**Opportunities and challenges for the marble mining industry in North-West Pakistan: a systemic analysis of low-tech innovation**

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*Abstract*

This paper examines the marble industry of North-West Pakistan. Although this low-tech (LT) sector is characterized by a lack of innovation and resource wastage, it has been earmarked for upgrade as one of Pakistan’s three SME-based industries where policy or institutional actions can have the greatest positive impact for regional development. The aim of this study is to generate an in-depth understanding of the sector by exploring the perspectives of key stakeholders. In doing so, it is hoped that entrepreneurship and SME development will be stimulated with positive benefits for the region. A systemic perspective is employed to try and gain insight into interactions and connections between actors in the value creation system, to better identify where improvement might be made. The paper uses a multilevel analytical framework within a case study approach overall. The study adds to our knowledge of LT innovation, which tends to be forgotten in innovation policy, particularly in developing countries. The study also adds to our understanding of the potential for entrepreneurial behaviour at the micro-level where ongoing conflict is a significant element to consider in achieving change. The results of the study enable asharper focus on where improvement attempts should be made.

Key words: innovation; entrepreneurship; Pakistan; regional development; marble industry; low-tech

**Opportunities and challenges for the marble industry in North-West Pakistan: a systemic analysis of low-tech innovation (or the lack of it)**

In recent times, North-West Pakistan has had the misfortune of making headlines for all the wrong reasons, including ongoing regional conflict, terrorism, and damaging floods. Yet the province has much good to offer, particularly in the field of enterprise development, with small business sectors rich in potential, particularly leather, jewellery, furniture, marble and agriculture.

This research is empirically rooted in the marble industry of North-West Pakistan, which has two subsectors (mining and processing). Characterized by a lack of innovation, the sector suffers from up to 70% resource wastage with $ 60 – 70 million losses per year in exports alone (SMEDA 2002; IMS 2007). However, the sector has been earmarked for an overall upgrade of the whole value chain, as 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). This is in line with a regional development agenda that seeks to enhance local industries by exploiting the area’s natural resources. The marble sector is challenging, however, in that the marble mining and processing firms have historically demonstrated very limited, incremental product and process innovations. Lack of innovation has been the norm, whereby the same products (tiles, slabs, decorative items) are being produced, applying the same production technologies (blasting, driller, excavator, loader, vertical/horizontal cutter, gang saw, polisher and others) that have been in place for decades. The overall aim of this research is to generate an in-depth understanding of the lack of innovation in this low-technology (LT) sector by exploring the perspectives of key stakeholders in the industry. In doing so, it is hoped that entrepreneurship and SME development will be stimulated with positive benefits for the region. We use a systemic perspective to try and gain insight into interactions and connections between actors in the value creation system, in order to gain a sense of the overall picture, and of course, better identify where improvement might be made. One distinctive contribution of this research is that data collection has been carried out in very inaccessible regions (through geographical and social constraints), by a local researcher who is able to access and assess appropriate resources in situ. This adds great power to this distinctive study that can add real value to the efforts of the Pakistan government to improve the region.

Further, the study adds to our knowledge of LT innovation, particularly in developing countries. LT sectors (characterized by zero or limited R&D intensity) are considered the ‘forgotten sectors’ in innovation policy (Hirsch-Kreinsen 2008a). Much greater attention has been paid to high-tech (HT) due to the long-held linear view of innovation that tends to overemphasize the influence of R&D and modern technologies. As a consequence, LT innovation is an under-researched topic. Yet the potential and value of LT and low- and medium-tech (LMT) sectors should not be underestimated (Robertson et al. 2009; Hirsch-Kriensen & Jacobson 2008; Bender 2004; Evers 2011) as they contribute 90% of the growth output in developed countries; further, they have a pivotal role in the developing economies. Recognizing that innovation (including LT innovation) is systemic and non-sequential in nature, a multilevel (micro-meso-macro, individual-firm-contextual) analytical framework guides this research.

Finally, the study adds to our understanding of the potential for entrepreneurial behaviour at the micro-level where ongoing conflict is a significant element to consider in achieving change. Mapping the domain in this way is important for the development of future research agendas; as Shepherd (2011) states, emphasising the importance of multilevel approaches, “*A deeper understanding of entrepreneurial phenomena will come from investigating how the context in which the individual is embedded influences the decision policy for an entrepreneurial task and the nature of the relationship between individual differences and the decision policy for an entrepreneurial task”.* Such an approach enables asharper focus on where improvement attempts should be made.

The overarching research objectives (ROs) are therefore:

RO1: To understand the phenomena of innovation and entrepreneurship within a low-technology sector (the marble industry in North-West Pakistan

RO2: To explain how a low-technology innovation value creation system exists in terms of its elements, key stakeholders and actors, and the interactions between them

RO3: By studying and explaining the structure of the innovation value creation system, developing recommendations for improvement

Two case studies from the region are presented, one centred in Peshawar, the other centred in Buner. Characterized by the largest marble reserves and highest number of firms, both cases have two embedded units of analysis (mining and processing firms). The main focus of the study is on owners and managers of these firms, their attitudes (entrepreneurial or otherwise) and constraining/enabling circumstances; in order to gauge context, data has also been collected from the representatives of non-firms, such as government and non-government support agencies, and a variety of intermediaries. Structured and semi-structured interviews, as well as questionnaires were used to develop a micro-meso-macro depiction of the industry, and the interplay of the actors in this value creation system, to support the development of opportunities, as well as identifying challenges.

The research reveals a complex set of relations between actors and stakeholders, but a rather disconnected value chain with, at times, limited interactions between key elements. We use our analysis to identify opportunities and challenges for the industry, concluding with recommendations for policy makers and practitioners, and suggestions for further research.

**Background**

Following the OECD, Hirsch-Kreinsen (2008b) classifies industries into three types: High Technology (HT) sectors (R&D intensity of above 5 %), Low and medium Technology (LMT) sectors (R&D intensity between 0.9 and 5 %) and Low Technology (LT) (R&D intensity between zero and 0.9 %). The developed countries of the post-industrial revolution have mainly invested in R&D-intensive HT to achieve innovation success and economic growth, with a strong focus on regional development through entrepreneurship and innovation policy and SME support. However there has been 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.

Thus, 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 a growing understanding that because an industry is LT, it is not necessarily simple, devoid of entrepreneurship, or lacking in a requirement for understanding or support. Innovation generally, and HT specifically, have long been recognised as being systemic in character (Rothwell 1992; Teece 1989; Kline & Rosenberg 1986).; for example, Teece (1989, 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’. Underscoring the systemic and interconnected character for LT innovation too, 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, 38) concludes that these sectors are ‘innovative in a very specific way’ especially when compared to HT (Table 1), but like HT, are systemic, characterized by the interplay of many factors (including entrepreneurial agency) internal and external to a firm:

INSERT TABLE 1 ABOUT HERE

Figure 1 (adapted from Nouman and Warren 2010a, b; Nouman et al 2011; Nouman, 2011) depicts the LT space in relation to the far more extensively studied HT domain:

INSERT FIGURE 1 ABOUT HERE

Analysis of the fairly limited literature on LT/LMT innovation (Nouman and Warren, 2010a, b; Nouman et al, 2011; Nouman, 2011) shows that most studies focus on activities or determinants that drive innovation, particularly at the industry and firm level of analysis. This reveals a notable gap regarding the entrepreneurial agency which may (or may not) take place at the individual level (albeit in a social context). Further, little attention is paid to identifying and analysing those factors or determinants that serve as barriers. These aspects are especially relevant in developing countries, particularly those suffering from conflictual situations, where entrepreneurial agency and wider innovation contexts may be more severely affected in comparison with developed countries. Indeed, most of the existing research has been carried out in developed European countries. More research is needed therefore in this regard to enhance understanding and generate meaningful suggestions for improvement, in this case, the desire of the Pakistan government to reconfigure the value chain for this industry, in itself a systemic objective, involving multiple interactions between support and development agencies, firms and individuals). In the next section, we therefore develop a contextual mapping and a conceptual framework for the cases in question.

**The cases: context, methodology and conceptual framework**

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 processing and/or mining 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. Mohmand Agency is the major source of raw marble to Peshawar’s marble processing businesses. Mohmand can be accessed through the Warsak and Nasirbagh areas of Peshawar; however, the distances between processing and mining units are considerable further aggravated by the 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 leading to the presence of both mining and processing units within the same region.

3. Mohmand Agency in its own right – a Federally Administered Tribal Area with a particular tribal culture and customs and both marble mining and processing units. However, the region has been severely affected by a poor law and order situation in the last 4-5 years adversely affecting marble businesses.

From the three regions, two cases have been developed in such a way that Case 1 – PeMaS consists of both Peshawar and Mohmand Agency while Case 2 – BuMaS consists of Buner alone. The reason 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 has actually resulted in the closure of many marble businesses and the risks associated with travel to the area (mostly located in far-flung mountains) for data collection meant it had to be excluded. Thus Case 1 comprises of mining units in Mohmand and processing units in Peshawar since they are the main users of marble from Mohmand under current conditions. This is represented schematically in Figure 2 below:

INSERT FIGURE 2 ABOUT HERE

Figure 3 provides a visual representation of the industry, which shows the different elements that we might expect to interact as part of the value network. The diagram was derived from consultations with two key organizational stakeholders, namely the Small and Medium Enterprise Development Authority (SMEDA), Government of Pakistan and the Pakistan Stone Development Company (PASDEC). These organisations also provided a range of reports and documents related to the sector. Other documents were obtained from miscellaneous sources, notably, the Pakistan Initiative for Strategic Development and Competitiveness (PISDAC) At this point, we did not presume interactions, concentrating instead on identifying key firms and non-firm entities within the sector.

INSERT FIGURE 3 ABOUT HERE

From figures 2/3, the outline framework for data collection and analysis in Table 2 and Figure 4 was derived:

INSERT TABLE 2 ABOUT HERE

INSERT FIGURE 4 ABOUT HERE

Table 3 summarises the sample and the data collection methods used:

INSERT TABLE 3 ABOUT HERE

Data collection was carried out from 2008-11 in three phases. One of the authors (MN) carried out much of the data collection in person, in full accordance with risk assessments, norms and protocols applied by his home institution in Pakistan and local government research agencies in the region. The Preliminary Phase (i) was to develop an initial in-depth understanding of the marble sector and help address RO1 and RO2; detailed probing also enabled the development of data collection instruments for the next phase.. Developing a deeper and more comprehensive understanding of the working of marble sector required that for each of the two cases (PeMaS and BuMaS), the key stakeholders were identified and their perspectives are explored in detail through semi-structured interviews. These 12 interviews were carried out by one of the authors (MN).

During the Development Phase (ii) of data collection, the aim was to further enhance the understanding of low-tech innovation and focus on the elements and structure of the marble mining marble (RO2 and RO3). Structured interviews and questionnaires were used for collecting data. Here, a more focused and relevant understanding of the role of individual, the firm and the context within which these firms operate was generated. The 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 the 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: to keep the conversation focused, and to 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 an in-depth understanding of each sub-group. Observations were considered, but not used, due to the security situation.

Another issue concerned the use of enumerators for data collection during Phase (ii).

Caution was exercised as MN was advised not to travel unaccompanied and during late hours of the day to certain locations. Although MN conducted structured interviews and administered 5 questionnaires where this was deemed safe by local risk assessment procedures, to help address this and also ensure timely and quick completion of, two enumerators from the regions in question were hired from agencies, a common practice for government researchers in North-west Pakistan. The following three criteria were used to select them;

(1) Education and qualification (minimum Masters degree)

(2) Enumerators’ familiarity with area under investigation (local residents 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 MN 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)

• Help them understand the logic and purpose of each question

• Answer any queries that they may have

The Closing Phase of data collection was conducted through semi-structured interviews to seek closure, confirmation of understanding, reiteration of some of the research outcomes and help address any ambiguities still left after completion of the data analysis process.

Turning to the analysis, following transcription, this was completed by hand using coding, memos, matrices, network diagrams and tables, using qualitative research protocols devised by Miles and Huberman (1994). Questions were asked that sought to elucidate roles, structures, processes and relationships, as well as attitudes and behaviours in areas related to innovation mindsets, entrepreneurial agency and views of risktaking, in accordance with Table 3. Diagrams were created to map out relationships across the industry overall.

**Analysis**

The first part of this section commences with a discussion of themes identified from the structured and semi-structured interviews. We commence with an overview, then consider each level of analysis, micro-meso-macro. The interview phase enabled us tease out some of the more subtle relationships in the industry. The questionnaires enabled us to determine the relative importance of factors that contributed to low levels (or non) innovation.

Overview

To provide some sense of the industry overall, the mining and processing pathways are summarised in figure 5 below, and a context chart for marketing shown in Figure 6.

INSERT FIGURES 5 AND 6 ABOUT HERE

Overall, as expected, the amount of LT innovation is low. We probed for levels of innovation in products, processes, marketing strategies and organisational structures in both processing and mining firms. As can be seen, there was very little difference between the two regions, so the two cases act to internally verify each other, rather than support any basis for drawing comparisons. From here on in, discussions and conclusions refer to both cases.

* *product innovation* is almost non-existent amongst mining firms. Some processing units have introduced product improvements or new products although this is not a common event. Both cases 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 (Table 4).

INSERT TABLE 4 ABOUT HERE

* *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 (Table 5).

INSERT TABLE 5 ABOUT HERE

* *marketing* innovation was more noticeable, but only for processing firms as shown in Table 6 below.

INSERT TABLE 6 ABOUT HERE

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

* *Organisational*  improvement through innovation is minimal.

The question for us is to identify in a rigorous manner the systemic connections that offer the possibility of systemic improvement of the value chain through focussed policy intervention. The next section analyses these outcomes from a micro-meso-macro perspective.

Micro: Individual perspective

From a micro perspective, the most important factors were around role models and influencers, levels of awareness and the alignment between the potential for innovation returns and the nature of the stake in the business. Table 7 summarises the roles and issues relating to individuals in the PeMAs and BuMas regions, and reveals a strong role-ordered perspective.

INSERT TABLE 7 ABOUT HERE

For the mining subsector, three key individuals with distinct roles were present. They include the mine owner (MO), the mine manager (MM) and a supervisor also called ‘munshi’ in the local language. For the processing subsector, three variants of owner-manager organisation have been found. These are:

1. Variant 1 - one owner-manager (O-M): a single individual owns as well as manages or operates the processing factory

2. Variant 2 – one owner and one manager (O&M): the owner and manager are two separate individuals with distinctly different roles

3. Variant 3 – one owner plus one manager (O+M): , the owner and manager while being separate individuals, manage the business together

*a) Individuals’ Influence on LT Innovation in Marble Mining Firms*

For the mining firm, a key determinant of innovation is the non-alignment of the owner’s and the manager’s business interests. While the former has a prime stake in ensuring that the lease payments on the marble mine from the manager are received regularly, the latter is concerned more about minimizing operational costs. The owner has no direct stake in improving product quality or increasing sales/profits. The manager on the other hand is under pressure to produce more (quantity) without any regard for marble resource wastage resulting from blasting. He does not own the raw marble anyway and is not concerned with extracting it efficiently. Moreover, the owner does not have any direct investment in the mining business in terms of equipment, machinery and other resources. His only investment is payment to the government’s Directorate General Mines and Minerals (DGMM) for acquiring the mining license for a given location. On the other hand the manager has invested in the mining business in terms of equipment and pays salary to the workers. However, because he is making a fixed payment (per month or per unit of excavated marble stone) to the owner his approach is towards maximizing production regardless of wastage resulting from blasting that leaves stones with cracks and irregular shapes/sizes, while a lot of smaller stone becomes commercially useless. The supervisor or ‘munshi’ represents the interest of the owner by keeping track of how much stone is being extracted per day and per month. As a result, the owner tends not to have an innovation mindset because it is not relevant or in line with his business stake, while the manager is too focussed on cost reduction. Any entrepreneurial vigour on the part of the owner is mainly concerned with establishing and maintaining good contacts and relationships with the government officials who have the authority to issue, renew and cancel mining licenses. On the contrary, the manager is more concerned with ensuring the trust of mine owner, in order to keep his mining business operational. A key characteristic of innovation is that it entails risk-taking behaviour, at least in some form. However, the owner’s only risk is investment in the business through purchase of mining license while the manager’s risk is the dealing with uncertain law and order situation in the mining areas and inconsistency of business revenues due to uneven demand and sales trends. While both key individuals have the ability to influence innovation within the mining firm, the owner does not seem to be applying it due to no direct stake or benefit derived from innovation. On the other hand the manager does not appear to exercise that influence because of greater concerns external to his business. These include maintaining good relationships with the local tribes or villagers, maintaining a good working relation with the owner based on trust and keeping operational costs as low as possible to ensure minimum level of profit margins. The diverging interests of two key individuals in the mining firm with no priority for innovation or product/process improvement leads to lack of LT innovation in the mining subsectors of PeMaS and BuMaS.

*Individuals’ Influence on LT Innovation in Marble Processing Firms*

The individuals’ influence on LT innovation varies for the specific organisation present in the processing firm. Variant 1 (O-M) turns out to be the strongest possible arrangement that can influence LT innovation. The primary reason is that the firm owner who also manages the processing business has a direct stake in all aspects of the business. Not only is he inclined to minimize wastage of stone during different processing activities, but he is also more determined to improve quality of the product to ensure greater sales and profitability. Moreover, because of absolute authority within the firm, the owner-manager directly influences types of products produced, the production processes used to manufacture these products, decisions on which markets and customers to target and what kind of organizational structure is implemented (including number of workers, supervisor, if any, and assignment of tasks, responsibilities and authority). Some respondents in the variant 1 category demonstrated a strongly entrepreneurial mindset, with a willingness to take risks and invest in better technologies. They also had a strong ability to influence innovation by being authoritative and having a long-term vision for their business. On the contrary, other respondents were unwilling to take risk or improve products/processes. Their ability to influence innovation was also limited or non-existent.

Variant 2 (O&M) is found to be the weakest arrangement in terms of influence on LT innovation. The main reason is somewhat similar to the owner-manager arrangement identified for mining units. While the owner of the processing unit is better off financially he does not have a direct involvement in day-to-day operations (activities performed by the manager). The manager has more technical knowledge about products and processes and a direct influence on workers’ productivity. On the other hand the owner has a stake in returns on his investment and costs reduction to maximize profits. Since the manager is paid a monthly salary only (direct stake) he has an indirect stake in cost reduction and profit maximization as this ensures his own employment in the long-run. Similar to variant 1 there is unclear evidence for entrepreneurial mindsets of O&M. For some processing firms it is there, while for others it is not found. One important finding is that the owner can have a greater influence on innovation because of investments in better technologies and marketing decisions. However, this influence subsides considerably if the manager does not reciprocate the owner’s mindset by improving operational activities that lead to product/process innovation. In term of an entrepreneurial approach, the owner is concerned more with return on investment while the manager’s priority is to maintain the owner’s trust in him. Again, the main reason for weak influence of O&M on LT innovation is found to be the diluted influence of owner and manager due to a lack of complementarities of their roles.

