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**Using Business Process Reengineering (BPR) to Improve the
Operations Management of Cottage Industries in Developing Countries:
A Case Study of Bani Hamida Project in Jordan**

By

**Valantina Qussisiya, B. Sc
University of Jordan**

**A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of the
requirement for a
Masters of Management Studies**

**Carleton University
School of Business
Ottawa, Ontario**

**August 19, 1996
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**“Using Business Process Reengineering (BPR) to Improve the Operations
Management of Cottage Industries in Developing Countries: A Case Study
of Bani Hamida Project in Jordan”**

submitted by Valantina Qussisiya, B.Sc.
in partial fulfillment of the requirements
for the degree of Masters of Management Studies

Thesis Supervisor

Director, School of Business

School of Business
Carleton University
August 19, 1996

ABSTRACT

The purpose of this research was to investigate whether modern management practices such as Business Process Reengineering (BPR) provide similar benefits in a traditional business environment, such as in a cottage industry in a developing country, as it does in a Western business environment. A case of a cottage industry in Jordan was used to study the impact of performance of applying BPR to its processes. The findings indicated that BPR generates similar values with cottage industries. However, these results have to take into consideration the surrounding environment. Cottage industries, and especially those in developing countries, suffer from profound technological and capital inadequacies. This is why BPR has to be slowly introduced within a firm until enough financial funds can be raised and until the participants can accept such a change.

ACKNOWLEDGEMENT

This thesis would not have been possible without the support of many people. I would like to express my profound gratitude to both my supervisors, Professor Oscar Hauptman and Professor Wojtek Michalowski for their guidance, encouragement, endless patience and support. I would like to thank my committee members, Professor Moses Kiggundu, Professor Nicholas Papadopoulos and Professor Bruce MacFarlane for their helpful advice. I am grateful to all my friends for their encouragement and support, and in particular, Dayle Prowse, Samuel Asiedu, Jason Gilmore and Stéphane Chérel.

The financial aid that was provided by CIDA is greatly appreciated. Very special thanks to Janette Edward, the WUSC CIDA program officer for her support. My sincere gratitude to the Bani Hamida Weaving project for their willing participation in my study. Without their participation this study would have not been possible.

Last, but not least, I am indebted to my parents, brother and sisters for their love and encouragement over the period of my study in Canada.

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1. INTRODUCTION

The aim of this thesis is to evaluate the impact of the performance of Business Process Re-engineering (BPR) on cottage industries in developing countries. The BPR approach is the redesign of operations management (OM) processes¹ in order to improve the performance of the business or the service. A case study of an industry in Jordan (Bani Hamida Women Weaving Project) is used to evaluate the effects of applying BPR to its processes. Bani Hamida Women Weaving Project is a non-profit income-generating project that provides better living conditions for Bedouin women and their families by providing work opportunities for them.

The fundamental question this thesis seeks to explore is what benefits could be derived by applying a modern management practice such as BPR in a traditional craft industry. The first step to addressing this question was the application of BPR to the OM of Bani Hamida (BH) project. The potential benefits of BPR are assessed by simulating the operations of BH before and after the application of BPR and comparing the performance of the system. Field research was conducted to collect data on the problems that needed to be resolved in the production processes, and to determine what processes need to be redesigned.

¹Operation management processes include order processing, billing, purchasing, shipping, receiving, inventory management, business planning, budget planning, accounts payable, accounts receivable, performance appraisal, credit approval process, facility-change, request process, continuous improvement process, human resource planning, new employee processing.

A process is a set of activities where one or more inputs are transformed into one or more outputs. All business processes involve the flow and exchange of information in some form or another [Rogers, 1992].

The second step involves modifying the results of BPR technology to apply to the specific context of Bani Hamida quasi-nomadic workers. The BPR approach will involve a radical change in the OM processes. Both the management and the Bedouin workers will be affected by the change. Consequently, the application of BPR must be adapted to the cottage-like industry and developing countries' management contexts when implemented.

The process of BPR has been successfully simulated in a cottage industry, the BH project, which is a more traditional business environment. Evidence from the simulation results indicated that BPR did improve the production processes in the BH project

2. BUSINESS PROCESS REENGINEERING (BPR)

2.1 What Is BPR?

Business process re-engineering, first introduced by Michael Hammer, is considered to be a more appropriate approach for conducting radical changes to improve the business processes [Hammer: 1990, Hammer and Champy: 1994, Stewart: 1993, Caron et al.: 1994, Davenport: 1993, Macarthur et al.: 1994]. Hammer emphasized that process-oriented firms have a better opportunity for greater improvement results than product-oriented firms, since processes work around customer needs [Roberts, 1994]. He defined business processes as "a set of combined activities, with inputs and outputs, that result in a greater value to the customer". Although this is every firm's objective, he found that most firms rarely focus on processes, but rather on tasks, people, jobs, and structures, which usually have no contribution to customer needs (i.e. creating a product with high quality, low price and excellent service) [Hammer and Champy, 1993].

With the rise of globalization, tough competition and sophisticated consumers, firms tried to adapt and improve their processes to the new circumstances, but it only created more problems and the improvement results did not meet the expectations. These old processes were created in a different time and in different conditions than what exists now [Hammer, 1990]. Firms using old processes now find it difficult to meet the level of performance required in the current business environment. Most processes were created in the period when modern computers and advanced high-technology did not exist.

Accordingly, in the mid 1990's, Hammer introduced the concept of "reengineering". He explained that business reengineering is not about fixing anything; it is about starting the business all over again, from scratch.

'Reengineering strives to break away from the old rules about how we organize and conduct business... by recognizing and rejecting some of them and then finding imaginative new ways to accomplish work' [Hammer and Champy, 1993: 3].

In reengineering, rather than improving the current processes, managers should abolish the old processes and create new ones. The company should evaluate which of its activities really contribute to customer needs and search for new methods to achieve them. Wright and Adams [1996] add that BPR is a strategy based on combining excellent customer focus and high quality low priced goods and services in order to remain competitive in a highly aggressive environment. BPR provides an approach to attain productivity improvement through "concentrating on product development cycle time, market responsiveness, customer focused operations and service quality" [Macarthur et al., 1994].

Competition can initiate change, but customers are the largest influence to the initiation of change [Davenport, 1993]. "Customers are more likely to take their business elsewhere because of poor business process opposed to poor products" [Roberts, 1994]. Their expectations have changed in response to the ever increasing range of choices and alternatives. Successful process re-engineering ensures that processes effectively and efficiently match all requirements and customer needs [Stewart, 1993, Caron et al.,

1994]. Such a strategy requires the organization to probe its current processes, functions and structures and to consider the BPR approach if it wants to stay competitive. It should focus on service, quality, cost, flexibility, speed and innovation rather than on control and planning. This means dropping the current rules and procedures of the firm and inventing new and improved ways of doing the work required to create the company's product or service, and to satisfy the customer's needs.

Nevertheless, process improvement is complementary to process re-engineering. As the processes are re-engineered, there is a need to continuously measure the performance of the processes and improve it if needed later on. In addition, a process could be re-engineered several times as the external environment is changing. Through re-engineering, bottlenecks and long unresolved problems can be identified and resolved. Roberts [1994] stated that dramatic improvements in cycle times, process costs and customer satisfaction are key success factors in process re-engineering. Hammer and Champy [1993] add that reengineering eliminates waste and tasks that have no contribution in meeting the customers' requirements. They emphasized that reengineering would eliminate most of the checking, reconciling, waiting, monitoring and tracking, which add nothing to the customers' requirements but were created for internal organizational reasons. Accordingly, people will spend more time doing "real" work.

Although the customer is the first driver for radical change, information technology (IT) also provides opportunities for process redesign. IT is related to the successful design and

implementation of a new process, and it plays an important role as a process support to improve productivity by improving speed, quality and service [Davenport, 1993]. IT offers opportunities for innovation since by using new technologies processes can be prototyped while being designed. Prototyping enables processes to be designed in a new and more efficient manner.

Unfortunately, managers have been using computers and information technology as a method to speed up rather than to improve or redesign their current processes [Davenport, 1993]. Thus, instead of automating these processes, the company should "reengineer" them and use the technology to redesign their processes in order to achieve a dramatic improvement in its process performance; IT offers many options for reorganizing work [Hammer and Stanton, 1995, Venkatraman, 1994].

BPR is very expensive. Feasibility studies are required to justify the cost and benefit gained for undergoing a dramatic change. Financial support is essential for BPR implementation since it requires the use of IT and infrastructure modifications. To achieve access to budgets and gain commitment to follow up with the reengineering process, senior management must be involved throughout the re-engineering process, and should support the need for this change so they can link it to the organizational strategy plan. Unless top management believe in this change and support the effort, reengineering will not take place and employees will not take it seriously and work together to achieve good results and quick improvements from the process redesign.

2.2 What Is Not BPR?

Considering that reengineering is a new concept, misconceptions of this terminology have to be clarified. For example, reengineering has been confused with downsizing and restructuring. Reengineering is about reorganizing *work* from top to bottom in order to eliminate unnecessary work and to find better ways of doing work and *not* to eliminate jobs or people. Although in some cases, there is a need to reduce the number of people performing certain tasks, this is not the objective of BPR. Also, reengineering is not "restructuring". Reengineering is concerned with work and tasks, not with organizational structure [Hammer and Stanton, 1995]

These misconceptions have been formed as a result of the high percentage of failures in BPR attempts. Over 70% of firms which have conducted or claimed to have conducted BPR have failed in their BPR efforts [Hammer and Champy, 1993]. These failures were found not to be related to BPR, but to the way these firms conducted BPR. Because of the high risk related to BPR, many firms have taken on strategies to improve their processes rather than seeking dramatic change, yet these firms still called it reengineering.

BPR is a disruptive step for any firm to undertake. Reengineering is mainly conducted in conditions of uncertainty, pressure and experimentation. Reengineering requires people to let go of their old ways of doing work and to start new ones [Hammer and Stanton, 1995]. Usually, when the new design is made, it has to be implemented. Accordingly, many errors occur and many repetitions are needed, bearing in mind that no one can generate

the correct design that fits in real life the first time. Undergoing such a reorganization will certainly put the firm under real pressure, stress and anxiety until the results are accomplished. Consequently, BPR cannot be planned meticulously or accomplished slowly and in cautious steps. It is an "all-or-nothing proposition" with an uncertain result. Companies have no choice but to do it if they want to stay competitive [Hammer and Champy, 1993].

2.3 How To Implement BPR?

Since BPR requires a fundamental reassessment of business operations, a methodology is required which can act as a basic framework to coordinate the complexity of the BPR activities [Fitzgerald and Murphy, 1996].

Reviewing the firms that had successfully implemented BPR and the procedures they followed to reach their objectives, authors like Davenport [1993], Davenport and Short [1990], Hammer and Champy [1993], Roberts [1994] and Macarthur et al [1994] identified the different stages they consider essential for successful implementation of BPR (see figure 1). They identified that to implement BPR, the firm must go through the following common stages: (1) development of business vision and identification of processes for reengineering stage; (2) definition and assessment of the current processes stage; (3) designing the new processes stage; and, (4) the implementation stage. These stages are discussed below in further detail.

The vision stage: This stage provides a startup for the reengineering process. It furnishes information on how things should be done and helps to identify which processes need to be changed according to areas of waste and inefficiency.

Usually, reengineering is called upon when a process no longer produces adequate results and a new one must be created, or when there is a need to increase efficiency and performance to adjust to the competition. By classifying the desired performance results and the best ways to reach them, the firm can identify possibilities for change with the current rules or processes.

Problems with the current processes are identified with respect to basic performance measures such as waste, amount of work in process, number of interruptions in a process, quality, etc. Hammer and Champy [1993] classified the following: (1) extensive information exchange, (2) data redundancy and rekeying, (3) high ratio of checking and control to value-adding to customer needs, (4) rework and iteration, (5) product cost, (6) delivery time and, (7) product features as identification of faulty processes that need to be redesigned.

It is very hard to decide which process should be selected for redesign. Processes with high impact on customers are more likely to be selected. As such, the best place to identify problems with a process is at the customer's end. What do the customers really want? What do they say they want and really need? What problems do they face? Since

the eventual goal of redesigning a process is to create ones which add value to the customers. it is really important to understand and satisfy their needs.

In order to get the best results from a process redesign, the process should be selected according to specific criteria suggested by Davenport [1993]:

1. The process should be essential and in the center of the firm's mission, and have the greatest impact on the customers.
2. The process must be problematic and there must be a great need to get it fixed and improved.
3. The process redesign should have the support of top management. This will facilitate accurate and timely data collection and successful implementation of the project.
4. The scope of the process should be somewhat small, to make its redesign manageable.

Definition of the current processes stage: Before reengineering, there is the need to know more about the existing processes: what they do, how well they perform, and the critical assumptions that affect their performance.

Since the goal is not to improve the current processes, there is no need to analyze and document the current processes in very specific details; just enough information to answer the following two main questions:

1. What does this process do?
2. Why does this process do what it is doing?

There is no need to explain in details how these processes perform since the old rules will be abolished and new and better rules will be created.

Thus, this stage requires information gathering from inside and outside the organization on the processes and their performance. The definition of the old process must be very well understood in order to fully understand the new design.

The information which would be collected should focus on waste, inefficiency, cost and WIP reduction, etc. taking into account both the customers' and employees' opinions. It involves the examination of relevant documents and interviews with relevant personnel within the firm. In addition, an assessment of the availability and requirement of any information technology should be considered.

Through the information gathering, the flaws in the old process can be identified and solved, and the capabilities of the business can be assessed, making it easier to redesign a new process while including all the requirements for IT. Also, information is needed from outside the firm, such as the market and the customers to identify the customers' needs.

Hammer [1995] warns about falling in the trap of over-analysis. He stresses limiting the amount of time spent on understanding and examining the current process. He states that the study should not exceed four to six weeks to reach the level of understanding necessary for reengineering. That is because there is no need to spend a lot of time

analyzing processes that will be abolished. All that is needed to be known is what the process does, how well or poorly it performs and why it doesn't perform better.

Design of the new process stage: This stage includes redesigning business processes to ensure that they meet with customers' requirements. The actions needed to move to the new processes need to be drawn and prioritized.

This stage begins with developing new ways of doing the work by questioning why these processes are done and how can they be performed in a better way. The new design should focus on key factors such as waste reduction, speed, quality, etc. which can be identified from understanding the old processes and identifying their weaknesses as discussed earlier. Also, by seeing the processes from the eyes of the customers, one can identify their unsatisfied needs, and invent new ways of doing business according to these requirements. By applying what-if questions to the old processes, the firm can identify which steps are essential and those that are meaningless.

Although this is a very critical step in reengineering, it should not be intimidating since very effective and innovative ideas come up in this stage. Many mistakes happen because of timidity in providing ideas for redesign. Hammer stated that reengineering requires "bold and imaginative thinking" about process design and how work is done, but many people worry about being unable to provide these new ideas and they consider it the hardest part of the reengineering stage [Hammer and Champy, 1994].

In order to accustom the new designs to the surrounding environment, the proposed ideas will be changed many times before settling on the final design. Also, the new design may require a change in the organizational boundaries while performing the new design. A careful analysis of costs versus benefits of the most feasible options allows an organization to select the best design.

The Implementation stage: this stage is a transition phase from the old processes to the new ones. It takes into consideration all requirements for any information technology, training of employees to adapt to the changes in processes and establishment of a continuous improvement strategy for the new processes.

Roberts [1994] and Macarthur et al [1994] extended their framework to include tracking the new processes performance and improve them to stay competitive with the ever-changing environment [see figure 2].

3. PROBLEM STATEMENT AND RESEARCH QUESTIONS

3.1 Problem Statement

Business Process Reengineering is a Western management practice which was primarily developed for a Western business environment. Management practices are affected by the values, attitudes and beliefs of the surrounding environment to which they are going to be applied. Thus, the success or failure of any management practice is not only dependent on the core of the organization but also on the surrounding business environment.

The surrounding environments of cottage industries and developing countries are very different from that of the West. In addition, cottage industries, mainly in developing countries, are still based on traditional management practices and business strategies which usually exert many problems to the way their business operates. Thus, the main problem here is to identify whether BPR can be implemented in a traditional industry and if it can prove beneficial in a different and traditional environment.

A case of a cottage industry in Jordan is used to study these problems which will help answer the following research questions:

3.2 Research Questions

Q1. What benefits could be derived by applying a modern management practice such as BPR in a traditional craft industry?

Q2. Can BPR approach improve BH project OM processes? And how?

The BPR steps have been implemented successfully on the BH weaving project and will be discussed in the following chapters. But before, one should assess whether BPR is viable to traditional business settings such as cottage industries within developing countries given that they are much different than the Western business environment.

Cottage industries in an environment such as that of a developing country are faced with many difficulties which emerge from the way they conduct business. Their business processes are very much dependent on the traditional environment that surrounds them. Thus, understanding these difficulties can help identify the extent to which BPR can be adapted to the surrounding environment and what kind of performance outcome would be generated in accordance to that environment. Section four describes the characteristics of developing countries and the problems they face. Sections five and six provide a description of cottage industries in general followed by a presentation of the industry under study, the Bani Hamida weaving project and its operation management processes.

4. CHARACTERISTICS OF DEVELOPING COUNTRIES

Managing organizations in developing countries is very complex. It requires careful understanding of both the internal and external environment of organizations. Every organization must deal with both the management of people within the organization as well as the relationship with the outside environment. For instance, the organization must deal with ways to improve the performance of organizational members to deliver its goods and services. Organizational effectiveness depends on the current management practices and the employees' response to the work environment. Management practices result from the employees values, attitudes and beliefs regarding work. These beliefs, norms and attitudes are influenced by the surrounding environment in which the organization operates [Jaeger and Kanungo, 1990].

Jaeger and Kanungo [1990] define three aspects of environment which give rise to constraints and opportunities to organizations. These aspects are: 1. economic and technological, 2. political and legal and 3. socio-cultural environment.

The economic and technological environment generates constraints and opportunities with respect to the technological, material, monetary and human resources necessary for the organization to function effectively. The legal and political environment either facilitate or complicate the conditions for the organization to perform effectively. Jaeger and Kanungo [1990]

organizations and the "bureaucratic hurdles" that the organizations in developing countries often face are guarantees to organizational failure. The socio-cultural environment relates to the interaction of the human resources within the organization and the clients outside the organization. The socio-cultural environment determines organizational effectiveness, since the organization performance is influenced by the values, attitudes and behaviors of the personnel within.

Hofstede [1980] defines four criteria by which developing countries cultures differ from that of developed countries. These are: (1) small versus large power distance, (2) weak versus strong uncertainty avoidance, (3) individualism versus collectivism and (4) masculinity versus femininity.

Power distance is concerned with the extent to which different members of a society accept the unequal distribution of power within organizations. Uncertainty avoidance refers to the extent to which members of a society feel intimidated by complex situations and try to avoid them. Such societies tend to provide their citizens with life-time stable careers, develop formal rules and procedures, reject new ideas and believe in "absolute truth and the attainment of expertise" [Hofstede, 1980].

Individualism refers to the relationship between the members of a society. It refers to the independence of the individuals or the extent to which individuals take care of themselves and their immediate family members only, while collectivism is characterized by which a

society's norms and values precede over those of the individuals. Hence, the individual's priority is towards family's and friends' obligation rather than self-fulfillment [Hofstede, 1980].

Masculinity refers to extent to which societies emphasize masculine traits such as achievement, courage and competition over feminine values such as quality of life, preservation of the environment and helping others [Kiggundu, 1989].

The external environment of developing countries is different from that of industrialized countries. The weak economic environment of developing countries poses obstacles to obtaining financial, technological and human resources. In addition, organizations are under regular governmental interference in their management practices.

Developing countries are characterized with high power distance, high uncertainty avoidance, collectivism and femininity compared to low power distance, low uncertainty avoidance, individualism and masculinity characteristics of the socio-cultural environment of industrialized countries.

Firms in developing countries are distinguished by traditional organizational specialization, many hierarchical levels, high levels of centralization, hierarchical forms of control, over-staffing, low morale and little cooperation among the employees [Kiggundu, 1989]. Managers take on more tasks than they can handle because they fear

that any mistake can jeopardize their already limited resources. Productivity of the employees is poor and the reward system is based on rank, seniority and age rather than performance.

Due to the large number of workers in the organization, the boundaries of organizations in developing countries are too broad, thus, "leaving the technical core of the organization unprotected and susceptible to abuse by outside societal interests" and government interference [Kiggundu, 1989].

It is a common negative trait of employees in developing countries to minimize the importance of deadlines and quality. In addition, management neglects to stress the importance of these principles. Also, developing countries suffer from infrastructure problems, both physical and informational. Physical infrastructure is very weak and transportation in rural area is inadequate. Word-of-mouth information and personal communication networks are considered the firm's management information systems. As well, kinship relations affect the structure and the way firms operate. These different networks can be either advantageous where they ensure employee's loyalty, or disadvantageous where decisions and rewards are made based on social rather than economic reasons [Austin, 1990].

5. COTTAGE INDUSTRIES

A cottage industry is any small-scale, home-based industry that uses labor-intensive technology of production. Most cottage industries have emerged in rural areas where the workers are mostly women, with poor living conditions, very high unemployment rates, and very little or no education. However, most have a craft that they have learned from their ancestors [United Nations, 1972]. The International Labor Organization (ILO) acknowledged that more than 90% of cottage industries are set up in developing countries where household income is very low, and they are used as a way of decreasing mass poverty [Allal and Chuta, 1982].

Kiggundu [1989] has identified that developing countries suffer from profound capital inadequacy, unemployment and uneducated workers; this has even been exhibited in a large number of urban areas. These unemployed and uneducated workers account for a large portion of cheap labor in these areas. These problems have increased the need to set up cottage industries to employ this cheap labor, through "employment generation, expansion of rural industrialization and the local production of consumer goods in accordance with the needs, tastes, purchasing power of low income groups" [Allal and Chuta, 1982].

However, social barriers present a source of resistance against participation in such assignments. Traditions and superstitions bring resistance to change and the low level of

education makes it harder for the workers to accept both change and technology transfer. For example, in the area of BH project, culture and tradition have prohibited the women from indulging in work other than house work. Also women were never encouraged to attend school [McCann, 1994]. Nevertheless, "no matter how ignorant people might be, they can never resist a source of extra money" [United Nations, 1972]. Rogers [1962:61] has identified that it is the traditional social systems that causes resistance to innovation. He explained that the behaviors of the participants stem from the characteristics of their social system. Participants of a traditional social system are characterized by having a very simple, less developed occupation. Their common occupation is either subsistence farming or they work in cottage industries. They have little or no education and verbal communication represents their information system. They rarely integrate with other societies and they lack economic rationality. Accordingly, no new ideas enter their social system and no one adopts roles or new occupations. "Individuals in a traditional system usually play one role, never learn other roles, and seldom learn how to learn them" [Rogers, 1962].

Singh and Kelles-Viitanen [1987:13] pointed out that there is a great difficulty in obtaining data about home-based or cottage industries' workers, as there is no reliable source at the "national or international level."

Most cottage industry workers are piece rate workers. The production operations of cottage industries start by providing the workers with the required raw material, who then

work on it at their homes and finish when returning the finished item to their employer [Bhatt, 1987:30]. Piece rate home-based workers are usually women who combine their household task with income-generating work. In cottage industries, as they are home-based, there are no overhead costs, or a need to invest in machinery or tools. The worker's room is used as the work place, and the workers must provide their own tools and machines. Usually, home-based workers are not covered by labor laws, paid below minimum wage, not covered by welfare, health insurance, or maternity coverage, and they are not paid for holidays [Singh and Kelles-Viitanen, 1987: 22].

Employment is irregular and uncertain for the workers depending on the market demand on the items they produce. They may have to work over twelve hours a day during peak seasons and sit idle for days during the low season. Depending on the number of pieces they produce, they are paid accordingly. Some workers are even paid less than the minimum if their idle time was very long, not forgetting that cottage industry workers are paid less than the minimum wage.

6. BANI HAMIDA WEAVING PROJECT

6.1. Background to Bani Hamida Project

This study is based on a cottage industry in Jordan. This cottage industry was established in 1985 in a Bedouin area named Bani Hamida. Bani Hamida refers to the sons of Hamida, a woman who, seeking food and water, moved the tribe to Jordan from the peninsula of Arabia. A few decades ago, the tribe endured a tremendous drought which left them in huge poverty and debt and the cattle industry was no longer profitable.

Bani Hamida Mountain, seventy five kilometers south of Amman, the capital of Jordan, was surveyed by the Save the Children Federation and was found to be one of the least privileged areas in Jordan. The Bani Hamida project was established there to improve the area and reduce mass poverty [Adapted from Bani Hamida project documents].

6.2 Bani Hamida Project OM Processes

The Bani Hamida weaving project was established in 1985 by the U.S. Save the Children Federation (SCF), to provide better living conditions for the Bedouins and their children. As weaving was a tribal traditional craft and the only craft the Bedouins knew, the project directed its goals at the production of weavings of rugs, cushions, wallhangings, etc. by the women to be sold through SCF employees located in the capital of Jordan, Amman. The SCF employees are educated and trained in marketing, production, accounting and management.

Labor in the Bani Hamida area is cheap and the weaving process is an inherited craft passed on from "mother-to-daughter". Although it does not have the prestige it once had, the basic skills and knowledge are still in the minds of the older women who provided training to the other workers at the inception of the project.

The project started with only eight Bedouin workers, as the traditions and culture have stood in the way of women employment. Nevertheless, as the project began to provide an extra source of income to the Bedouins, more women were encouraged to participate in it. The project now employs more than 1200 women scattered around the BH area in twelve villages. A field office has been created and the villages are mainly supervised by local staff that consists of a field manager, an assistant manager, two bookkeepers, three drivers, three production supervisors and one technical assistant (see Figure 2: Organizational Chart).

The BH project started as a non-profit income-generating project, and evolved into a sustainable not-for-profit cottage industry that deals with manufacturing and marketing hand-made, high-quality weavings. The women workers are home-based so they are not taken away from their children and family. The workers are paid at a piece rate as described before.

No machines or sophisticated equipment are used in the production process and all processes of production are performed manually. The processes in the project include

washing the raw wool, spinning, dyeing and weaving it into a custom-made or a standard-design item. A ground traditional loom is used for the weaving. The workers are to provide their own tools, such as the wooden beams for the loom and the latch hook needle. The output varies from very small pieces of 0.1 kg per piece to huge pieces items with no size limit. The ability to produce different size products derives from the flexibility to sew different pieces together thus, allowing any design to be customized.

6.2.1 Production Process

The production process (see figure 3) starts by providing raw material to the workers for the specific task they are involved in at that specific time. To explain this, the workers do not have a fixed task. Each worker can either be a spinner or a weaver at a specific time according to the needs. Either they receive washed wool for spinning or dyed spun wool for weaving. Dyers are specialized in dyeing the wool, because this is a complex task and requires a lot of concentration and time.

The raw material is purchased in the months of May and June, the sheering season. The wool must be washed as soon as it arrives and moth-proofed to ensure an adequate quantity of spun wool. The raw wool is transported from the supplier three different times during the purchase season, because of the inadequacy of storage space in the area. The washing process takes place in a specific village center, "Ballouta", where there is a large storage place and a large well to solve the problem of inadequate water supply.

Spinning starts as soon as the washed wool is available. The washed wool is distributed to the spinners and the spun wool is collected within three weeks. The spun wool is then distributed to the dyers. The project has eight home-based dyers, and a dyeing center that employs nine dyers and a supervisor. The home-based dyers are very experienced and have been with the project since its inception. The main objective of the center is to take over the dyeing process, obtain new colour mixtures, and supervise the few dyeing processes in the homes.

The dyeing process takes two to five days. The reason for this is that the wool is dried outdoors and, thus, weather conditions play a major part in drying it. Then, the output is collected from the dyers to start preparing for the weaving orders. As such, the office supervisors prepare the required amount of coloured wool for every order, and distribute the orders to the available weaving supervisors who, in return, distribute the orders to their subordinates according to their turn.

The weaving process takes around a month to be completed. There are two designs in the weaving: plain design and geometric (hattou) design. The latter is a more complex weaving style and requires in-depth experience. The weaver has a big challenge to keep the item with straight edges and high quality weaving. A small mistake can damage a whole month's work. Continuous and heavy supervision is required throughout the weaving process. Complex designs and lengthy orders (over five meters) require very special weaving skills few workers can provide.

Each weaver is assigned to a supervisor. The supervisor is responsible for four to ten workers. The supervisor must remain close to these workers in order to provide continuous supervision and help. As the supervision process is not a very demanding task, the supervisor can be assigned to weave or spin. Most of the supervisors are very experienced, and can provide on-the-job training and quick solutions to weaving problems.

Weavers are divided into three divisions according to their experience and skills, such as "A", "AB" and "B" weavers. "A" weavers are the most qualified and experienced weavers. They are assigned to customer orders, export orders, and complex and new-designed items. "AB" workers are less qualified and are, thus, given less complex orders. The "B" weavers are weavers who can weave only easy and simple items and are under continuous supervision and training. "AB" and "B" weavers are provided with on-going training to upgrade them to "A" level.

After the weaving is done, the supervisor collects the woven pieces from weavers and sews them together as per order. The supervisor's job, among others, involves supervision of the weavers, cutting the woven pieces and sewing them in the required order dimensions.

6.2.2 Planning

Each product item is given a number. This number consists of the year of production and a digital serial number which ranges between 1 and 1999 for stock orders² and between 2000 and 4000 for customer orders and export orders. In addition, a letter can be added at the end of the serial number to indicate that the item is a part of an identical collection woven on the same loom.

An example would be: stock items produced on the same loom:

1256.94 : a rug

1256.94A : could be one of these items: a small rug, a runner, a wall-hanging, a place mat, or a basket woven by the same weaver and on the same loom of item #1256.94.

1256.94B : same as A

Each number is a unique number and it identifies the worker for the purpose of payment, in accordance with the specification of that item such as weight, quality and design.

Most of the production planning is done manually. The use of computers is only to generate sales reports, production reports, and inventory reports. Also, a spreadsheet is used for simple calculations.

The master plan for the following year is prepared at the end of each year. The plan is arranged by the production manager, marketing manager, and the project manager. Each month's forecasted sales figures are calculated according to the previous year's figures.

²Stock orders are the order for standard-designed orders or new-designed orders that are to be sold in the showroom of the project.

The environment has a great influence on the performance of this project. Since the weavings are not an essential commodity, sales vary according to political activities and the external environment. In addition, the raw wool is affected by the weather and the wealth of the farmers who raise the sheep. Sheep's wool is affected by rain and availability of grass, and can only be purchased at a specific time, the month of May or June. Most of the suppliers are independent individuals who buy the fleece from farmers and sell them in large quantities. These suppliers require immediate cash payments for the wool. Other sources for wool, which are very few, are small projects that buy wool and sell it as ready washed and spun but at higher prices. Although this can be a beneficial source, the volume is not large and the price is frequently unaffordable.

The required quantity for raw wool is calculated by dividing the forecasted sales figures of every month by the price per kilogram of wool, taking into account that only 30% of the fleece can be used, and the rest (70%) is waste.

After calculating the required kilograms of wool, the required inventory can be calculated by dividing the number of kilograms of wool by the average weight of a unit (five kg per unit). These units must be planned by the production type (what percentage of rugs, runners, wallhangings, place mats, saddles, and baskets are to be made), and by colour and design specifications. This requires full and detailed reports of the previous year's

sales figures, in addition to market research which identifies the new colour combinations that are in style at that time.

The inventory is considered throughout the production plan. The design/style/colour/size and number of pieces in inventory make the base for the production plan, and dictate the quantity of raw wool needed to be purchased in order to fill the gap. This requires good communication channels and parallel integration between production and marketing employees.

Scheduling every order and doing preparations can be tedious. Every order is given a priority, and queued according to FIFO management (first-in-first-out). The orders have to wait according to the availability of the weavers. Export orders, complex orders, and customer orders are assigned to the most experienced weavers. They also need full supervision in case of inadequate material or inability of the weaver to spare time for the weaving. To start preparing such an order, the weavers selected to do the job must finish the items that they are working on or assign them to other weavers in order to be available for the new assignments. This is only done if the order is not an export or a complex customer order. Stock orders can either wait until the weaver is no longer busy, or be assigned to a different weaver.

Each order takes three months in production before it is delivered to the customer. Customers continuously complain about such a long delivery time and the management

agrees on the need to reduce the production processing time if they want to stay competitive.

Although the production time should not exceed a period of one month, problems and constraints from both outside and inside the organization impede the smooth process flow and stretch the processing time to over three months.

Production processes in BH project, as any other business, face internal and external difficulties. Being established in a developing country may cause many difficulties that impede the development of the business. These problems and constraints include the acquisition of raw material and fund, social norms and behaviors of the surrounding social system, political environment and the influence of the traditional environment on the business as described in the problem statement section.

Raw material is in short supply and BH finds it increasingly difficult to obtain an adequate amount of high-grade wool suitable for use in the weavings. Prices of wool have been rising, and can be purchased mainly during the sheering season, and therefore the firm has to pay for the full year's demand all at once. The suppliers of raw wool are individual farmers, and need the money at the time of the purchase, so who pays first, gets it first. Dyes and moth-proof material are not available in the market. The project has to import these products, and in which case the cost is very high. As a result of the reported shortage and high prices of wool, and the waste involved in low-yield wool, BH is looking for other ways to attract customers and increase the quality of their items.

Establishing the project within a Bedouin society has its difficulties too. Social barriers and customs prevent the worker from being very productive in his/her work. For instance, the social order demands the man to work in the city while the woman stays at home harvesting and shepherding [Marx and Shmueli, 1984:114]. The bedouins move in the months of July until October for the dry crop cultivation [Salzman and Sadala, 1980]. Also, the social norms in BH area restricted the workers from indulging in work while mourning for forty days. In addition, the workers are unable to work while shepherding or harvesting.

The infrastructure of the BH area is very weak: transportation is unavailable which makes it hard to travel within the area. Most of the workers are uneducated, especially the elder ones, and they do not integrate with the outside environment. Consequently, they are unable to understand or learn the business structure and procedures.

In addition to the above difficulties, the cottage industry context also introduces difficulties for the firm. Production in cottage industries is done at the homes of the workers where direct supervision is unavailable. Supervision is irregular and depends on the supervisors' time. Consequently, problems cannot be solved on the spot compared to production within a factory. Moreover, hand-made items are not consistent in quality; every worker has her own skill and precision. Women also find it difficult to separate the home activities and the work activities [Singh and Kelles-Viitanen, 1987:14]

Also, the project faces managerial problem such as over-worked managers, limited in-house and formal training, poor scheduling of workers, and continuous change on the production plan. Kiggundu [1989] identified that these problems exist in most developing countries as well.

The managers in the BH project engage in tasks they are not supposed to handle. They take on these tasks because they fear delegating authority to employees because any mistake will jeopardize their already scarce resources. The managers tend to overwork themselves on tasks they should not normally do and, hence, deviate from their own tasks.

Workers tend to underestimate the importance of deadlines and quality regulations because of their lack of education and inadequate training. Training is conducted on a small scale; on-going training is rarely carried out, and is usually offered only to new weavers. Kiggundu [1989] states that opportunities for formal training in developing countries are very limited, leaving only a small percentage of workers with a higher education and thus able to take over the strategic management positions while the majority of the people are with little or no education. Although there is some in-house training within the BH project, it is limited to specific job skills and cannot cover more than few workers a month.

Various departments within the organization reveal inadequate coordination and communication. This can be identified from the continuous change in the production plan. There is not enough integration between the marketing and production people. The monthly production plan is not prepared through a formal meeting between the production and marketing people. The marketing people give informal and oral feedback to the production people continuously. The monthly production plan stock orders are prepared according to the inventory, the basic items, the informal feedback from the marketing, but mainly it depends on the production staff's choice.

The production plan is modified continuously according to market's demand. There is no system or procedure to regulate the change. This process is still very dynamic and needs to be modified. Continuous change in the plan is not healthy for the production processes. This continuous change will result in complexity, and inability to control the production orders. Because the new master production plan is dependent upon the previous monthly production plan and inventory levels, if the master production plan is not consistent with the actual production, then the following master production plan will also entail continuous modifications.

Overtime operation is quite commonly used in BH as a means of adjusting production to the seasonal variations and demand which occur. It has been considered impractical to produce inventories of finished weavings during a slack period for sales in the later peak

periods because of the possibility of changes in style, the demand for certain sizes and volumes of the weavings, and the cost of the items.

It is almost impossible to patent weaving designs because nearly all of them, with the exception of few modern designs, are modified copies of traditional designs. Since all designs can be proven to be reproductions of some older designs, all firms can copy designs from their competitors without any risk. When a particular design is found to be selling well in the market, any firm can copy its specifications and, within few weeks, an identical item can be found in its showrooms.

BH is under a huge pressure to restyle a major portion of their lines frequently. The "new" designs are used as a mean of attracting the customers to their exhibits. BH employees state that they must have "something new" to offer at each exhibition, if they are to attract customers. The customers also exert pressure on the project to carry a number of different colors and patterns. Individual tastes with regard to weavings vary widely and the BH feels that they must, therefore, keep a fairly broad selection on the floor of their showrooms. Most BH sales are to tourists or for exporting where there are large variations in consumer preferences from different countries which force them to carry a large number of colors and patterns.

The majority of customer orders are customized. Therefore, the project builds a stock design system that can be reconfigured according to customer requirements. The order

processing, distribution and finished-goods inventory departments are all part of the production operation. The marketing is primarily responsible for customer service. The order-to-delivery time is very long, and thus, the work in process (WIP) inventory is large. It takes three months for any order to be processed and delivered. Every order, either a customer order or a stock order, has to be planned in the Amman office. The order has to be translated into a more specific format including the number of threads and the initial length, etc. A coloured sample drawing is attached to the geometrical design to give more specifications in the colour combination especially for the custom-made orders. This WIP problem emerges from either the long process of order preparation or the long customer order list. Scheduling of workers to orders, upgrading workers' job skills, and providing more incentives to the workers can help reduce this problem by motivating and increasing the productivity of the workers.

Market research has identified that prices are more important than quality for the customers. Two major disadvantages of the project are identified: product cost and lead time. The project's products are highly priced, on both the national and international scale, that arise from high quality and higher labor costs compared with other competitive projects that provide similar products. Also, the lead time of three months is a very long time that makes customers decline to order products. Both of these problems contribute to a decrease in sales volume. Unfortunately, the BH project is facing a huge competition from within the country. This has already affected its sales figures. So, unless BH project finds a new way to attract consumers it will not be able to stay competitive. One way for

the BH project to regain its status is by redesigning its OM processes to go about solving the above stated problems, which can be done by applying BPR. However, can Western or modern management practices be applied to cottage industries or developing countries business environment, and still perform as effectively?

Kiggundu et al. [1983] stated that developing countries are greatly interested in Western management and they have already utilized it. Moursi [1975] also indicated that the business environment of developing countries encourages the use of these techniques since the environmental factors that encourage their use are stronger than the obstacle to impede them. However, literature concerning Western management applicability in developing countries that did consider or study the effect of the surrounding business environment on the business operations identified problems related to the utilization of Western management in these developing countries [Kiggundu et al., 1983].

However, not all firms have the same business structure and not all developing countries are the same either. There are big differences between developing countries themselves, between organizations and even within communities in the same country. These differences result from the values that the different people believe in, and as the organization is influenced by the behavior and attitude of the people working in it, then the organization is influenced by the social and cultural environment surrounding it [Kiggundu, 1986]. Management practices and employee behavior within an organization result from managerial and employee values, attitudes and beliefs regarding work.

Although most developing countries have the same cultural characteristics, they may not apply to every developing country and in every dimension.

Nevertheless, developing countries no longer represent the traditional society but are on their way to industrialization [Jaeger and Kanungo, 1990]. Managers and employees are becoming highly educated and the business environment is getting more influenced by the Western environment especially since the world is becoming more interdependent. Moursi [1975] indicated that the current high educational level of managers in developing countries makes it easier to employ Western management techniques. The difficulty with Western management arises from the "inadequate resources and unstable political environment" [Kiggundu, 1983].

To generalize if BPR is applicable in cottage industries in developing countries, the BPR steps were implemented on the BH project as described in the following sections.

7. METHODOLOGY

In order to answer the research questions stated above, two methodologies will be used: BPR and XCELL simulation. First, BPR will be applied to the Bani Hamida project to improve its production operation management processes. The benefits of this methodology will be verified by simulating the business processes in the Bani Hamida project before and after BPR application and comparing the results. The simulation process will be implemented by using XCELL simulation software. The simulation process will incorporate adaptation of BPR to cottage industries and developing countries contexts.

7.1 Data Collection

In order to understand the current processes, and to identify the ones that need to be reengineered, data are required to describe the production processes at BH and to show how well or poorly they perform. Since there is no control over the processes and there is no clear idea about the outcomes, an exploratory case study³ was applied on the BH operation management.

Data about the current OM was collected in Jordan. Direct observation and interviewing⁴ was conducted at both the Amman and the BH office to clarify the current processes.

³Case studies "retain the holistic and meaningful characteristics of real-life events - such as individual life cycles, organizational and management processes,..." Yin [1989].

⁴Collecting data for reengineering requires standard analysis procedures such as observing the processes, interviewing the related personnel and reviewing forms, files, memo, etc. in order to capture the structure and dynamics of the business as it operates in real life [Macarthur et al., 1994].

Each interview consisted of open-ended questions which were given to the three departments to contribute on any critical issues and problems they face regarding the production process.

The project manager and the production and the marketing managers provided a complete presentation about the production process structure. The project manager plays a major role in preparing the master production plan. It is her responsibility to assemble the monthly production and sales forecasts from the marketing and the production departments, follow up on resources and modify the final master production plan.

The marketing department was asked to provide information on customer orders, customer requirements and customers complaints. They were also asked to provide information on the level of communication they had with the production department. These questions are essential to identify the reasons and processes for reengineering, since the most critical processes are the ones related to customer needs.

The production department was asked to describe their current processes including their monthly production plan, workers/orders scheduling, waste, delivery time and performance measures of workers. These data were used to describe the current processes and to illustrate the performance of these processes. The data was also used to identify the processes that needed to be redesigned.

Furthermore, three focus group of Bedouin workers were asked for their opinions as a source of enrichment to better understand potential process improvements from their point of view. Their opinions are valuable because they are more acquainted than anyone else with the day-to-day problems of the system. Also, their views and opinions about the problems they encounter may be different from those of the management. Each group was selected from a different village and each consisted of five workers representing supervisors, weavers and dyers.

Another method of data collection was a three-week period of direct observation of the production processes in December 1996. Time was spent participating with the BH staff in casual conversation and in observing the steps of production while they are in progress. The purpose of the observational data was to provide a complete understanding of the production processes and to gain a better understanding of the issues of concern to the employees in relation to the production processes.

In conducting case study interviews, it is not preferable that the researcher be the investigator. This is done to considerably limit the researcher's bias on the data. Such bias may result in directing the objectives of the interview or directing the interviewees towards the expected outcomes. Nevertheless, I was able to conduct the interviews for the following reasons:

1. I have the background of both developing countries and cottage industries, as I worked in the BH project for four years.

2. I have the language necessary to interpret the questions and answers of the interview to the interviewees.
3. In situations of misunderstanding, I was able solve the problem on the spot and restate the question.
4. The employees felt very comfortable providing valuable and private information to a familiar interviewer.

7.2 Data Analysis

Data collected through the interviews with BH staff were used to verify: 1- the need to reengineer its OM processes, 2- to identify the most critical processes which require reengineering and 3- to provide a description of the current processes. This study does not include the costs associated with the production process because it is affected by external variables such as salaries and wages which are confidential.

A simulation software was used to simulate the old process, to design new ones and to apply what-if questions to come up with the best design that match the customer requirements while considering the surrounding environment.

7.2.1 Process Modeling

Computer simulation is a method that can be used to study and describe the performance of a real-world system. Computer simulation represents reality and it can be used as a descriptive tool [Lapin, 1994]. It aims to analyze and diagnose an organizations' current situation with simulation and subsequently help to identify and evaluate alternatives for

change. Thus, computer simulation helps improve system design by creating a model or a modified model of the real system. By observing the behavior of the modified models, one can make decisions on the future designs without actually changing the real system [Anderson et al., 1992].

Simulation allows the evaluation of several designs before selecting a final one. It can identify deficiencies at an earlier stage in the process design, and when corrections can be easily done at a cheaper cost. The costs involved, lack of time, production losses and safety risks often make it difficult to test various alternatives in practice. However, computer simulation requires a great deal of time and effort to run every alternative of the design [Lapin 1994, Anderson et al. 1992].

By evaluating the statistical data generated from both the old process and the new one, an assessment can be conducted on the improvement that may be obtained from implementing the specific design in a specific context.

Validation of the computer system requires that the model accurately represent real-world systems. Thus, before acknowledging the simulation results, model validation must be performed. The validation procedure examines whether the model in a statistical form conforms sufficiently to the modeled part of the problem situation. The simulation results can be compared to current data obtained from the real system to determine the validity of the model. If a major difference results, then this is an indication that the model is

invalid. On the other hand, the model verification can be performed by checking to see if the model behaves as intended by the simulation designer [De Vreede et al., 1996].

To select a simulation tool that can provide this support, the following requirements must be taken into consideration:

1. Ability to model resource allocation problems, and to identify by whom and where the processes are performed.
2. Simplicity and ease of use.
3. Includes a time dimension. A time dimension is necessary in managing the implementation of BPR. It removes any error that may occur in underestimating the time required for any process to be performed.

According to these requirements, XCELL+ software will be used to simulate the current operations as discussed below.

7.2.1.1 XCELL + Factory Modeling® System

XCELL+ is an off-the-shelf simulation package to model manufacturing processes and factory operations. It offers the following [Conway et al., 1990]:

1. Ease of use and symbolic graphical representation to symbolize different processes.
2. Offer elapsed time which could be represented in different forms such as:
 - Constant or linear distribution
 - Normal distribution
 - Exponential distribution and

- **General distribution**

3. Offer statistical data such as throughput, work-in-process inventory, working area utilization, capital and operating costs, and flowtime.
4. Demonstrates working area and personnel related to each task

In the design of a model, the XCELL + offers different types of elements such as:

- **Work centers:** where processes perform work.
- **Receiving Area:** where raw material is received.
- **Shipping Area:** where finished material is shipped for sales.
- **Buffers:** where work-in-process is stored.
- **Maintenance Centers:** from which service teams are sent to repair or provide scheduled maintenance for workcenters.
- **Control Points:** used in material handling as intersection points between paths and other elements.
- **Auxiliary resources:** represents additional staff and resources.
- **Path segments:** connects between control points, over which carriers transport material.

In addition to processes, there are links and carriers to move and work on the material. (see figure 4 for an illustration of the graphical representation of each of these elements).

An example of a work center model with the data files the package uses to define it was developed [figure 6]. The user defines each element with its relevant data, such as the name of each work center, followed by the name of the process(s), processing time, maintenance, costs and rejection rate per process. If the work center includes more than one process, it indicates the current process at the time the results were checked. Also, it can calculate costs, processing time per unit, utilization of work centers, and WIP.

7.2.2 The Vision Stage

The staff at the BH project expressed their concerns about the customers' complaints about their order-to-delivery process, which was identified as the most critical to the projects' core operations. It has the greatest impact on customer requirements, starting from the order taking to the order delivery. Thus, this process has been chosen to be reengineered. As discussed before, the Bani Hamida project has been facing a lot of pressure to reduce its delivery time of customer orders to stay competitive against all other local and international carpet industries. Customers have always complained that the delivery time takes far too long and many have declined from ordering an item because of the long delivery cycle that exceeds three months. The interviews and the data collected from the BH staff identified that this is due to the large number of errors in the production cycle and to the unavailability of customer order personnel to price and register the orders and to call the customers to collect their orders.

To improve the delivery cycle, the following have been identified as performance goals in designing a new way of producing the customer orders:

1. Reduce delivery time approximately by half. This time match the local competitors' delivery time.
2. Reduce WIP and waste.
3. Assign one person to handle post production tasks including order pricing, payments and delivery.

7.2.3 Current Processes Analysis

From the BH main office and showroom, orders taken go through the following stages: order preparation and translation into more detailed production specifications, preparation of washed, spun and dyed wool for weaving, pricing and delivery.

7.2.3.1 Order Preparation

As the customer's order is taken, the order needs to be translated into production specifications. This step is conducted at the main office. At this stage, the order could be a completely customized new design or an old design that the customer ordered with slight changes in colors and design. If the design is new, although it is a rare process, then the Customer Orders Manager designs the order in detail to make it produceable. This step takes about two days to complete. If the design is an old one, it only takes few hours to search for the design from the archives for customization.

Although the order preparation should not take more than a couple of hours before it is sent to production, the order often is delayed for few days before it is processed. This is due to the long queue of customer orders that results from the unavailability of the Customer Orders Manager who is the only person responsible for preparing the orders and supervising the production staff and workers in the BH area.

The order is then sent to the field office at Bani Hamida area, where it is translated into more detailed specifications such as: the amount of raw wool required, dye orders

preparation and the destination (i.e. at which dyer(s) should they be processed), amount of dyed for the weaving, selection of the weaver, collection day, etc.

The order preparation takes about four days at the main office between queuing and processing, in addition to four or five days at the field office for the same purpose. The processing of the order cannot begin before supplying the spun wool which is always in short supply. If the spun wool is available, then the associated dye order is started as soon as possible, else, the order has to wait until spun wool orders are sent, processed and then collected.

Usually, the dye order waits for a minimum of ten days until the spun wool is available. Thus, in parallel with the order preparation, two processes takes place: the washing and the spinning process.

7.2.3.2 Washing Process

The washing phase starts as soon as the raw wool is purchased during the sheering season which is during the months of May and June (as discussed earlier). Usually, between fifty to sixty tons of raw wool is purchased annually. The washing process is compressed to six months starting in May to complete the whole amount before the warm season ends. But, only forty to fifty percent of the actual amount of raw wool is gained after the washing while the rest is wasted as a result of dirt and scrapped parts. There are ten workers to wash a quantity of 500 kilograms daily which requires a day or two to dry. For

the purpose of this study the design of the washing process was simulated [Figure 7.1]. The design depicts each stage of the washing process starting from receiving the raw wool to storing the washed wool.

7.2.3.3 Spinning Process

The spinning phase starts as soon as the washed wool is available. It is a continuous process that does not stop while there is wool to be spun. An approximate amount of 17.5% of the washed wool is usually returned by the spinners due to its short length which cannot be hand-spun, but normally this wool is sold back. In addition, 11% of the wool is reduced to dust. About 1.500 kilograms of wool are spun per month, but this amount varies depending on the season and the time for exhibitions. The spinners are selected according to turn and speed as every unit takes a week to be spun. Usually, every spinner has two units per month of which 90% of the spun wool is formed into skeins to be dyed, while the rest (10%) are kept to be used as natural colors.

The quality of the spun wool falls into two main categories: excellent and good quality ["A" wool] which represent 80% of the spun wool and bad quality ["B" wool] which represent 20% of the spun wool. Both qualities are dyed and used in the weavings. Usually the spun wool with the bad quality is used in the weft of some items where it is hidden. This makes the item very heavy and thick (usually unpreferable) thus it is not used with the customer orders [see figure 7.2 for the simulated design of the spinning process].

7.2.3.4 Dyeing Process

The dyeing process is delayed until spun wool becomes available. As the spinning process is long, both the dyeing and the weaving processes are obstructed. The dyeing process takes four days per unit. This time may vary depending on the weather for the wool to dry. Unfortunately, there is a fifty percent chance that the process must be repeated because the color generated did not match the color required. Thus, more time, effort and resources may be needed. This will consequently affect the weaving process.

While the dye mixture order is prepared, the center supervisor selects where to send the order: to a home-based dyer or to process it at the center. Usually, 90% of the dye orders are processed at the center. There are between 200-250 dye orders per month [see figure 7.3].

7.2.3.5 Weaving Process

The weaving order is prepared when the dyed wool becomes available. This process takes one to two days between selecting the supervisor, weaver, loomsetter, etc.

The weaving process starts after the dyed wool is ready for the item. Two types of weavings are processed: plain and hattou⁵. A supervisor is needed for every worker to ensure quality of the weaving and to sew or to complete the item into the required specifications.

⁵The combination of both plain and hattou designs is still called hattou

There are around 200 customer and stock orders (orders-to-stock) every month. The weaving process takes around twenty to twenty-five days in addition to an extra five days for sewing. Also, there is a fifty percent chance that the weaving process may be repeated if the item did not accurately match the given design. Therefore, it takes two months, which is double the time, to produce a weaving order.

The sewing stage takes between six to ten days, taking into account the repetition time. The collection of the items from the weavers requires almost two days, including measuring and bookkeeping time [see figure 7.4].

7.2.3.6 Pricing And Delivery

Subsequently, the item is sent to the main office for pricing where it usually waits for two to four days before being processed and a week to be displayed for sale or until the customer collects his/her order. This step is performed by the Customer Orders manager or the sales and marketing staff.

The whole production process was simulated [Figure 7.5]. The whole processing period from order-take to order-delivery takes an average of ninety days, which is considered to be very long. Thus, the following reengineering steps are recommended to reduce the processing time.

The data obtained from the simulation of the current processes, namely the time spent and the number of units processed, have been checked with the data obtained from the

interviews and have been found to match. Therefore, this test supports accuracy of the simulation representation (see Table 1 for a comparison between the simulation data and the data obtained from the interviews with the BH staff).

7.2.4 Process Redesign

The redesign of the BH project's processes is expected to reduce work-in-process (WIP) and waste, and improve productivity and quality.

Currently, any order has to go through as many as nineteen steps and involve up to fifteen people. At its very best, the BH staff can process any order in three weeks but more typical process ranged from two to three months in which most of this time is spent queuing orders in one department before sending them to another and in rework.

While the order waits ten days before preparation, it is actually worked on for a maximum of two hours before being sent for processing. If preparing a customer's order takes a long time, it is usually not because it takes a long time to perform the required tasks, but rather, it is the queuing and transferring between the tasks or departments that consumes so much time.

This fragmentation is the source of performance problems and the only way to achieve dramatic performance improvements is by conducting the redesign on all processes starting from order preparation and all the way to order delivery, since these processes are all interactive.

The redesigned process will help to provide a better order processing system that encompasses all other departments and can also be adapted to the workers' background and developing countries' culture.

The assessment conducted on the current process model of BH helped to identify its shortcomings. These shortcomings represent the long preparation stages, the waste and repetition from both the weaving and dyeing processes, in addition to the waiting period for the spun wool to be available.

First, an extensive period of time is spent before actual production of the order begins. This time accounts for four days of preparation in addition to other four days in a long queue period between the production preparation stages at both the main office and the BH-office. This stage should not take more than a couple of hours. This time was reduced in the new simulated design by applying proper documentation and automation of the production designs. This enables the project to shift the preparation of orders to the BH office only. Instead of drawing and translating every order into production specifications at the main office and sending it to the BH office for preparation, the BH office need only to search for the design from the automated archive system, apply few changes to it to make it conform to the customer's requirements and then start on the dyeing stage. In fact, an automation of these designs can reduce the search time and the preparation time of the order by half simply by removing the preparation step from the main office. As the design number is known, the design could be retrieved from an archive file where the

production specifications are already incorporated into the design. IT is very advantageous for managing a wide range of data and in delivering results very quickly. Thus, in this case, the use of IT would eliminate the need to prepare the order at the main office. Accordingly, a new employee needs to be recruited to retrieve the designs from the computerized documentation system and modify them to conform to customer orders. This employee must go through an intensive training session on how to implement the system to eliminate the possibility of errors.

In the current situation, many designs are lost because of the manual archive system. Also, the search time takes more time than necessary before the design is found. The production staff could get help from the sales and marketing personnel on lost designs. Sometimes the resolution took weeks to trace and clarify the design. The simulation of the new design eliminated mistakes and lost designs, thus proving that the preparation time can be reduced from eight days to four days.

Another problem is that the washing and the spinning processes take the focus off the more important weaving process. In order to specialize the weaving process and reduce the bottleneck resulting from waiting for spun wool, both the washing and the spinning stages could be outsourced while ensuring that the quality of the spun wool would at least stay the same and would not be reduced. By modeling the removal of the bottleneck, i.e. the washing and spinning stages, the simulation results showed a reduction of the queuing

time for spun wool by ten days. These ten days stand for the time the dyeing order has to wait before the spun wool is available.

Also, it is considered essential to reduce the waste and repetition from both the dyeing and weaving processes. As mentioned before, 90% of the dye orders are prepared at the dyeing center. Although, this is the objective of the dye center, there is still a high probability (almost 40%) that the dyed wool will not match the customer's order and will have to be redyed. The reason for this is that although the suppliers of dyes have been changed, the recipes of dye mixtures have not changed which creates the problem with the mixtures.

Also, the dyers' efficiency at the dye center is much higher than the home-based dyers. This encourages the elimination of home-based dyers and allows the center to increase capacity. The center dyers produce a higher dyed wool quality than home-based dyers because of specialization and dedication to the dyeing process only and, thus, they have no side tasks in the house as compared to the home-based dyers. But before eliminating the home-based dyers, a transition step is required where the dye orders should be processed by the home-based dyers while the center is used to update the dye mixture recipes.

Simulating the update of these mixtures, and the increase of the capacity of the dye center was found to eliminate the waste of dyes and decrease the time of dyeing to five days rather than ten days thus, eliminating the repetition time.

To eliminate or reduce the waste and repetition time of the weaving and sewing, management must increase the training of workers and establish performance measures for the supervisors. Supervisors' efficiency and productivity is expected to increase by providing them with meaningful incentives according to their performance reports and thus increase their dedication to the supervision and training of their subordinates (the weavers).

A transition stage is required to upgrade the expertise of the supervisors through training. In addition, an intensive on-going training of the workers should be emphasized to ensure they provide higher quality of dyed wool and weavings. This will eliminate the repetition time. Simulation has identified a reduction in weaving time by twenty to thirty days (the repetition time) if repetition is decreased. The rate of repetition is not expected to decrease below 15%⁶ until all weavers are upgraded to "A" weavers.

Both qualitative and quantitative data are needed to formulate the conclusions that will be used to assess the process design improvements.

⁶This percentage represent the "B" weavers who make up almost one third of the weavers.

8. RESULTS OF BPR

The results of reengineering obtained from the simulation models prove promising. The flow time⁷ obtained from both the old [factory MAIN] and the new [factory MAIN-ALL] designs of the production system were determined [Figure 8.1]. The difference in utilization of the workers between the old and the new situation has increased twofold. The order processing, in the simulation model, has gone down by half, from three months to a month and half.

By implementing BPR, the production process at the BH project was improved through:

1- Reducing the preparation time of any order due to the cutback in the waiting time each order has to undergo before it can be handled. This time is decreased by producing a computerized documentation system and through implementing this system the order design can be recalled within seconds. Also, by relocating this system at the BH office, the order does not have to wait at the main office before it is transferred to the BH office. This new structure can improve the order preparation process by decreasing the order processing time by half. A comparison between the old and the new design was made [Figure 8.3] wherein the old design the BH office starts preparing the order at time $t = 8.11$, while in the new design the BH office starts preparing the order at time $t = 2.10$.

A transition period is required to raise adequate funds to finance the acquisition of computers, prepare the computer system, recruit a new employee and train her on using

⁷Flow-time: time for a unit to pass through the production system, from release from receiving area to acceptance at shipping area [Conway et al., 1990].

the new system. BPR can be effective if the new design is implemented into stages rather than quickly to prepare the employees and educate them on the new design, increase their understanding of the importance of deadlines and quality principles and to prepare the management to take the risk and delegate this responsibility to the BH workers. This stage is very risky because it would reduce the quality of the output and delay the delivery dates if not managed properly.

2- Outsourcing both the washing and spinning designs to eliminate the waiting time before the dyeing process can start. These processes can be outsourced to other projects or societies to ensure they provide a quality no less than the one currently produced. This stage can improve the BH production processes by reducing the order processing time by ten days and increase the focus on the weaving process. A comparison between the old and the new design was made [Figure 8.3] wherein the old design the dyeing process starts at time $t = 13.01$, while in the new design the dyeing process starts at time $t = 3.10$ which means that the dyeing process in the new design does not have to wait for spun wool to become available.

These other projects and societies have the same problems with the lack of workers' understanding of time and quality importance, thus the new process design cannot expect an increase in quality of washed and spun wool after outsourcing them.

3- Reduce the dyeing time, eliminate repetition and improve the quality of dyeing by updating the dye mixture recipes. This stage also improves the production process by reducing waste and increasing the quality of the end output.

A comparison between the old and the new design was made [Figure 8.4] wherein the old design the weaving process starts at time $t = 24.01$, while in the new design the weaving process starts at time $t = 8.00$. Thus, the waiting time, the order preparation time and the dyeing process time has been reduced by implementing the new design.

Again, implementing the reengineered design requires a transition stage to produce new dye mixtures, increase the training of workers and increase the quality of dyed wool. BPR has to be implemented slowly until adequate monetary resources can be raised.

4- Increasing the training of supervisors and modifying the reward system to provide meaningful incentives to them would improve the quality of weaving and reduce the number of rejected items. This can be generated as the supervisors will provide more supervision and assistance to workers to improve the quality. The production process will improve considerably since quality would increase and repetition will be eliminated.

Once more, a transition period is required to increase the expertise of the supervisors. BPR should be expected to take a longer time since training the workers will take time as they lack education and business knowledge.

When productivity is defined as the number of units processed within a time frame, then we can conclude that productivity will increase as more units will be processed in a time unit. There is no longer the need to repeat orders. The quality will increase since the workers will be better trained. In addition, management can concentrate on "real" work issues rather than fixing problems with the waste, washing and spinning processes.

Although Hammer [1990] emphasized on quick implementation of BPR results, this cannot happen with developing countries' businesses. Management must first supply adequate financial support, IT, and train its employees which are all essential to implement BPR. Information Technology is important to reduce the search and the preparation time of designs. It also provides a dependable documentation system instead of wasting days or sometimes weeks to find a lost design.

Training is necessary to increase workers' and (mainly) supervisors' expertise. The use of training is mandatory to reduce the large percentage of waste and repetition. Training is most effective if considered as an integral part of the production strategy, and is seen as an ongoing activity alongside employees daily tasks [Austin, 1990].

These changes have consequences on the work situations at BH. Workers will be under less pressure as a result of eliminating the repetition of processes. They will spend more time on new orders and less time fixing the old ones. Since the designs are generated by

computers, the time for retrieval and upgrades will decrease in addition to the reduction in lost designs.

Infrastructure modifications are required if reengineering is to be implemented. For example, the incentive system must be changed to incorporate the performance incentives for the workers, especially the supervisors. This step is required to motivate the supervisors and increase their sense of responsibility in ensuring the elimination of repetition and the production of zero-defect items. Also, management is required to delegate more responsibility to the BH production staff who will be expected to prepare the whole production orders instead of some parts.

9. TRANSITION STEPS

Although the results of reengineering in this study provided promising improvements, there might be major obstacles in implementing it within the specific context of developing countries and within that of a nomadic culture. The reason for this is that BPR requires: delegation of authority down the line, infrastructure modifications, employee participation, material, financial and human resources, technological development and on-going training. These characteristics do not coincide with the characteristics of the developing countries current business environment. In addition, the social norms of a Bedouin society may restrict the smooth flow of the production processes. Therefore, the previous results need to be adapted to the context of Bani Hamida and that of a Bedouin culture in addition to that of a developing country's environment.

Bedouins are known for their continuous movement and involvement in shepherding, harvesting and butter churning during the summer season. Their nomadic life style creates a problem for the weaving, dyeing and supervision processes since many workers are not available at their home to accept or finish their assignments. Establishing a scheduling system might provide a solution to this problem where workers would identify the dates on which they will be busy and cannot accept work assignments. Although the dates of Bedouin movements cannot be specified exactly still, this system can play a major role in identifying the availability of workers. Other problems such as the stigma

attached to working women and other social interactions have already been resolved by the project since its inception.

Also, to accommodate the results to the context of a developing country, the firm should consider the inadequacy of IT and financial funds and should prepare for the slow implementation of BPR until their employees are educated on new changes that are to be introduced. At BH, computers are already in place for such a change and computer staff is available to produce the computer systems necessary to build and manage the documentation system. Also, the organizational culture within this company is somewhat receptive to change and taking risks, when funds are available, which is mainly due to the highly educated management staff at the main office. Financial support is the main problem that has to be resolved before implementation of BPR. Hence, BPR cannot be quickly implemented until they allocate adequate funds.

Even though BH project employs over a 1,000 workers, it is considered to be a small firm due to the size of its operations. The BH project has a few operations that mainly include sales, production and finance, and these operations are managed by a team of twelve highly educated employees at the main office.

Usually, new and private companies in developing countries are less dependent on culture and norms and are more receptive to change. Thus, they are more likely to succeed with

BPR. Countries that are more dependent on government, or older firms will have difficulties in providing technology, financing and diverging from the traditional norms.

The case of BH does not represent a traditional business setting since it was primarily established by a Western firm, and it already incorporates Western practices. Still, the study did consider the surrounding environment and the traditional values. The simulation did not carry out unrealistic expectations in relation to the reduction of the rate of repetition by the weavers and the quality of the spun wool from the new societies. This is due to the workers lack of education and their exclusion from the business environment. It would also take a long time to educate them on the importance of quality and deadlines.

The study did not propose automation of production processes for reasons other than keeping the production in a traditional setting. These reasons are related to the inadequate financial resources and the weak infrastructure in developing countries to support such a change. In addition, the surrounding environment of the Bedouin society restrict the movement of women away from their children.

A third consideration of developing countries' business environment is associated with securing employees' jobs. The new design did not eliminate any worker's position or job. The business environment in developing countries tends to restrict downsizing or the laying off of employees.

Accordingly, BPR will be applicable to firms that are less dependent on traditional culture and norms and also on the educated management of that firm. These are the new industries or firms where tradition is not the base for their business strategies. Firms that are very dependent on the government will not succeed with BPR since government business strategy is based on the tradition and the multi-level of management, which will impede the implementation of BPR.

10. CONCLUSION

After assessing the results of reengineering obtained from the simulation, and finding that the improvements to the production process in BH were enormous, one can conclude that modern Western management techniques can be used in cottage industries in developing countries. But, this is mainly possible only with firms that are operated by highly educated workers who are open to Western management and emphasize less on traditional development strategies and norms.

Tradition and norms within developing countries exert obstacles to Western management techniques, which stress individualism, risk taking, and thrive on financial resources. These requirements are not available in developing countries whose industries are dependent on the government. Most governments in developing countries are still based on traditional values and are reluctant to take risks and are incapable of raising funds. However, new and young firms in developing countries, such as BH project, are no longer based on traditional norms; they are on their way to industrialization and are open to new management techniques. Since the production problems of fragmentation, WIP, excess stock levels and technology change are common to both developing and developed countries business settings, similar management techniques can be applied to new and young firms with very few modifications.

Due to the many similarities between Western industrial business settings and that of the young firms in developing countries, the answer to the research question posed for this study, whether a modern management practice (BPR) can be used in management of a traditional craft industry, can be answered positively if implemented within young and small firms. This means that the same management techniques can be used in both with few modifications. Although this study focused on one case study, this may not be a limitation because there is no great difference in culture and industrial strategies between the different industries in most developing countries [Kiggundu, 1989].

If traditional firms within developing countries want to succeed in BPR, management has to exert less control, delegate authority to employees, increase employees training and raise sufficient funds. Also, implementation should be slowly undertaken to prepare the employees to participate in such a change.

Changing a process cannot be done without changing its surrounding business environment which includes related processes and employees. Introducing change within any organization will affect almost all its processes: the process flow, the communication system, the power distribution, the ranking and control system, and the organizational culture. Such changes are not insignificant: it is very risky and most employees are likely to resist the change. Any reengineering process must recognize the personal needs of the individuals who are affected by it. Thus, the new process must offer some benefit and incentives to the people who are asked to undergo such enormous change.

11. LIMITATIONS OF THE STUDY AND DIRECTION FOR FUTURE RESEARCH

This case study was conducted on a cottage industry in Jordan. However, this may not be a limitation since most cottage industries and most developing countries have the same business characteristics. Further research is needed to identify the differences. For instance, the BH project has adequate information technology and their workers are trained on the use of computers. However, other cottage industries and other organizations in developing countries may lack information infrastructure which can make it rather difficult to implement BPR.

Also, most developing countries lack financial resources. This might limit the applicability of BPR since BPR requires adequate funds to train employees, acquire IT and modify the business structure.

Another limitation is related to the simulation process. The simulated design proved that according to time reduction BPR can be beneficial in cottage industries. Nevertheless, the simulation might not give the same results if evaluated according to cost reduction. In addition, there is no proof that the suggested design will be completely reliable and applicable to the BH project processes.

A number of points can also be considered in future research. First, one can investigate if the implementation of the reengineering steps to the BH project will be effective. Second,

one can assess whether the same results will occur when evaluating performance improvements with respect to cost and flexibility rather than time. And third, research is needed to identify the benefit and incentives which can be meaningful to the people who are asked to undergo such enormous change.

As mentioned before, this study could be adapted to young and new firms in developing countries but no research has been done with regards to its applicability. Thus, further research would be required.

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Reengineering stages	Davenport/ 1993	Hammer & Champy/ 1993	Roberts/ 1994	Macarthur et al/ 1994
Stage 1	Selecting processes for innovation	Choosing the process to reengineer	Opportunity assessment	Develop business vision and process objectives
Stage 2	Creating a process vision	Understanding processes	Current capability analysis	Identify processes to be reengineered
Stage 3	Identify change levers	Identifying information technology levers	Process design	Understand and measure existing processes
Stage 4	Understanding and improving existing processes	Redesigning the processes	Risk and impact assessment	Identify IT levers
Stage 5	Designing the new process	Implementing the new design	Transition plan	Design and build a prototype of the process
Stage 6	Implementing the new process		Pilot test	Implementation stage
Stage 7			Infrastructure modification	Continuous process improvement
Stage 8			Implementation and transition	Performance assessment
Stage 9			Tracking and performance	
Stage 10			Continuous improvement process	

Figure 1 Process reengineering frameworks

Figure 3. Organizational Chart

•• Weavers, spinners, loomsellers and dyers are distributed in 12 villages. Except the washers, they are only from one village, where they are near to the washing center.

Figure 4. Production Process Flow in Bani Hamida Project

Figure 5. Graphical representation of XCELL elements

Main menu:

1 change 2 analysis 3 new 4 design 5 file 6 manager 7 run 8 quit

Figure 6.: Sample of a simulation model with its data representation.

Receiving area sends input (orders) to BH. BH office prepares the washing order and sends it with raw material for washing. The washed wool is sent to a spinner where she works on the raw wool for 3.52 days. The spun wool is then sent for storage at the spun wool storage

The work center SPINNER is represented as follows:

WorkCenter *Spinner*, has process names:

Spinning (current process)

no breakdowns or scheduled maintenance

units processed (period, cum): 12, 24

% of time (proc'g, setup, mtn): 66.67 0.00 0.00

costs (capital, unit operating): 120.00 3.00

Process *Spinning* at workcenter *Spinner*

inputs: x-input from process *Washing* at *Washing center*; no y-input

normal output to: shippingArea *Spun wool storage*

reject-output: % reject: 0.00

processing-time dist'n: <CONSTANT>

every proc'g time is: 3.52

units processed (period, cum): 12 24

$60,000 \text{ kg} \cdot 47\% = 28,200 / 8 = 3,525 \text{ bags} \sim 3,600 \text{ bags per year.}$
The process takes six months to wash the whole amount of wool.

Figure 7.1 Simulated design of the Washing process

Figure 7.2 Simulated design of the Spinning process

Figure 7.3 Simulated design of the Dyeing process

Figure 7.4 Simulated design of the Weaving process

Figure 7.5 Simulated design of the complete production process

Figure 8.1. Flow time

Old Design : it took around three month to deliver one order

Results for factory MAIN				
FLOW-TIME: ShippingArea output at time <u>89.00</u>				
(based on tagged-units arriving at ShippingArea)				
	number	avg-flow	avg-proc'g	avg-wait'g
CUSTOMERS	1	88.327	71.680	<u>16.647</u>

Average time for an order to be prepared, produced and delivered to a customer takes 88.327 days. Almost 20% (16.647 days) of this time is spent in waiting while actual production time takes 71.680

New Design: it takes around six weeks to deliver an order

Results for factory MAIN-ALL				
FLOW-TIME: ShippingArea output at time <u>41.70</u>				
(based on tagged-units arriving at ShippingArea)				
	number	avg-flow	avg-proc'g	avg-wait'g
CUSTOMERS	1	41.600	36.801	<u>4.799</u>

Average time for an order to be prepared, produced and delivered to a customer takes 41.70 days. Almost 10% (4.799 days) of this time is spent in waiting while actual production time takes 36.801

The new design have reduced the flow time (from ordering to delivering) by half, from 89 to 41.70. Also, the waiting time is reduced from 20% of the processing time to 10%.

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PM-1 3 1/2"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

Figure 8.2. Comparison between the old and the new design on the time required before order preparation

Figure 8.3. Comparison between the old and the new design on the time required before the dyeing process starts.

Figure 8.4. Comparison between the old and the new design on the time required before the weaving process starts.

Table 1 (A comparison between the data obtained from both the interviews and the simulation)

Current washing process		
	data obtained from the interviews	data obtained from the simulation
Raw wool purchased per year	60,000 kg per year	15,000 fleece per month 1 fleece = 4 kg
Wool washed per month	10,000 kg per month	2510 fleece per month
Percentage of waste	45% - 55%	50%
Washed wool produced	~5,000 per months	630 bags per month: 1 bag = 8kg
Output per year	33,000 - 27,000 kg	30,240 kg
Time to wash the whole amount	six months	six months

Current spinning process		
	data obtained from the interviews	data obtained from the simulation
Spun wool per month	2,300 kg	283 orders 1 order = 8kg
Percentage of waste	11.3%	30%
Percentage of wool which cannot be hand-spun	~ 17.5%	
Percentage of skeins to balls	90 : 10	90 : 10
"A" type wool to "B" type wool	82 : 20	80 : 20
Spun wool ready to be dyed per month	~ 1,500	~ 1,470

Table 1 (con't)

Current dyeing process		
	data obtained from the interviews	data obtained from the simulation
Spun wool ready to be dyed per month	~ 1,500	~ 1,470
Dye orders per month	200 in regular season, doubled in high season	200-400
Percentage of waste	minimal	none
rate of repetition	40%	40%
Percentage of orders processed at center	90%	90%

Current weaving and sewing processes		
	data obtained from the interviews	data obtained from the simulation
# of orders per months	220 orders increases in high season	200-300 according to season
Weaving time per order	25 days for weaving 5 days for sewing	25 days for weaving 5 days for sewing
Percentage of waste	11%	11%
rate of repetition	50%	50%
Percentage of plain to hattou design	4: 3	4: 3

END

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FIN