QUALITY ISSUES RELATED TO APPAREL MERCHANDISING IN SOUTH AFRICA

SWETA DAS

2011
QUALITY ISSUES RELATED TO APPAREL MERCHANDISING IN SOUTH AFRICA

By
Sweta Das

Submitted in fulfillment of the requirements for the Master of Science Degree in the Department of Textile Science at the Nelson Mandela Metropolitan University, Port Elizabeth.

December, 2011

Supervisor: Prof. Lawrance Hunter
DECLARATION BY CANDIDATE

NAME:  ____________________________  

STUDENT NUMBER:  ____________________________  

QUALIFICATION:  ____________________________  

TITLE OF PROJECT:  Quality issues related to apparel merchandising in South Africa  

DECLARATION :

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE:  ____________________________  

DATE:  ____________________________  

NAME:  Sweta Das  

STUDENT NUMBER:  s211234834  

QUALIFICATION:  Master in Textile Science  

TITLE OF PROJECT:  Quality issues related to apparel merchandising in South Africa  

CONFIRMED:  ____________________________  

DATE:  ____________________________  

SIGNATURE:  ____________________________  

DATE:  ____________________________  

NAME:  Sweta Das  

STUDENT NUMBER:  s211234834  

QUALIFICATION:  Master in Textile Science  

TITLE OF PROJECT:  Quality issues related to apparel merchandising in South Africa  

DECLARATION :

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.
DECLARATION

I, Sweta Das, student number s21123484, hereby declare that the dissertation for M Sc in Textiles to be awarded is my own work and that it has not previously been submitted for assessment or completion of any post-graduate qualification to another University or for another qualification.

Sweta Das
Acknowledgements

I am heartily thankful to my supervisor, Prof. Lawrance Hunter, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject.

This research project would not have been possible without the support of many people. My gratitude to the management and employees of the many companies, who have offered so much invaluable assistance, support and guidance and without whose knowledge and assistance this study would not have been possible.

Lastly, I offer my regards and blessings to those who supported me in any way during the duration of the project.
# INDEX

<table>
<thead>
<tr>
<th>Contents</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction</td>
<td>2</td>
</tr>
<tr>
<td>1.1 Country Analysis – South Africa</td>
<td>2</td>
</tr>
<tr>
<td>1.2 National Economic Performance</td>
<td>3</td>
</tr>
<tr>
<td>1.3 Cluster Analysis</td>
<td>6</td>
</tr>
<tr>
<td>1.4 Textile and Clothing Sector in South Africa</td>
<td>10</td>
</tr>
<tr>
<td>1.5 Clothing Trade under AGOA</td>
<td>14</td>
</tr>
<tr>
<td>1.6 Availability of Raw Materials</td>
<td>16</td>
</tr>
<tr>
<td>1.7 South African Textile Industry</td>
<td>20</td>
</tr>
<tr>
<td>1.8 Competitive Advantages of the South African Textile and Clothing Sector</td>
<td>24</td>
</tr>
<tr>
<td>1.9 Clothing and Textile Manufacturing Sector in South Africa</td>
<td>26</td>
</tr>
<tr>
<td>1.10 Clothing Manufacturers of South Africa</td>
<td>28</td>
</tr>
<tr>
<td>1.11 Retail Sector in South Africa</td>
<td>30</td>
</tr>
<tr>
<td>1.12 Large Clothing Retailers of South Africa</td>
<td>31</td>
</tr>
<tr>
<td>2. Objectives of the Study</td>
<td>37</td>
</tr>
</tbody>
</table>
3. Literature Review

3.1 Merchandising

3.1.1 Merchandising Process

3.1.2 Some Important Documents which the Merchandiser is Required to Draft are:

3.2 Quality

3.2.1 Fabric Strength

3.2.2 Seam Strength

3.2.3 Yarn Slippage in Fabrics

3.2.4 Fabric Stretch

3.2.5 Durable Press

3.2.6 Sewability of Fabrics

3.2.7 Moisture Absorbency

3.2.8 Bow and Skewness (Bias) in Woven and Knitted Fabrics

3.2.9 Fabric Thickness

3.2.10 Pilling

3.2.11 Snagging
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.12 Colourfastness</td>
<td>61</td>
</tr>
<tr>
<td>3.2.13 Stiffness</td>
<td>61</td>
</tr>
<tr>
<td>3.2.14 Drape</td>
<td>62</td>
</tr>
<tr>
<td>3.2.15 Wrinkling</td>
<td>62</td>
</tr>
<tr>
<td>3.3 Fabric Handle, Tailorability and Objective Measurement</td>
<td>63</td>
</tr>
<tr>
<td>3.3.1 Introduction</td>
<td>63</td>
</tr>
<tr>
<td>3.3.2 Kawabata Evaluation System (KES)</td>
<td>65</td>
</tr>
<tr>
<td>3.3.3 SiroFAST</td>
<td>72</td>
</tr>
<tr>
<td>4. Research Methodology &amp; Experimental</td>
<td>86</td>
</tr>
<tr>
<td>5. Results and Discussions</td>
<td>91</td>
</tr>
<tr>
<td>5.1 Analysis of Questionnaire Responses</td>
<td>91</td>
</tr>
<tr>
<td>5.1.1 Introduction</td>
<td>91</td>
</tr>
<tr>
<td>5.1.2 Graphical Analysis and Presentation</td>
<td>92</td>
</tr>
<tr>
<td>5.1.3 Statistical Analysis</td>
<td>111</td>
</tr>
<tr>
<td>5.2 Interview Feedback</td>
<td>121</td>
</tr>
<tr>
<td>5.3 FAST Test Results</td>
<td>122</td>
</tr>
<tr>
<td>5.4 Worldwide FOM Application and Distribution</td>
<td>126</td>
</tr>
</tbody>
</table>
6. Summary and Conclusions 131

7. Recommendations and Scope for Further Study 139

8. References 141

9. Annexure 152

9.1 Sample Questionnaire 152

9.2 Individual Responses to Each of the Questions Framed in the Questionnaire 158

**List of Figures**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>South African Annualised GDP Growth Rate from Jan., 2007 – Oct., 2011</td>
<td>3</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Map of South African Textile/Clothing Sector</td>
<td>10</td>
</tr>
<tr>
<td>Figure 3</td>
<td>South Africa Textile/Clothing Cluster Diamond</td>
<td>12</td>
</tr>
<tr>
<td>Figure 4</td>
<td>AGOA Clothing Exports</td>
<td>15</td>
</tr>
</tbody>
</table>
Figure 5: Merchandising Workflow

Figure 6: Merchandising Processflow

Figure 7: Workflow of Sampling

Figure 8: KES FB - Auto – A System

Figure 9: Fingerprint Chart of a Man’s Winter Suit Obtained using KES – FB Instruments

Figure 10: Fast - 1, 2 and 3 Instruments

Figure 11: FAST Control Chart for Light-weight Suiting Fabrics

Figure 12: Control Chart for Fused Composites Showing Various Zones

Figure 13: Individual and Overall Responses to Question 1

Figure 14: Individual and Overall Responses to Question 2

Figure 15: Individual and Overall Responses to Question 3

Figure 16: Individual and Overall Responses to Question 4

Figure 17: Individual and Overall Responses to Question 5

Figure 18: Individual and Overall Responses to Question 6

Figure 19: Individual and Overall Responses to Question 7

Figure 20: Individual and Overall Responses to Question 8
List of Tables

Table 1: Wool Production 2010 ........................................... 17
Table 2: Cotton Production, Imports, Consumption and Exports for SA ........................................... 19
Table 3: South African Textile Statistics Summary 2006 – 2010 ........................................... 22
Table 4: Production Price Index, Consumer Price Index, Employment, Production capacity and Value of Sales from 2006-2010 ........................................... 23
Table 5: The Parameters describing Fabric Mechanical and Surface Properties ........................................... 66
Table 6: Hand values ........................................... 70
Table 7: Mean and Standard Deviation of the Hand Values of the Fabrics Produced in Japan ........................................... 70
Table 8: List of Fabric Properties Measured using SiroFAST ........................................... 75
Table 9: List of Fabric Properties which can be Derived from Measurements made using SiroFAST ........................................... 75
Table 10: Summary of CSIRO FAST System ........................................... 81
Table 11: Fabric Properties Associated with Problems in Garment Making

Table 12: Fabric Properties Associated with Potential Poor Garment Appearance in Wear

Table 13: Quality, Merchandising and Product Benchmarking

Table 14: Fabric and Garment Testing as per Standards

Table 15: Fabric and Garment Tests done on Regular/Routine basis and new tests for future use

Table 16: Fabric Types used in Garment Making

Table 17: Number of Kawabata KES – FB1-4 Users Worldwide

Table 18: Number of SiroFAST Users Worldwide
Abstract

The objectives of this study are to develop an understanding of the quality related issues and gaps relevant to apparel merchandising within the South African context, with a specific focus on Fabric Objective Measurement, a relatively new technology and one which could fruitfully be applied in South Africa, but which appears to have been largely neglected to date.

Fabric Objective Measurement (FOM) represents a new generation of instrumentally measured parameters which provide a more complete picture of fabric quality, tailorability and clothing performance. The two main FOM systems, FAST and Kawabata, are discussed under FOM in terms of their applications, control charts and their worldwide utilisation. A literature review has been done on the global clothing sector as well as South African clothing industry.

The research involved a questionnaire survey of, and interviews with major clothing and retail companies in South Africa with a specific focus on the gap in the South African clothing industry in terms of FOM and other quality related issues. The data and information so captured are presented graphically, statistically analyzed and interpreted, to arrive at the main conclusions and recommendations.

Trubok, Newcastle, the only company in South Africa utilizing FOM, was visited in order to obtain hands on experience with the FAST system as operated in a mill. Two different fabrics were tested and the control charts obtained were interpreted. According to the analysis of the questionnaires and interviews, various conclusions could be drawn. When benchmarking a product, quality emerged as the first criterion, 100% retailers and manufacturers agreed to this. Most respondents stated that their fabric and garment testing is mostly done in-house while other respondents stated that their fabric and garment testing is mostly done by their respective suppliers. The most commonly used outside laboratories are SGS and ITS.
Merchandising and quality complement each other and with proper quality assessment the merchandising workflow becomes smooth, easy and timely delivery of products. All of the respondents (100%) supported this fact. Retailers and manufacturers agreed that quality and merchandising are related to each other and hence helping those in achieving product benchmarking (statistically significant at 95% confidence level). Retailers and manufacturers conduct fabric and garment tests on a regular/routine basis and mostly use knitted and woven fabrics in garment making.

In addition to the above, the worldwide manufacturers and suppliers of the FAST and Kawabata systems were approached to obtain data and information about the number of such systems sold worldwide and their fields of application. This information was considered important in promoting FOM in South Africa.

Only one manufacturer is presently using FAST for quality control purposes. Of the manufacturers and retailers covered, most of them were either unfamiliar or totally unaware of FOM and its application. This indicates that there is considerable scope for introducing this highly advanced technology into the textile and clothing manufacturing and retail pipeline in South Africa.

Most of the manufacturers and retailers (50%) intend to introduce certain new tests in future. The tests that they are planning to introduce in future may include FAST, which is fairly simple, reliable and productive, as well as enhancing the quality of the garment. If used, FOM can improve the quality and competitiveness on the international level which is currently lacking in the South African clothing sector.
INTRODUCTION
1. Introduction

1.1 Country Analysis – South Africa

(i) Geography

Located at the Southern tip of the African continent, South Africa borders Namibia, Botswana, Zimbabwe and Mozambique and has more than 1500km of coastline along the Atlantic and Indian Oceans. In 1652, Dutch settlers established an outpost of the Dutch East India Company at the Cape of Good Hope – an important stop-over along the trade routes to the east.

The discovery of diamonds in 1867 and gold in 1886 stimulated rapid economic growth in the 19th century, although the economy has since become diverse, with many natural resources including gold, coal, iron ore, phosphates, diamonds and copper. Johannesburg is the economic centre of the country, and Cape Town is the key economical hub in the Western Cape. The ports in South Africa, notably Cape Town and Durban, are the main entry points for incoming shipments to the South Africa region, particularly markets in Europe and North America.

(ii) Society

It was estimated that mid-2010 South Africa had a population of about 50 million (www.southafrica.info) which makes it the 26th in the world by population, a national census having been completed in October, 2011. According to earlier data, the median age of the population is 24.5 years, which is kept low by the high prevalence of HIV/AIDS (18% adult prevalence rate). Approximately 60% of the population lives in urban areas, mainly in Johannesburg, Cape Town and Durban. As an indication of the general standard of living, South Africa ranks 123rd among all countries in the Human Development Index, which is low relative to its position of 72 in terms of GDP per capita (UNDP, 2010; IMF, 2011). The South African society comprises four general racial categories: African, White, Coloured and Indian. The African category encompasses several different ethnic groups, including Zulu, Xhosa and Sotho. More recently, migrants from other African countries, notably Zimbabwe, Somalia and the Congo have relocated to South Africa.
1.2 National Economic Performance

(i) GDP and Growth

The Gross Domestic Product (GDP) in South Africa expanded 1.3 % in the second quarter of 2011 over the previous quarter (StatsSA). Historically, from 1993 until 2011, South Africa's average quarterly GDP Growth was 3.3 %, reaching an historical high of 7.6 % in December of 1994 and a record low of -5.90 % in March of 2009 (Figure 1). South Africa has a two-tiered economy; the one rivaling other developed countries and the other with only the most basic infrastructure. It therefore has a productive and highly industrialized economy but which also exhibits many characteristics associated with developing countries, including a division of labour between formal and informal sectors and an uneven distribution of wealth and income. The primary sector, based on manufacturing, services, mining, and agriculture, is well developed (www.tradingeconomics.com).

Source: TradingEconomics.com; Statistics South Africa

Figure 1: South African Annualised GDP Growth Rate from Jan., 2007 – Oct., 2011
(ii) Constraints to Continued and Shared Growth

Since 2005 the government has pursued the Accelerated and Shared Growth Initiative for South Africa (ASGISA)– a macro-economic policy framework that aims to raise the annual growth rate to 6% and reduce poverty and unemployment by half by 2014 (www.asgisa-ec.co.za). The challenges facing South Africa are marked by an underlying tension between the objectives of efficiency, which requires improved competitiveness, and equality through the creation of opportunities for the previously disadvantaged black population.

The robust demand that has been driving recent growth has been met by imports. Since South Africa cannot rely on domestic demand remaining high, it would face an extremely difficult challenge in maintaining growth and employment in the absence of increased exports. Several other factors constraining South Africa’s growth potential include trade policy and labour market rigidities. Furthermore, a central element of the government’s strategy to address inequality, the Black Economic Empowerment (BEE) policy, has focused on extending opportunities to black South Africans at the managerial and ownership levels.

Government’s New Growth Path aims to create 5 million new jobs by 2020. It seeks to do so by providing a supportive environment for growth and development, while promoting a more labour-absorptive economy. Its proposals are intended to lower the cost of living for poor households and for businesses through targeted micro economic reforms, especially in transport, public services, telecommunications and food.

The recently released National Development Plan proposes to create 11 million jobs and reduce unemployment from 27% to 6%, increase the number of matriculants with university exemption from 13% to 30% and increase the expenditure on infrastructure from 17% to 25% of GDP by 2030 by:

- Realising an environment for sustainable employment and inclusive economic growth
- Promoting employment in labour-absorbing industries
- Raising exports and competitiveness
- Strengthening government’s capacity to give leadership to economic development
- Mobilising all sectors of society around a national vision
Proposals to increase employment and growth include the following:

- Raise exports, focusing on those areas where South Africa already has the endowments and comparative advantage, such as mining, construction, mid-skill manufacturing, agriculture and agro-processing, tourism and business services.
- Increase the size and effectiveness of the innovation system, and ensure closer alignment with companies that operate in sectors consistent with the growth strategy.
- Improve the functioning of the labour market to help the economy absorb more labour, through reforms and specific proposals concerning dispute resolution and discipline.
- Support small businesses through better coordination of activities in small business agencies, development of financial institutions and public and private incubators.
- Improve the skill base through better education and vocational training.
- Increase investment in social and economic infrastructure to lower costs, raise productivity and bring more people into the mainstream of the economy.
- Reduce the regulatory burden in sectors where the private sector is the main investor, such as Broadband internet connectivity, to achieve greater capacity and lower prices.
- Improve the capacity of the state to effectively implement economic policy.

Some argue that the economy is not competitive in labour-intensive manufacturing because the cost structure is too high, labour laws are not conducive to such industries, and the country lacks the management acumen to manage large, labour-intensive firms. This may be true in certain sectors. But in certain higher-value goods or niche markets, South African firms can compete. These including agricultural and agro-processing, white goods and appliances, and certain niches in clothing and footwear (Source: www.npconline.co.za/Trevor Manuel, November 2011).

Speaking at the Clothing and Textile Industries National Bargaining Council annual general meeting (29 November, 2011), Trade and Industry Minister Rob Davies stated that the clothing and textile industry was only slightly affected by the recent global financial crisis as the competitiveness improvement incentive program had helped stimulate it. He also pointed to the employment numbers in the sector having increased slightly over the past year i.e. 57 728 as of
September 30, 2011 in comparison to 56,985 in October, 2010. He went on to say that the medium-term budget policy statement had announced additional competitiveness incentive measures that would be followed through in the national budget of 2012 and that the lessons from applying the incentives used in the clothing and textile sector could be generalized and applied to other manufacturing sectors. The preferential procurement framework regulations would be in effect from December 7, 2011. These would allow government procurement officers to preferentially buy locally manufactured workwear, bedding and linen (Source: www.businesslive.co.za/southafrica/sa-markets/2011).

1.3 Cluster Analysis

(i) Global Textiles and Clothing Industry

Since the termination of the Multi-Fibre Agreement (MFA) quota system, the global textile and clothing industry has been in a state of flux. Under the MFA, global trade in textiles and clothing was restricted using a complex quota system. As a new era in global textiles emerged, numerous developing countries faced greater competition in terms of prices (McNamara, 2008).

Globally, textile and clothing trade grew by 10.6% to US$583bn in 2007, while textile exports from Asia to Africa increased by 18% and from Asia to Europe by 16%. The world’s biggest textile exporter in 2007 was the EU27, followed by China, Hong Kong, the USA, South Korea, Taiwan, India, Turkey, Pakistan and Japan. The EU27 was also the biggest textile importer, followed by the USA— China ranking third, followed by Hong Kong, Japan, Turkey, Mexico, Vietnam, Canada and Russia (www.emergingt textiles.com).

In terms of clothing imports, 46% of the world total went to EU countries in 2007, 24% to the USA and 7% to Japan. The countries which followed in importance were relatively small in terms of imports and included Hong Kong, Russia, Canada, Switzerland, the United Arab Emirates, South Korea and Australia (www.emergingt textiles.com).
Global clothing exports rose 70% between 2000 and 2009, although falling more than 13% in the past year (2010), according to the latest data from the WTO. China in 2010 was the world’s leading exporter for the second year running, followed by the EU27, Hong Kong, Turkey, Bangladesh, India, Vietnam, Indonesia, Mexico and the USA. The European Union remained the second largest clothing exporter after the surging China. EU clothing imports also strongly increased, which is in contrast with the weakness of the US clothing import market, in value terms (www.emergingtextiles.com).

China is increasingly confronted by a severe slowdown in sales with a rise in textile and clothing production costs. Fibre and yarn prices already jumped in the last year (2010), while energy costs continue to increase. Minimum wages continue to climb and will increase by more than 80% until 2015. Clothing retail sales in the three largest European markets were much weaker in December 2010, mostly due to cold and snowy weather keeping consumers away from stores. The VAT rise in the UK has depressed sales in the first quarter of 2011. For the first time since 2007, retail sales reached a new record high for US clothing stores in March, 2011 (www.emergingtextiles.com).

**World Economy Forecasts 2012:** The prospects for the world economy have improved in 2011. In the latest report published by the International Monetary Fund (IMF) on Nov. 1, 2011 the IMF suggested that the global recovery has been under way. The institution predicted that the world economy in 2010 will grow by 3.1% year on year (YOY), up 0.6% from its previous forecast in July, 2009, and its projection of the 2009 growth rate was also revised upwards to -1.1% from the earlier projection of -1.4% made in July. With the gradual recovery of the global economy, global retailers are expected to step up their sourcing activities throughout the Asian region. Leading organizations will actively begin evaluating destination network strategies. In addition to India and Philippines as large scale destinations, organizations will gain interest in new delivery locations in emerging African, Central and Latin American markets and economies. Both India and the Philippines are expected to experience a revival in their extensive offshore services industry (www.oavci.com).
As per the ATA Journal, since 2010 the price of raw materials, especially cotton, has surged to previously unknown levels, but this year has witnessed a drop in price from the peak levels. Shortage of labour was also a challenge for countries like China. The spotlight of the textile industry is increasingly falling on the emerging Asian countries of Bangladesh, India, Cambodia, Vietnam and Pakistan. According to the Clothing Industry Training Authority, Hong Kong, the above emerging Asian countries will be playing a more significant part in the industry in 2011, due to their price-competitiveness. As for India, more and more buyers have come to trust it as a competent and reliable manufacturing country. In fact, China’s success in the textile industry has set an example for other developing countries in Asia (ATA Journal for Asia on Textile and Clothing, February, 2011).

(iii) Quotas, Tariffs and the End of the MFA

At the beginning of 2005, restrictions on trade in textiles and clothing imposed by the MFA expired and today trade in these areas is governed by the normal WTO rules. Under the MFA, the amount of exports from a number of low-cost countries into the US and Europe was limited to enable the domestic producers in these countries to compete. While designed to protect US and EU producers, the MFA had limited success in this respect. The restrictions stimulated an “unintended growth in clothing manufacturing in a number of low-cost quota-free countries in Africa and Asia” (McNamara, 2008). Concurrently the quota system kept prices artificially higher for European and American consumers. As a consequence, trading patterns were distorted, which predicted clear winners and losers once the quotas were to be lifted.

For many low-income producers, a complex system of tariffs and preferential trade agreements remains firmly in place. Among them is the African Growth and Opportunity Act (AGOA), which offers duty- and quota-free entry into the US until 2015 for certain textile and clothing products from designated sub-Saharan African countries. As tariffs on textiles and clothing are usually higher than on other manufactured goods, preferential market access offers many developing countries a platform from which to devise a strategy for their textile and clothing industries.
(iii) Africa’s Cotton, Textile and Clothing Industry Harnesses Technology and Talent to Increase Global Market Share

The outlook is bright for Africa’s cotton, textile and clothing sector. The industry is undergoing a renaissance fuelled by a global demand for cotton, diversification of sourcing and manufacturing locations around the world and an African middle class that is stimulating demand for African-made clothing. To capitalize on these trends, USAID East Africa’s Competitiveness and Trade Expansion (COMPETE) programme brought industry buyers and designers together to share innovations in textile technology and showcase Africa’s fashion designers at Origin Africa Fibre to Fashion in Port Louis, Mauritius March 17-18, 2011. This event was organized together with the Mauritius Export Association (MEXA), Enterprise Mauritius (EM) and the African Cotton and Textile Industries Federation (ACTIF). Its aim was to strengthen business relationships and develop new trade opportunities for the hundreds of producers, traders and buyers who will attend the event (www.eastafrica.usaid.gov).

Origin Africa Fibre to Fashion 2011 was divided into a Fibre to Fashion Symposium, a Pan-African Graphic Design Show and the Origin Africa Designer Showcase. Symposium agenda items included Green/Eco-friendly manufacturing practices, New Product Development and Innovation in Cotton Fabric and Fibre, and Integrating Design and Marketing. The Pan-Africa Graphic Design Show taps into Africa’s new and exciting design talent. The competition asked designers to create compelling designs for the Africa of yesterday, today and tomorrow (www.eastafrica.usaid.gov). The colourful prints and textures of African fabrics were featured as upcoming designers showed their collections in the Origin Africa Designer Showcase. This competition challenges designers to create collections with commercial appeal using locally sourced fabrics and facilities. Participation in the Origin Africa Designer Showcase gives international exposure to promising African design talent. The Designer Showcase winner was flown to New York and featured at AFRICA Fashion Week New York in July, 2011. USAID COMPETE’s Origin Africa global awareness campaign is changing perceptions about doing business in Africa, while USAID COMPETE’s East and Central Africa Trade Hub helps African businesses take advantage of preferential trade opportunities available under the AGOA. Over the past two years the East and Central Africa Hub has facilitated nearly USD $35 million of
exports in clothing, cut flowers, specialty foods and home decor/fashion accessories under AGOA (www.eastafrica.usaid.gov).

1.4 Textile and Clothing Sector in South Africa

Figure 2 provides a map of the South African Textile and Clothing Sector

Source: www.isc.hbs.edu/pdf/Student.../SouthAfrica_Textiles_2009

Figure 2: Map of South African Textile and Clothing Sector
(i) Development of the Sector

In the early 1920s, South African clothing was almost nonexistent; clothing being either imported or locally tailored (Sawkut, 2008). The industry began with the manufacturing of blankets by a limited number of small companies in Johannesburg and Cape Town in 1920s and 1930s. During World War II, the industry provided blankets, rugs and sheeting; employed 3500 workers; and supplied 90% of domestic need (the RATES Centre, 2005). After World War II, the sector expanded into furnishings, industrial textiles and clothing. In the 1960s, the cluster further expanded into synthetic fibres and the sector almost doubled in size (Morris et al, 2005). Because apartheid policies limited the use of African labor in urban areas there was a concentration of Indian and coloured labor in Durban, Cape Town and surrounding areas. Cape Town soon became the centre of the South African clothing industry, partly driven by the large retail chains based there.

South Africa implemented trade liberalization in the 1990s, and joined GATT in 1994 (Mabugu, 2004). Levies on imported machinery, however, limited upgrading. Liberalization, with associated international competition and the restructuring of the industry, resulted in large decreases in employment, while productivity increased through cost-minimization and downsizing rather than through production growth. In the 2000s, as global competition intensified, continued job losses and many firms went out of business. The industries in Gauteng (Johannesburg) and KwaZulu-Natal (Durban) were harder hit than those in the Western Cape, which now has both the largest number of firms and the highest employment level in the clothing sector. The signing of the Free Trade Agreement with the European Union, together with potential benefits from the AGOA by the US, provided significant export opportunities. These and various other relevant factors are captured in Figure 3.
Source: www.isc.hbs.edu/pdf/Student.../SouthAfrica_Textiles_2009

Figure 3: South Africa Textile/Clothing Cluster Diamond
(ii) Western Cape: Trying to Survive by Cluster Initiatives

The Western Cape is now the central region for the clothing and textile cluster in South Africa, creating 35% of South Africa’s total added value in terms of textiles, clothing and leather goods (Morris et al, 2005). The provincial government of Western Cape is supporting the local textile and clothing industry through a cluster initiative, with companies seeking ways to compete in domestic and international markets other than through price. Compared to clusters in Gauteng and Kwazulu-Natal, firms in Western Cape survived not by cost minimization but by differentiating and upgrading the value chain (Gwynne-Evans, 2009).

Traditionally, the clothing industry in the Western Cape targeted higher value-added fabrics (e.g. wool). While firms in Kwazulu-Natal, many of which are foreign owned by Chinese, Taiwanese, Indonesian and Singaporean investors, have lower cost structures and tend to target lower end markets, firms in the Western Cape are mostly South African-owned, have higher cost structures, with more of their production aimed at the higher end of the market (Barnes, 2005). The Cape Clothing and Textile Cluster (CCTC) Initiative began in 2004, by co-ordinating national government, firms, IFCs, the design industry, and universities (Cape Clothing and Textile Cluster, 2009). Since Cape Town is one of the wealthiest cities in the country, the proximity to the sophisticated market and various retail head offices in Cape Town also encourage firms to produce high value end products for such markets. Its coastal location also provides advantages in terms of logistics (Gwynne-Evans, 2009).

(iii) Textile and Clothing Industries

The South African textile and clothing industries together employ about 170 000 (100 000 clothing and 70 000 textiles) and have an annual turnover of over R 20bn, there being over 500 textile companies and over 1000 clothing companies. More than 85% of the companies and employees are in KZN (41%), Western Cape (25%), Gauteng (20%) and with some 13% in the Eastern Cape. About 80% of the outputs consist of commodity products, and only about 5% of high-tech products, there also being a large and growing informal SME sector. Textile and clothing industries are interdependent, as the fabric is the single most significant input into the clothing sector, accounting for approximately half of the cost to produce a garment. On the other
hand, the clothing industry’s growth in export would have a positive impact on the textile industry by creating a higher demand for local fabrics. The clothing industry requires a significant amount of low-skilled labour; as much as 83% of employees in the Western Cape clothing industry are semi- and unskilled. Firms in the textile and clothing sector vary from well-established large firms to SMEs and home industries, the latter two being particularly prevalent in the clothing industry (www.mbendi.com).

The textile industry in South Africa can be segmented into the following major sectors:

- Fibre production
- Spinning (yarn production)
- Weaving
- Knitting
- Nonwovens
- Carpet production

(www.mbendi.com)

There is also a wide range of other consumer and industrial product converting sectors, including; home fabrics, filtration fabrics, tarpaulins, geotextiles, sewing threads, sleeping bags and fibre production. The major fibre types used include cotton, staple and filament polyester, acrylic, nylon, polypropylene, viscose, and jute/sisal (www.mbendi.com).

1.5 Clothing Trade under AGOA

The African Growth and Opportunity Act (AGOA) is a United States Trade Act that significantly enhances US market access for (currently) 41 Sub-Saharan African (SSA) countries. The Act originally covered the 8-year period from October, 2000 to September, 2008, but amendments signed into law by US President George Bush in July, 2004 further extended AGOA to 2015. At the same time, a special dispensation, relating to clothing, was extended by three years to 2007. On 20 December, 2006, key changes to AGOA were signed into law, extending the garment
provisions to 2012. In June, 2007, a revised textile certificate of origin was published to give effect to the "abundant supply" provisions contained in the most recent legislative changes. These changes were repealed in 2009 (www.agoa.info).

Clothing trade data shows, that currently only a relatively small number of countries export clothing to the US under AGOA (see Figure 4), as some of these countries (e.g. Lesotho, Kenya) showing a very high utilization rate (i.e. proportion of exports under the Trade and Development Act (AGOA) to total exports of clothing) in their clothing exports to the US (www.agoa.info).

Source: www.AGOA.info

**Figure 4: AGOA Clothing Exports**

Other countries have a far lower utilization rate, with a much smaller percentage of clothing exports falling under AGOA's duty-free provisions. Generally, countries still able to utilize third
country textile inputs for their AGOA-eligible exports tend to have far higher utilization ratios.

1.6 Availability of Raw Materials

Competitive advantages for the sector lie in competitive labour costs and the ready availability of good quality natural fibre raw materials.

(i) Wool

South Africa is the world's fifth largest producer of wool; the wool being produced in most parts of South Africa under various conditions (See Table I). South Africa produces high quality, environmentally sound apparel wool, which is predominantly Merino. Strict precautionary measures to guard against contaminating the wool during growing, shearing and packing have been instituted as an integral part of the marketing process. More than 90% of the wool is sold through the auction system, which has been centralised in Port Elizabeth. The prices paid for wool are determined by free market supply and demand forces and are closely linked to international prices for apparel wool, which is largely determined by the Australian market, Australia being the largest producer of wool in the world.
Table 1: Wool Production 2010

<table>
<thead>
<tr>
<th>Province</th>
<th>Grease Mass (Kg)</th>
<th>2009/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>35 078 764</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>9 087 336</td>
<td></td>
</tr>
<tr>
<td>Direct Purchases</td>
<td>1 615 040</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>251 964 6 9</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>48 300 787</td>
<td></td>
</tr>
<tr>
<td>Eastern Cape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>10 390 684</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>2 829 394</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>585 149</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13 805 227</td>
<td></td>
</tr>
<tr>
<td>Northern Cape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>4 597 308</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>1 020 011</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5 617 319</td>
<td></td>
</tr>
<tr>
<td>Western Cape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>6 631 542</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>1 853 321</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>8 997</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8 493 860</td>
<td></td>
</tr>
<tr>
<td>Free State</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>7 303 663</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>2 025 503</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1 026 426</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10 355 592</td>
<td></td>
</tr>
<tr>
<td>Mpumalanga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>1 957 805</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>513 070</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2 470 875</td>
<td></td>
</tr>
<tr>
<td>Limpopo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer Lots</td>
<td>3 996</td>
<td></td>
</tr>
<tr>
<td>Bins &amp; Other</td>
<td>3 282</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7 279</td>
<td></td>
</tr>
</tbody>
</table>

Source: www.capewools.co.za
(ii) Mohair

South Africa is the world’s largest producer of mohair, with the Eastern Cape of South Africa the world leader in mohair production. This fibre, however, constitutes less than 1% of all global natural fibres. Currently, about 54% of the world’s mohair production is generated in South Africa, the mohair commonly referred to as Cape Mohair being regarded as the best in the world. Advanced breeding and farming techniques in the country ensure consistent fibre availability and quality (www.texfed.co.za).

(iii) Cotton

World cotton prices recently rose sharply and reached a new record level of US$2.44/lb on 8 March 2011, which is almost 3 times the value of the index at the beginning of the season 8 months before. According to the International Cotton Advisory Committee (ICAC) the main reasons for the surge in prices include low world stocks, lower-than-expected production, robust demand and panic buying at the beginning of the season. Since it reached its peak, cotton prices have dropped sharply and stood at around to US $ 1.0/lb in October, 2011. According to the International Cotton Advisory Committee (ICAC), the expected world cotton surplus of 2.2 million tons this season (2011/12) will give rise to a 24% increase in global cotton stocks. This, together with the expectation that the stocks-to-use ratio (China excluded) will increase from 47% in 2010/11 to 54% in 2011/12, could translate to a significant decline in the average A index for 2011/12 as has already occurred. The average A index for 2011/12 is, however, likely to remain above the 10-year average figure of 60 US c/lb according to the ICAC (www.cottonsa.org.za).

The major areas where cotton is produced in South Africa are the Springbok Flats, the Limpopo Valley, the lower Orange river, North West Province, Mpumalanga and KwaZulu-Natal. The seed cotton yields are approximately 700 kg/hectare in respect of dry land and 4000 kg/hectare in respect of irrigated land. Zimbabwe and Zambia are the major suppliers of cotton lint to South Africa. South Africa has a number of mills producing cotton and polyester/cotton fabrics.
(iv) Leather

SA has the raw materials needed to produce any type of footwear, from low end to high end. Bovine, ostrich, Nile crocodile, game leather, textile and PVC and PU synthetic raw materials can all be sourced locally without difficulty. Nevertheless, the sector has suffered huge market and employment losses because of its inability to effectively compete with low cost international countries (www.southafrica.info).
(v) Vegetable Fibres

The quality of the South African grown sisal is graded according to International Sisal Grading Regulations, which are universally accepted.

The local sisal fibre is of a high quality and is well received on world markets. SA is also beginning to grow and process other natural fibres, such as flax and hemp, in response to increasing demand from the automotive and aeronautics industries for environmentally friendly body parts (www.southafrica.info).

(vi) Man-made Fibres

In the past South Africa was a fairly large producer of man-made fibres such as polyester and polyamide (nylon), although its production has been dropping steadily (Table 3). During 2008, the man-made fibre consumption represented approximately 50% of the total South African fibre consumption. Hosaf is the major producer of polyester staple fibres, while SAPY, situated in Hammarsdale, KZN, is the major producer and exporter of multifilament polypropylene yarns.

Various mills produce synthetic woven and knitted fabrics (www.texfed.co.za).

1.7 South African Textile Industry

The South African textile industry has reacted in varying ways to the changing global economic environment and the global economic crisis. Overall employment has kept falling and a number of textile mills and clothing manufacturers have closed. From 2009 to 2010 the volume of the production index (for textiles, excluding the knitting mills) decreased by approximately 4%, while that of knitting mills increased by 4%. There is sufficient production capacity available locally, but due to the lower import duties and cheap imported products, textile factories were only producing at around 72% of capacity during 2008 (www.texfed.co.za/2010-2011).

Ex-factory turnover for textiles was R15.1 billion in 2009, which is 10% lower than in 2008. The turnover for knitting mills (both fabrics and garments) was R1.6 billion, 17% lower than the previous year (www.texfed.co.za). The value of imports of both textiles and clothing has decreased. From 2008 to 2009 the value of textile imports has decreased as a result of the global
economic crisis. The value of textile imports during 2009 amounted to R8.6 billion which is nearly 9% less than in 2008. During 2009 the value of textile exports has decreased by 13% to R3.9 billion. Exports of wool in raw form represent approximately 50% of the value of total textile exports. Retail trade sales for textiles, clothing, leather and footwear, at current prices, increased by 4% from 2008 to 2009. At constant 2008 prices it showed a 2% decrease (www.texfed.co.za/2010-2011).

The concern that Eastern countries are “dumping” textiles and textile products, covering a wide spectrum of the industry, is still real. According to official import statistics, finished cotton textile goods, like bed linen and curtains, are in some instances being imported into South Africa at prices equal to, and sometimes even less than, the cotton lint price. This practice is extremely damaging to the local industry (www.texfed.co.za/2010-2011).

Since 2005 exports of textiles showed an increasing trend, largely because of wool exports. Taking into account the general economic conditions, the decline in exports of manufactured goods, continued low priced imports mainly from China and a decline in local production since 2005, the local textile industry has not been able to recover and grow. As a result of the Credit Act, and the higher fuel and electricity prices, increased interest rates during 2007 and 2008, as well as the global economic crisis, the economy showed signs of a slow down during the latter part of 2008 and during 2009, with the resultant decline in production as a result of the decline in demand for textile products. China is still the major source of imported textiles and clothing. As a result of the quotas on imports of certain textiles and clothing from China during 2007 and 2008, clothing from other low-cost Eastern countries showed a significant increase during these two years. However, apparel sourcing has largely returned to China since then (www.texfed.co.za/2010-2011).

2010 appears to be still a difficult year for the local textile and clothing industries, with 2011 much on par with 2010.
<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment (average)*</td>
<td>46947</td>
<td>47647</td>
<td>45673</td>
<td>40207</td>
<td>35757</td>
</tr>
<tr>
<td>Sales (R'mill)</td>
<td>16562</td>
<td>17311</td>
<td>16771</td>
<td>15100</td>
<td>14594</td>
</tr>
<tr>
<td>Imports (R'mill)</td>
<td>7472</td>
<td>8080</td>
<td>9498</td>
<td>8623</td>
<td>9287</td>
</tr>
<tr>
<td>Exports (R'mill)</td>
<td>3462</td>
<td>4190</td>
<td>4489</td>
<td>3907</td>
<td>3733</td>
</tr>
<tr>
<td><strong>Fabric production (mill m2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>131</td>
<td>129</td>
<td>120</td>
<td>98</td>
<td>92</td>
</tr>
<tr>
<td>Spun synthetic</td>
<td>135</td>
<td>133</td>
<td>123</td>
<td>101</td>
<td>94</td>
</tr>
<tr>
<td>Continuous filament</td>
<td>43</td>
<td>42</td>
<td>39</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>Worsteds</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Wovens - total</td>
<td>316</td>
<td>311</td>
<td>289</td>
<td>237</td>
<td>221</td>
</tr>
<tr>
<td>Knitted</td>
<td>114</td>
<td>117</td>
<td>122</td>
<td>115</td>
<td>114</td>
</tr>
<tr>
<td>Fabrics – total</td>
<td>430</td>
<td>428</td>
<td>411</td>
<td>352</td>
<td>335</td>
</tr>
<tr>
<td>Fibre consumption ('000 tons)</td>
<td>203</td>
<td>174</td>
<td>172</td>
<td>147</td>
<td>151</td>
</tr>
<tr>
<td>Spun yarn production ('000 tons)**</td>
<td>75</td>
<td>74</td>
<td>68</td>
<td>56</td>
<td>52</td>
</tr>
<tr>
<td><strong>Equipment:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spindles</td>
<td>N/a</td>
<td>234930</td>
<td>140120</td>
<td>92644</td>
<td>n/a</td>
</tr>
<tr>
<td>Looms</td>
<td>N/a</td>
<td>1634</td>
<td>1587</td>
<td>1362</td>
<td>n/a</td>
</tr>
</tbody>
</table>

* Textiles (excluding knitting)  ** Estimates

Source: StatsSA
Table 4: Production Price Index, Consumer Price Index, Employment, Production Capacity and Value of Sales from 2006-2010

**PRODUCTION PRICE INDEX**

<table>
<thead>
<tr>
<th>Year</th>
<th>Manufacturing</th>
<th>Textiles</th>
<th>Clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>142.8</td>
<td>123.1</td>
<td>121.6</td>
</tr>
<tr>
<td>2007</td>
<td>156.8</td>
<td>129.2</td>
<td>123.9</td>
</tr>
<tr>
<td>2008</td>
<td>180.5</td>
<td>135.0</td>
<td>126.7</td>
</tr>
<tr>
<td>2009</td>
<td>181.9</td>
<td>142.2</td>
<td>128.3</td>
</tr>
<tr>
<td>2010</td>
<td>185.3</td>
<td>145.3</td>
<td>128.7</td>
</tr>
</tbody>
</table>

Source: Stats SA

**INDEX OF PHYSICAL VOLUME OF PRODUCTION**

*Seasonally adjusted*

<table>
<thead>
<tr>
<th>Index: 2005=100</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>104.7</td>
<td>109.5</td>
<td>110.5</td>
<td>96.7</td>
<td>101.2</td>
</tr>
<tr>
<td>Spin, weave, finishing</td>
<td>99.4</td>
<td>98</td>
<td>90.7</td>
<td>73.7</td>
<td>69.4</td>
</tr>
<tr>
<td>Other textiles</td>
<td>102.9</td>
<td>101.8</td>
<td>99.9</td>
<td>78.1</td>
<td>73.2</td>
</tr>
<tr>
<td>TEXTILES</td>
<td>101.2</td>
<td>99.9</td>
<td>95.3</td>
<td>75.9</td>
<td>71.3</td>
</tr>
<tr>
<td>Knitting mills (fabrics and garments)</td>
<td>104.3</td>
<td>106.8</td>
<td>111.5</td>
<td>104.4</td>
<td>104.4</td>
</tr>
<tr>
<td>Clothing</td>
<td>102.6</td>
<td>109.4</td>
<td>110.6</td>
<td>96.5</td>
<td>86.8</td>
</tr>
</tbody>
</table>

Source: Stats SA

**CONSUMER PRICE INDEX**

<table>
<thead>
<tr>
<th>Year</th>
<th>TOTAL</th>
<th>CLOTHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;All items&quot;</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>124.7</td>
<td>97.7</td>
</tr>
<tr>
<td>2005</td>
<td>129.0</td>
<td>95.1</td>
</tr>
<tr>
<td>2006</td>
<td>134.4</td>
<td>88.8</td>
</tr>
<tr>
<td>2007</td>
<td>144.6</td>
<td>82.5</td>
</tr>
<tr>
<td>2008</td>
<td>160.7</td>
<td>91.5</td>
</tr>
</tbody>
</table>

Source: Stats SA

**CONSUMER PRICE INDEX**

<table>
<thead>
<tr>
<th>Year</th>
<th>TOTAL</th>
<th>CLOTHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;All items&quot;</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2009</td>
<td>107.1</td>
<td>105.2</td>
</tr>
<tr>
<td>2010</td>
<td>111.7</td>
<td>107.5</td>
</tr>
</tbody>
</table>

Source: Stats SA

**EMPLOYMENT**

<table>
<thead>
<tr>
<th>Category</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010 Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing (‘000)</td>
<td>1300</td>
<td>1319</td>
<td>1300</td>
<td>1213</td>
<td>1163</td>
</tr>
<tr>
<td>TEXTILES (total - excl knitting)</td>
<td>46947</td>
<td>47647</td>
<td>45673</td>
<td>40207</td>
<td>36812</td>
</tr>
<tr>
<td>- spin, weave and finish</td>
<td>17616</td>
<td>16719</td>
<td>15141</td>
<td>13465</td>
<td>9989</td>
</tr>
</tbody>
</table>

Source: Stats SA
| - other Knitting Mills (fabrics and garments) | 30607 | 30928 | 30732 | 26742 | 26823 |
| Clothing | 7251 | 6865 | 6286 | 5537 | 5237 |
| Total | 69538 | 63725 | 56576 | 49490 | 49987 |
| percentage change | -4.4 | -8.2 | -12.3 | -3.4 |

Source: Stats SA

**UTILISATION OF PRODUCTION CAPACITY**

| percentage | 2006 | 2007 | 2008 | 2009 | 2010 |
| Manufacturing | 86 | 86 | 84 | 78 | 80 |
| Textiles | 86 | 84 | 81 | 72 | 71 |
| Clothing | 83 | 83 | 83 | 80 | 77 |

Source: Stats SA

**VALUE OF SALES (EX-FACTORY)**

| R'MILLION | 2006 | 2007 | 2008 | 2009 | 2010 |
| Manufacturing | 974593 | 1123545 | 1343926 | 1161600 | 1235193 |
| Spin, weave, finishing | 6176 | 6543 | 6555 | 5755 | 5423 |
| Other textiles | 10386 | 10768 | 10216 | 9345 | 9171 |
| Total Textiles | 16562 | 17311 | 16771 | 15100 | 14594 |
| Knitting mills (fabrics and garments) | 1710 | 1801 | 1986 | 1646 | 1734 |
| Wearing clothing | 13475 | 14582 | 15267 | 14093 | 12866 |

Source: Stats SA (Actual values)

1.8 Competitive Advantages of the South African Textile and Clothing Sector

(i) Preferential Market Access

Preferential market access is perhaps the strongest competitive advantage that South Africa has in this sector. South Africa has entered into preferential agreements with the US, EU and Sub-Saharan countries. These agreements confer generous trade benefits as detailed below.
(ii) Africa Growth and Opportunity Act (for the US market)

As mentioned earlier, the African Growth and Opportunity Act (AGOA) is a United States Trade Act that significantly enhances US market access for (currently) 41 Sub-Saharan African (SSA) countries. The Act originally covered the 8-year period from October 2000 to September 2008, but amendments signed into law by US President George Bush in July, 2004 further extend AGOA to 2015. At the same time, a special dispensation relating to clothing was extended by three years to 2007. On 20 December, 2006, key changes to AGOA were signed into law, extending the garment provisions to 2012 (www.agoa.info).

(iii) European Union – South Africa Free Trade Agreement

A Trade, Development and Cooperation Agreement, containing a Free Trade Agreement (FTA), went into effect between South Africa and the European Union on 01 January 2000. Under the FTA, the EU is committed to the full liberalisation of 95% of South African imports over a 10-year transitional period, while South Africa is to liberalise 86% of EU imports over a 12-year transitional period.

(iv) Southern African Development Community (SADC)

The SADC trade protocol, which came into effect in September, 2000, provides for the phasing down of tariffs for 11 of the 14 SADC member countries. The participating member countries are from the Sub-Saharan region, but exclude SADC members Angola, the Democratic Republic of Congo and Seychelles. This trade bloc has a combined population of 135 million.

(v) Southern Africa Customs Union (SACU)

Under the present SACU agreement, participating member countries South Africa, Botswana, Lesotho, Namibia and Swaziland have totally abolished internal tariff barriers. Their respective governments are presently ratifying an agreement finalised on the 25 October 2002. The main change introduced in this agreement pertains to revenue sharing.
1.9 Clothing and Textile Manufacturing Sector in South Africa

The South African clothing and textile manufacturing industry is highly diverse and mature. Products produced in both industries range from inexpensive mass produced basics to higher value added fashion and tailored garments, and specialized textiles. The textile and clothing industries are interdependent, the fabric being the single most significant input into the clothing sector, accounting for approximately half of the cost to produce a garment. About 48% of the output from the textile industry in South Africa goes to the domestic clothing industry. Without an efficient and supportive textile industry, the expansion of the clothing industry is seriously constrained. On the other hand, the clothing industry’s growth in exports would have a positive impact on the textile industry by creating a higher demand for local fabrics (Barnes, 2005). The clothing industry requires a significant amount of low-skilled labour; as much as 83% of employees in the Western Cape clothing industry being semi- and unskilled in 2004 (Sawkut, 2008). In the production of poly-cotton fabric for garments, for example, labour costs comprise only 14% of the ex-factory price. The costs of other inputs are, fibre/raw material (18 %); spinning process (18%, of which 6% is labour cost); yarn (36%); weaving process (20%, of which 5% is labour cost), and finishing (44%, of which 4% is labour cost) (The RATES Centre, 2005). Firms in the textile and clothing cluster vary from well-established large firms to SMEs and home industries.

South Africa’s clothing industry is dominated by a small number of large retailers, most with head offices in Cape Town. These retailers have the power to set prices, as well as make demands on fashion, quality and delivery. The regional location of the Western Cape manufacturers enabled them to meet delivery requirements, speed up purchasing processes and ease of dealing with problems, and hence historically advantaged them. However, retailers now source from across the country and globally, with price, delivery and the quality of service playing a pivotal role.

The price pressures from trade liberalization, currency strengthening, and the exercise of local retailers’ power within domestic value chains have resulted in clothing firms following a number of different survival strategies. In line with global trends, there has been a restructuring of the industry and recomposition of labour, with a move towards subcontracting and informalisation as
retailers and many larger firms have outsourced parts of their production to Cut-Make-and-Trim (CMT) enterprises providing production services at lower costs due to lower overhead structures. In addition, formal factory downsizing and closures have resulted in the establishment of micro-enterprises, home industries and unregistered firms, causing an increase in the number of people employed in the informal sector of the clothing industry and making it difficult to accurately calculate employment figures (Edwards and Morris 2006).

A second important trend, mainly by firms that are well integrated into local retailer value chains, has been a process of sharp learning through the adoption of World Class Manufacturing (WCM) techniques. This focus on upgrading operational performance has concentrated on internal processes to speed up delivery and lead times, cut inventory levels, reduce defect rates, introduce new work practices, and create value chain alignment between retailers and suppliers. The Western Cape and KZN Clothing and Textile Clusters have played an increasingly pivotal role in this drive to greater competitiveness and upgrading process. The result has been a change in the types of skills demanded and utilized on the factory floor.

In the textile industry, firms have also been increasingly confronted with cheap imports due to trade liberalization, rising costs and pressures in terms of lower prices and more stringent quality demands. However, the strategies followed by textile companies to cope with these pressures have been different to those followed by the clothing firms. Textile firms have moved to focusing on core products, closing non-core functions and following vertical disintegration strategies. Many textile firms have chosen to focus on niche markets and therefore restructuring has resulted in greater specialization and longer production runs. This survival strategy adopted by textile firms has been criticized by the clothing industry because it has resulted in them moving away from the production of clothing textiles towards technical, industrial, and household textiles, which are more secure, and have higher margins.
1.10 Clothing Manufacturers of South Africa

“trubok.co.za”

Trubok is one of the leading suppliers in South Africa of quality clothing to the retail trade, serving both the major clothing retail groups and independent boutique retailers, and it is well known for its design and manufacturing, as well as logistical and distribution capabilities.

With its locally-manufactured and imported lines, Trubok has a significant market share and is the preferred supplier to the majority of menswear outfitters and large clothing retailers in South Africa, as well as the corporate sector. With a large and growing range of women’s clothing, Trubok is able to supply the needs of both men’s and women’s fashion outfitters. Trubok specializes in men’s and women’s suiting, formal wear and casual wear, as well as corporate wear and healthcare clothing. Their men’s and women’s fashion ranges include labels like Jean Pierre, Lancetti and Docklanders along with many others developed over the years as custom in-house brands, as well as those created for retail customers, also manufacturing clothing for many international brands (trubok.co.za).

“cecilaron.co.za”

Cecil Aron has more than 50 years experience in the clothing industry, and has the necessary expertise to produce quality products, notably for the high end of the market. They are one of the largest school uniform manufacturers and suppliers in South Africa and supply many major wholesalers and are also specialized in sublimation printing.
Cecil Aron supplies locally manufactured products from their own factory, specializing in:

- Men’s and boy’s formal wear
- Ladies formal wear
- School Wear
- Security clothing
- Corporate wear
- Running shorts and vests
- Casual jackets
  (www.cecilaron.co.za)

“monatic.co.za”

House of Monatic was established more than 100 years ago, specialising in the production and manufacturing of high quality ladies and men's corporate wear, and is a 100% owned subsidiary of Brimstone Investment Corporation, a highly successful black empowerment company. It is one of the leading manufacturers of suits, shirts and ties. Computerised pattern making and grading linked to automated cutting, enable House of Monatic to achieve a high degree of accuracy, while working to tolerances demanded by their top end labels (www.monatic.co.za).

“pals.co.za”

Pals Clothing Pty, founded in 1925, is an ISO 9001 compliant company and is a major supplier of both locally manufactured and imported goods to all the major customers in South Africa,
including The Woolworth Group, Foschini, Edgars, Pick n Pay, