors and others
	Geographical concentration of knowledge	***Greater*** Knowledge from processing sub-sector or other LT/LMT sectors does not spread within mining sub-sector	***Lesser*** Knowledge from other LT/LMT sectors spreads relatively widely and quickly compared to mining sub-sector

Table 10.3: Thematic Conceptual Matrix (Differences between sub-sectors for knowledgebase and learning processes)

10.6. Demand (Macro-Element/Object)

Within the SSI approach a sector is 'a set of activities...for a given or emerging demand' (Malerba, 2005, pp. 385). Besides 'product groups' the concept of demand helps us conceptualize a sectoral system and establish its boundaries in light of activities that are linked by these product groups. Breschi and Malerba (1997) and Malerba (2004) suggest that a sector undergoes co-evolution and transformation mainly influenced by the type and dynamics of demand as well as links and complementarities among activities within the sector. Demand within SSI is composed of heterogeneous agents that interact with producers in various ways. These agents do not include consumers only but also firms and public agencies. The links can be static in nature for example input activities of firms resulting in outputs. Also, these links can be dynamic because they take influence from the changing demand and production aspects of the system.

Analysis of data reveals four dimensions of demand discussed below. These dimensions also offer an understanding of relevant causal mechanisms associated with this sectoral element.

10.6.1. Types of Demand

Demand within PeMaS and BuMaS can be broadly categorized into two types;

- Individual demand
- Joint demand

Individual demand is where an individual customer demands a particular quantity of the marble product at a given point in time and pays a specific price mutually agreed between the buyer and the seller. The individual customer can be a domestic consumer or a business buyer. The latter can be a processing unit (buying from mining unit) or middlemen (buying from mining and/or processing unit for onward sale to another business without changing the original product). Joint demand is when a customer demands a particular quantity of more than one kind of marble product. It is mostly common in the case of business customers (especially in processing sub-sector) who place bulk orders seeking more than one kind of product such as tiles, slabs and others.

10.6.2. Demand across Three Market Tiers

The local market remains the main buyer and consumer of marble products during the mining phase. Very little evidence was also found about products making it to national markets while none reach the international markets. Explaining this scenario, a mine owner in PeMaS explained;

> *'It is the huge size and raw nature of the product that makes it unfeasible for us to sell in the national or international market. Unless the raw stone is very good quality like white marble found in some parts of Mohmand Agency, I cannot recall any instances of stone reaching national markets...(while) international markets are out of the question'*

For the two processing sub-sectors there is considerable evidence of products in demand in the local as well as national markets especially Punjab. The semi-finished dimensional blocks are in greater demand in Karachi. However, like mining sub-sectors, no evidence of the product meeting demands in the international markets was found.

An important difference for demand emerges between PeMaS and BuMaS from the data. Respondents suggested that products manufactured in BuMaS address demand mostly in the local market. However, a number of marble varieties and products in PeMaS are in demand not just locally but also in the national market. Citing reasons for this manager of a processing unit in PeMaS explained;

> *'Some regions in Mohmand Agency have very good quality natural stone…the white varieties of marble with fewer impurities. Products made from these varieties sell more in Karachi and fetch a better price. Varieties in Buner such as sunny grey, sunny white and black jet do not meet the same standard. The stone is harder with higher impurity levels and not suitable for flexible cutting and designs such as decorative products. Also, Peshawar is a main city with better access to other areas in Pakistan through GT road and the motorway. I can fulfil demand in the national market better than a businessmen sitting in Buner'*

However, with little or no differentiation within a particular product category demand is not really segmented resulting in greater price-based competition. Mining and processing units usually do not focus on product, process and marketing innovation because their product is mostly fulfilling demand in the local market and as long as they can sell, they believe the business is achieving its potential without realizing the greater revenues and benefits that might come from improving product quality in line with international market needs. Offering his understanding of why this is happening, a processing unit manager in BuMaS who also owned a mine stated;

> *'…the way the product is being manufactured, the kind of production methods we have and machinery and skills, it is really only useful for addressing demand within Pakistani markets'*

10.6.3. Fluctuations in Demand

Demand generally tends to be inelastic in LT/LMT sectors thus firms seek new markets to address slow demand changes (Von Tunzelmann & Acha, 2005). While for mining units no evidence was found to suggest this scenario for overcoming inelastic demand, data from processing units point out that some owners/managers move from their local markets and target national markets (especially Punjab). When asked to provide reasons for this, manager of a processing unit in BuMaS stated;

> *'Many people have started marble business over the last 10-15 years. They have the impression it is easy to start-up and profits come quickly. That is not the case. Many vendors having the same products meant I could not sell my product at a reasonable price locally…sales were going down. That is when I decided to target Rawalpindi region (a national market) with greater demand'*

This is an example of marketing innovation whereby some processing firms seek new markets (national) to address slow demand changes within PeMaS and BuMaS.

The lack of demand elasticity that is triggered from changes in customers/markets and their needs means marble firms are not driven to innovate and improve products and/or processes (Equist, 2005). Becheikh et al. (2006) point out that demand growth in an industry is a major determinant of innovation which is not the case in PeMaS and BuMaS. Guerzoni (2010) suggests that market size and user sophistication are important influencers on innovation because of their relationship with demand. Increase in sophistication of users (local and national market) who require better quality products in terms of design and a market demonstrating growth (due to accessing international customers) will lead to LT innovation. Absence of these causal mechanisms means there is a lack of such innovation in the two marble SSI. However demand changes in the local and national market connected with user sophistication will not happen automatically. Marble firms will need to adapt and implement new technologies to help improve product quality that will result in changing demand conditions (Von Tunzelmann & Acha, 2005). Technology will remain the single most important influencer on addressing international market demands as well. In the case of all three market tiers product and process innovation through better technology can influence demand during the initial stages and not vice versa. This is just like marketing innovation by some processing units that has helped them address lack of demand changes by targeting national markets instead of relying on local ones only. However, once the improved marble products start replacing the older low quality ones, demand will gradually increase and opportunities identified to sell more. As a result during the later stage the increase in demand for better products can push other marble firms to innovate and improve as a result of realizing greater opportunities for profits.

There is evidence of the above-mentioned phenomenon already. Better quality marble tiles and slabs manufactured in China were found to be on sale at a major marble market in Peshawar (PeMaS). When asked to explain the reasons behind having Chinese marble products the owner of a large marble showroom (middleman/business buyer) in Peshawar explained;

> *'Even though they are higher priced, they sell more because of better cutting, polishing, designing and stone variety. The marble from Mohmand agency and Buner also sells here. But its price is lower due to quality problems and is not in much demand'*

This suggests that if provided with product improvements and innovations resulting from process innovations (technology-related), even the domestic/local market will respond positively in terms of increased demand. Also, the same effect can trickle down to national and international markets.

10.6.4. Other Demand Factors within and outside Marble SSI

An unclear relationship between demand and price emerges from data. Products manufactured from low quality varieties (raw stone and semi-finished) and available in abundance do not fetch a higher price. Such varieties are in greater demand amongst price-sensitive customers. For better quality varieties (especially finished products) the relationship is opposite. In this case demand influences price whereby quality-conscious customers pay a higher price because of greater demand. Three factors shape demand within PeMaS and BuMaS taking influence from this scenario;

a) Nature of customer requirement
b) Type of stone variety
c) Price

Another set of demand-related factors relates to processing firm's ability to address demand. It includes

d) Location of marble showroom or factory
e) Ability of the firm to establish and maintain relationships with business customers present both locally and nationally

For (d), processing units in PeMaS have an advantage due to easily accessible showroom locations within Peshawar. However, abundance of showrooms also means tougher competition for customers. Competition intensifies further by presence of showroom owners who do not own a processing unit but rather buy products from different processing units and sell onwards. They also carry products from China. For (e), some processing units without a showroom compensate for it by establishing and maintaining direct contacts with customers locally and nationally. In this regard the role of firm owner/manager is central. Outcomes reveal that owners/managers who themselves seek opportunities for identifying demand both in the local and national markets and have a proactive approach towards business are able to respond to market and customer requirements better.

Two more factors surface from data that originate from outside the firm. These are;

f) Inconsistent supply of electricity
g) Activities under construction business in local and national markets

While mining units do not use electricity, processing units have been affected by power outages due to electricity shortfall since 2005-06. Consequently many processing units have been struggling to operate at optimal levels and fulfil customer orders and demand. For (g), since most construction (buildings, houses) involves use of marble tiles and slabs, these two types of finished products are in greater demand in the local and national market compared to any other types.

One last factor that is beyond any form of control of mining and processing units is;

h) Presence of substitute products especially ceramic tiles and slabs

Elaborating on the negative influence of this factor, manager of a processing unit in PeMaS stated;

> *'Ceramic products are available in a large number of colours, designs and sizes. They do not have cracks or quality problems, have a shinier surface and are more attractive. The price is also not really different from locally available marble thus many business customers prefer ceramic tiles. The only advantages marble products have over ceramic is durability and strength'*

Figure 10.4 below illustrates the four dimensions of demand.

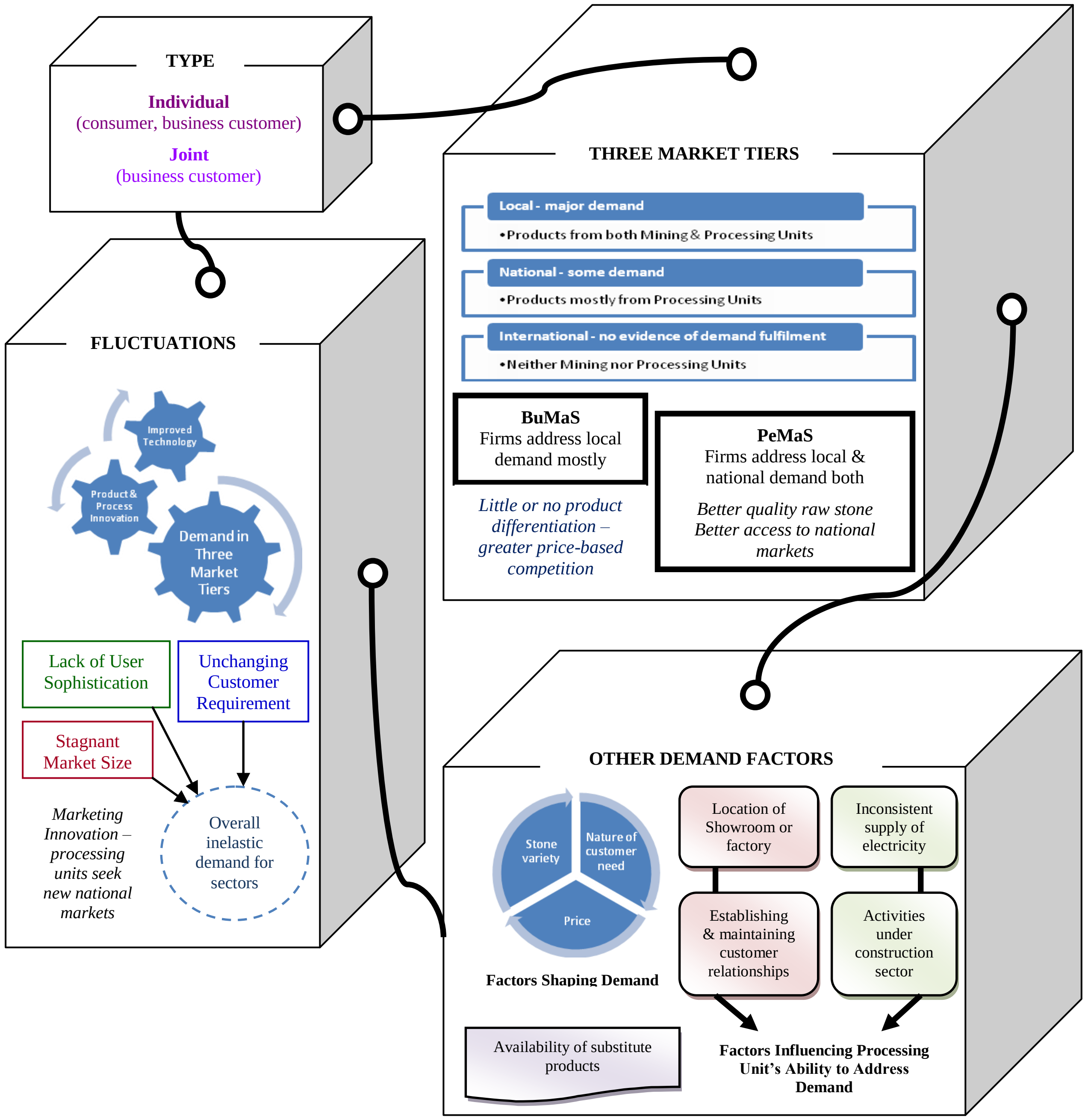


Figure 10.4: Four Dimensions of Demand within PeMaS and BuMaS

10. 7. Institutions (Macro-Elements/Objects)

Besides 'structure of production' it is 'institutional setup' that forms the second key dimension of system of innovation (Lundvall, 1992, pp. 10). Freeman (1987), Lundvall (1992) and Nelson (1993) in their pioneering works on SI underscore the institutional embeddedness of innovative firms. Conceptualizing sectoral system of innovation Malerba (2002; 2005) describes institutions as one of SSI's three dimensions.

Four dimensions of institutions (discussed below) emerge from data. They also help in understanding the underlying causal mechanisms associated with institutions influencing occurrences of LT innovation for this research.

10.7.1. Types and Roles of Institutions: Formal (Regulative) and Informal (Normative and Cognitive)

Institutions can be divided into three broad types, regulative (formal in nature), normative and cognitive (informal in nature) (Scott, 2001; Geels; 2004). Data analysis reveals that PeMaS and BuMaS are mostly similar with regards to the types and roles of institutions. However, differences become more conspicuous across the mining and processing subsectors.

For the two mining subsectors, the main formal institutions are mining laws, rules and procedures implemented by the government through two offices, DGMM for BuMaS and DoM for PeMaS (discussed in section 10.3.3). Both offices operate in the same manner as far as rules and procedures are concerned. They are responsible for the management of mineral resources. This also includes the exploration and development of these resources through implementation of Annual Development Plan (ADP) and Public Sector Development Plan (PSDP) funded schemes. Additionally, both offices regulate mining concessions (prospecting licenses, exploration licenses and mining leases) on various categories of minerals including marble. Records are maintained for mineral production, royalty and excise duty. Mine owners are responsible for paying these on annual or biannual basis mostly. Additionally mining firms are also required to perform welfare of mining community, ensure safety of mine workers, and abide by mining labor laws enforced by both offices.

The formal institutions for processing subsectors mainly relate to tax payments on income and revenues, payment on electricity consumption and compliance with environmental standards. Processing units themselves are either sole proprietorships or partnerships. Owners adapt a simple procedure whereby the document that provides legal status to the business consists of a stamp paper or deed prepared by the notary public with his seal and signature.

It also bears signatures of the partners with a formal name given to the business.

A lack of uniform implementation regarding bills for electricity consumption was discovered. It has created a perception of disadvantage amongst some processing firms. Firms that are within Mohmand Agency (PeMaS) are required to pay a fixed amount per month for electricity consumption regardless of how many units are consumed. However, processing firms in Peshawar within PeMaS and all areas in BuMaS pay per unit. The tax regime is relatively weak for Mohmand Agency compared to Peshawar in PeMaS and Buner in BuMaS emanating from the weakening affects of formal institutions in tribal areas. Moreover, collected data did not provide any evidence of formal institutions facilitating or encouraging marble firms to improve products and processes and innovate.

Informal institutions within both subsectors are mainly related to local traditions, customs, beliefs, perceptions and tribal code of conduct. The region is characterized by a collectivist culture. People expect favours from others and offer favours in return (normative institution). This tendency that trickles down to the marble industry also is stronger for members of the same family, tribe and/or village. Many times friendships and relations tend to overshadow professionalism and business-oriented approach. Narrating this, a middleman (cutting blade expert) stated;

> *'Many owners hire a person because he is a relative, a friend, an acquaintance of a friend or a worker and not because he has more experience or better skills.'*

Most business activities including procurements, transactions and payments are not formalized or documented. Most owners or managers rely on establishing relationships with other businesses, organizations and individuals based on their trustworthiness (cognitive institution). Owner/manager's business experience plays a major role here. Manager of a processing unit in PeMaS explained;

> *'I have always tried to maintain contacts with those business customers who are known to me for at least a few years and have proved to be reliable and*

responsible. You cannot trust everyone when it comes to selling products in bulk. Payments are usually made much later by the buyer. Even now I have at least Rs. 0.2 million owed to me by various businesses. I owe money to mine owners for raw stone.'

Focusing on beliefs and perceptions, collectivist culture also plays an influential role. Firms imitate other firms (cognitive institution) in terms of products, processes and other activities. Respondents suggested that most people have joined the marble business by following the example of someone they knew. However, explaining why innovation is not common, owner of a processing unit in BuMaS stated;

'There aren't any examples or role models for us. If we could see individuals and firms around us achieving greater business success due to innovative products and processes, we would definitely be inspired and motivated to follow in their footsteps.'

A number of perceptions (cognitive institutions) that owners/managers have about their business in particular and the industry in general were also identified. They are highlighted in Figure 10.6. Additionally, it was found that in many cases 'experts' in PeMaS and BuMaS such as machinery installation and maintenance experts and skilled workers rely on a false reputation of being expert rather than having actual formal skills and expertise. Problems associated with product quality emanate from this aspect when the so-called experts are unable to properly install equipments and perform maintenance operations.

The final set of informal institutions mainly present in the mining subsectors relate to the tribal code of conduct (normative institution). A key feature of this code is the concept of collective rights and responsibilities. All natural resources including marble are essentially the property of the state. However, weaker implementation of formal institutions due to government's relative inability to completely formalize and legalize commerce and trade in these areas means that the local population especially tribal chiefs and elders have significant influence. A mining unit despite having mining license from DGMM or DoM cannot operate unless it has also acquired consent of the local tribes inhabiting the area. This results in levies or taxes (mainly road or transportation tax) charged by tribes during product shipment. The amount of these taxes varies between Rs. 1000 to Rs. 5000 per truckload of raw marble and is essentially informal in nature. The imposition of this tax was found to be more common in PeMaS (because of Mohmand tribal area) as compared to BuMaS.

10.7.2. Relationship among Sectoral, Regional and National Institutions

PeMaS and BuMaS are characterized by informal institutions that have both sectoral and regional characteristics and are stronger compared to formal institutions. The formal institutions such as laws, regulations and standards do not seem to be in tune with informal institutions and also lack consistency as there is not one single implementing agency. The DGMM (under provincial government) along with provincial departments of industry and commerce, excise and taxation, environment and others have a regional focus on the province. The DoM along with FATA Governor's Secretariat and its constituent departments has a regional focus on the FATA region. While Small and Medium Enterprise Development Authority (SMEDA), Pakistan Stone Development Company (PASDEC) and others have a national orientation and do not exclusively focus on the marble sector only. Also, these multiple agencies have weak coordination with regards to implementation from national to regional to sectoral levels. As illustrated by a sector expert;

> *'All these organizations have a short-term and internally oriented focus. They lack collaborative efforts. For example SMEDA and PASDEC do not collaborate the way they should because one organization does not want the other to take credit for its efforts or programs. This means that standards such as quality are not specified nor consistent and coordinated efforts take place for uplift of the industry'*

This results in creating perceptions of 'unfair play' (for example, differences in costs of electricity), 'lack of clarity' (for example, formal regional institutions are different from formal national institutions such as mining license fees) and 'government's indifference and cold shoulder attitude' (for example, respondents' repeated assertion that the government does not create a conducive business environment by providing tax relief or declaring the marble industry as an industrial zone or estate with concessions and benefits). This contributes to an inability of the firms to innovate in terms of products and processes. Figure 10.5 below provides the relationship among sectoral, regional and national institutions and their weakening effects due to policy inconsistency.

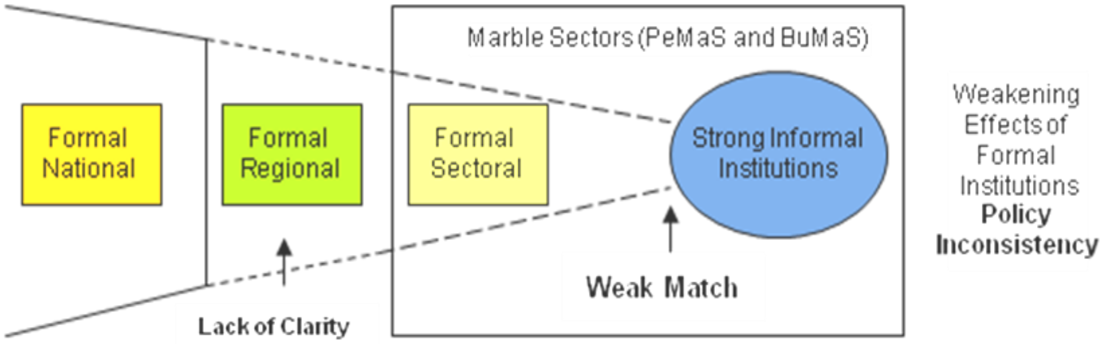


Figure 10.5: Relationship among sectoral, regional and national institutions

Figure 10.5 helps underscore that LT innovation in marble firms can occur if formal institutions have a conducive-to-innovation but strong (across-the-board) implementation in the industry. Moreover, these formal institutions should be formulated in line with the nature and strong influence of informal institutions currently prevalent in PeMaS and BuMaS. Non-existence of these causal mechanisms results in lack of LT innovation amongst marble firms.

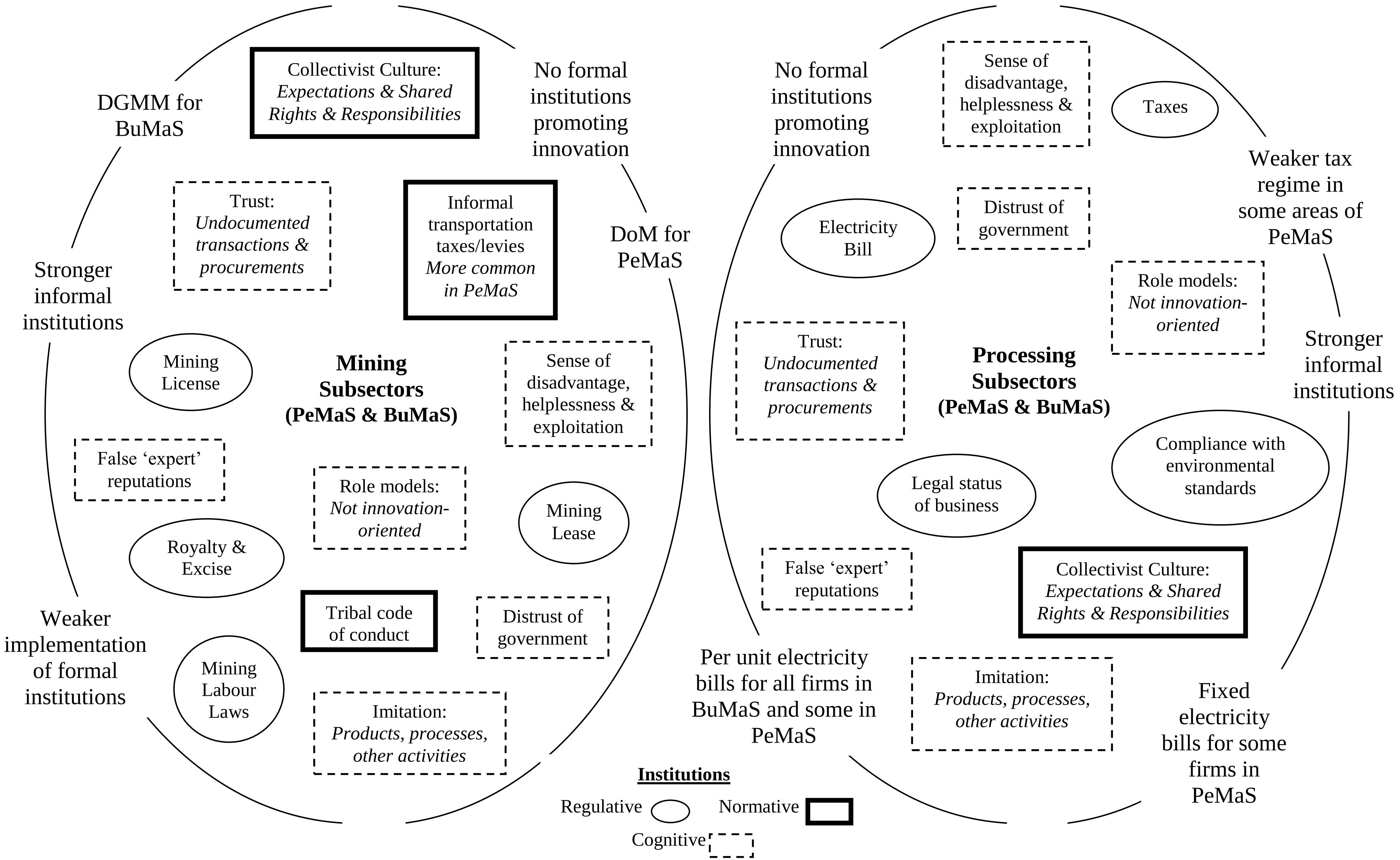
10.7.3. Influence on Interactions (both formal and informal institutions)

Institutions help us understand interactions (focus of Chapter 11) between actors and other elements of SSI (Geels, 2004). Outcomes suggest that formal institutions have a greater influence on interactions between firms and non-firms representing the government (for example licenses, taxes, electricity bills). Informal institutions especially normative have a greater role to play with regards to interactions between firms and non-firms such as middlemen, distributors, business customers and others. Examples include sale and purchase of marble products taking place between a mining firm and processing firm or processing firm and business customer. Cognitive institutions play a more relevant role when firms interact with knowledgebase, technologies, learning processes and demand. Examples include workers' informal learning about operating equipment, processing units interacting with customers informally, mining or processing units acquiring technologies and equipments through informal contacts with suppliers of such equipments.

10.7.4. Institutional Framework for PeMaS and BuMaS

The discussions on various aspects of institutions help in developing the institutional framework present within PeMaS and BuMaS. Figure 10.6 provides this framework.

Figure 10.6: Institutional Framework for PeMaS and BuMaS



10.8. Conclusion:

This chapter presented research outcomes about elements of marble SSI by conceptualizing them as objects/entities from a critical realist perspective and explaining their underlying components. The elements included firms, non-firms, knowledgebase and technologies, learning processes, demand and institutions. Discussions also focused on mechanisms or ways in which these objects cause events (occurence of LT innovation). Outcomes suggest that divergent stakes of owners and managers and lack of innovation focus amongst firms combined with weak role of sector support organizations contribute to lack of innovation. Similarly a weak learning orientation combined with reliance on the same knowledge and technologies, stagnant demand conditions and a weak match between strong informal institutions and weakening (national to regional to sectoral) formal institutions are some of the underlying reasons behind lack of LT innovation.

Chapter Eleven

STRUCTURE OF MARBLE SSI: NECESSARY AND CONTINGENT RELATIONS, MECHANISMS AND CAUSAL POWERS

11.1. Introduction

This chapter provides analysis and discussions to address research objective 3 (RO3) and related questions RQ3.1 to 3.6. The purpose is to explain why or why not low-technology innovation exists within LT sector by studying and explaining the structure of sectoral system of innovation. Taking influence from critical realism, the structure of SSI (interactions/relationships among entities or sectoral elements) has been conceptualized in the form of necessary and contingent relations. While elaborating on these relations, discussions also lead into mechanisms or ways in which interactions among entities influence events (occurrences of LT innovation). Deriving from Chapters 9, 10 and 11 causal powers of entities (determinants of LT innovation) are presented in a categorized manner along with their descriptions or meanings. Finally relative importance or influence of these determinants on LT innovation as envisaged by respondents is presented. Data has been analysed using techniques and procedures highlighted in Chapter 8. Due to application of 'replication logic' (Yin, 2003), the two cases PeMaS and BuMaS have been selected more for their similarities. During the discussions a constant and consistent effort has been made to refer to the particular case and referents (respondents). Moreover, influence is drawn from the conceptual framework including the micro-meso-macro framework and SSI approach.

For this chapter the analysis and discussions below are a result of different phases of research provided in the table below;

Marble Sub-Sector	Case 1 and Case 2		Data Collection Tool Phase 1	Data Collection Tool Phase 2	Analysis
	Structure of SSI (Interactions)	**Framework Level**			
Mining	Firms and Non-firms	Micro-Individual, Meso-Firm, Macro-Contextual	Semi-Structured In-Depth Interview **Sections 5 & 6**	Structured Interview ***Que. 3A, 3B, 4A, 4B, 4C, 4D, 4E, 5A, 5B1, 5B2, 5C, 6, 7, 8, 9, 10***	**Step I:** Coding, Splitting, Memos **Step II:** Coding, Splicing Memos Displays
	Firms and Knowledgebase	Meso-Firm, Macro-Contextual			
	Firms and Technologies				
	Firms and Learning Processes				
	Firms and Demand	Macro-Contextual			
	Firms and Institutions				
	Determinants of Low-tech Innovation	Micro-Individual, Meso-Firm, Macro-Contextual			
Processing	Firms and Non-firms	Micro-Individual, Meso-Firm, Macro-Contextual	Semi-Structured In-Depth Interview **Sections 5 & 6**	Questionnaire ***Que. 3A, 3B, 4A, 4B, 4C, 4D, 4E, 5A, 5B1, 5B2, 5C, 6, 7, 8, 9, 10***	
	Firms and Knowledgebase	Meso-Firm, Macro-Contextual			
	Firms and Technologies				
	Firms and Learning Processes				
	Firms and Demand	Macro-Contextual			
	Firms and Institutions				
	Determinants of Low-tech Innovation	Micro-Individual, Meso-Firm, Macro-Contextual			

Table 11.1: Phases of Research to Address RO3 (RQ3.1, 3.2, 3.3, 3.4, 3.5 and 3.6)

11.2. Interactions between Firms and Non-Firms (Necessary and Contingent)

Firms and non-firms (actors or agents) are key elements and objects/entities within SSI (Malerba, 2002). Provided in the subsections below is a discussion on interactions between firms and non-firms.

11.2.1. Interactions between Mining Unit and Non-Firms (MU-NF)

Analysis reveals two types of interactions between mining firms and non-firms in PeMaS and BuMaS emanating from two distinctly different individual roles.

a. Relationships between mine owner and government sector support organizations (predominantly necessary)

b. Relationships between mine manager and all other non-firms (necessary and contingent)

Interactions (a) mainly revolve around issuance and renewal of mining license. Department of Minerals (DoM) for PeMaS and Directorate General Mines and Minerals (DGMM) for BuMaS are the license issuance and renewal authorities. Elaborating on the nature of these interactions, a mine owner in BuMaS stated;

> *'Personal contacts and references are necessary. It is very difficult to acquire a mining license unless you know key individuals within the concerned department. I have also heard of instances of money or bribes being paid to the officials by license seekers'*

The above outcome reveals that the nature of type (a) interactions is purely centred on an individual-individual or individual-department contact that has nothing to do with actual running of the mining business. Rather the focus is to ensure that mining as an activity can be initiated and continued at a given location.

Interactions (b) reveal greater variations in possible relationships. Other than DGMM and DoM, non-firms in the two mining subsectors indentified in Chapter 11 are;

- Suppliers (i. equipment/component suppliers and ii. machinery manufacturers/suppliers) – necessary and contingent relations respectively
- Middlemen/Distributors (iii. Transporters responsible for shipment of stone to processing units) – necessary relations
- Sector Support Organizations (iv. SMEDA, v. PASDEC, vi. FDA, vii. Financial institutions, viii. HEIs, ix, Consulting firms, x. Donor agencies) – contingent relations

The most common interactions are with non-firm type (i) and (iii). They are characterized by limited focus dealing only with mining equipment component replacements/repairs and shipment of stones from mine. Additionally, interactions reveal a 'one-way' character. Mine managers approach both types of supplier non-firms when needed. This emanates from the fact that both groups of suppliers do not have a direct or indirect stake in the mining business. They do not specialize in only marble-specific products and are oriented towards other sectors or businesses also such as vehicle spare parts and others.

Very little evidence of interactions between mine manager or unit and non-firm types (iv) to (x) was found pointing to their contingent nature. Contrary to claims from representatives of SMEDA and PASDEC, respondents in the mining business in PeMaS and BuMaS were overwhelmingly suggesting lack of interaction with this group of non-firms. Providing evidence in this regard, a mine owner who also manages a few mines in BuMaS stated;

> *'To be very frank, these officials will not come to us. They are happy taking their salaries sitting in offices and do not really come forward. I believe it is us who will have to reach out to them for help and ideas to improve our business.'*

11.2.2. Interactions between Mining Unit and Processing Unit – the Contextual Non-Firm (MU-PU – Necessary Relations)

Another set of interactions necessary in nature is between mining units and processing units that are non-firms from the perspective of the mining subsector. Outcomes suggest limited evidence of direct contact between the two as the middlemen/distributor non-firm (the transporters) mostly play the role of intermediary. In some instances, managers of both firms communicate with or personally meet each other especially when either of the two seeks new marble varieties or business contacts. Two payment modes influence these interactions. Under the first and more common arrangement, the transporter takes payment from processing unit owner/manager for the delivered raw stone and makes onward payment to mining unit manager after deducting its share. Under the second arrangement, the processing unit makes direct payment to mining unit while the transporter is paid separately by the processing unit.

11.2.3. Interactions between Processing Unit and Non-Firms (PU-NF)

Three variants of individual roles were identified in Chapter 10. However, compared to mining units where a clearer difference between owner and manager was identified in terms of interactions with specific non-firms, a similar scenario was not found for the two processing subsectors. Processing units through the key individual-roles (O-M, O&M or O+M) interact with the following three types of non-firms;

- Suppliers (i. Mining units, ii. Transporters carrying raw stone from mining units, iii. Equipment and component suppliers, iv. Machinery manufacturers and suppliers, v. Machinery installation and maintenance experts) – predominantly necessary relations
- Middlemen/Distributors (vi. Bulk buyers/wholesalers of semi-finished blocks, vii. Bulk buyers/wholesalers of finished products, viii. Bulk buyers/wholesalers of decorative items) – predominantly necessary relations
- Sector Support Organizations (ix. SMEDA, x. PASDEC, xi. FDA, xii. Financial institutions, xiii. HEIs, xiv, Consulting firms, xv. Donor agencies) – contingent relations

The most common interactions are with non-firm types (ii), (iii) and (vii) followed by (v). A processing unit's interactions with suppliers have a limited focus ensuring delivery of raw material (raw excavated stone) in the case of type (i) and (ii) and machinery component supply and replacements especially cutting blade tips in the case of type (iii). Interactions with type (iv) non-firms only occur when a processing unit is starting up or an existing unit is upgrading machinery. Compared to mining unit's interactions with suppliers, the same non-firms' interactions with processing units reveal a greater 'two-way' character. This is because compared to the mining subsectors there is greater presence of specialized suppliers in processing subsectors. Elaborating this aspect, manager of a processing unit in PeMaS stated;

'I have particular mining units and transporters who supply raw stone to my factory. I have been in contact with specific suppliers of blades who know my requirements and offer a good price. Most relationships in this business are trust based and exist for longer period of time. Otherwise it is difficult to survive in a tough market.'

While processing units mostly interact with type (vii) middlemen, the only identifiable reason emerging from data is that most firms produce products that are bought by this type of non-firm for onward sale within PeMaS and BuMaS (local markets) while some are sold in national markets as well. Narrating the mostly 'one-way' character of these interactions, manager of a unit in BuMaS pointed out;

> *'It is difficult to have loyal customers in this business. If I do not offer my product at a reasonable price, the wholesaler can easily switch to another processing factory because he can find a similar product easily.'*

Some evidence of interactions between processing unit and non-firm types (ix), (x), (xi), (xiii), (xiv) and (xv) was found while no interactions were revealed for (xii). Providing possible reasons for presence of interactions, manager or a processing unit in PeMaS stated;

> *'...probably it is because we are producing end-products and are located in the major cities that are easily accessible like Peshawar, Buner, Nowshera, Mardan and others. Organizations like SMEDA and others have conducted trainings in the past on product design, mosaic and others. But such activities have not been consistent.'*

From owners'/managers' perspective the level of interactions was found to be far lesser than their expectations. This is again contrary to claims from representatives of SMEDA, PASDEC and others who were making the case for equal priority for mining and processing subsectors.

11.3. Influence of MU-NF, MU-PU and PU-NF on LT Innovation – Identifying Causal Mechanisms

The discussions about MU-NF, MU-PU and PU-NF reveal a clear lack of innovation-oriented interactions. Some interactions act as indirect barriers to firms' ability to innovate. Shown in Figure 11.1, key characteristics of MU-NF, MU-PU and PU-NF in PeMaS and BuMaS help illustrate these points. These include;

- A predominant 'unidirectional' character of interactions

- Presence of ‘two-partner’ relationships but no examples of ‘multi-partner’ relationships
- Non-existent or weak collaborations
- ‘Single objective’ or ‘low-focus’ of interactions

For mining firm there is a lack of mutual incentive for both firm and non-firm that can lead to product or process innovation. Non-firms are not proactive as they are doing business in other sectors (especially for suppliers) or lack interest in mining activities (especially sector support organizations). For processing units ‘two-partner’ relationships were more common whereby a mining or processing firm interacts with a single non-firm to achieve a particular objective. However interactions where three or more than three partners collaborate resulting in improved products or processes were not found.

There is a strong perception amongst respondents that the key to improving marble industry is sector support organizations whereby the government needs to play a strong facilitative role. However, almost all respondents in PeMaS and BuMaS complained of very weak or non-existent interactions with these non-firms. Similarly, very weak or non-existent NF-NF interactions were also revealed. For instance, no evidence surfaced whereby a sector-support organization or a government department collaborated with another support organization or suppliers, transporters or distributors to help mining and processing firms improve or innovate.

Driven by short-term, immediate and limited requirements, interactions mostly remain ‘single-objective’ or ‘low-focus’. The following statement by a mine manager in PeMaS helps explain this scenario.

> *‘We are more concerned about keeping operational costs low. The cheaper the mining equipment the better, the faster our products leave the mining site the happier we are. We have a simple business which needs simple solutions so we solve them locally as it is easy, quick and low-cost. We do not have the support, resources or vision to enter in to business collaborations especially outside our area that can help us improve our mining techniques.’*

The outcome regarding weak interactions between firms and non-firms leading to poor innovation performance of marble firms adheres to Freel (1999). There are different ways to improve these interactions such as through 'bridging' non-firms (Sapsed, 2007), technology intermediaries (Spithoven et al., 2010) and industry liaison offices (Jones-Evans et al., 1999) that help firms link up with agents within SSI such as HEIs, research centres and others. However, no such non-firms that perform the 'bridging', intermediary or liaison roles were identified within PeMaS and BuMaS. Had such roles been performed by non-firms, it would also lead to the presence of 'multi-partner' interactions facilitating innovation better.

Another aspect to interactions is whether firms have established links with non-firms in other industries outside their own SSI. Intra-industry links influence innovation more than inter-industry links (Vale & Caldeira, 2008; Ronde & Hussler, 2005). However, outcomes do not suggest that marble firms collaborate with agents or actors outside their own SSI. This also offers a possible explanation for lack of innovation amongst many firms. Collaborations with research organizations and suppliers are the two most important sources of external technological knowledge for firms (Tsai & Wang, 2009) whereby research organizations need to facilitate users (firms) of technology in its adoption while accounting for nature of firms' innovation (Douthwaite et al., 2001). However, no research-based non-firm was identified within the two SSI while collaborations with suppliers are mostly unidirectional and low-focus in nature. Also, dependence of supplier firms on buying firms results in lack of skill development, knowledge and competence amongst suppliers (Petroni, 2000). The mining firms remain dependent on transporters and processing firms for purchase of their raw excavated stone. The processing firms in turn depend on business buyers for purchase of semi-finished and finished products. This also suggests a possible reason for lack of skill development and knowledge amongst firms in PeMaS and BuMaS.

Collaboration among firms and non-firms is positively affected by external knowledge flows and public financial support (Abramovsky et al., 2004). In the case of PeMaS and BuMaS limited evidence of knowledge flow was found along with a clear lack of public financial support for improvement of the marble industry. Thus these outcomes also explain the lack of interactions amongst marble firms and non-firms. However, firms especially processing firms do interact with their customers regarding product design and customer preferences. These interactions have led to incremental innovations suggested by Salavou (2002) also. Providing one such evidence, owner/manager of a processing unit in PeMaS stated;

> *'A different and unique product I can talk about is a specific design of marble floor tile I was asked to produce by my client, a construction firm working on a university building. They needed a raised tile to be placed at the door entrance of each room with the specific aim of avoiding water entering the room.'*

Figure 11.1 on the next page provides visual description of firm-firm and firm-non-firm interactions and their influence on LT innovation in PeMaS and BuMaS. The figure illustrates the important role of key individuals. Based on discussions in section 11.3 the figure also provides the causal mechanisms that should lead to the occurrences of LT innovation. The less likelihood of innovation in PeMaS and BuMaS (as found in the marble industry) is a result of the absence of these mechanisms.

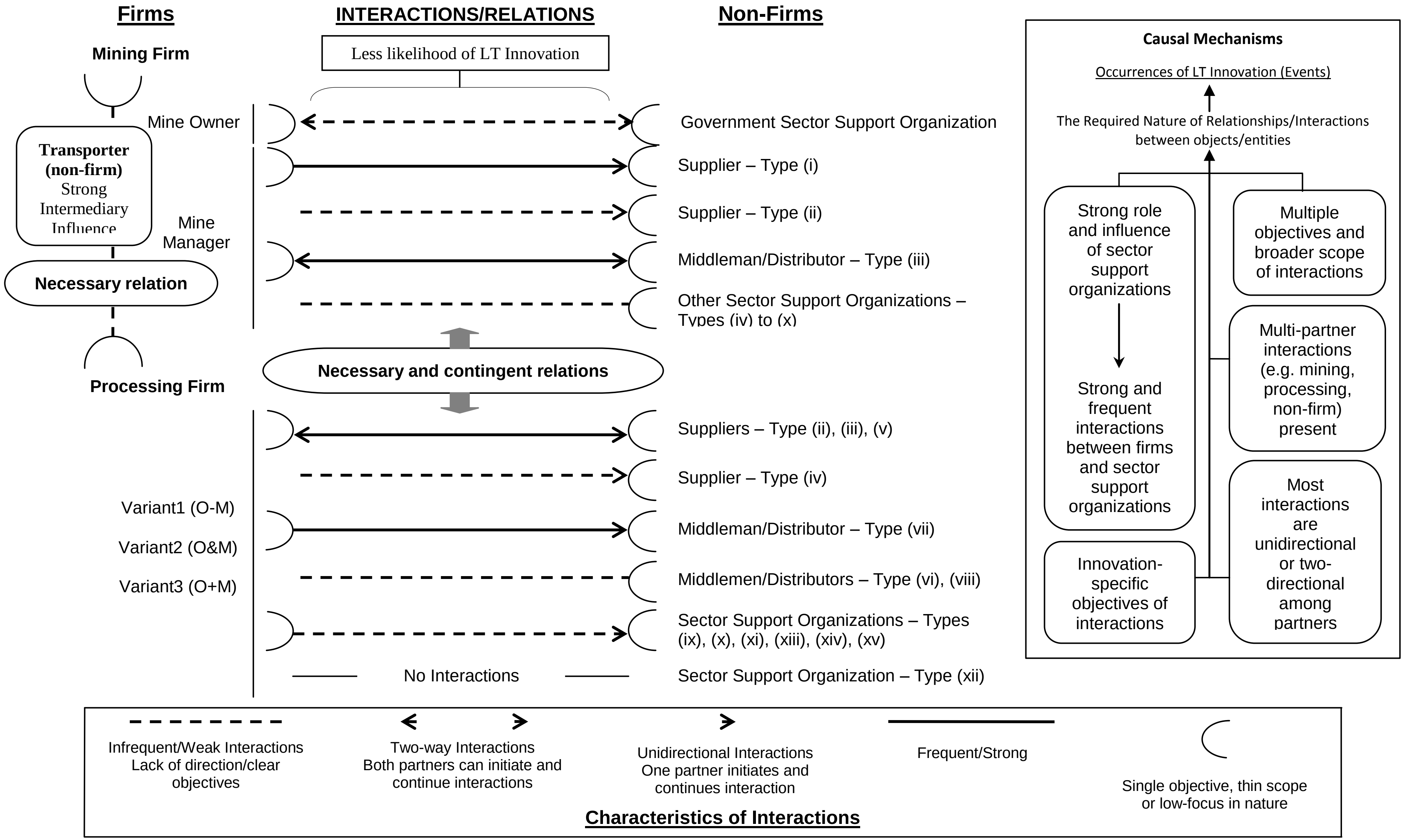


Figure 11.1: Firm-Non-Firm Interactions/Relations and their influence on LT Innovation

11.4. Interactions between Marble Firms and Knowledge/Technologies (MF-K/T) – Predominantly Contingent

Knowledge and technologies are two key elements of marble SSI that firms interact with to influence occurrence/non-occurrence of LT innovation. Data reveals four major characteristics of these interactions discussed below;

11.4.1. Infrequent interactions

Knowledge and technologies within PeMaS and BuMaS have mostly remained stagnant (changes or improvements are too slow or non-existent) both at the firm-level as well as sector-level. Interactions between firms and knowledge/technologies remain very infrequent. Even if they occur they do not concern with new knowledge thus providing reason for interactions' contingent nature. A number of factors are responsible for this shown in Figure 11.2 later.

11.4.2. A weak knowledge/technology role of non-firms

The weak influence of many non-firms has already been highlighted in Chapter 10. As shown in Figure 11.2 no non-firms are engaged in the creation and dissemination or transfer of new knowledge (be it technical or market knowledge) to help enhance internal capabilities of marble firms. This weak role of non-firms leads to weak innovation performance. It also contributes to lack of opportunities for firms to interact with new knowledge and technologies.

11.4.3. Lack of knowledge/technology interactions with other sectors

As shown in Figure 11.2, neither PeMaS nor BuMaS interact with any other sector to acquire improved technologies or new knowledge. These sectors can be another marble industry in a different region of Pakistan or a sector dealing with a different set of products.

11.4.4. No knowledge/technology flow pattern

In order to further understand the nature of interactions, it is also important to find out how knowledge flows with regards to PeMaS and BuMaS. With no marble firms and non-firms playing a proactive role, no particular knowledge flow pattern was identified. Questions like where the current knowledge of marble products and processes has been generated and how it disseminated or spread were difficult to answer as respondents' answers either remained inconclusive or lacked genuine insights. Manager of a processing unit in PeMaS stated;

> *'There is no formal training where a worker can learn about production process. Similar is the case with knowledge of managing a business. It is difficult to determine how exactly it developed'*

11.5. Influence of MF-K/T on LT Innovation – Identifying Causal Mechanisms

The stagnant nature of knowledge/technologies contributes to lack of interactions between firms and knowledge/technologies which can at best be described as infrequent. Firms' accumulated experience combined with path dependent nature of technological development creates a technology lock-in. In order to come out of this lock-in public sector especially government support is necessary (Ahman & Nilsson, 2008) which is not forthcoming in the case of PeMaS and BuMaS. Thus both sectors suffer from a 'knowledge lock-in' also whereby innovation is more difficult to carry out as a business activity.

Firms in LT/LMT sectors are generally characterized by weak absorptive capacity to internalize knowledge from external sources. In order to facilitate firms' interaction with knowledge and facilitate them to internalize knowledge non-firms that play the role of 'technology intermediary' is crucial (Spithoven et al., 2010). No such intermediaries were identified in PeMaS and BuMaS. Dell'Era and Verganti (2010) point out that the more LT/LMT firms interact with non-firms, customers and others the more they can develop capabilities to access and interpret tacit and distributed knowledge. However, due to a lack of such interactions the same capabilities of marble firms remain weak.

A key contributing factor to LMT firm's weak absorptive capacity is poor knowledge transfer to employees resulting from poor organizational structure. This leads to lack of innovation (Cetindamar & Ulusoy, 2008). Evidence suggests that marble firms' organizational structure is not geared towards employee training and transfer of knowledge as it is not a priority. This also results in lack of innovation. In addition to the above factors and also pointed out in the previous section, no patterns of knowledge flow for example inter-sectoral within same region or inter-regional within same sector (Ronde & Hussler, 2005) were found. This means marble firms adhere to the status quo and continue to produce same products using the same processes.

11.6. Interactions between Marble Firms and Learning Processes (MF-LP) – Predominantly Contingent

Learning processes and knowledgebase being two important elements of a sectoral system are closely linked together where the former influences the latter and vice versa (Malerba, 2005). The same is the case with interactions. Two key characteristics of MF-LP (also shown in Figure 11.2 later) are discussed below.

11.6.1. Informal and limited or non-existent interactions

A key characteristic of marble firms (discussed in Chapter 10) is weak learning orientation since they continue to depend on existing knowledgebase and technologies. Also, as the mining firms continue to serve their existing customers (processing units) and the processing units continue to provide product to a largely domestic and national market or customers, this market orientation of the firms influences their learning orientation, a characteristic also pointed out by Keskin (2006). Thus marble firms have limited (predominantly informal) or non-existent interactions with learning processes.

11.6.2. Individual-oriented interactions (non-collective from firm's perspective)

Learning processes are predominantly informal (Chapter 10). Thus interactions with learning processes are informal as well. Important evidence is that knowledge and learning remain individual-oriented. For example, hard/technical knowledge is a result of workers' informal learning from each other or their seniors such as 'ustaz' or 'master'. Soft knowledge remains even more intangible in nature and acquired completely through informal means by observing and hit and trial. If an individual, be it a senior worker/'ustaz' or manager, leaves a mining or processing unit, he carries his knowledge acquired through learning and experience elsewhere. Thus knowledge (highly unstructured and informal) does not reside with the firm as a collective entity whereby it can be accumulated, protected and effectively utilized it on order to compete with others. Rather, marble firms tend not to value interaction with learning processes. Offering an explanation, manager of a processing unit in BuMaS stated;

> *'Even if the ustaz operating the machinery leaves my factory, I can hire someone else to replace him. Or his immediate subordinate worker can take over his place. There is no need to hire a new worker and make him learn about stone cutting or design from the basics'*

11.7. Influence of MF-LP on LT Innovation – Identifying Causal Mechanisms

Limited or non-existent nature of interactions results in a lack of LT innovation because a weak learning orientation does not contribute to firm's knowledge positively. Consequently firm knowledge remains stagnant. Moreover, the lack of collective (firm-level) interactions with learning process also means that marble firms do not take innovation as an activity at the firm-level.

Figure 11.2 on the next page provides a visual understanding of MF-K/T and MF-LP and their influence on LT innovation in PeMaS and BuMaS. Based on discussions in sections 11.5 and 11.7, the figure also provides the causal mechanisms that should lead to occurrences of LT innovation. The less likelihood of innovation in PeMaS and BuMaS (as found in the marble industry) is a result of the absence of these mechanisms.

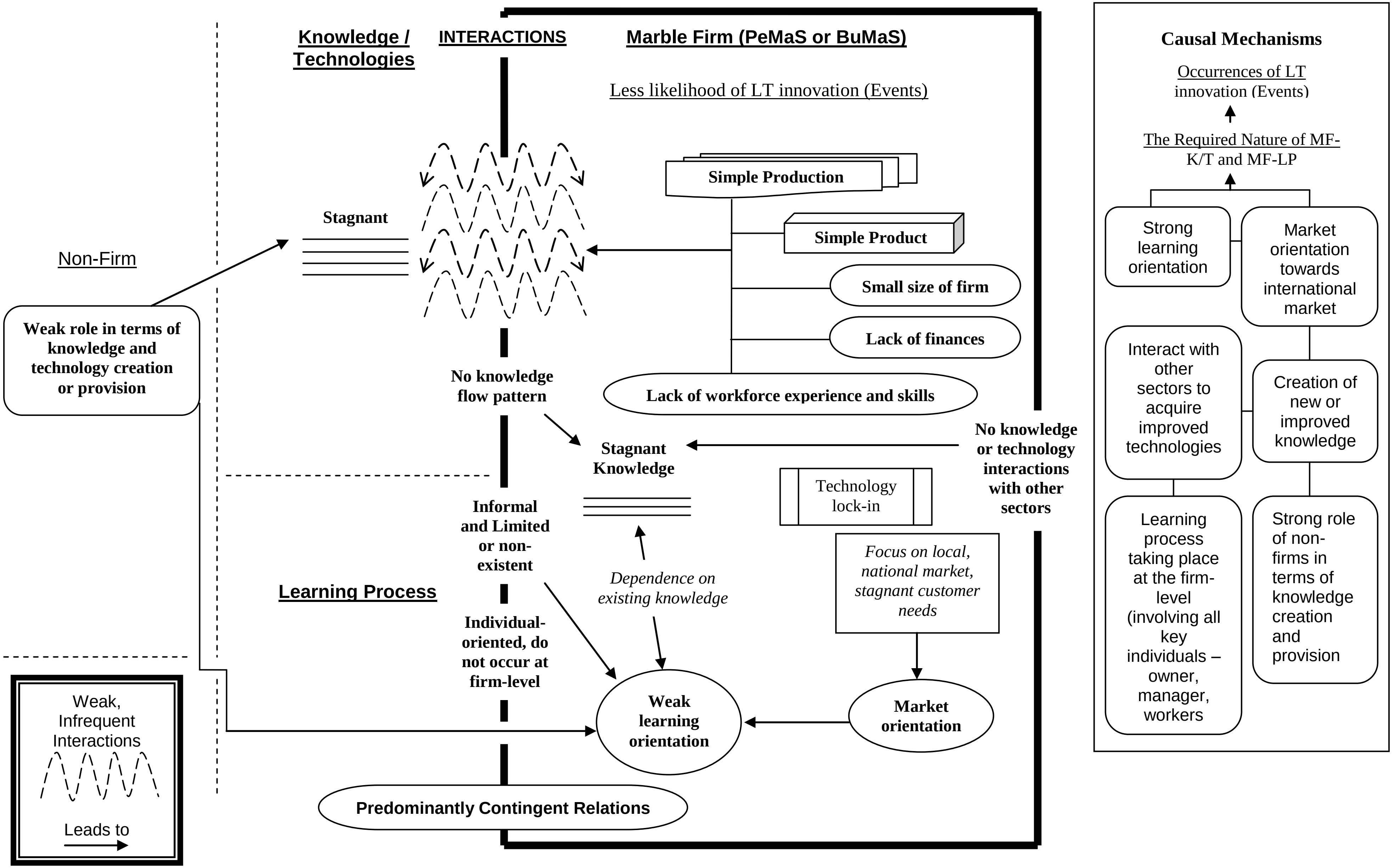


Figure 11.2: Firm-Knowledge/Technology Interactions/Relations and their influence on LT Innovation

11.8. Interactions between Marble Firms and Demand (MF-D) – Predominantly Contingent

Marble firms' interactions with demand are mainly a result of firm-customer interactions. Both PeMaS and BuMaS do not address large and collective market needs. Rather, individual firms cater to consumer or business customer requirements with a predominant focus on local markets, lesser focus on national markets and almost non-existent focus on international markets. Discussed below are four key characteristics of MF-D.

11.8.1. Firms' weak proactive role

Marble firms tend not to engage with customers to seek opportunities for demand in a proactive manner. This emanates from a lack of clear marketing focus or weak market orientation amongst firms. While some processing units actively engage in seeking new opportunities, the situation leaves much more to be desired for mining firms. Most firms (mining and processing units both) however, have a 'wait-for-customer-order' approach thus influencing the way they interact with demand.

11.8.2. Interactions' inability to trigger new demand or create new needs

Most MF-D studied for this research did not trigger new demand or create new needs. The most important contributing factor in this regard is the firm's own weak market orientation whereby no new/improved products are offered to the market. However, for processing subsector, some firms were identified that were able to create new demand for themselves by interacting with demand outside the local market (that is the national market). In the real sense though, new demand or needs would come from the international customers. However, interactions between firms and international demand were non-existent whereby non-firms do not play any kind of support role to help firms connect with international markets.

11.8.3. Interactions' focus on fulfilling unchanging demand

As pointed out in the discussions about nature of marble products in Chapter 10, mining firms in PeMaS and BuMaS produce raw excavated stone of varying shapes, sizes and colours. Mining firms interact with demand from processing firms resulting in production and sale of these products. While quantity demanded by processing units may vary depending on each unit's requirement and estimates of semi-finished and finished product demand, their demand for the raw excavated stone in its current form as a raw material remains unchanged.

Processing firms in the two sectors produce semi-finished dimensional blocks and finished products (mainly tiles and slabs, decorative items, mosaic). These firms interact with demand from a mostly local market comprising of business customers (wholesalers, showroom owners and others) as well as individual consumers. Additionally, some processing firms interact with customers in the national markets also. While the types of products and quantity demanded varies depending on customer requirements, the demand for products in their current form remains mostly unchanged. Thus MF-Ds mostly focus on addressing unchanging demand.

11.8.4. Greater supply-push than demand-pull

Another feature of MF-D is a greater focus on supply-push rather than demand pull. This is especially the case for mining firms whereby the raw excavated stone is pushed through the supply chain in its current form while problems such as rough edges and internal cracks resulting from indiscriminate blasting are present in the product. On the other hand the processing units themselves also accept and purchase this raw excavated stone. Pointing out reasons for this dependence on mining units, owner-manager of a processing unit in BuMaS stated;

> *We purchase our raw material in this form because it is affordable and the only choice we have. Where else could we get the stones from? There is no alternative.'*

In the case of processing units, evidence suggests mostly supply-push but some demand-pull as well. Two particular products produced in greater abundance are marble tiles and slabs. Some of these produced from certain stone varieties such as white marble are in greater demand and fetch higher prices. This suggests presence of demand-pull. However, because the demand from local and national customer remains stagnant with regards to product type (same tile or slab), the demand-pull does not lead to new or improved products. Respondents' replies also suggest a laid-back attitude. To put it in the words of a processing unit manager from BuMaS;

> *'What else can I do, this is the product I can produce with the available machinery and based on the kind of stone variety supplied from the mining area. If someone has to buy it, they will buy it. And believe me there are buyers of my product in the local market.'*

11.9. Influence of MF-D on LT Innovation – Identifying Causal Mechanisms

The influence of MF-D on innovation in PeMaS and BuMaS results from a combination of the four characteristics of MF-D discussed in the previous section. All mining firms and most processing firms have no explicit marketing objective or function. This causes firms not to seek out new opportunities that can lead to innovation. The firms' weak proactive role means they continue to produce and sell the same products to the same customers in the local markets.

Additionally, MF-Ds in the two sectors essentially remain more about supply-push. Unless a demand-pull strategy is adopted whereby non-firms including the government actively engage is helping marble firms seek out demand opportunities in the international market, firms will not be driven to invest in new technologies (Laranja, 2009) that lead to product/process innovation. Respondents repeatedly suggest why it is not possible for them to do things on their own. For instance, manager of a processing unit in PeMaS stated;

> *'...the government should help identify and procure product orders for us in the international market for example the gulf region. With some minimization of our risk this way we can purchase new technologies, train our workforce leading to our ability to address this demand. We are poor businessmen with limited resources and cannot take risks on our own.'*

Figure 11.9 provides a visual description of MF-D and its influence on LT innovation. Based on discussion in section 11.9, the figure also provides the causal mechanisms that should lead to occurrences of LT innovation. The lack of innovation in PeMaS and BuMaS (as found in the two SSI) is a result of the absence of these mechanisms.

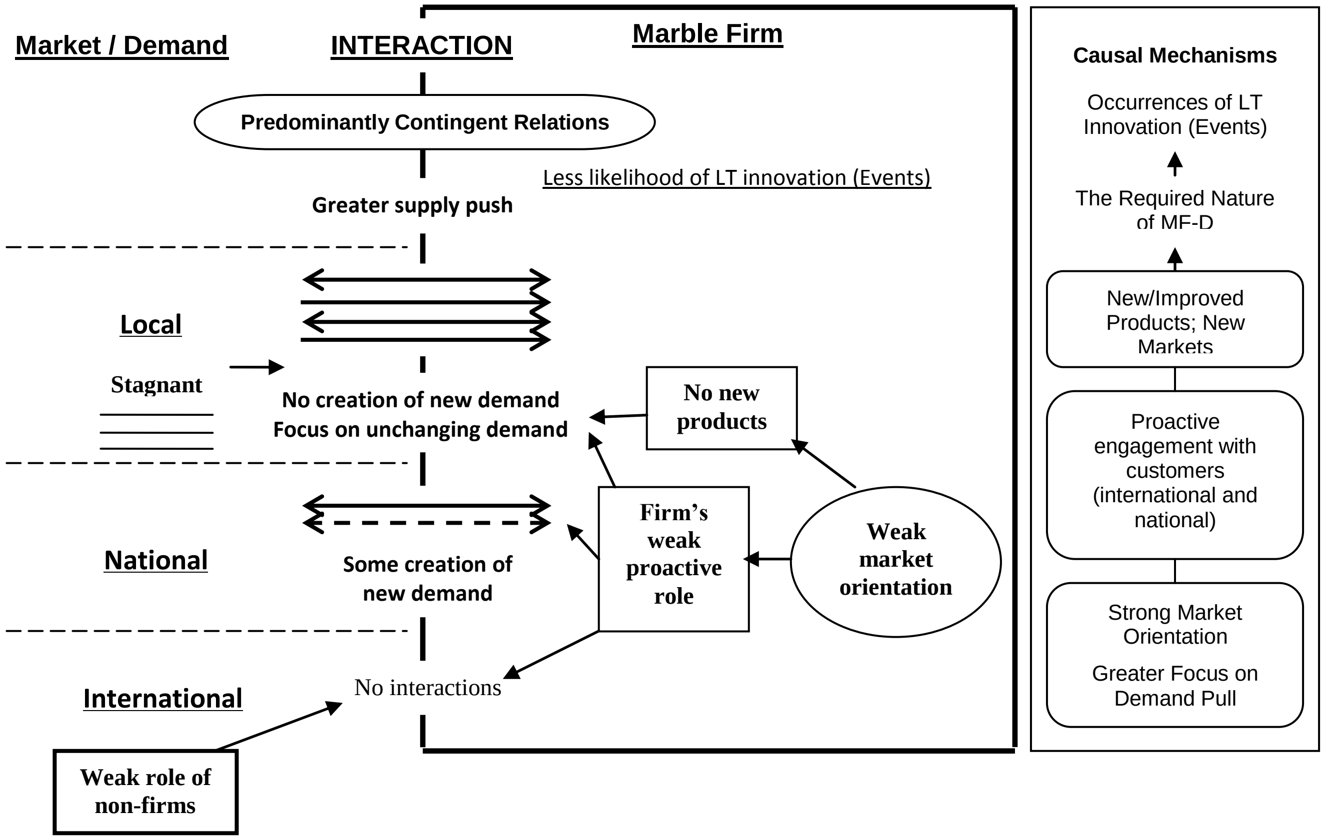


Figure 11.3: Firm-Demand Interactions/Relations and their influence on LT Innovation

11.10. Interactions between Marble Firms and Institutions (MF-I) – Necessary and Contingent

Institutions help us understand interactions between actors (firms and non-firms) as well as other sectoral elements (Geels, 2004). Data reveals four dimensions of MF-I. As each dimension of MF-I is discussed below, the focus remains on explaining how they occur and what the desired objectives are.

11.10.1. Consistent but weak interactions (regulative – mining)

Four formal institutions for mining subsectors were identified and discussed in Chapter 10. These include (a) mining license, (b) mining lease, (c) royalty and excise, and (d) mining labour laws. All mining firms have to interact with these regulative institutions thus suggesting the consistent nature of interactions regardless of sector or firm. However, interactions between mining firms and regulations (a) and (b) usually occur when a mining business is initiated. Mine owner is the interactive link for (a) and (b) and mine manager for (c) and (d). Thus firms as a collective entity do not interact.

Respondents' answers suggest that mining firms do not interact with regulative institutions on a regular basis pointing to interactions' weak characteristic. Interactions occur only at the start of a mining business (regulations (a) and (b)). Or there is weak implementation role of non-firms especially Directorate General Mines and Minerals (DGMM) and Department of Minerals (DoM) (regulations (c) and (d)) emanating from weaker influence of the government and its related departments in the mining areas.

DGMM in BuMaS and DoM in PeMaS remain the initiators for enforcing interactions between formal institutions and mining firms. The desired objectives of these interactions are;

1. Enforcing the federal and provincial government's authority with regards to exploration of a natural resource that is ultimately the property of the state
2. Contributing to the national exchequer in the form of fees and taxes imposed on mining firms

11.10.2. Inconsistent and weak interactions (regulative – processing)

Four formal institutions for processing subsectors were identified and discussed in Chapter 10. These include (a) electricity bill, (b) taxes, (c) compliance with environmental standards and (d) legal status of business. Data suggests that different processing firms interact differently with these regulative institutions pointing to the inconsistent nature of interactions. For example, some processing firms pay for electricity (a major input) per unit at a predetermined commercial rate while others especially in some areas of PeMaS pay at a predetermined amount regardless of units consumed. This inconsistency emanates from the inconsistent implementation of the regulative institution by Water and Power Development Authority (WAPDA), Government of Pakistan.

Respondents suggest that processing firms do not interact with regulative institutions on a regular basis suggesting the interactions' weak characteristic. For example, some processing firms are involved in electricity theft. The tax regime is also not implemented across the board. As stated by a processing unit manager in PeMaS;

> *'...the factories in the main city of Peshawar are subjected to greater and more frequent taxation however, nothing like this happens in the Mohmand region which is just outside Peshawar.'*

Similarly processing units are seldom penalized for breach of environmental standards such as proper disposal of marble powder/dust. Excise and Taxation Department of the provincial government, Environment Protection Agency and WAPDA representing the federal government perform the implementation function for regulative institutions. The desired objectives of these interactions are;

1. Enforcing the federal and provincial government's authority with regards to regulating the initiation and onward working of processing firms in a consistent manner
2. Contributing to the national exchequer in the form of bills and taxes imposed on processing firms

11.10.3. Inconsistent but strong interactions (normative – mining and processing)

Three normative institutions for mining and one for processing subsectors were identified and discussed in Chapter 10. These include (a) collectivist culture, (b) tribal code of conduct and (c) informal transportation taxes/levies for mining subsectors while (d) collectivist culture for processing subsectors. For mining subsectors data suggests that different firms interact differently with normative institutions pointing to the inconsistent nature of interactions. Characterized by far flung locations, poor infrastructure development, poverty and lack of basic amenities, mining areas are inhabited by tribes (for PeMaS) and regular village folk (for BuMaS). Presence of a collectivist culture means that mining firms cannot operate in isolation. Marble reserves are considered a shared asset by the local population thus the concept of shared right over the natural resource. Mine owners/managers have to be mindful of this perception. The shared expectation is that local villagers/tribesmen will be given jobs as mineworkers regardless of their skills, expertise or knowhow. Similarly, shared responsibility refers to the tribes and villagers taking it as a joint responsibility to ensure that mining activities continue in their area without undue risk to the safety and security of people associated with this business. However, inconsistencies remain with regards to nature of interactions. For example, in PeMaS the tribes demonstrate a stronger sense of shared rights and responsibilities compared to BuMaS by influencing mining activities much more. This leads to weakening influence of regulative institutions in PeMaS' mining subsector.

Firms' interactions with tribal code of conduct are characterized by inconsistencies because of three factors;

- Non-existent tribal code of conduct in BuMaS because of lack of a tribal culture in Buner
- Vast geographical spread of marble mines meaning all mining activities are not under a similar tribal/local population influence
- Uncertain law and order situation (continuing war between Pakistan Army and Taliban) in both sectors resulting in uncertain and inconsistent influence of local population.

Marble firms' interactions with informal transportation taxes/levies are characterized by inconsistencies due to two reasons.

- No presence of the normative institution in BuMaS
- Inconsistent imposition of levies due to varying rates in various regions of Mohmand Agency
- No single implementation authority with no legal basis for imposition of levies

Mining firms interact with normative institutions on a routine basis (strong interactions) reflected in the activities/operations like hiring/firing mineworkers while taking into account the sensitive issue of which family/tribe a worker belongs to, input purchases from the local area, local businesses/suppliers and local population. Citing one example of strong influence, an owner and manager in PeMaS stated;

> *'I had to negotiate with a local tribal chief for months. The purpose was to acquire approval for safe and secure passage of my products for onward shipment to processing factories in Peshawar. We have to account for these things including levies on a very regular basis.'*

For processing firms interactions with a collectivist culture mean that they have to operate within the local environment intermingling with local population. In most cases they hire workers from the local areas or relatives/friends of existing workers because of a shared sense of rights and responsibilities. However, this is not always the case as the 'ustaz' or master worker is usually employed mainly because of his skill and experience rather than affiliation. Consequently, processing firms' interactions with the normative institution are inconsistent.

Interactions in the two processing subsectors demonstrate a strong characteristic whereby all firms are influenced by normative institutions on a regular basis. The following statements from respondents help underscore this aspect.

> *'...decisions I make have to account for local sensitivities. The main supplier of cutting blade is the brother of my chief machine operator. He gives discount and I can trust him and offer him business. It is a give and take scenario, you see.'*

> *'Of course we are mindful of family and local people's expectations. My sons expect me to handover this business to them and I expect them to take it over when I become old...almost all businesses are family-owned and family-operated. Business is not just about making profits but also about obliging your near and dear ones.'*

Unlike regulative institutions, there is no role of non-firms in implementing normative institutions. The desired objectives of firms' interactions with normative institutions are;

1. Fulfilling cultural and social obligations and avoiding the pressure of disgrace or dishonour which is ingrained in collectivist culture
2. Intermingling with local norms and codes/beliefs in order to ensure continuity of mining and processing activities/business

11.10.4. Consistent and strong interactions (cognitive – mining and processing)

Six cognitive institutions each for mining and processing subsectors were identified and discussed in Chapter 11. However, the six institutions in mining subsectors are the same in terms of their basic character to the six in processing subsectors. They include (a) trust, (b) sense of disadvantage, (c) false 'expert' reputations, (d) role models not innovation-oriented, (e) distrust of government and (f) imitation. Data reveals that both types of firms interact with these cognitive institutions in the same manner suggesting interactions' consistent characteristic. Also, mining and processing firms have frequent interactions that point to a strong character of these interactions

Most business activities in PeMaS and BuMaS remain undocumented or characterized by limited documentation (for example sales/purchase records, salaries, tax payments). Consequently firms rely frequently on trusting business customers, middlemen and suppliers. Manager of a processing unit in PeMaS stated;

> *'One learns through experience whom to trust and whom not to. There is no option for us but to trust others in this business. We operate on credit. If I purchase raw stone from the mining unit, I do not make a payment immediately. My capital is invested in the business and I await payments from business customers to make onward payment to the mining firm. This way money keeps circulating.'*

Another widespread cognitive institution is the sense of neglect and disadvantage among the marble industry. It emanates from a wider perception of neglect of the industry by the government in the north-west regions of Pakistan. Both mining and processing firms interact with this sense of disadvantage leading to a lack of confidence and belief amongst owners and managers in terms of improvement of business.

PeMaS and BuMaS are also characterized by false ‘expert’ reputations. Firms seek ‘expert’ help in terms of machinery installation and maintenance, machinery parts replacements, blade tips instalment on cutters, excavator and loader manufacturing and others. However, data suggests that none of the so-called experts have any formal training. They rely on self-acquired knowledge gained through a trial-and-error approach. Firms’ frequent interaction with such ‘experts’ leads to two major problems;

1. Poor machinery maintenance
2. Poor quality manufacturing from poorly installed machinery and cutters/blades

Another widespread cognitive institution in both sectors is lack of innovation-oriented role models. Mining and processing firms (particularly owners and managers) are unable to observe real examples of innovation-oriented behaviour of other firms or individuals that can serve as inspiration and motivate them to invest in modern technologies, equipments and seeking international markets for improved products.

The fifth cognitive institution is distrust of the government especially amongst owners and managers of business. Similar in nature to the sense of disadvantage, the distrust has its roots in poor governance and lack of transparency amongst government departments such as Department of Minerals, Director General Mines and Minerals, Department of Industries, Excise and Taxation Department, Environment Protection Agency, Water and Power Development Authority and others. Respondents frequently complained of exploitation by representatives of these departments who seek bribes and apply fines unjustly. As a result firms’ interactions with this widespread sense of distrust lead them to;

- Hide sales figures (due to fear of taxation)

- Shy away from investment in business (due to fear of standing out and targeted for greater exploitation)
- Not to respond to government initiatives for industry development

Moreover, presence of a collectivist culture discussed earlier leads to a lack of original approach towards business. Owners and managers seeing and observing what other firms are producing accept it as the norm and imitate it as is. Many businesses started simply because the owner believed that if another person in the area could do it, he can also. Imitation in terms of products and processes, equipments and machinery and other activities is very common. Elaborating on this aspect, manager of a processing unit in PeMaS stated;

> *'Many people have come into this business simply by copying others and lack originality. They distort the market by producing poor quality products selling it at much lower price. This has led to a decrease in demand for good quality products. Customers have switched to substitutes since they cannot find the product they prefer.'*

The desired objective of mining/processing firms' interactions with cognitive institutions is;

1. Providing a shared sense of understanding regarding business environment and how do other firms perceive and operate in this environment

11.11. Influence of MF-I on LT Innovation – Identifying Causal Mechanisms

Three major outcomes about MF-I emerge that help explain their influence on innovation;

1. None of the MF-Is have an explicit or implicit innovation-oriented focus whereby firms are driven to innovate as a result of interactions with institutions (formal or informal)
2. Understanding influence of MF-Is in the industry is complicated by a mix of consistent versus inconsistent and strong versus weak interactions. This suggests a lack of direction and purpose of MF-Is

3. Some MF-Is especially involving cognitive institutions inadvertently serve as barriers to innovation amongst marble firms

Regulative institutions in the mining subsectors while consistently present across PeMaS and BuMaS have a weak enforcement. On the other hand different processing firms experience a different implementation mechanism for regulative institutions (suggesting inconsistency) which leads to weak enforcement. Such differences for regulative institutions suggest a lack of collective and consistent focus and priorities on the part of government and regulatory authorities to support the marble industry as a whole. Moreover firms' stronger interactions with normative and cognitive institutions, compared to regulative ones, suggest that they have limited and localized approaches towards business. Firms' goals, strategies, products, processes, marketing and resource utilization are heavily constrained by the local norms, values, culture, social obligations and a collective sense of government distrust and exploitation. The lack of innovation-oriented regulative institutions and highly restrictive and localized normative and cognitive institutions means MF-Is do not influence innovation amongst firms positively.

Outcomes also suggest the negative influence of some MF-Is on innovation amongst marble firms. In this regard interactions between firms and some cognitive institutions serve as key barriers to innovation. A strong sense of disadvantage and government distrust prevails emanating from a strong feeling that marble firms are not being provided with the desired opportunities to realize their business potential. Being part of the local community of marble businessmen, the more an owner or manager interacts with his fellow colleagues and observes the working of the industry on a daily basis the more he is convinced about his perceived sense of disadvantage. This discourages him from investing in technologies or knowledge that can lead to innovation. Further, there is a clear lack of role models (owners/managers who have achieved greater success through innovation) particularly vital as imitation is a common practice. Interactions with such cognitive institutions mean marble firms are locked in a repetitive cycle whereby businesses are being run in the same old manner without changes or innovation.

Figure 11.4 on the next page provides a visual representation of MF-Is and their influence on LT innovation in PeMaS and BuMaS. Based on discussion in Section 11.11, the figure also provides the causal mechanisms that should lead to occurrences of LT innovation. The lack of innovation in the two SSI is a result of the absence of these mechanisms.

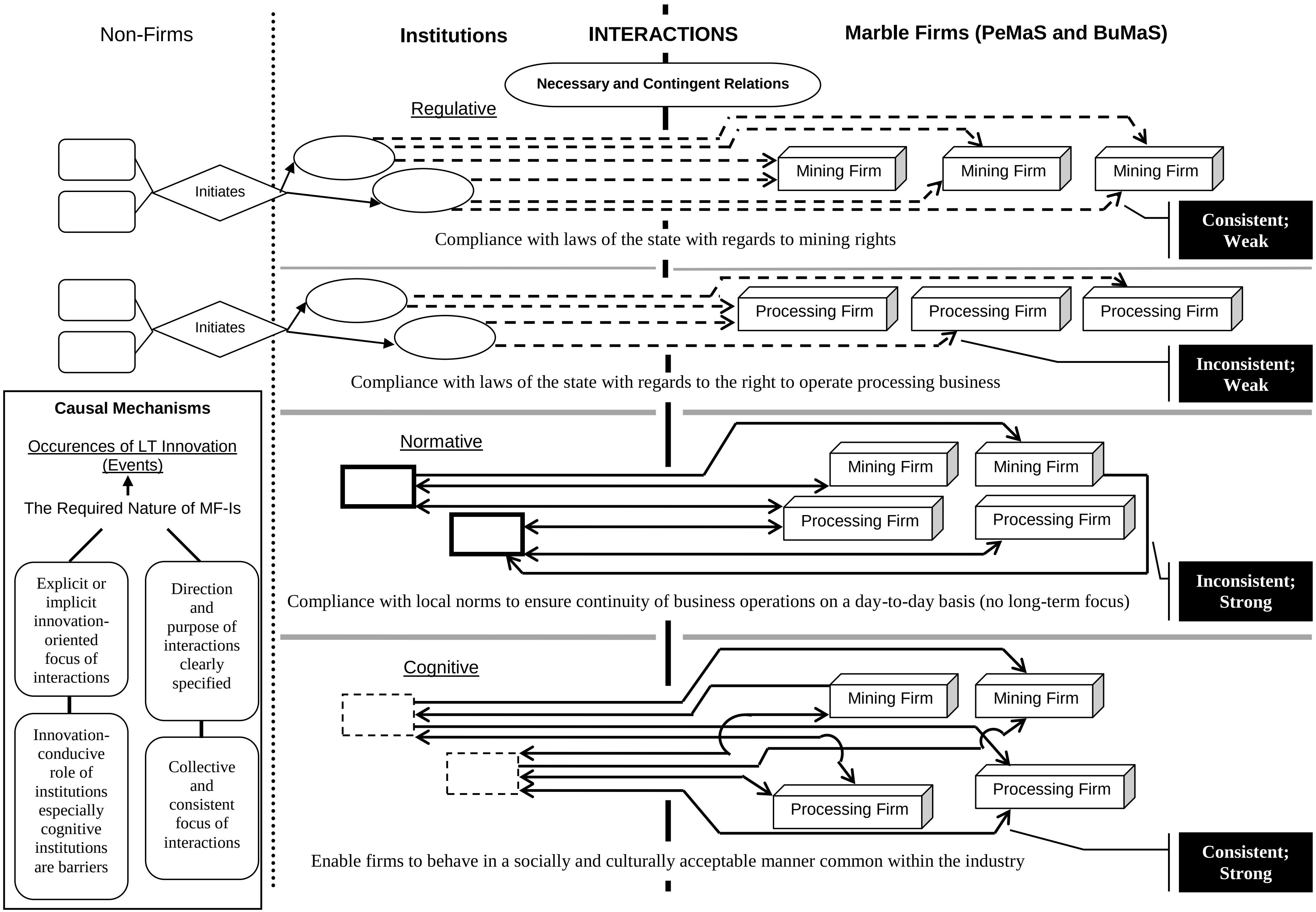


Figure 11.4: Firm-Institution Interactions/Relations and their influence on LT Innovation

11.12. Factors Influencing Lack of LT Innovation (Causal Powers Underlying Stasis)

This section provides a categorized list of factors that result in lack of LT innovation in the two marble sectors. In essence these factors are the causal powers that objects/entities have resulting in a stasis (non-occurrence of LT innovation). The factors have been categorized across two dimensions;

1. Existence of factor at the micro-individual, meso-firm or macro-contextual level
2. Origin of the factor with regards object/entity (element of SSI)

A total of 133 (63 mining + 63 processing + 7 either mining or processing only) factors responsible for lack of LT innovation have been identified. However, since most factors are common for both subsectors they have been presented only once. Those factors present in only one subsector have been marked with either of the two symbols;

- F-M-only (factor for mining subsector only)
- F-P-only (factor for processing subsector only)

Thus the final total is 70 factors of LT innovation (63 for mining and processing combined + 7 for either mining or processing). Figures 11.5, 11.6 and 11.7 below provide a categorized list of causal powers along with their descriptions.

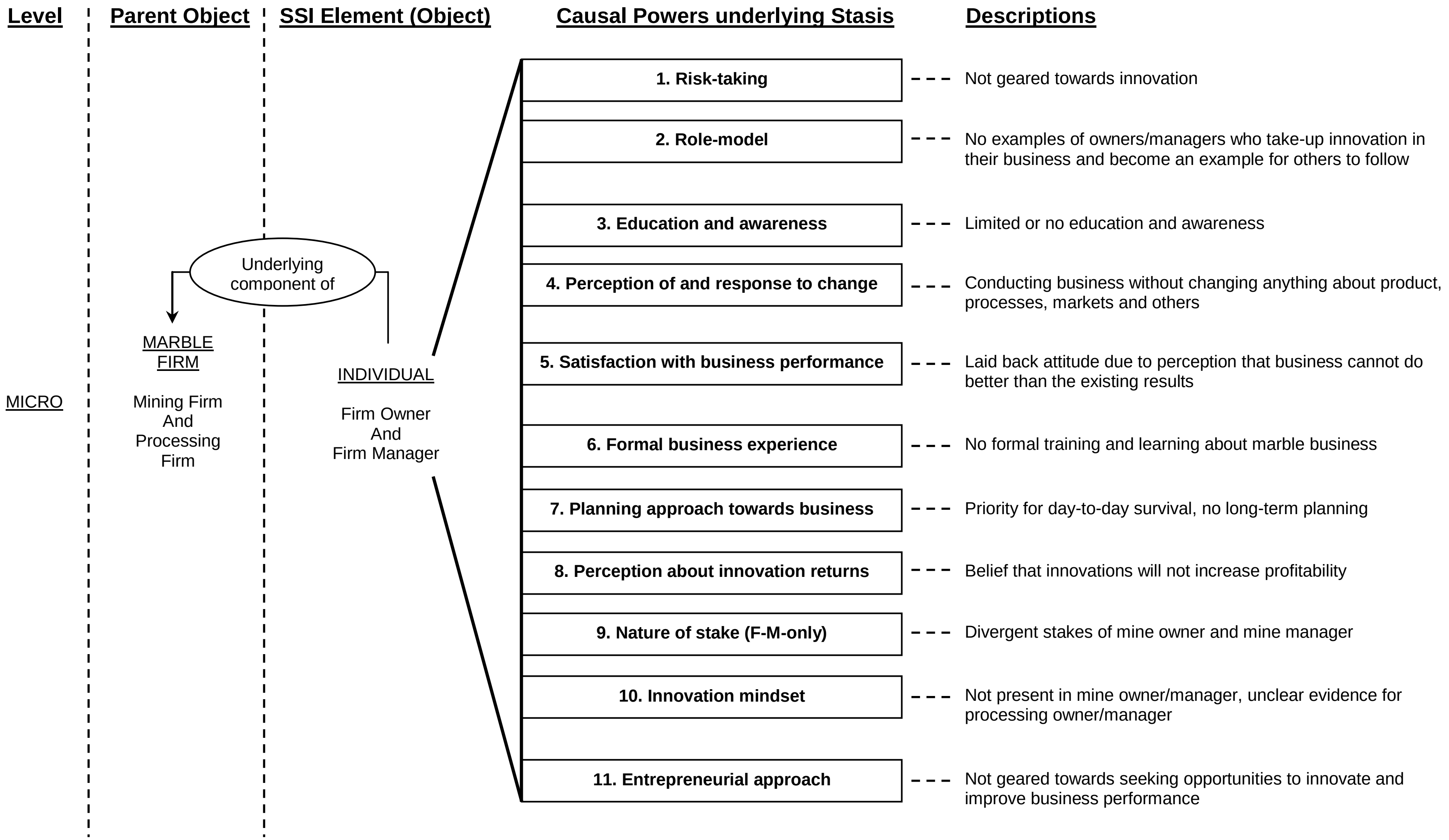


Figure 11.5: Micro-Individual Factors Influencing Non-Occurrence of LT Innovation

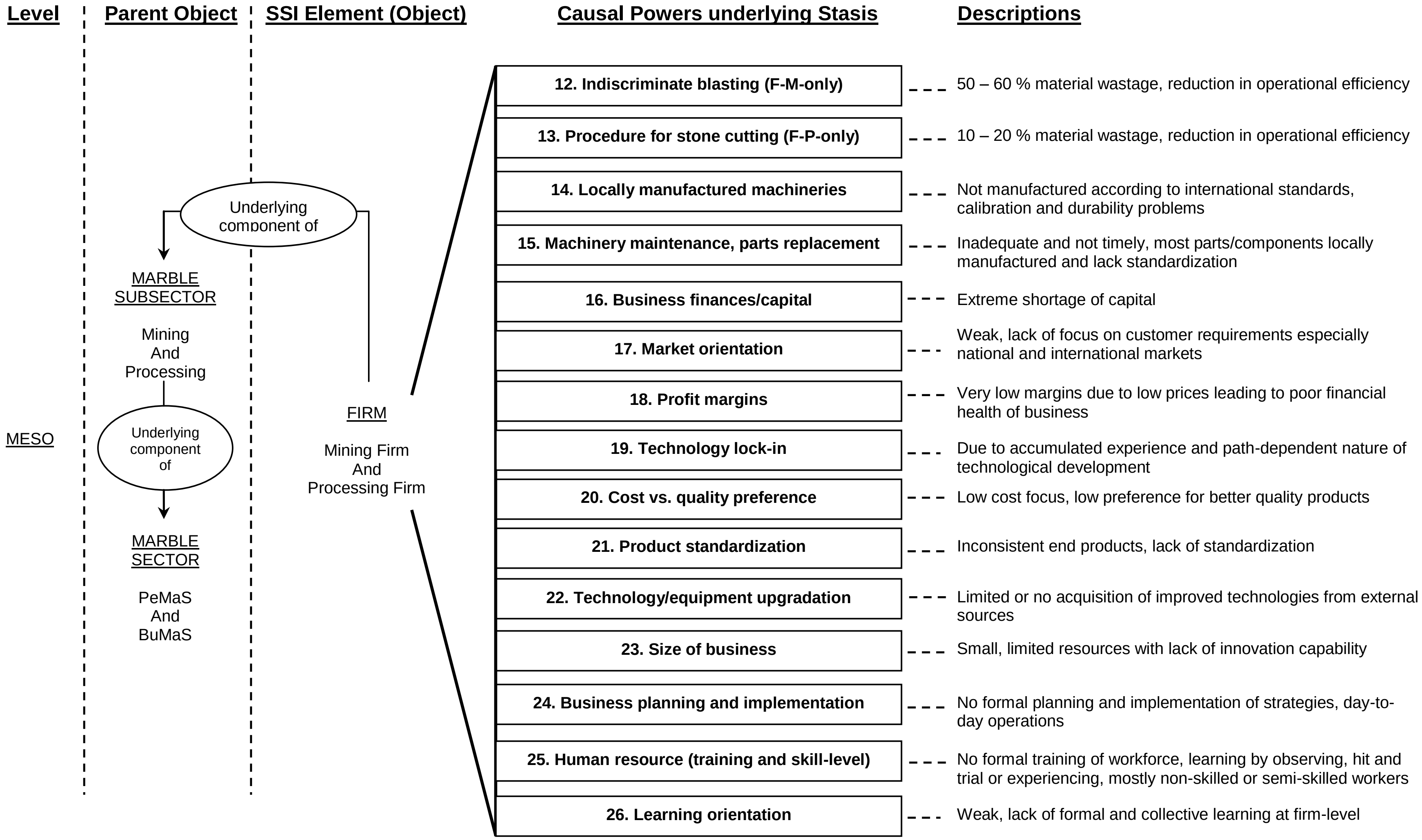


Figure 11.6: Meso-Firm Factors Inlfuencing Non-Occurrence of LT Innovation

Level	Parent Object	SSI Element (Objects)	Causal Powers underlying Stasis	Descriptions
MESO	MARBLE SUBSECTOR Mining And Processing	RAW PRODUCT	**27. Nature of excavated stone (F-P-only)**	Irregularly shaped and with internal cracks
			28. Stone variety	Uniqueness of colour and pattern
			29. Quality of excavated stone (F-P-only)	Extent of impurities/sand and hardness/softness
	MARBLE SECTOR PeMaS And BuMaS	NON-FIRM	**30. Skill of machinery installation experts**	Low, not trained formally, rely on false reputation at times
			31. Business loans from financial institutions	Lack of customized products (loan schemes)
			32. Financial institution's lending procedures	Complex and cumbersome with tough conditions
			33. Influence of transport non-firm (F-P-only)	High shipment costs, adds to overall costs of processing firm
			34. Influence of technology supplier	Strong but present through provision of old technologies, no supply of latest technologies and equipments
			35. Collaboration with support organization	Weak incentives offered to marble firms by support organizations especially those representing government
			36. Involvement of support organization at local level	Low, leading to lack of influence of support organizations representing the government
			37. Knowledge creation/provision by support organization	Low, resulting in marble firms' reliance on old knowledge
			38. Implementation of formal institutions by government	Weak or inconsistent contributing to uncertainty of business environment
			39. Infrastructure support by government	No formal planning and implementation of strategies, day-to-day operations
			40. Association or union of marble firms	No formal training of workforce, learning by observing, hit and trial or experiencing, mostly non-skilled or semi-skilled workers
			41. Overall law and order situation (F-M-only)	Uncertain due to government's weak influence
			42. Influence of middlemen/distributors	Somewhat exploitative, takes bigger chunk of profit

Underlying component of (RAW PRODUCT → MARBLE SUBSECTOR)

Underlying component of (NON-FIRM → MARBLE SUBSECTOR)

Underlying component of (MARBLE SUBSECTOR → MARBLE SECTOR)

Level	Parent Object	SSI Element (Objects)	Causal Powers underlying Stasis	Descriptions
MESO	MARBLE SUBSECTOR Mining And Processing (Underlying component of MARBLE SECTOR PeMaS And BuMaS)	TECHNOLOGY or MACHINERY (Underlying component of MARBLE SUBSECTOR)	**43. Availability (local or imported)**	Locally manufactured machinery more common; offers lesser efficiency and lower quality compared to imported one
			44. Options/features for product design	Local machinery offers lesser design flexibility compared to imported one
			45. Quality and durability of components	Quality of cutters, tips, others affects product quality
		KNOWLEDGE (Underlying component of MARBLE SUBSECTOR)	**46. Knowledge transformation**	Slow or non-existent; lack of new knowledge means lack of improvement in products, processes, others
			47. Knowledge appropriability	Low, firms struggle to derive profits from knowledge as they lack other inputs for example modern technologies
			48. Existing knowledge	Similar utilization by all firms, no differences found
			49. Formal Knowledge	Non-existent
			50. Geographical concentration of knowledge	Higher for mining sub-sector (knowledge improvement more difficult) while comparatively lower for processing sub-sector
			51. Knowledge of international customers' preferences	Not found
		MARKET (Underlying component of MARBLE SUBSECTOR)	**52. Prevalent market scenario**	Distorted (terms of competition unclear) due to presence of non-professionals in the industry
			53. Competition in local and national markets	Predominantly price-based
			54. Accessing national markets	Less common, greater focus on local markets
			55. Accessing international markets	Non-existent
			56. Predominant marketing strategy	Greater supply-push; lesser demand-pull
			57. Competition from parallel markets	Onyx (a soft variety of marble) excavated in southwest region of Baluchistan; market present in southern port city of Karachi
			58. Geographical spread of market	Greater distances between firms and markets especially national and international markets

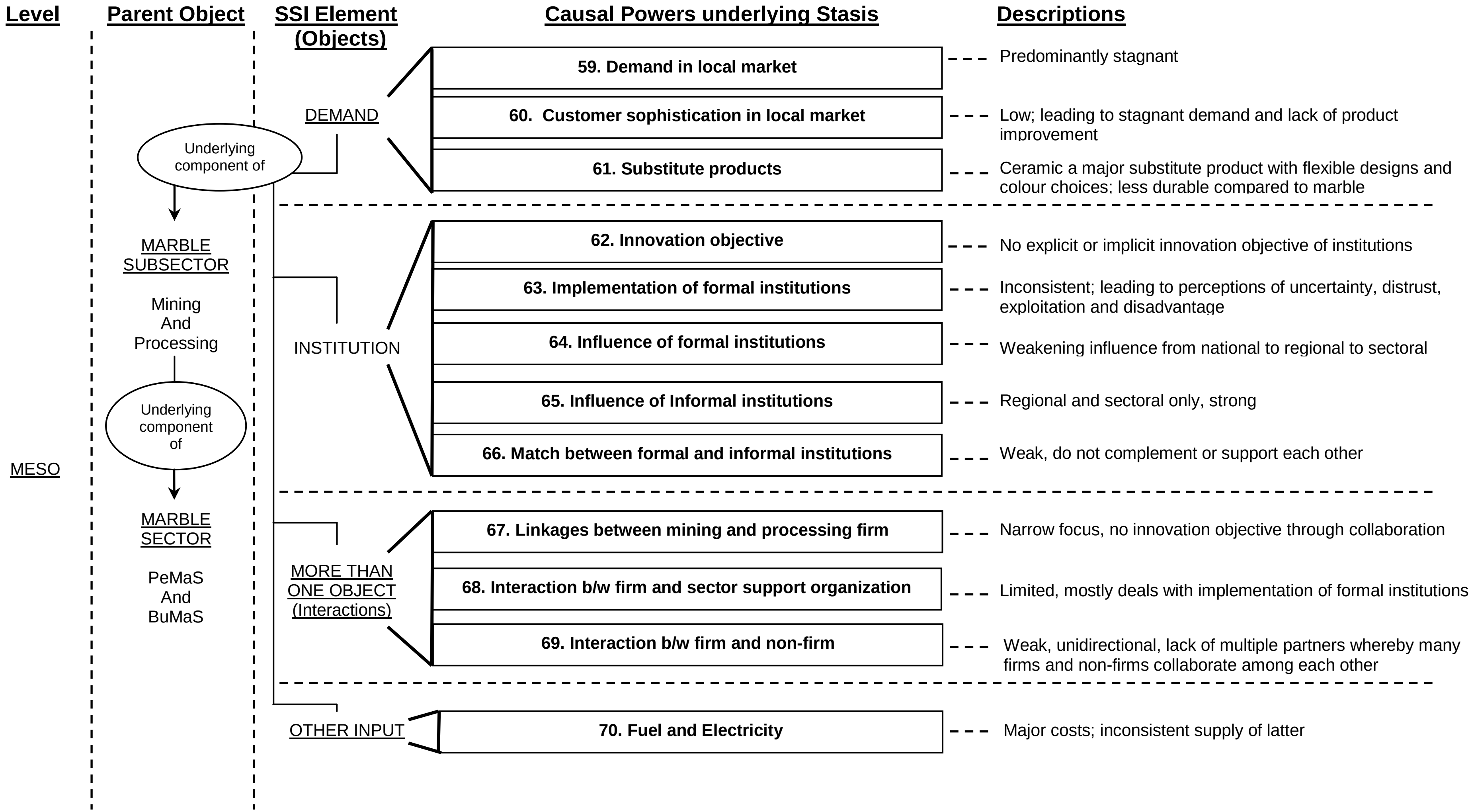


Figure 11.7: Macro-Contextual Factors Influencing Non-Occurrence of LT Innovation

11.13. Relative Importance of Factors (Causal Powers Underlying Stasis)

One objective of Data Collection Phase 2 (Structured Interview and Questionnaire) was to gather data on the relative importance of each factor provided in Figures 11.5 to 11.7. In this regard, respondents were asked to rank the factors applying ordinal scale approach (rank order). Under this approach a factor perceived as not an important influence on LT innovation was ranked '0', the least important was ranked '1' and so on. Rank score for each factor was calculated by determining the number of highest rank that each factor achieved. For example, a rank score of 12 for factor 'A' means that it achieved the highest rank amongst all factors in its category 12 times as a result of respondents' replies.

Table 11.2: Relative Importance of Factors Underlying Lack of LT Innovation

FACTOR NO.	INTERNAL FACTORS (MICRO-INDIVIDUAL)	RANK SCORE
1	Risk-taking	8
2	Role-model	21
3	Education and awareness	15
4	Perception of and response to change	4
5	Satisfaction with business performance	5
6	Formal business experience	3
7	Planning approach towards business	6
8	Perception about innovation returns	9
9	Nature of stake (D-M only)	11
10	Innovation mindset	4
11	Entrepreneurial approach	2
FACTOR NO.	**INTERNAL FACTORS (MESO-FIRM)**	**RANK SCORE**
12	Indiscriminate blasting (D-M only)	17
13	Procedure for stone cutting (D-P only)	12
14	Locally manufactured machineries	8
15	Machinery maintenance (parts replacement)	4
16	Business finances/capital	14
17	Market orientation	5
18	Profit margins	7
19	Technology lock-in	1
20	Cost vs. quality preference	1
21	Product standardization	4
22	Technology/equipment upgradation	4
23	Size of business	2
24	Business planning and implementation	1
25	Human resource (training and skill-level)	3
26	Learning orientation	5
FACTOR NO.	**EXTERNAL FACTORS (MACRO-CONTEXTUAL)**	**RANK**

	SUPPLY-SIDE	SCORE
27	Nature of excavated stone (D-P-only)	12
28	Stone variety	1
29	Quality of excavated stone (D-P-only)	4
30	Skill of machinery installation expert	2
31	Business loans from financial institutions	9
33	Influence of transport non-firm (D-P-only)	1
34	Influence of technology supplier	1
35	Collaboration with support organization	7
36	Involvement of support organization at local level	3
39	Infrastructure support by government	6
43	(Technology) availability (local or imported)	10
44	Options/features for product design	1
45	(Technology) quality and durability of components	3
46	Knowledge transformation	4
47	Knowledge appropriability	5
48	Existing knowledge	2
49	Formal knowledge	2
50	Geographical concentration of knowledge	1
67	Linkages between mining and processing firm	7
70	Fuel and electricity	7
FACTOR NO.	**EXTERNAL FACTORS (MACRO-CONTEXTUAL) DEMAND-SIDE**	**RANK SCORE**
51	Knowledge of international customers' preferences	6
53	Competition in local and national markets	3
54	Accessing national markets	5
55	Accessing international markets	22
56	Predominant marketing strategy	4
57	Competition from parallel markets	12
59	Demand in local market	15
60	Customer sophistication in local market	9
61	Substitute product	12
FACTOR NO.	**EXTERNAL FACTORS (MACRO-CONTEXTUAL) OTHERS**	**RANK SCORE**
32	Financial institution's lending procedures	7
37	Knowledge creation/provision by support organization	16
38	Implementation of formal institutions by government	10
40	Association or union of marble firms	2
41	Overall law and order situation (D-M-only)	3
42	Influence of middlemen/distributors	1
52	Prevalent market scenario	4
58	Geographical spread of market	5
62	(Institution) Innovation objective	5
63	Implementation of formal institutions	8
64	Influence of formal institutions	11
65	Influence of informal institutions	8
66	Match between formal and informal institutions	4
68	Interaction between firm and sector support organization	3

69	Interaction between firm and non-firm	1

11.14. Causal Powers (Extant but Latent) Underlying LT Innovation

Taking influence from the notion of 'stratified ontology' presented by critical realists (and discussed in Chapters 2 and 7) the causal powers of objects discussed in this section are implied to be present in the 'real' characterized by structures and mechanisms. The 'actual' comprises of processes amd events (occurrences of LT innovation) while the 'empirical' (that part of the 'real' and 'actual' which is within our conceptual domain) helps in conceptualizing and identifying these causal powers. It is important to note that these causal powers are extant but latent due to the absence of causal mechanisms and necessary and contingent relations provided in Chapters 10 and 11 as a result of which LT innovation does not occur in most instances in PeMaS and BuMaS.

11.14.1. Causal Powers (Micro-Individual Level)

Deriving from Figures 11.1 and 11.5, Table 11.2, Chapter 10 section 10.2.3 and Chapter 11 section 11.3, it is evident that individuals (firm owners and managers) who demonstrate risk-taking behaviour with an entrepreneurial approach geared towards innovation have the power to influence LT innovation within marble firms. Individuals as objects have liabilities that can be characterized as susceptibility to the influence of other objects. Findings reveal that owners and managers are influenced by each other whereby an individual who has been successful at LT innovation in his business and has derived benefits for his business can serve as a role model to influence other individuals. Morever, owners and managers responsible for the same firm who have a convergence of stake in their business and seek similar objective of profit maximization through product and process improvements and seeking new markets are more likely to influence occurrence of LT innovation by influencing each other. This convergence of stake also means they are able to proactively establish multipartner relationships with similar non-firms including suppliers, middlemen and sector support organizations that are explicitly innovation-oriented.

11.14.2. Causal Powers (Meso-Firm Level)

Deriving from Figures 11.1 and 11.6, Table 11.2, Chapter 10 section 10.2.6 and Chapter 11 section 11.3, it is evident that the use of updated technologies by mining firms (process innovation) that allows for dimensional cutting (limited wastage and no internal cracks) has the power to result in innovation in the raw excavated stone during the mining phase. Similarly the use of updated equipment – processing innovation – (scientifically calibrated and installed machineries and high quality cutters and blades) on this improved raw stone by the processing firms will lead to product innovation (better quality semi-finished and finished products). Processing firms have liabilities whereby they are susceptible to the influence of the raw material (raw stone) supplied by the mining firms. While the relation between a mining firm and a processing firm is necessary (both cannot exist without each other), the relation between the firms' use of updated mining/processing technologies and LT innovation is contingent (one is influenced by the other).

Occurrences of LT innovation amongst some processing firms found from the empirical data suggest presence of mechanisms actively causing innovation. Findings reveal that firms' learning orientation is influenced by their market orientation towards the national market. This has the power to influence firms to improve or upgrade equipments (process innovation), design and manufacture new products (product innovation) and target new markets (marketing innovation) in regions of Pakistan other than the local or nearby cities including Peshawar and Buner. The relation among the marble firms' market orientation, learning orientation and LT innovation is contingent. Marble firms with a greater focus on quality rather than cost, financial strength (business capital) to invest in modern technologies/equipments, better trained and skilled human resource emanating from a strong learnining orientation which in turn is influenced by a strong market orientation especially towards international markets will lead to occurrences of LT innovation.

11.14.3. Causal Powers (Macro-Contextual Level – Non-Firms)

Deriving from Figures 11.1 and 11.7, Table 11.2, Chapter 10 section 10.3.4 and Chapter 11 section 11.3, it is evident that suppliers who specialize in the provision of industry-specific upgraded technologies/equipments and accompanying services (equipment installation and maintenance on scientific basis) have the power to influence marble firms to innovate. The relation between marble firms and technology suppliers is necessary as both are dependent on one another. Suppliers have liabilities whereby they are susceptible to the influence of marble firms' buying power and needs for technologies. Moreover, they are susceptible to the availability of upgraded technologies/equipments and the ease of its availability from the national/international markets.

Another key non-firm group is the sector support organizations. Organizations that have a strong presence and frequent interactions at the local level (where marble firms are operating) and engage in innovation-oriented multi-partner relations (for example involving mining firms, processing firms and support organization) through sharing of knowledge, expertise and resources have the power to influence marble firms and result in occurrence of LT innovation. However, these sector support organizations have liabilities in terms of being susceptible to the influence of the policy priorities and incentives offered by the government. The relations between marble firms and sector support organizations are predominantly contingent whereby firms can be influenced by these organizations.

11.14.4. Causal Powers (Macro-Contextual Level – Other Sectoral Elements)

In order to identify the causal powers underlyling LT innovation that are associated with knowledgebase/technologies and learning processes findings presented in Figures 11.2 and 11.7, Table 11.2, Chapter 10 sections 10.4 and 10.5 and Chapter 11 sections 11.5 and 11.7 are useful. Formal knowledge (especially connected with new technologies) provided to marble firms from external sources and acquired and adapted through formal learning processes has the power to lead to LT innovation in PeMaS and BuMaS. The key influence in this regard is the role of non-firms especially sector support organizations in facilitating access to and adoption of this formal knowledge and help firms free themselves from the technology and knowledge lock-in that is currently prevalent. Easy availability of new knowledge will also increase the likelihood of marble firms interacting with this new knowledge. Knowledgebase and technologies in the sector have liabilities and are susceptible to the actions of non-firms particularly sector support organizations and the prevalence of formal learning processes in the marble sector and amongst firms. Relations between knowledgebase/technologies and firms are contingent because the former can influence the latter with regards to LT innovation. Same is the case for the relation between learning processes and firms.

The causal powers underlying LT innovation that are linked with demand can be derived from the findings presented in Figures 11.3 and 11.7, Table 11.2, Chapter 10 section 10.6 and Chapter 11 section 11.9. Demand connected with international markets (new markets) has the power to influence marble firms to innovate. However, identification of such demand has liabilities in terms of being susceptible to the support provided by non-firms (especially sector support organizations) that can help in identifying international markets (international customers), assessing their needs and serve as a 'bridge' between them and marble firms. Applying a 'demand pull' strategy is the key whereby multiple partners (firms and non-firms) ensure its implementation through a strong market orientation (underscored by a proactive engagement with international customers). As the firms start addressing the international demand through innovative products, the availability of these improved products also has the power to influence local and national customers. Two evidences of this can be identified for the stasis. Substitute products like ceramics are currently in greater demand compared to marble as they address the quality concerns of local/national customers better. Similarly, innovative marble products (with better quality, designs and finishing) from China are becoming popular in the local/national markets. This suggests the presence of latent causal powers associated with demand that can lead to LT innovation in PeMaS and BuMaS. The relation between demand and firms is essentially contingent as the former can influence firms to go for LT innovation.

The causal powers underlying LT innovation that are linked with institutions can be derived from the findings presented in Figures 11.4 and 11.7, Chapter 10 section 10.7 and Chapter 11 section 11.11. Formal institutions implemented across the board for all firms that encourage them to innovate or have an innovation objective (such as tax breaks and credit incentives for firms that install new equipments and/or produce new/improved products for new markets) have the power to influence low-tech innovation. However, these formal institutions have liabilities in terms of being susceptible to the influence of the government and its concerned departments. These departments will need to ensure that policies and incentives offered with regards to innovation are implemented at the sectoral and regional level rather than remaining visible only at the national level. Implementation of formal institutions in this manner also has the power to influence cognitive institutions including marble firms' trust over the authorities, strengthening of a sense of support by the government amongst firms and creation of role models (entrepreneurs and businesses who achieve greater success and profits by being innovative). Consequently, such cognitive institutions have the power to influence innovation amongst firms in PeMaS and BuMaS. The relation between formal institutions and firms is contingent as the former influences the latter to innovate. A similar scenario is prevalent for the relation between cognitive institutions and firms and formal institutions and cognitive institutions.

11.15. Conclusion

This chapter presented research outcomes about the structure of marble SSI by conceptualizing interactions among SSI elements as necessary and contingent relations from critical realist perspective. Discussions focused on causal powers of stasis (lack of LT innovation). Discussions also focused on causal powers, liabilities and necessary or contingent relations related to the occurrence of LT innovation. Outcomes suggest that no innovation objective of interactions, weak interactions between firms and sector support organizations, limited and informal interactions between firms and knowledge and firms and learning processes, inability of firm-demand interactions to trigger new demand and lack of direction and purpose of firm-institution interactions are some of the reasons underlying lack of LT innovation. A total of 133 factors (causal powers of objects) underlying lack of LT innovation were identified that were grouped together into 70 factors. Lack of innovation role models, indiscriminate blasting, problems with excavated stone, low quality of available technology, non-existent access to international markets and weak knowledge creation and provision role of support organizations emerge as some of the most influential factors responsible for the stasis (non-occurrence of LT innovation).

Chapter Twelve

CONCLUSIONS AND RECOMMENDATIONS

12.1. Introduction

The purpose of this chapter is to present a summary of the research in terms of outcomes and overall contributions. Next, recommendations for future work are provided across two dimensions. These include implications for researchers and for practitioners.

12.2. Summary of Research Outcomes

The research aim, objectives (ROs) and questions (RQs) were presented in Chapters 1 and 6. Outcomes for RO1 suggested that the products in both cases (PeMaS and BuMaS) are non-complex having multiple dimensions. The production processes, linear in nature, comprise of a series of steps that can be divided into two interconnected phases, mining phase and processing phase. Marble firms have a predominant focus on local markets and no presence in international markets. Occurrences of incremental LT innovation, though limited, were found.

Outcomes for RO2 explained why LT innovation is limited. Reasons included the divergent roles of individuals (owner and manager) for mining firm. For processing firm three variants of individual roles were found. Firms had a low-cost focus characterized by use of low-technologies, financial constraints and untrained and unskilled/semi-skilled human resource. There was a strong dependence on non-firms including suppliers (for new technologies that are unavailable) and middlemen/distributors (for sales and market access). Sector support organizations play a weak role contributing to firms' inability to innovate. Both sectors were characterized by informal knowledge resulting from informal learning processes and weak learning orientation amongst firms. Knowledge, technology and demand changes were very slow to occur. LT innovation was also negatively influenced by strong normative and cognitive institutions and a weak match between formal and informal institutions.

Outcomes for RO3 further explained why LT innovation was limited by revealing that interactions/relations between sectoral elements did not have an explicit or implicit innovation objective. Firm-non-firm interactions were limited in scope lacking multiple partners. Firm's interactions with knowledge, technologies and learning processes were weak and infrequent. Similarly interactions with market or demand did not result in creation of new demand due to greater focus on supply-push. Firm-institution interactions suffered from lack of direction and collective and consistent focus on innovation. A total of 133 factors categorized into 70 determinants of LT innovation were found.

12.3. Overall Contributions

Although this study revealed an emerging trend over the last few years concerning research and publications on LT (Chapter 5), the literature review as a whole identified a number of gaps with regards to the existing knowledge of LT innovation. Provided below are contributions of this research that help address these gaps;

12.3.1. Reflecting on the Paradigmatic Influence

As demonstrated in Chapter 5, most research on LT/LMT innovation draws influence from positivist paradigms (67% of reviewed work) followed by phenomenological approaches (20% studies). Attention to use of mixed methods and alternative paradigms like critical realism is almost non-existent in innovation research. This study offers a rare but much needed critical realist perspective of LT innovation through use of mixed methods and continuous and consistent reference to referents (owners and managers of marble firms) during data collection and analysis procedures. As a result, the tenets of critical realism have been integrated with empirical work which is one of the rare contributions to our understanding of the paradigm in innovation research.

This research offers a unique and non-existent perspective of SSI while taking influence from critical realism. Events (conceptualized as occurrences of LT innovation) and objects/entities (conceptualized as elements of marble SSI) have been explained. To provide a deeper understanding, objects have been investigated in terms of their underlying structures or as objects within objects. Other key components of critical realist thought include causal powers of stasis (conceptualized as factors influencing lack of LT innovation), causal powers that can lead to LT innovation and necessary and contingent relations among objects (conceptualized as structure of SSI). Outcomes regarding the above-mentioned components of critical realism help present a much needed understanding of causal mechanisms (ways in which objects cause events – the central concern of critical realism) provided in this research. It is hoped that this study will serve as a catalyst to making critical realism a more mainstream paradigm influencing innovation research.

Drawing influence from Critical Realism this research has identified the extant causal powers present in the 'real' within SSI that can lead to LT innovation. However, these powers are latent because of the absence of contingent relations or mechanisms identified by this research that underlie the event of LT innovation. By applying concepts of critical realism in this way the research makes a unique and rare contribution to our understanding of SSI and helps understand why LT innovation is so limited within the marble sector. Previous research work focused on understanding the dynamics of LT innovation from various perspectives that were narrow in focus. However, this research not only provides an all-encompassing understanding of LT innovation but also offers a previously non-existent perspective of causal powers and mechanisms of the stasis (where LT innovation is very limited in the marble sectors). Also it provides an understanding of the causal powers and mechanisms within the marble SSI that can lead to LT innovation.

12.3.2. Contributions to Sectoral System of Innovation Approach

This research addressed the lack of an all-encompassing and exhaustive perspective of LT innovation that recognizes the systemic nature of innovation. A vast range of factors internal and external to firms were considered that influence firm-oriented LT innovation as a result of their interplay. By integrating the conceptual and theoretical aspects of system of innovation (SI) particularly its variant sectoral system of innovation (SSI) with empirical evidence, this research not only enhanced our understanding of SSI beyond a mere conceptual approach but also provided new perspectives to the approach. Provided below are specific contributions;

- This research identifies the need to recognize low-tech SSI as a distinct variant of SSI approach in future keeping in view its peculiar characteristics. These characteristics include the distinctly different nature of technologies (characterized by zero or very limited R&D), interactions among elements (particularly firm-non-firm interactions) and LT-SSI's peculiar institutional structure (having the interplay of weak regulative institutions with strong normative and cognitive institutions).

- Despite the existing research on LT innovation and an emerging research trend focusing on this form of innovation, a multi-level approach has not been used to understand LT innovation in a sector. This study applies the micro-meso-macro (individual-firm-contextual) framework to complement SSI for the first time. By cutting across boundaries of the three levels of analysis this thesis offers a powerful explanation of the complex interplay of SSI elements (sectoral structure) influencing LT innovation.

- A key concern addressed as a result of applying the micro-meso-macro framework in this research is the need to understand the influence of individuals (especially firm owners and managers) on LT innovation. This is particularly vital as studying the influence of individual on LT innovation has been an ignored area in research (Chapter 5). The individual is particularly important since most LT firms are small enterprises where owners and managers have a key influential role in terms of how a firm behaves. Consequently, this research identifies the need to recognize individual as a distinctly separate element and not ignored by only focusing on firm as a collective entity.

- Compared to firms that are the central element, non-firms have a secondary contextual role within traditional SSI approach. Because LT firms are characterized by weak internal capabilities, non-firms' support to overcome these weaknesses in order for firms to innovate is the key. Consequently, rather than being a somewhat peripheral contextual element within traditional SSI, non-firms need to be considered as a more central and influential element within LT-SSI that are at par with firms.

- Research on the role of learning processes and demand as elements within SSI is very limited with regards to LT innovation. This research addresses these gaps. Moreover it points out that unless demand conditions within a sector change, efforts to encourage LT firms to innovate will not succeed. Compared to LT firms, it is the non-firms that need to be treated as a sectoral element more closely associated with demand within LT-SSI. This is because non-firms need to have a more proactive role as an element within SSI to help identify new demand and support firms to fulfil this new demand.

- This research addresses the need to determine specific factors influencing specific types of innovation. For the first time a unique set of seventy factors (or causal powers of the stasis) have been revealed that help explain why LT innovation is not occurring in the marble industry. Moreover, these factors have been categorized and presented across three dimensions;
    1. Micro-individual, meso-firm and macro-contextual origin of the factor
    2. Object or element origin of the factor within an SSI
    3. Relative importance or influence of the factor on LT innovation within an SSI

- This research focuses on an often ignored developing country context as compared to the more common developed country contexts. Despite differences emanating from contextual influences, outcomes reveal that LT innovation in a particular sector (marble) of a developing country (Pakistan) demonstrates many characteristics similar to LT innovations in sectors in developed economies that were revealed during literature review. Two examples are LT sectors' adherence to supplier-dominated taxonomy (Pavit, 1984) and dominant presence of small firms and incremental nature of innovation (Hirsch-Kreinsen, 2008a). This gives greater credence to the existing theories and perspectives on LT innovation by demonstrating their wider applicability to not just developed country contexts but developing countries too.

12.4. Limitations of the Study

Methodologically the research had a rigorous and robust design as explained in Chapters 2, 7 and 8. However, like any other research work, there are limitations that need to be acknowledged;

- An important limitation from a critical realist perspective was the difficulty in determining whether the metaphysical ontology of LT innovation revealed through this research is the actual truth (the 'real') or not. Even though this limitation remains, influence was drawn from Sayer (1992, pp. 7-8) (Chapter 2) who suggests that while there is an external reality independent of the human mind, it is also resistant to it. Pointing to the limitations of our conceptual resources he argues that rather than worrying about the 'absolute truth' critical realists should focus on 'epistemic gain' about truth no matter how limited that might be.

- The second phase of data collection involved 18 structured interviews with mining and 70 questionnaires with processing firms. More data could have been collected to provide greater richness to the study. However, financial limitations, limited resources and time constraints coupled with high levels of risks associated with poor law and order situation in the region were major limitations. Consequently, maximum caution was exercised to limit travel within these areas and contact a practically feasible number of respondents.

- In addition to interview and questionnaire data collection methods such as focus group discussions and observations could have been applied. Both could provide additional insights about LT innovation. However, the former was avoided due to practical problems and financial constraints associated with gathering respondents from far-flung areas. Similarly, the latter method was not used because the research was concerned with firm-oriented LT innovation whereby the individual (respondent) was the focal point of all data collection activities. Using observations carried the risk of inducing researcher bias.

- Due to time constraints associated with timely completion of a doctoral degree, this research was essentially cross-sectional in nature. In order to capture the transformational and evolutionary aspect of an SSI, a longitudinal study can be undertaken in future.

12.5. Recommendations for Future Work

Outcomes from this research help develop a portfolio of recommendations. They have been categorized across two dimensions discussed below;

12.5.1. Implications for Researchers

1. LT innovation in a developing country and particular sector context demonstrates many characteristics similar to LT innovations in sectors in developed countries. However, it is important to avoid generalizations as the particular sectoral context within which LT firms operate needs to be investigated to better understand the complexity of this form of innovation.

2. Without due attention to contextual details, any policy or strategic initiatives to encourage LT firms to innovate are likely to fail. Past initiatives by the Government of Pakistan through sector support organizations failed to achieve desired results for the marble industry because they failed to recognize the systemic and non-sequential nature of LT innovation (Rothwell, 1992). As demonstrated by this

research, LT innovation is linked to a complex interplay of multiple sectoral elements in the form of interactions between or among them (sectoral structure).

3. There is a need to revisit our priorities regarding research on high-tech and low-tech innovation. Our world needs both and not just HT. Evidence that this is happening is the increase in research on LT innovation (demonstrated in Chapter 5) over the last few years. However, whether this phenomenon will lead to a balance between our priorities for HT and LT or not remains to be seen.

4. While this research exclusively focuses on LT innovation, there is a need to undertake further empirical case studies in order to generate a consensus amongst the research community regarding how this often ignored form of innovation occurs and how it can be managed within a system of innovation.

5. Seventy factors (causal powers of the stasis) that explain the lack of LT innovation were revealed by this study. Moreover, causal powers and mechanisms that underlie the occurrence of LT innovation have also been provided. However, further research is needed to develop a consensus around the key causal powers and mechanisms that can lead to LT innovation. Also, unless further attempts are made to find out and categorize the causal powers for particular types of innovation (including low-tech) we will not be able to draw the much needed understanding of the differences between LT innovation (where R&D might not be occurring at all) and other forms of innovation (where R&D is present) such as LMT and HT.

6. While this research addresses the lack of research on influence of the individual on innovation, there is a need for future research work to further address the lack of empirical work in this regard. This can be possible by treating individual as a distinct element within SSI and not ignored by focusing on the firm only.

7. Considerable research has been carried out in Europe and USA. However, more researchers need to come to the forefront and take up work on innovation in sectors/industries located in developing countries and poor regions of the world characterized by greater presence of LT and LMT sectors.

8. If critical realism has to develop as a more mainstream alternative to the two predominant paradigm choices, positivism and phenomenology, more empirical work will need to draw influence from it in the future. There is a need for the research community to revisit its foregone ontological and epistemological conclusions about the world. Critical realism challenges these assumptions by espousing the need to separate objectivist ontology from a subjectivist epistemology.

12.5.2. Implications for Practitioners: Initiating and Managing LT Innovation

9. Despite the apparent non-complex nature of products in an LT sector, this study found that these products are a result of a two-phased (mining and processing) production process sequential in nature where technologies play a central role. It is important that future initiatives launched to encourage marble firms to innovate consider opportunities for innovation at every step of this two-phased production process. Both phases just like both subsectors need to be recognized as inseparable with new technologies playing a central role every step of the way unlike previous half-hearted government initiatives that focused on either the mining subsector or processing subsector or a few firms only.

10. This research found that sector support organizations (especially SMEDA and PASDEC) play a weak role in the industry evident from their limited interactions with the firms and other non-firms. This is demonstrative of the low priority given by the government to improvement of the industry. There is a need for these organizations to

take up a more proactive role and help link up marble firms with the international markets and customers (no evidence of any such initiative was found). Support needs to come from other non-firm groups like technology suppliers, middlemen/distributors and financial institutions which in turn also need government incentives. Only then firms will demonstrate a willingness to take risks and invest in technologies, knowledge and learning in order to address this international demand for better products. Presence of better quality marble products will also trigger new customer needs in the local and national markets once a better alternative to some of the existing substitute products like ceramics is offered.

11. One outcome of this research was that marble firms' focus on producing and selling products in the local markets has led to a 'laid-back' attitude amongst firm owners and managers. Firms continue to rely on the same outdated knowledge and technologies as was the case 20 – 30 years ago as this is all they see happening around them. Role-models (one of the most important determinants of LT innovation revealed in Chapter 11) need to be created from within the local people whereby individual businessmen take up innovation as a business activity and derive additional profits to serve as inspiration. This is in line with a strong local collectivist culture whereby imitation in terms of business activities is a strong cognitive institution (Chapters 10).

12. A fundamental problem identified in the marble industry is lack of innovation-specific institutions particularly regulative institutions. Instead, inconsistent and poorly managed implementation of some regulative institutions has led to strengthening of cognitive institutions amongst firms (a consequence of firm-institution interactions) including sense of disadvantage, helplessness and exploitation as well as distrust of the government. Regulative institutions need to be revised by the government to include for example, tax breaks, reduced electricity tariffs, mining license concessions and subsidies on inputs. Only then the negative effects of cognitive institutions can be countered

convincing individuals and firms to take up LT innovation as a core business activity.

12.6. Conclusion

This chapter presented a summary of the research in terms of outcomes and overall contributions followed by recommendations for future work.

APPENDIX I

Semi-Structured In-Depth Interview (Firms and Non-Firms)

List of Questions

- What kinds of products are produced by marble the firm? Explain **Probe further*
- What kinds of production processes are in place at the firm? Explain in terms of phases of production and nature of technologies **Probe further*
- What kind of market do firms operate in? How do they address supply and demand issues? What are the firms' marketing practices? Explain **Probe further*
- What is the existing organizational structure at firms? Explain **Probe further*
- What kind of innovation have you tried or observed? This includes product, process, marketing and organizational innovation. Explain **Probe further*
- What is the nature of knowledge and learning processes in the industry? **Probe further*
- Explain the kinds of resources that are being deployed in marble firms? For example, finances, human resource (worker skills, training), technologies/equipments and others **Probe further*
- How would you describe your or other owners/managers' role and approach towards the business? Explain **Probe further*
- What is the role of the government, its departments and sector support organizations regarding the marble sector? Explain **Probe further*
- What is the role of suppliers, middlemen/distributors? Explain **Probe further*
- Share your experience as a stakeholder in the marble industry? **Probe further*
- Elaborate on problems that firms and the marble industry in general are currently facing? **Probe further*
- Elaborate on the factors that in your view are responsible for lack of innovation in the marble sector? **Probe further*

APPENDIX II

STRUCTURED INTERVIEW– *(Marble Mining Unit)*

FIRM INFORMATION

(a) Firm No. _____ (b) Names/Types of Products: ________________________________

(c) Machinery/Equipment in the Factory (Quantity & Name): ________________________________

(d) How long has the business been operational (Years): _____ (e) No. of Employees: ______

(f) Encircle Correct Option:

f1. Owner & Manager are same *f2. Owner & Manager are separate* *f3. Owner & Manager both operate the business*

(g) Respondent's (Owner or Manager) Experience in Marble Business: _______ years

(h) Factory Location: ________________ (i) Markets for Products: ______________________________

Enumerator Name: ____________________

1A: Excavated marble stone and the processes used to excavate it need improvement

a. YES b. NO c. I AM NOT SURE

1B: Which innovation have you tried in your business?

Product/Market/Organization	Mining Process
a. Introduced a new or rare variety of marble b. Sold my product in a completely new market where I did not sell before c. Made changes to the firm's organizational structure (hire better employees, got rid of old ones, improved accounting/financial or other procedures etc.) d. I have been selling the same product in the same market to the same customers If a, b and/or c please describe below which new variety or new market or nature of organizational change; ________________________________ ________________________________	a. Improved mining process in terms of updating existing machinery or technology b. Introduced completely new mining process such as purchased, installed and used new mining equipment different from one used previously c. I did not innovate & have been applying same mining processes using same technology If a and/or b please describe below the nature of process improvement, name of new machinery or equipment etc. ________________________________ ________________________________

1C: On a scale of 1 to 5, please select level of innovation you have carried out in your business?

1 ------ 2 ------ 3 ------ 4 ------ 5

(No Innovation/Improvement) (Improved existing product/process/organization) (Introduced new product/process or entered new market)

2A: If at all, you have introduced a new or rare marble variety or installed new or better mining equipment or tried to access new markets for your products or improve your business in any form, who/what was the main influencer in this regard? *(If needed, the respondent needs to be reminded about any recent improvement or anything new he has tried in his business that he can recall and provide reason for undertaking it)*

2B: Describe how you were influenced? *(This can be a short narration of what had happened that resulted in improvement that the respondent introduced in his business)*

Interactions between Firm and Non-Firms:

3A: Which individuals or organizations do you mostly deal with on a routine basis for running your mining business (fellow marble mine owners/managers, lease owner, machinery/equipment suppliers, middlemen/distributors/transporters, customers, government departments, others)? (List or name individuals and organizations)

3B: What are these interactions about? (Describe the purposes/reasons for interacting with individuals/organizations identified in Q. 3A.)

Interactions between Firm and Knowledge/Technologies:

4A: Do you think that you have learnt something new or gained additional knowledge and experience about marble mining with the passage of time and this process continues even today?

4B: Give some examples of knowledge/experience you have gained? *(For example knowledge about new marble varieties, new/improved mining processes, markets, managing business in general, any other technical or business knowhow)*

4C: What was the source of this knowledge/experience? *(Where from did the respondent gain this new knowledge/experience?)*

4D: How and from where do you acquire machineries/technologies for your business?

4E: How do your workers learn to operate a machinery/equipment?

Interactions between Firm and Institutions

5A: How do you learn about rules/procedures/norms/practices required to run your marble mining business?

5B1: Give examples of rules/procedures/norms/practices for operating a marble mine that are formal (like imposed by government departments/agencies)?

5B2: Give examples of rules/procedures/norms/practices for operating a marble mine that are informal (like influenced by customs/practices common in the region)?

5C: Describe how these rules/procedures/practices facilitate you or create hurdles for you in terms of improving your business? *(The respondent can give some specific examples)*

6. Which of the following activities/factors influence or can influence a marble enterprise not to innovate in terms of products, processes, marketing and others?

Rank in order of preference:

- 0 if not considered an influential factor by respondent
- 1 for least influential and so on
- Highest number for most influential factor

ACTIVITIES/FACTORS	
Internal Factors	RANK
Business owner unwilling to take risks	______
Examples of new/improved excavation methods set by fellow marble businessmen in my area do not exist for me to follow	______
Wastage of stone during blasting process results in higher costs and poor quality	______
Inappropriate machinery/equipment maintenance and replacement of parts	______
Machinery/equipment used in mining is locally manufactured and of poor quality	______
Lack of business finances & low profit margins	______
Small size of business	______
Lack of skill and formal training of workers and machine operators	______
Lack of education/awareness amongst marble mine owner/manager	______
Lack of owner's formal business experience	______
Lack of proper business planning and implementation	______
Reluctance of marble businessman to adopt change or new technology	______

Separation of mine lease holder from mine operator/manager resulting in lack of ownership	______
The product I as a businessman currently produce sells so no need for me to change or improve anything	______
I am more concerned about day-to-day survival rather than investing in any kind of innovation	______
Improving products/processes will not earn me more revenues so no advantage investing in new/improved technology	______
Any other: ____________________	______
Contextual Factors (Supply-Side)	RANK
Non-availability of unique or better quality marble varieties from mining area	______
Weak linkages with marble processing units and businessmen in terms of nature/quality of stone required and continuous demand of stone	______
Non-availability of improved locally manufactured & better priced machinery in the local market	______
Non-availability of imported even though expensive marble machinery in the local market	______
Non-provision of leasing facility on easy terms & conditions through government/banks/PASDEC to acquire marble machinery (be it local or imported)	______
Lack of experienced/trained technicians who can install marble equipment in mining area properly and professionally	______
Inadequate infrastructure support such as lack of electricity for operating heavy machinery and lack of proper roads for transporting marble blocks	______
High cost of fuel to operate mining equipment	______
Any other: ____________________	______
Contextual Factors (Demand-Side)	
Limited or no opportunity to access national markets like Punjab, Sindh especially Karachi	______
Lack of direct access to international markets of the world	______
Demand for marble products in local market has remained stagnant/unchanging so I cannot improve current products or offer new ones because no one buys/demands it	______
Greater demand for marble from China, Baluchistan and other areas means the local stone is does not fetch better price	______
Greater demand for cheaper substitute products in local market like ceramic, porcelain and other kinds of tiles	______
Any other: ____________________	______
Other Contextual Factors	RANK
Strong, active and supportive union/association of marble businessmen of the area does not exist	______
Weak/non-existent support from SMEDA, PASDEC, other government or private sector	

organizations in terms of trainings & imparting business/marketing & technical know-how	______
Proper support from government in terms of tax incentives, proper provision of infrastructure including electricity etc. does not exist	______
Entrance of non-serious and non-professional individuals in this business resulting in market distortion & poor business practices	______
Poor location of business and huge distance of mines from market especially port city/international market	______
Cultural and social pressures (Namoos/Izzat/Pukhto/Tribe) resulting in inability of businessman to manage business professionally. He is more concerned about relationships/friendships/people's or family's expectations rather than making business truly profitable	______
Culture of collectivism (we tend to look at others rather than act on our own in terms of trying new things)	______
Complex lending procedures and lack of soft loans from banks	______
Exploitation of government departments (mines/tax department etc.) in terms of unfair demands and practices, poor/unjust implementation of rules/regulations	______
Lack of direct access to market due to presence of middlemen who enjoy better market contacts and accumulate greater share of profit margins	______
Uncertainty about local law and order situation	______
General uncertainty about the economy & government distrust	______
Any other: ______________________________	______

7. The marble industry in North-West Frontier Province can prosper if:
(Select only one option)

1. Mining processes and the quality of excavated stone is improved
2. Manufacturing processes at processing units are improved
3. Both mining processes during the mining phase as well as manufacturing processes during the processing phase are improved

8. Which statements do you agree with? *(You can select more than one)*

A. Innovating/improving marble mining processes will;

1. Reduce wastage of product during mining resulting in cost saving
2. Be more efficient (more production in less time) resulting in cost saving
3. Improve quality of excavated marble stone
4. Not result in any extra benefit like cost saving or better quality

B. Innovative/improved marble stone excavated from mine will;

1. Fetch higher price resulting in more revenues and profits for my business
2. Not fetch higher price as there is no demand for new/improved products in the market

9. Please make the appropriate choice:

Statement	Yes	No
A unique marble variety/stone and/or unique technology used to excavate stone cannot be protected legally from competitors		
Most marble mining businesses have similar stone, machinery/technology so one competitor has the same product as the other		
Most marble mining businesses have similar skills and knowledge so a competitor can copy ideas easily		
Marble stones are simple and mostly similar in types/designs (blocks etc.) so one competitor has the same product as the other		

10: Give at least 3 suggestions most important in your view for improvement of marble industry especially in terms of better quality products that meet national and international standards?

(1)

(2)

(3)

APPENDIX III

QUESTIONNAIRE – (Marble Processing Unit)

FIRM INFORMATION

(a) Firm No. _____ (b) Names/Types of Products: ________________________________

(c) Machinery/Equipment in the Factory (Quantity & Name): ________________________________

(d) How long has the business been operational (Years): _____ (e) No. of Employees: _____

(f) Encircle Correct Option:

f1. Owner & Manager are same *f2. Owner & Manager are separate* *f3. Owner & Manager both operate the business*

(g) Respondent's (Owner or Manager) Experience in Marble Business: ______ years

(h) Factory Location: _______________ (i) Markets for Products: ____________________________

Enumerator Name: __________________

1A: Marble as an industry needs improvement especially in terms of products, processes, marketing and other areas

a. YES b. NO c. I AM NOT SURE

1B: Which last innovation have you tried in your business? *(Encircle the correct option)*

Product/Market/Organization	Production Process
a. Improved existing products in terms of design, quality **b.** Introduced a completely new product that I had not manufactured before **c.** Sold my product in a completely new market where I did not sell before **d.** Made changes to the firm's organizational structure (hire better employees, got rid of old ones, improved accounting/financial or other procedures etc.) **e.** I did not innovate in terms of products, marketing and/or firm's organization If **a, b, c** and/or **d**, please describe below the nature of improvement for example product type, new market or nature of organizational change ________________________________ ________________________________	**a.** Improved existing production process in terms of machinery or technology or existing worker's skill **b.** Introduced completely new production process such as purchased, installed and used new machinery, technology **c.** I did not innovate & have been implementing same processes using same technology/workers If **a** and/or **b**, please describe below the nature of process improvement e.g. name of new machinery or equipment etc. ________________________________ ________________________________ ________________________________

1C: On a scale of 1 to 5, please select level of innovation you have carried out in your business?

1 ------- 2 ------- 3 ------- 4 ------- 5

(No Innovation/Improvement) (Improved existing product/process/organization) (Introduced new product/process or entered new market)

2A: If at all, you have produced a better quality product or installed new or better machinery/equipment or tried to access new markets for your products or improve your business in any form, who/what was the main influencer in this regard? *(If needed, the respondent needs to be reminded about any recent improvement or anything new he has tried in his business that he can recall and provide reason for undertaking it)*

2B: Describe how you were influenced? *(This can be a short narration of what had happened tha resulted in improvement that the respondent introduced in his business)*

Interactions between Firm and Non-Firms:

3A: Which individuals or organizations do you mostly deal with on a routine basis for running your marble business (fellow marble factory owners, marble suppliers, middlemen/distributors, customers, government departments, others)? (List or name individuals and/or organizations)

3B: What are these interactions about? (Describe the purposes/reasons for interacting with individuals/organizations identified in Q. 3A.)

Interactions between Firm and Knowledge/Technologies:

4A: Do you think that you have gained new knowledge and experience about your business with the passage of time?

a. YES b. NO c. I AM NOT SURE

4B: Give some examples of knowledge/experience you have gained? *(For example knowledge about new marble varieties, new marble products, production processes, markets, managing business in general, any other technical or business knowhow)*

4C: What was the source of this knowledge/experience? *(Where from did the respondent gain this new knowledge/experience?)*

4D: How and from where do you acquire machineries/technologies for your business?

4E: How do your workers learn to operate a machinery/equipment or create a new product design that has been ordered by a customer?

Interactions between Firm and Institutions

5A: How do you learn about rules/procedures/norms/practices required to run your marble business?

5B1: Give examples of rules/procedures/norms/practices for operating a marble business that are formal (like imposed by government departments/agencies)

5B2: Give examples of rules/procedures/norms/practices for operating a marble business that are informal (like influenced by customs/practices common in the region)

5C: Describe how these rules/procedures/practices facilitate you or create hurdles for you in terms of improving your business? *(The respondent can give some specific examples)*

6. Which of the following activities/factors influence or can influence a marble enterprise not to innovate in terms of products, processes, marketing and others?
Rank in order of preference:

- 0 if not considered an influential factor by respondent
- 1 for least influential and so on
- Highest number for most influential factor

ACTIVITIES/FACTORS	
Internal Factors	RANK
Business owner unwilling to take risks	______
Examples of new/improved marble products set by fellow marble businessmen in my area do not exist for me to follow	______
Wastage of stone during cutting process results in higher costs and poor quality	______
Inappropriate machinery/equipment maintenance like calibration, blade/cutter installation and replacement	______
Machinery/equipment used in the factory is locally manufactured and of poor quality	______
Lack of business finances & low profit margins	______
Small size of business	______
Lack of skill and formal training of factory workers and machine operators	______
Lack of education/awareness amongst marble business owner/manager	______

Lack of owner's formal business experience	______
Lack of proper business planning and implementation	______
Reluctance of marble businessman to adopt change or new technology	______
The product I as a businessman currently produce sells so no need for me to change or improve anything	______
I am more concerned about day-to-day survival rather than investing in any kind of innovation	______
Improving products/processes will not earn me more revenues so no advantage investing in new/improved technology	______
Any other: ______________________________	______
Contextual Factors (Supply-Side)	RANK
Non-availability of dimensional/squared marble blocks with no cracks & rough edges	______
Non-availability of unique or better quality marble varieties from mining area	______
Weak linkages with marble mining units and businessmen in terms of nature/quality of stone required and continuous supply of stone	______
Non-availability of improved locally manufactured & better priced machinery in the local market	______
Non-availability of imported even though expensive marble machinery in the local market	______
Non-provision of leasing facility on easy terms & conditions through government/banks/PASDEC to acquire marble machinery (bet it local or imported)	______
Lack of improved machinery designs that allow more flexibility in cutting/processing resulting in new/improved product designs/varieties	______
Lack of experienced/trained technicians who can install marble machinery in processing units properly and professionally	______
Low quality blades, cutters and other machine components available in the market resulting in poor quality of product	______
Inadequate infrastructure support such as lack of non-stop electricity affecting production schedules and efficiency	______
The supplied stone from mines is inappropriate (too hard/impurities) for making better products	______
High cost of transportation/freight charges incurred on shipping stone from mine to factory	______
Any other: ______________________________	______
Contextual Factors (Demand-Side)	
Limited or no opportunity to access national markets like Punjab, Sindh especially Karachi	______
Lack of direct access to international markets of the world	______
Awareness/information of international customer's product requirements and needs does not exist	______

Demand for marble products in local market has remained stagnant/unchanging so I cannot improve current products or offer new ones because no one buys/demands it	______
Greater demand for cheaper substitute products in local market like ceramic, porcelain and other kinds of tiles that are more flexible in terms of designs/colours	______
Marble from Balochistan (especially Onyx) is in greater demand in Karachi/International Market as compared to marble of N-WFP thus the marble I have cannot fetch better prices	______
Any other: ____	______
Other Contextual Factors	**RANK**
Strong, active and supportive union/association of marble businessmen of the area does not exist	______
Weak/non-existent support from SMEDA, PASDEC, other government or private sector organizations in terms of trainings & imparting business/marketing & technical know-how	______
Proper support from government in terms of tax incentives, proper provision of infrastructure including electricity etc. does not exist	______
Processing units misuse infrastructure/facilities e.g. lack of on-time payment of electricity bills, payment of taxes/fees, improper business practices like bribing government officials	______
Entrance of non-serious and non-professional individuals in this business resulting in market distortion & poor business practices	______
Poor location of business and huge distance from market especially port city/international market	______
Cultural and social pressures (Namoos/Izzat/Pukhto/Tribe) resulting in inability of businessman to manage business professionally. He is more concerned about relationships/friendships/people's or family's expectations rather than making business truly profitable	______
Culture of collectivism (we tend to look at others rather than act on our own in terms of trying new things)	______
Complex lending procedures and lack of soft loans from banks	______
Exploitation of government departments (mines/tax department etc.) in terms of unfair demands and practices, poor/unjust implementation of rules/regulations	______
Lack of direct access to market due to presence of middlemen who enjoy better market contacts and accumulate greater share of profit margins	______
Uncertainty about local law and order situation	______
General uncertainty about the economy & government distrust	______
Any other: ____	______

7. The marble industry in North-West Frontier Province can prosper if:
(Select only one option)
1. Mining processes and the quality of excavated stone is improved
2. Manufacturing processes at processing units are improved

8. Which statements do you agree with? *(You can select more than one)*

A. Innovating/improving marble processes will;

1. Reduce wastage of product during processing resulting in cost saving
2. Be more efficient (more production in less time) resulting in cost saving
3. Improve quality of marble products
4. Not result in any extra benefit like cost saving or better quality

B. Innovative/improved marble products will;

1. Fetch higher price resulting in more revenues and profits for my business
2. Not fetch higher price as there is no demand for new/improved products in the market

9. Please make the appropriate choice:

Statement	Yes	No
A unique marble product idea/design or manufacturing technology cannot be protected legally from copying by competitors		
Most marble businesses have similar machinery, technology so a competitor can copy ideas easily		
Most marble businesses have similar skills and knowledge so a competitor can copy ideas easily		
Marble products are simple and mostly similar in types/designs (tiles etc.) so it is easy for a competitor to copy these products		

10: Give at least 3 suggestions most important in your view for improvement of marble industry especially in terms of better quality products that meet national and international standards?

(1)

(2)

(3)

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