Variant 3 (O+M) lies somewhere between 1 and 2. The main reason identified for greater influence than variant 2 is the both the owner and manager are involved in day-to-day operations whereby the manager’s main role is that of supervising and interacting with workers. However, both individuals are involved in decisions regarding products and production processes. Also, both have a sound knowledge of products and processes. On the other hand the main reason identified for weaker influence on LT innovation than variant 1 is the differences in nature of stake. While the owner has a direct stake in ensuring returns on investment, the manager’s stake in this regard is indirect as he is more concerned about the salary and maintaining trust of the owner.

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. The study reveals 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. Moreover, 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. Thus, providing the organizational relationship is well-founded, the more entrepreneurial managers are able to establish a greater degree of interconnectedness and systemicity.

**Meso (firm) perspective**

The most significant factors for firms were quality issues caused by indiscriminate blasting, poor stone cutting procedures and a lack of finance to support technology improvement. Although some marble firms demonstrate incremental innovation, they 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 leading to incremental product innovation. However, unless the excavated stone is improved, improving product within processing subsector will be much more difficult. For mining units, 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. Figure 7 illustrates the roles of firms within PeMaS and BuMaS.

PLEASE INSERT FIGURE 7 AROUND HERE

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).

The study further reveals that firms’ learning orientation is influenced by their market orientation towards the wider national (beyond regional) market. This influences firms to improve or upgrade equipment (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/equipment, better trained and skilled human resource emanating from a strong learning orientation which in turn is influenced by a strong market orientation especially towards international markets will lead to improved innovation overall.

**Macro (industry) level**

In terms of structures relevant to the marble value creating system, we found:

1. Key individuals playing a ‘meta’ role in the value chain: suppliers/middlemen/distributors
2. Sector support organizations
3. National institutions

PeMaS and BuMaS adhere to a supplier-dominated taxonomy (Pavitt 1984; Pavitt et al. 1989; De Jong & Marsili 2006), where the availability of modern equipment from suppliers could be a key source of innovation (Duguet 2006). However, this is not happening in PeMaS and BuMaS as these suppliers do not specialize in industry specific equipment, technologies and services. *Suppliers* in our study did not specialize in marble-specific inputs, but catered to other SME manufacturing sectors, competing on price (rather than quality). This lack of specialisation and quality leads to a fragmented value network which does not, in its current form, support innovation. *Middlemen* too were important in overcoming 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. Again, this weakness in the value chain overall tended to detract from the potential for entrepreneurial behaviour.

*Support organisations* include both ‘generic’ support organisations such as the Small and Medium-sized Enterprise Development Authority (SMEDA) and banks, and ‘specific’ agencies such as the Pakistan Stone Development Company (PASDEC) and the Directorate General Mines and Minerals (DGMM), Government of N-WFP and Department of Minerals (DoM), FATA Governor’s Secretariat, as well as donor agencies linked to USAID and European Commission

SMEDA does have two marble-specific initiatives:

* 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 any 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 a ‘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.

Overall, the roles of sector support organizations, especially those representing the government (Souitaris 2002) should be 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. The situation is summarised in Figure 8 below, illustrating the mismatch between strong informal institutions in the mining regions based on tribal codes of conduct and a sense of disadvantage, combined with a distrust of the weaker formal institutions nationally and regionally.

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.

INSERT FIGURE 8 ABOUT HERE

**Discussion**

In summary, we began with an expressed problem that indiscriminate blasting, problems with excavated stone and low quality of available technology are leading to 70% resource wastage with $ 60 – 70 million losses per year in exports. If increasing innovation in the value chain overall is seen at least in part as a mechanism to improve this situation, it is important to recognise that the factors behind the paucity of innovation are interconnected and systemic:

* *At the micro-level*, no overarching climate for innovation in the industry in the community of firm owners; though entrepreneurial individuals can be influential, overall, there is a lack of role models
* *At the meso-level*, limited and informal interactions between firms in relation to knowledge and learning processes
* *Meso-micro interactions* between individuals and firms are role-dominated, often with weak connections between investment in innovation and reward
* *At the macro-level*, weak institutions combined with sector support organisations with a lack of trust, direction and purpose within a conflictual region result in non-existent access to international markets
* *Macro-meso interactions* result in the inability of firms to trigger new demand and weak knowledge creation and learning.

Knowledge and demand management are two key areas where it is possible to stimulate and lead LT innovation. Formal knowledge (especially connected with new technologies) provided to marble firms from external sources and acquired and adapted through formal learning processes is essential. The key influence in this regard is the role of non-firms, especially sector support organizations. in facilitating access to, and the adoption of this formal knowledge thus helping 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.

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. There is some evidence for this 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 demand that could potentially lead to LT innovation in PeMaS and BuMaS.

. 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 equipment and/or produce new/improved products for new markets) have the power to influence LT 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.

Conclusion

This distinctive study provides a great deal of insight into a hitherto poorly understood value creation system that has the potential to contribute to the development of a volatile and troubled region. In succeeding in gathering and analyzing empirical data from this difficult to access region, we have achieved our research objectives 1 and 2:

RO1: To understand the phenomena of innovation and entrepreneurship within a low-technology sector (the marble industry in North-West Pakistan

RO2: To explain how a low-technology innovation value creation system exists in terms of its elements, key stakeholders and actors, and the interactions between them

Turning to RO3: *By studying and explaining the structure of the innovation value creation system, developing recommendations for improvement*, it would be easy to focus on the negatives and the difficulties, rather than the opportunities for this industry. Our study has overall contributed to the relatively small literature on LT innovation, demonstrating as Hirsch-Kreinsen (2008) suggested that LT innovation is not straightforward – it is systemic, with a multitude of interactions between a number of actors including individuals, firms and institutions. By taking a systemic approach, we are able to support the development of recommendations for improvement:

1. Despite the apparent non-complex nature of products in an LT sector, we 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.
2. We 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.
3. 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 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 driver.
4. A fundamental problem identified in the marble industry is lack of innovation-specific institutions particularly regulative institutions, particularly with specific knowledge of the marble industry.. Instead, inconsistent and poorly managed implementation of some regulative institutions in the past has lead to a 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 will individuals and firms be convinced to take up LT innovation as a core business activity.

Of course, further research needs to be carried out. Areas that we have identified include:

* A deeper study of the dynamics and interactions within this value creation system, to further theoretical understanding of LT innovation systems
* A fuller exposition of the learning and knowledge processes, to make recommendations in regard to education and training providers.
* A further consideration of the nature of entrepreneurial agency in this complex context, to deepen understanding of issues of identity, discourse and culture.

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TABLES

|  |  |
| --- | --- |
| **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 1. Analysis of LT Innovation Adopted from Hirsch-Kreinsen (2008a, 39)

|  |  |
| --- | --- |
| **Analytical Level** | **Translation to this research** |
| ***Micro-individual level*** | **Entity:** 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) |
| **Attribute:** Activities/behaviours relating to entrepreneurship and innovation |
| ***Meso-firm***  ***Level*** | **Entity:** Firms, Non-firms (mining units, processing units, suppliers, distributors, public/private organizations related to marble sector) |
| **Attribute:** Activities/determinants/factors concerning innovation, types of products and innovations, interactions among agents (firms and non-firms) |
| ***Macro-contextual level*** | **Entity:** Marble sector of north-west Pakistan |
| **Attribute:** 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 2. Applying micro-meso-macro framework to marble industry (1)

|  |  |  |  |
| --- | --- | --- | --- |
| **PHASE** | **TOOL** | **NUMBER** | **RESPONDENTS** |
| I  (preliminary) | Semi-structured In-depth Interview | 12 | 1. Owners/Managers of mining and processing firms 2. Suppliers/Middlemen of marble equipment/machineries/technologies 3. Sector experts 4. Representatives of government and marble sector support organizations |
| II  (development) | Structured Interview | 18 | 1. Owners/Managers of mining firm |
| Questionnaire | 70 | 1. Owners/Managers of processing firm |
| Iii  (closing) | Semi-structured in-depth interview | 6 | 1. Owners/Managers 2. Sector experts 3. Mddleman 4. Representatives of government and marble sector support organizations |

Table 3. Three-Phased Data Collection

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 4. Product Innovation in PeMaS and BuMaS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 5. Process Innovation in PeMaS and BuMaS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 6. Marketing Innovation in PeMaS and BuMaS

Mine Owner

(MO)

**Individual**

Mine Manager

(MM)

Supervisor/ ‘Munshi’

**Professional Characteristics**

**Nature of Business Stake**

**Individual characteristics**

- 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?**

**NK**

- Satisfy MO in terms of trust

- Draw monthly salary

**IM** – ~~ **EA** – ~~

**RTB** – ~~ **AII** – ~~

- 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?**

**Variant 3**

One Owner

+

One Manager

(**O**+**M**) of Proc. Unit

**Variant 2**

One Owner and

One Manager

(**O**&**M**) of Proc. Unit

**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

**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?**

- 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

- **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** 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** – Diluted as a result of **O** & **M** having different roles

**A1?** and **A2?**

**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?**

- **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

**Key:**

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 characteristic

~~ = Irrelevant characteristic **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 7. Role-Ordered Matrix – Roles of Individuals within PeMaS and BuMaS

FIGURES

Figure 1. Placing Low-Tech on the Innovation Landscape

Transformation, Disruptive, Discontinuous

High R&D Intensity

DETERMINANTS OF INNOVATION

Factors, determinants, activities, inputs

Knowledge & Technologies

R&D

DEGREE OF INNOVATION

High-Tech Innovation

*(Research interest since 1940s & 50s)*

Entrepreneurship can occur for multiple levels and components]

Radical,

Breakthrough

Low R&D Intensity

**Low-Tech (LT) Innovation**

& Low- and Medium-Tech (LMT) Innovation

Incremental, Continuous

Product Process Position Paradigm

(Marketing) (Organizational)

Component Architectural Technical Administrative



**CONTEXT**

Buner (BuMaS)

Product groups, technologies, knowledgebase, learning processes, demand, institutions, non-firms, interactions/relationships

**CONTEXT**

Peshawar (PeMaS)

Product groups, technologies, knowledgebase, learning processes, demand, institutions, non-firms, interactions/relationships

**CASE 2**

Buner

Unit of Observation:

Owner/Manager

**CASE 1**

Peshawar & Mohmand Agency

Unit of Observation:

Owner/Manager

Embedded Unit of Analysis 1

‘Marble Mining Firm’

Embedded Unit of Analysis 1

‘Marble Mining Firm’

Embedded Unit of Analysis 2

‘Marble Processing Firm’

Embedded Unit of Analysis 2

‘Marble Processing Firm’

Figure 2. Case study design

Figure 3. Constituent elements of the marble industry

Mining Unit

Mining Unit

Mining Unit

Mining Unit

Intermediary or Middleman

Public-oriented Sector Support Organization

Supplier

Public-oriented Sector Support Organization

Other Stakeholder Organization

Private

Sector Support Organization

Intermediary or Middleman

Other Stakeholder Organization

Supplier

CONTEXT

**Marble Innovation (Marble SSI)**

**Levels within the Marble Sector**

**Micro-individual level**

**Meso-firm**

**level**

**Macro-contextual level**

Marble firm owner or manager

Representative of non-firm organization

Marble firm (mining or processing)

Non-firm organization

Institutions

Demand

Learning processes

Technologies

Knowledgebase

Figure 4. Applying micro-meso-macro framework to marble industry (2)

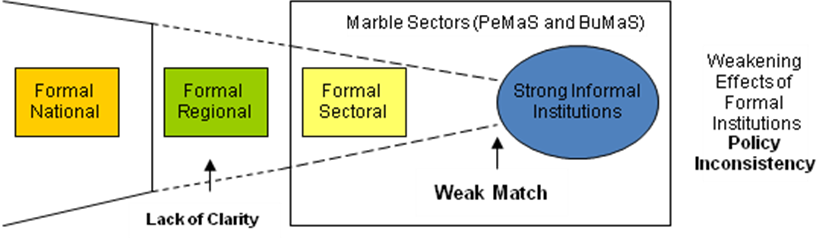


Figure 8 Relationship among sectoral, regional and national institutions

**STEP V**

Loading

**Equip. / Material:**

Loader or

Mechanical Winch

Vehicle – Truck

Fuel

**Manual Labour:**

Operate machinery

Manually direct stone onto vehicle

**Output:**

Raw excavated stone ready for shipment

**STEP IV**

Excavating

**Equip. / Material:**

Excavator or

Mechanical Winch

Bulldozer

Hooks, chains, pulleys, fuel

**Manual Labour:**

Operate machinery

Install chains & hooks

**Output:**

Raw excavated stone (3 sizes)

**STEP III**

Blasting

(Indiscriminate)

**Equip. / Material:**

Dynamite

**Manual Labour:**

Install equipment for blasting

**Output:**

Extractable & irregularly shaped marble rocks of different sizes

**STEP II**

Drilling

(Series Pattern)

Vertical, Horizontal

**Equip. / Material:**

Driller

Compressor

Fuel

**Manual Labour:**

Operate Driller

Operate compressor

**Output:**

Loosened rock ready for installing dynamite

**STEP I**

Benching

**Equip. / Material**:

Driller

Compressor

Fuel

**Manual Labour:**

Operate Driller

Operate compressor

Remove stone manually

**Output:**

Expose marble beneath the face of the mountain

**MINING**

**PHASE**

**RAW**

**MATERIAL**

Natural

Rock

**PROCESSING**

**PHASE**

**RAW**

**MATERIAL**

Raw

Excavated

Stone

(Block,

Half Block,

Boulder)

By Product

**Equip.:**

Grinder

**Output:**

Marble ‘Chips’

Marble Powder

**STEP I**

Unloading

**Equip. / Material:**

Fixed Crane with chains & hooks

**Manual Labour:**

Operate crane

Manually direct stone

**Output:**

Stone placed on to machinery platform

**STEP II**

Raw-Cutting

**Equip. / Material:**

Gang Saw

‘Vertical’

‘Horizontal’

‘Diamond’ Tips

Water

**Manual Labour:**

Position raw stone on to platform

Movement of cutter & blade

**Output:**

Slabs or tiles with rough edges or ‘Dimensional’ blocks

**STEP III**

Edge-Cutting

**Equip. / Material:**

‘Vertical’, ‘Horizontal’

‘Diamond’ Tips, Water

**Manual Labour:**

Position cut stone onto platform, movement of blade along rough edges

**Output I:**

Small stones – irregular

**Output II:**

Dimensional slabs & tiles

**Output III:**

‘Dimensional’ blocks

**STEP IV**

Polishing

**Equip. / Material:**

Polisher, Grinding Stone, Wax, Water

**Manual Labour:**

Position slab/tile on to platform

Apply grinding mechanism, wax, water

**Output:**

Finished slabs and/or tiles

**STEP I**

Designing

**Equip. / Material:** **Manual Labour**: **Output:**

Lathe Machine Crafting designs Decorative Items

Figure 5. Illustration of Production Processes during Mining and Processing

**Mining sub-sectors in PeMaS and BuMaS Processing sub-sectors in PeMaS and BuMaS**

**PeMaS vs. BuMaS**

Greater unauthorized imposition of levies in PeMaS adding to transportation costs

Stricter regulations for purchase of dynamite in BuMaS

**Input Supplies** Electricity shortfall a clear problem in BuMaS. Conflicting data in PeMaS

One processing machinery manufacturer in PeMaS

None in BuMaS

**Formal Promotion**

Showroom

Direct Buyers

No Product Branding

**Unclear Pricing Pattern**

Influencers

Variety of Product Types

Inconsistent Product Quality

Stone Variety

Different Production Processes

Different Market Needs

**Informal Promotion**

Personal Contacts based on Trust & Past Relationship

No promotional material, no branding

Stone varieties recognized by locally given names

**Non-standardized Pricing**

Influencers

Stone size

Stone variety

Freight charges

Another Business

Factory-Owned

Sells Through

Business Customers

Distributor

DOMESTIC/LOCAL

Machine Installation Expert

**Mining Firm**

**Processing Firm**

NATIONAL

Punjab Province & Karachi City

‘Tip’ Supplier

Sells Directly To

**Product Demand**

Influencers

Stone size

Stone variety

Processing unit’s preference

INTERNATIONAL

Business Customers

*(Processing Firm)*

*(Wholesaler)*

*(Distributor)*

**Materials or Equipments or Components**

Mostly available within Sector

**Machinery**

Only available outside sector i.e. Punjab

**Competition**

Somewhat Direct in Nature

*Some product differentiation*

*New market opportunities*

*Competing by imitating*

**Materials or Equipments or Components**

Mostly available within Sector

**Machinery**

Some available within Sector

Other available from Punjab

Contextual Link

Unclear Link

Sales Link

Market Category

**Competition**

Indirect in Nature

*Undifferentiated product*

*Mature market/demand*

**Product Demand** Influencers

Bus. Cust./Consumer Preferences (local & national)

Figure 6. Context Chart: Nature of Market and Marketing Practices in PeMaS and BuMaS

**Mining (PeMaS)**

**Mining (BuMaS)**

**Processing (PeMaS)**

**Processing (BuMaS)**

Mining Unit

Processing Unit

**Product**

**Innovation**

Process

**Innovation**

Low profit margins, cost reduction focus

Non-standardized products

No product differentiation except variety

Quality problems & inconsistencies

Same excavation technologies as others

No product, process, marketing, organizational innovation

Small size of business

Non-standardized products

Different processes for different products

Quality problems & inconsistencies

Poor quality/maintenance of blades – rough edges

Small size of business

Low profit margins, cost reduction focus

**Less likelihood of technology acquisition from external sources**

(Swan & Allred, 2003)

**Low innovation capability**

(Morone & Testa, 2008)

Poorly trained workforce

Poorly trained workforce

**More common than product innovation**

(Hall & Baghci-Sen, 2007; Moreone & Testat, 2008; Kirner, 2009)

**Low innovation capability**

(McAdam et al., 1998)

**Incremental**

(Pullen et al., 2009)

**Influenced more by internal factors and non-firms**

**Most important influence on**

**Processing Unit**

**Mining Unit**

**Leads to**

**Can influence strongly**

**Linking with literature**

Raw Stone

Figure 7. Roles of Firms within PeMaS and BuMaS

**Opportunities and challenges for the marble mining industry in North-West Pakistan: a systemic analysis of low-tech innovation**

*Abstract*

This paper examines the marble industry of North-West Pakistan. Although this low-tech (LT) sector is characterized by a lack of innovation and resource wastage, it has been earmarked for upgrade as one of Pakistan’s three SME-based industries where policy or institutional actions can have the greatest positive impact for regional development. The aim of this study is to generate an in-depth understanding of the sector by exploring the perspectives of key stakeholders. In doing so, it is hoped that entrepreneurship and SME development will be stimulated with positive benefits for the region. A systemic perspective is employed to try and gain insight into interactions and connections between actors in the value creation system, to better identify where improvement might be made. The paper uses a multilevel analytical framework within a case study approach overall. The study adds to our knowledge of LT innovation, which tends to be forgotten in innovation policy, particularly in developing countries. The study also adds to our understanding of the potential for entrepreneurial behaviour at the micro-level where ongoing conflict is a significant element to consider in achieving change. The results of the study enable asharper focus on where improvement attempts should be made.

Key words: innovation; entrepreneurship; Pakistan; regional development; marble industry; low-tech

**Opportunities and challenges for the marble industry in North-West Pakistan: a systemic analysis of low-tech innovation (or the lack of it)**

In recent times, North-West Pakistan has had the misfortune of making headlines for all the wrong reasons, including ongoing regional conflict, terrorism, and damaging floods. Yet the province has much good to offer, particularly in the field of enterprise development, with small business sectors rich in potential, particularly leather, jewellery, furniture, marble and agriculture.

This research is empirically rooted in the marble industry of North-West Pakistan, which has two subsectors (mining and processing). Characterized by a lack of innovation, the sector suffers from up to 70% resource wastage with $ 60 – 70 million losses per year in exports alone (SMEDA 2002; IMS 2007). However, the sector has been earmarked for an overall upgrade of the whole value chain, as 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). This is in line with a regional development agenda that seeks to enhance local industries by exploiting the area’s natural resources. The marble sector is challenging, however, in that the marble mining and processing firms have historically demonstrated very limited, incremental product and process innovations. Lack of innovation has been the norm, whereby the same products (tiles, slabs, decorative items) are being produced, applying the same production technologies (blasting, driller, excavator, loader, vertical/horizontal cutter, gang saw, polisher and others) that have been in place for decades. The overall aim of this research is to generate an in-depth understanding of the lack of innovation in this low-technology (LT) sector by exploring the perspectives of key stakeholders in the industry. In doing so, it is hoped that entrepreneurship and SME development will be stimulated with positive benefits for the region. We use a systemic perspective to try and gain insight into interactions and connections between actors in the value creation system, in order to gain a sense of the overall picture, and of course, better identify where improvement might be made. One distinctive contribution of this research is that data collection has been carried out in very inaccessible regions (through geographical and social constraints), by a local researcher who is able to access and assess appropriate resources in situ. This adds great power to this distinctive study that can add real value to the efforts of the Pakistan government to improve the region.

Further, the study adds to our knowledge of LT innovation, particularly in developing countries. LT sectors (characterized by zero or limited R&D intensity) are considered the ‘forgotten sectors’ in innovation policy (Hirsch-Kreinsen 2008a). Much greater attention has been paid to high-tech (HT) due to the long-held linear view of innovation that tends to overemphasize the influence of R&D and modern technologies. As a consequence, LT innovation is an under-researched topic. Yet the potential and value of LT and low- and medium-tech (LMT) sectors should not be underestimated (Robertson et al. 2009; Hirsch-Kriensen & Jacobson 2008; Bender 2004; Evers 2011) as they contribute 90% of the growth output in developed countries; further, they have a pivotal role in the developing economies. Recognizing that innovation (including LT innovation) is systemic and non-sequential in nature, a multilevel (micro-meso-macro, individual-firm-contextual) analytical framework guides this research.

Finally, the study adds to our understanding of the potential for entrepreneurial behaviour at the micro-level where ongoing conflict is a significant element to consider in achieving change. Mapping the domain in this way is important for the development of future research agendas; as Shepherd (2011) states, emphasising the importance of multilevel approaches, “*A deeper understanding of entrepreneurial phenomena will come from investigating how the context in which the individual is embedded influences the decision policy for an entrepreneurial task and the nature of the relationship between individual differences and the decision policy for an entrepreneurial task”.* Such an approach enables asharper focus on where improvement attempts should be made.

The overarching research objectives (ROs) are therefore:

RO1: To understand the phenomena of innovation and entrepreneurship within a low-technology sector (the marble industry in North-West Pakistan

RO2: To explain how a low-technology innovation value creation system exists in terms of its elements, key stakeholders and actors, and the interactions between them

RO3: By studying and explaining the structure of the innovation value creation system, developing recommendations for improvement

Two case studies from the region are presented, one centred in Peshawar, the other centred in Buner. Characterized by the largest marble reserves and highest number of firms, both cases have two embedded units of analysis (mining and processing firms). The main focus of the study is on owners and managers of these firms, their attitudes (entrepreneurial or otherwise) and constraining/enabling circumstances; in order to gauge context, data has also been collected from the representatives of non-firms, such as government and non-government support agencies, and a variety of intermediaries. Structured and semi-structured interviews, as well as questionnaires were used to develop a micro-meso-macro depiction of the industry, and the interplay of the actors in this value creation system, to support the development of opportunities, as well as identifying challenges.

The research reveals a complex set of relations between actors and stakeholders, but a rather disconnected value chain with, at times, limited interactions between key elements. We use our analysis to identify opportunities and challenges for the industry, concluding with recommendations for policy makers and practitioners, and suggestions for further research.

**Background**

Following the OECD, Hirsch-Kreinsen (2008b) classifies industries into three types: High Technology (HT) sectors (R&D intensity of above 5 %), Low and medium Technology (LMT) sectors (R&D intensity between 0.9 and 5 %) and Low Technology (LT) (R&D intensity between zero and 0.9 %). The developed countries of the post-industrial revolution have mainly invested in R&D-intensive HT to achieve innovation success and economic growth, with a strong focus on regional development through entrepreneurship and innovation policy and SME support. However there has been 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.

Thus, 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 a growing understanding that because an industry is LT, it is not necessarily simple, devoid of entrepreneurship, or lacking in a requirement for understanding or support. Innovation generally, and HT specifically, have long been recognised as being systemic in character (Rothwell 1992; Teece 1989; Kline & Rosenberg 1986).; for example, Teece (1989, 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’. Underscoring the systemic and interconnected character for LT innovation too, 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, 38) concludes that these sectors are ‘innovative in a very specific way’ especially when compared to HT (Table 1), but like HT, are systemic, characterized by the interplay of many factors (including entrepreneurial agency) internal and external to a firm:

INSERT TABLE 1 ABOUT HERE

Figure 1 (adapted from Nouman and Warren 2010a, b; Nouman et al 2011; Nouman, 2011) depicts the LT space in relation to the far more extensively studied HT domain:

INSERT FIGURE 1 ABOUT HERE

Analysis of the fairly limited literature on LT/LMT innovation (Nouman and Warren, 2010a, b; Nouman et al, 2011; Nouman, 2011) shows that most studies focus on activities or determinants that drive innovation, particularly at the industry and firm level of analysis. This reveals a notable gap regarding the entrepreneurial agency which may (or may not) take place at the individual level (albeit in a social context). Further, little attention is paid to identifying and analysing those factors or determinants that serve as barriers. These aspects are especially relevant in developing countries, particularly those suffering from conflictual situations, where entrepreneurial agency and wider innovation contexts may be more severely affected in comparison with developed countries. Indeed, most of the existing research has been carried out in developed European countries. More research is needed therefore in this regard to enhance understanding and generate meaningful suggestions for improvement, in this case, the desire of the Pakistan government to reconfigure the value chain for this industry, in itself a systemic objective, involving multiple interactions between support and development agencies, firms and individuals). In the next section, we therefore develop a contextual mapping and a conceptual framework for the cases in question.

**The cases: context, methodology and conceptual framework**

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 processing and/or mining 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. Mohmand Agency is the major source of raw marble to Peshawar’s marble processing businesses. Mohmand can be accessed through the Warsak and Nasirbagh areas of Peshawar; however, the distances between processing and mining units are considerable further aggravated by the 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 leading to the presence of both mining and processing units within the same region.

3. Mohmand Agency in its own right – a Federally Administered Tribal Area with a particular tribal culture and customs and both marble mining and processing units. However, the region has been severely affected by a poor law and order situation in the last 4-5 years adversely affecting marble businesses.

From the three regions, two cases have been developed in such a way that Case 1 – PeMaS consists of both Peshawar and Mohmand Agency while Case 2 – BuMaS consists of Buner alone. The reason 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 has actually resulted in the closure of many marble businesses and the risks associated with travel to the area (mostly located in far-flung mountains) for data collection meant it had to be excluded. Thus Case 1 comprises of mining units in Mohmand and processing units in Peshawar since they are the main users of marble from Mohmand under current conditions. This is represented schematically in Figure 2 below:

INSERT FIGURE 2 ABOUT HERE

Figure 3 provides a visual representation of the industry, which shows the different elements that we might expect to interact as part of the value network. The diagram was derived from consultations with two key organizational stakeholders, namely the Small and Medium Enterprise Development Authority (SMEDA), Government of Pakistan and the Pakistan Stone Development Company (PASDEC). These organisations also provided a range of reports and documents related to the sector. Other documents were obtained from miscellaneous sources, notably, the Pakistan Initiative for Strategic Development and Competitiveness (PISDAC) At this point, we did not presume interactions, concentrating instead on identifying key firms and non-firm entities within the sector.

INSERT FIGURE 3 ABOUT HERE

From figures 2/3, the outline framework for data collection and analysis in Table 2 and Figure 4 was derived:

INSERT TABLE 2 ABOUT HERE

INSERT FIGURE 4 ABOUT HERE

Table 3 summarises the sample and the data collection methods used:

INSERT TABLE 3 ABOUT HERE

Data collection was carried out from 2008-11 in three phases. One of the authors (MN) carried out much of the data collection in person, in full accordance with risk assessments, norms and protocols applied by his home institution in Pakistan and local government research agencies in the region. The Preliminary Phase (i) was to develop an initial in-depth understanding of the marble sector and help address RO1 and RO2; detailed probing also enabled the development of data collection instruments for the next phase.. Developing a deeper and more comprehensive understanding of the working of marble sector required that for each of the two cases (PeMaS and BuMaS), the key stakeholders were identified and their perspectives are explored in detail through semi-structured interviews. These 12 interviews were carried out by one of the authors (MN).

During the Development Phase (ii) of data collection, the aim was to further enhance the understanding of low-tech innovation and focus on the elements and structure of the marble mining marble (RO2 and RO3). Structured interviews and questionnaires were used for collecting data. Here, a more focused and relevant understanding of the role of individual, the firm and the context within which these firms operate was generated. The 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 the 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: to keep the conversation focused, and to 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 an in-depth understanding of each sub-group. Observations were considered, but not used, due to the security situation.

Another issue concerned the use of enumerators for data collection during Phase (ii).

Caution was exercised as MN was advised not to travel unaccompanied and during late hours of the day to certain locations. Although MN conducted structured interviews and administered 5 questionnaires where this was deemed safe by local risk assessment procedures, to help address this and also ensure timely and quick completion of, two enumerators from the regions in question were hired from agencies, a common practice for government researchers in North-west Pakistan. The following three criteria were used to select them;

(1) Education and qualification (minimum Masters degree)

(2) Enumerators’ familiarity with area under investigation (local residents 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 MN 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)

• Help them understand the logic and purpose of each question

• Answer any queries that they may have

The Closing Phase of data collection was conducted through semi-structured interviews to seek closure, confirmation of understanding, reiteration of some of the research outcomes and help address any ambiguities still left after completion of the data analysis process.

Turning to the analysis, following transcription, this was completed by hand using coding, memos, matrices, network diagrams and tables, using qualitative research protocols devised by Miles and Huberman (1994). Questions were asked that sought to elucidate roles, structures, processes and relationships, as well as attitudes and behaviours in areas related to innovation mindsets, entrepreneurial agency and views of risktaking, in accordance with Table 3. Diagrams were created to map out relationships across the industry overall.

**Analysis**

The first part of this section commences with a discussion of themes identified from the structured and semi-structured interviews. We commence with an overview, then consider each level of analysis, micro-meso-macro. The interview phase enabled us tease out some of the more subtle relationships in the industry. The questionnaires enabled us to determine the relative importance of factors that contributed to low levels (or non) innovation.

Overview

To provide some sense of the industry overall, the mining and processing pathways are summarised in figure 5 below, and a context chart for marketing shown in Figure 6.

INSERT FIGURES 5 AND 6 ABOUT HERE

Overall, as expected, the amount of LT innovation is low. We probed for levels of innovation in products, processes, marketing strategies and organisational structures in both processing and mining firms. As can be seen, there was very little difference between the two regions, so the two cases act to internally verify each other, rather than support any basis for drawing comparisons. From here on in, discussions and conclusions refer to both cases.

* *product innovation* is almost non-existent amongst mining firms. Some processing units have introduced product improvements or new products although this is not a common event. Both cases 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 (Table 4).

INSERT TABLE 4 ABOUT HERE

* *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 (Table 5).

INSERT TABLE 5 ABOUT HERE

* *marketing* innovation was more noticeable, but only for processing firms as shown in Table 6 below.

INSERT TABLE 6 ABOUT HERE

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

* *Organisational*  improvement through innovation is minimal.

The question for us is to identify in a rigorous manner the systemic connections that offer the possibility of systemic improvement of the value chain through focussed policy intervention. The next section analyses these outcomes from a micro-meso-macro perspective.

Micro: Individual perspective

From a micro perspective, the most important factors were around role models and influencers, levels of awareness and the alignment between the potential for innovation returns and the nature of the stake in the business. Table 7 summarises the roles and issues relating to individuals in the PeMAs and BuMas regions, and reveals a strong role-ordered perspective.

INSERT TABLE 7 ABOUT HERE

For the mining subsector, three key individuals with distinct roles were present. They include the mine owner (MO), the mine manager (MM) and a supervisor also called ‘munshi’ in the local language. For the processing subsector, three variants of owner-manager organisation have been found. These are:

1. Variant 1 - one owner-manager (O-M): a single individual owns as well as manages or operates the processing factory

2. Variant 2 – one owner and one manager (O&M): the owner and manager are two separate individuals with distinctly different roles

3. Variant 3 – one owner plus one manager (O+M): , the owner and manager while being separate individuals, manage the business together

*a) Individuals’ Influence on LT Innovation in Marble Mining Firms*

For the mining firm, a key determinant of innovation is the non-alignment of the owner’s and the manager’s business interests. While the former has a prime stake in ensuring that the lease payments on the marble mine from the manager are received regularly, the latter is concerned more about minimizing operational costs. The owner has no direct stake in improving product quality or increasing sales/profits. The manager on the other hand is under pressure to produce more (quantity) without any regard for marble resource wastage resulting from blasting. He does not own the raw marble anyway and is not concerned with extracting it efficiently. Moreover, the owner does not have any direct investment in the mining business in terms of equipment, machinery and other resources. His only investment is payment to the government’s Directorate General Mines and Minerals (DGMM) for acquiring the mining license for a given location. On the other hand the manager has invested in the mining business in terms of equipment and pays salary to the workers. However, because he is making a fixed payment (per month or per unit of excavated marble stone) to the owner his approach is towards maximizing production regardless of wastage resulting from blasting that leaves stones with cracks and irregular shapes/sizes, while a lot of smaller stone becomes commercially useless. The supervisor or ‘munshi’ represents the interest of the owner by keeping track of how much stone is being extracted per day and per month. As a result, the owner tends not to have an innovation mindset because it is not relevant or in line with his business stake, while the manager is too focussed on cost reduction. Any entrepreneurial vigour on the part of the owner is mainly concerned with establishing and maintaining good contacts and relationships with the government officials who have the authority to issue, renew and cancel mining licenses. On the contrary, the manager is more concerned with ensuring the trust of mine owner, in order to keep his mining business operational. A key characteristic of innovation is that it entails risk-taking behaviour, at least in some form. However, the owner’s only risk is investment in the business through purchase of mining license while the manager’s risk is the dealing with uncertain law and order situation in the mining areas and inconsistency of business revenues due to uneven demand and sales trends. While both key individuals have the ability to influence innovation within the mining firm, the owner does not seem to be applying it due to no direct stake or benefit derived from innovation. On the other hand the manager does not appear to exercise that influence because of greater concerns external to his business. These include maintaining good relationships with the local tribes or villagers, maintaining a good working relation with the owner based on trust and keeping operational costs as low as possible to ensure minimum level of profit margins. The diverging interests of two key individuals in the mining firm with no priority for innovation or product/process improvement leads to lack of LT innovation in the mining subsectors of PeMaS and BuMaS.

*Individuals’ Influence on LT Innovation in Marble Processing Firms*

The individuals’ influence on LT innovation varies for the specific organisation present in the processing firm. Variant 1 (O-M) turns out to be the strongest possible arrangement that can influence LT innovation. The primary reason is that the firm owner who also manages the processing business has a direct stake in all aspects of the business. Not only is he inclined to minimize wastage of stone during different processing activities, but he is also more determined to improve quality of the product to ensure greater sales and profitability. Moreover, because of absolute authority within the firm, the owner-manager directly influences types of products produced, the production processes used to manufacture these products, decisions on which markets and customers to target and what kind of organizational structure is implemented (including number of workers, supervisor, if any, and assignment of tasks, responsibilities and authority). Some respondents in the variant 1 category demonstrated a strongly entrepreneurial mindset, with a willingness to take risks and invest in better technologies. They also had a strong ability to influence innovation by being authoritative and having a long-term vision for their business. On the contrary, other respondents were unwilling to take risk or improve products/processes. Their ability to influence innovation was also limited or non-existent.

Variant 2 (O&M) is found to be the weakest arrangement in terms of influence on LT innovation. The main reason is somewhat similar to the owner-manager arrangement identified for mining units. While the owner of the processing unit is better off financially he does not have a direct involvement in day-to-day operations (activities performed by the manager). The manager has more technical knowledge about products and processes and a direct influence on workers’ productivity. On the other hand the owner has a stake in returns on his investment and costs reduction to maximize profits. Since the manager is paid a monthly salary only (direct stake) he has an indirect stake in cost reduction and profit maximization as this ensures his own employment in the long-run. Similar to variant 1 there is unclear evidence for entrepreneurial mindsets of O&M. For some processing firms it is there, while for others it is not found. One important finding is that the owner can have a greater influence on innovation because of investments in better technologies and marketing decisions. However, this influence subsides considerably if the manager does not reciprocate the owner’s mindset by improving operational activities that lead to product/process innovation. In term of an entrepreneurial approach, the owner is concerned more with return on investment while the manager’s priority is to maintain the owner’s trust in him. Again, the main reason for weak influence of O&M on LT innovation is found to be the diluted influence of owner and manager due to a lack of complementarities of their roles.

Variant 3 (O+M) lies somewhere between 1 and 2. The main reason identified for greater influence than variant 2 is the both the owner and manager are involved in day-to-day operations whereby the manager’s main role is that of supervising and interacting with workers. However, both individuals are involved in decisions regarding products and production processes. Also, both have a sound knowledge of products and processes. On the other hand the main reason identified for weaker influence on LT innovation than variant 1 is the differences in nature of stake. While the owner has a direct stake in ensuring returns on investment, the manager’s stake in this regard is indirect as he is more concerned about the salary and maintaining trust of the owner.

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. The study reveals 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. Moreover, 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. Thus, providing the organizational relationship is well-founded, the more entrepreneurial managers are able to establish a greater degree of interconnectedness and systemicity.

**Meso (firm) perspective**

The most significant factors for firms were quality issues caused by indiscriminate blasting, poor stone cutting procedures and a lack of finance to support technology improvement. Although some marble firms demonstrate incremental innovation, they 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 leading to incremental product innovation. However, unless the excavated stone is improved, improving product within processing subsector will be much more difficult. For mining units, 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. Figure 7 illustrates the roles of firms within PeMaS and BuMaS.

PLEASE INSERT FIGURE 7 AROUND HERE

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).

The study further reveals that firms’ learning orientation is influenced by their market orientation towards the wider national (beyond regional) market. This influences firms to improve or upgrade equipment (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/equipment, better trained and skilled human resource emanating from a strong learning orientation which in turn is influenced by a strong market orientation especially towards international markets will lead to improved innovation overall.

**Macro (industry) level**

In terms of structures relevant to the marble value creating system, we found:

1. Key individuals playing a ‘meta’ role in the value chain: suppliers/middlemen/distributors
2. Sector support organizations
3. National institutions

PeMaS and BuMaS adhere to a supplier-dominated taxonomy (Pavitt 1984; Pavitt et al. 1989; De Jong & Marsili 2006), where the availability of modern equipment from suppliers could be a key source of innovation (Duguet 2006). However, this is not happening in PeMaS and BuMaS as these suppliers do not specialize in industry specific equipment, technologies and services. *Suppliers* in our study did not specialize in marble-specific inputs, but catered to other SME manufacturing sectors, competing on price (rather than quality). This lack of specialisation and quality leads to a fragmented value network which does not, in its current form, support innovation. *Middlemen* too were important in overcoming 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. Again, this weakness in the value chain overall tended to detract from the potential for entrepreneurial behaviour.

*Support organisations* include both ‘generic’ support organisations such as the Small and Medium-sized Enterprise Development Authority (SMEDA) and banks, and ‘specific’ agencies such as the Pakistan Stone Development Company (PASDEC) and the Directorate General Mines and Minerals (DGMM), Government of N-WFP and Department of Minerals (DoM), FATA Governor’s Secretariat, as well as donor agencies linked to USAID and European Commission

SMEDA does have two marble-specific initiatives:

* 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 any 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 a ‘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.

Overall, the roles of sector support organizations, especially those representing the government (Souitaris 2002) should be 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. The situation is summarised in Figure 8 below, illustrating the mismatch between strong informal institutions in the mining regions based on tribal codes of conduct and a sense of disadvantage, combined with a distrust of the weaker formal institutions nationally and regionally.

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.

INSERT FIGURE 8 ABOUT HERE

**Discussion**

In summary, we began with an expressed problem that indiscriminate blasting, problems with excavated stone and low quality of available technology are leading to 70% resource wastage with $ 60 – 70 million losses per year in exports. If increasing innovation in the value chain overall is seen at least in part as a mechanism to improve this situation, it is important to recognise that the factors behind the paucity of innovation are interconnected and systemic:

* *At the micro-level*, no overarching climate for innovation in the industry in the community of firm owners; though entrepreneurial individuals can be influential, overall, there is a lack of role models
* *At the meso-level*, limited and informal interactions between firms in relation to knowledge and learning processes
* *Meso-micro interactions* between individuals and firms are role-dominated, often with weak connections between investment in innovation and reward
* *At the macro-level*, weak institutions combined with sector support organisations with a lack of trust, direction and purpose within a conflictual region result in non-existent access to international markets
* *Macro-meso interactions* result in the inability of firms to trigger new demand and weak knowledge creation and learning.

Knowledge and demand management are two key areas where it is possible to stimulate and lead LT innovation. Formal knowledge (especially connected with new technologies) provided to marble firms from external sources and acquired and adapted through formal learning processes is essential. The key influence in this regard is the role of non-firms, especially sector support organizations. in facilitating access to, and the adoption of this formal knowledge thus helping 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.

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. There is some evidence for this 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 demand that could potentially lead to LT innovation in PeMaS and BuMaS.

. 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 equipment and/or produce new/improved products for new markets) have the power to influence LT 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.

Conclusion

This distinctive study provides a great deal of insight into a hitherto poorly understood value creation system that has the potential to contribute to the development of a volatile and troubled region. In succeeding in gathering and analyzing empirical data from this difficult to access region, we have achieved our research objectives 1 and 2:

RO1: To understand the phenomena of innovation and entrepreneurship within a low-technology sector (the marble industry in North-West Pakistan

RO2: To explain how a low-technology innovation value creation system exists in terms of its elements, key stakeholders and actors, and the interactions between them

Turning to RO3: *By studying and explaining the structure of the innovation value creation system, developing recommendations for improvement*, it would be easy to focus on the negatives and the difficulties, rather than the opportunities for this industry. Our study has overall contributed to the relatively small literature on LT innovation, demonstrating as Hirsch-Kreinsen (2008) suggested that LT innovation is not straightforward – it is systemic, with a multitude of interactions between a number of actors including individuals, firms and institutions. By taking a systemic approach, we are able to support the development of recommendations for improvement:

1. Despite the apparent non-complex nature of products in an LT sector, we 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.
2. We 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.
3. 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 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 driver.
4. A fundamental problem identified in the marble industry is lack of innovation-specific institutions particularly regulative institutions, particularly with specific knowledge of the marble industry.. Instead, inconsistent and poorly managed implementation of some regulative institutions in the past has lead to a 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 will individuals and firms be convinced to take up LT innovation as a core business activity.

Of course, further research needs to be carried out. Areas that we have identified include:

* A deeper study of the dynamics and interactions within this value creation system, to further theoretical understanding of LT innovation systems
* A fuller exposition of the learning and knowledge processes, to make recommendations in regard to education and training providers.
* A further consideration of the nature of entrepreneurial agency in this complex context, to deepen understanding of issues of identity, discourse and culture.

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FIGURES

Figure 1. Placing Low-Tech on the Innovation Landscape

Transformation, Disruptive, Discontinuous

High R&D Intensity

DETERMINANTS OF INNOVATION

Factors, determinants, activities, inputs

Knowledge & Technologies

R&D

DEGREE OF INNOVATION

High-Tech Innovation

*(Research interest since 1940s & 50s)*

Entrepreneurship can occur for multiple levels and components]

Radical,

Breakthrough

Low R&D Intensity

**Low-Tech (LT) Innovation**

& Low- and Medium-Tech (LMT) Innovation

Incremental, Continuous

Product Process Position Paradigm

(Marketing) (Organizational)

Component Architectural Technical Administrative



**CONTEXT**

Buner (BuMaS)

Product groups, technologies, knowledgebase, learning processes, demand, institutions, non-firms, interactions/relationships

**CONTEXT**

Peshawar (PeMaS)

Product groups, technologies, knowledgebase, learning processes, demand, institutions, non-firms, interactions/relationships

**CASE 2**

Buner

Unit of Observation:

Owner/Manager

**CASE 1**

Peshawar & Mohmand Agency

Unit of Observation:

Owner/Manager

Embedded Unit of Analysis 1

‘Marble Mining Firm’

Embedded Unit of Analysis 1

‘Marble Mining Firm’

Embedded Unit of Analysis 2

‘Marble Processing Firm’

Embedded Unit of Analysis 2

‘Marble Processing Firm’

Figure 2. Case study design

Figure 3. Constituent elements of the marble industry

Mining Unit

Mining Unit

Mining Unit

Mining Unit

Intermediary or Middleman

Public-oriented Sector Support Organization

Supplier

Public-oriented Sector Support Organization

Other Stakeholder Organization

Private

Sector Support Organization

Intermediary or Middleman

Other Stakeholder Organization

Supplier

CONTEXT

**Marble Innovation (Marble SSI)**

**Levels within the Marble Sector**

**Micro-individual level**

**Meso-firm**

**level**

**Macro-contextual level**

Marble firm owner or manager

Representative of non-firm organization

Marble firm (mining or processing)

Non-firm organization

Institutions

Demand

Learning processes

Technologies

Knowledgebase

Figure 4. Applying micro-meso-macro framework to marble industry (2)

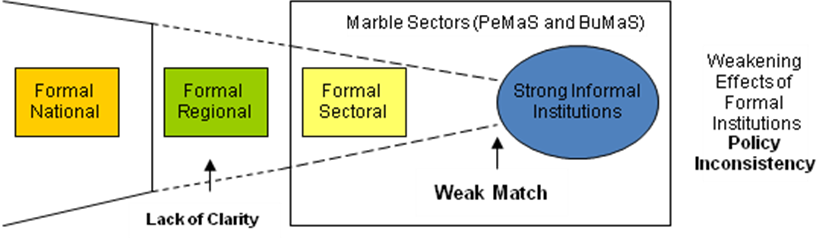


Figure 8 Relationship among sectoral, regional and national institutions

TABLES

|  |  |
| --- | --- |
| **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 1. Analysis of LT Innovation Adopted from Hirsch-Kreinsen (2008a, 39)

|  |  |
| --- | --- |
| **Analytical Level** | **Translation to this research** |
| ***Micro-individual level*** | **Entity:** 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) |
| **Attribute:** Activities/behaviours relating to entrepreneurship and innovation |
| ***Meso-firm***  ***Level*** | **Entity:** Firms, Non-firms (mining units, processing units, suppliers, distributors, public/private organizations related to marble sector) |
| **Attribute:** Activities/determinants/factors concerning innovation, types of products and innovations, interactions among agents (firms and non-firms) |
| ***Macro-contextual level*** | **Entity:** Marble sector of north-west Pakistan |
| **Attribute:** 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 2. Applying micro-meso-macro framework to marble industry (1)

|  |  |  |  |
| --- | --- | --- | --- |
| **PHASE** | **TOOL** | **NUMBER** | **RESPONDENTS** |
| I  (preliminary) | Semi-structured In-depth Interview | 12 | 1. Owners/Managers of mining and processing firms 2. Suppliers/Middlemen of marble equipment/machineries/technologies 3. Sector experts 4. Representatives of government and marble sector support organizations |
| II  (development) | Structured Interview | 18 | 1. Owners/Managers of mining firm |
| Questionnaire | 70 | 1. Owners/Managers of processing firm |
| Iii  (closing) | Semi-structured in-depth interview | 6 | 1. Owners/Managers 2. Sector experts 3. Mddleman 4. Representatives of government and marble sector support organizations |

Table 3. Three-Phased Data Collection

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 4. Product Innovation in PeMaS and BuMaS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 5. Process Innovation in PeMaS and BuMaS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 6. Marketing Innovation in PeMaS and BuMaS

Mine Owner

(MO)

**Individual**

Mine Manager

(MM)

Supervisor/ ‘Munshi’

**Professional Characteristics**

**Nature of Business Stake**

**Individual characteristics**

- 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?**

**NK**

- Satisfy MO in terms of trust

- Draw monthly salary

**IM** – ~~ **EA** – ~~

**RTB** – ~~ **AII** – ~~

- 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?**

**Variant 3**

One Owner

+

One Manager

(**O**+**M**) of Proc. Unit

**Variant 2**

One Owner and

One Manager

(**O**&**M**) of Proc. Unit

**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

**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?**

- 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

- **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** 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** – Diluted as a result of **O** & **M** having different roles

**A1?** and **A2?**

**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?**

- **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

**Key:**

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 characteristic

~~ = Irrelevant characteristic **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 7. Role-Ordered Matrix – Roles of Individuals within PeMaS and BuMaS

**STEP V**

Loading

**Equip. / Material:**

Loader or

Mechanical Winch

Vehicle – Truck

Fuel

**Manual Labour:**

Operate machinery

Manually direct stone onto vehicle

**Output:**

Raw excavated stone ready for shipment

**STEP IV**

Excavating

**Equip. / Material:**

Excavator or

Mechanical Winch

Bulldozer

Hooks, chains, pulleys, fuel

**Manual Labour:**

Operate machinery

Install chains & hooks

**Output:**

Raw excavated stone (3 sizes)

**STEP III**

Blasting

(Indiscriminate)

**Equip. / Material:**

Dynamite

**Manual Labour:**

Install equipment for blasting

**Output:**

Extractable & irregularly shaped marble rocks of different sizes

**STEP II**

Drilling

(Series Pattern)

Vertical, Horizontal

**Equip. / Material:**

Driller

Compressor

Fuel

**Manual Labour:**

Operate Driller

Operate compressor

**Output:**

Loosened rock ready for installing dynamite

**STEP I**

Benching

**Equip. / Material**:

Driller

Compressor

Fuel

**Manual Labour:**

Operate Driller

Operate compressor

Remove stone manually

**Output:**

Expose marble beneath the face of the mountain

**MINING**

**PHASE**

**RAW**

**MATERIAL**

Natural

Rock

**PROCESSING**

**PHASE**

**RAW**

**MATERIAL**

Raw

Excavated

Stone

(Block,

Half Block,

Boulder)

By Product

**Equip.:**

Grinder

**Output:**

Marble ‘Chips’

Marble Powder

**STEP I**

Unloading

**Equip. / Material:**

Fixed Crane with chains & hooks

**Manual Labour:**

Operate crane

Manually direct stone

**Output:**

Stone placed on to machinery platform

**STEP II**

Raw-Cutting

**Equip. / Material:**

Gang Saw

‘Vertical’

‘Horizontal’

‘Diamond’ Tips

Water

**Manual Labour:**

Position raw stone on to platform

Movement of cutter & blade

**Output:**

Slabs or tiles with rough edges or ‘Dimensional’ blocks

**STEP III**

Edge-Cutting

**Equip. / Material:**

‘Vertical’, ‘Horizontal’

‘Diamond’ Tips, Water

**Manual Labour:**

Position cut stone onto platform, movement of blade along rough edges

**Output I:**

Small stones – irregular

**Output II:**

Dimensional slabs & tiles

**Output III:**

‘Dimensional’ blocks

**STEP IV**

Polishing

**Equip. / Material:**

Polisher, Grinding Stone, Wax, Water

**Manual Labour:**

Position slab/tile on to platform

Apply grinding mechanism, wax, water

**Output:**

Finished slabs and/or tiles

**STEP I**

Designing

**Equip. / Material:** **Manual Labour**: **Output:**

Lathe Machine Crafting designs Decorative Items

Figure 5. Illustration of Production Processes during Mining and Processing

**Mining sub-sectors in PeMaS and BuMaS Processing sub-sectors in PeMaS and BuMaS**

**PeMaS vs. BuMaS**

Greater unauthorized imposition of levies in PeMaS adding to transportation costs

Stricter regulations for purchase of dynamite in BuMaS

**Input Supplies** Electricity shortfall a clear problem in BuMaS. Conflicting data in PeMaS

One processing machinery manufacturer in PeMaS

None in BuMaS

**Formal Promotion**

Showroom

Direct Buyers

No Product Branding

**Unclear Pricing Pattern**

Influencers

Variety of Product Types

Inconsistent Product Quality

Stone Variety

Different Production Processes

Different Market Needs

**Informal Promotion**

Personal Contacts based on Trust & Past Relationship

No promotional material, no branding

Stone varieties recognized by locally given names

**Non-standardized Pricing**

Influencers

Stone size

Stone variety

Freight charges

Another Business

Factory-Owned

Sells Through

Business Customers

Distributor

DOMESTIC/LOCAL

Machine Installation Expert

**Mining Firm**

**Processing Firm**

NATIONAL

Punjab Province & Karachi City

‘Tip’ Supplier

Sells Directly To

**Product Demand**

Influencers

Stone size

Stone variety

Processing unit’s preference

INTERNATIONAL

Business Customers

*(Processing Firm)*

*(Wholesaler)*

*(Distributor)*

**Materials or Equipments or Components**

Mostly available within Sector

**Machinery**

Only available outside sector i.e. Punjab

**Competition**

Somewhat Direct in Nature

*Some product differentiation*

*New market opportunities*

*Competing by imitating*

**Materials or Equipments or Components**

Mostly available within Sector

**Machinery**

Some available within Sector

Other available from Punjab

Contextual Link

Unclear Link

Sales Link

Market Category

**Competition**

Indirect in Nature

*Undifferentiated product*

*Mature market/demand*

**Product Demand** Influencers

Bus. Cust./Consumer Preferences (local & national)

Figure 6. Context Chart: Nature of Market and Marketing Practices in PeMaS and BuMaS

**Mining (PeMaS)**

**Mining (BuMaS)**

**Processing (PeMaS)**

**Processing (BuMaS)**

Mining Unit

Processing Unit

**Product**

**Innovation**

Process

**Innovation**

Low profit margins, cost reduction focus

Non-standardized products

No product differentiation except variety

Quality problems & inconsistencies

Same excavation technologies as others

No product, process, marketing, organizational innovation

Small size of business

Non-standardized products

Different processes for different products

Quality problems & inconsistencies

Poor quality/maintenance of blades – rough edges

Small size of business

Low profit margins, cost reduction focus

**Less likelihood of technology acquisition from external sources**

(Swan & Allred, 2003)

**Low innovation capability**

(Morone & Testa, 2008)

Poorly trained workforce

Poorly trained workforce

**More common than product innovation**

(Hall & Baghci-Sen, 2007; Moreone & Testat, 2008; Kirner, 2009)

**Low innovation capability**

(McAdam et al., 1998)

**Incremental**

(Pullen et al., 2009)

**Influenced more by internal factors and non-firms**

**Most important influence on**

**Processing Unit**

**Mining Unit**

**Leads to**

**Can influence strongly**

**Linking with literature**

Raw Stone

Figure 7. Roles of Firms within PeMaS and BuMaS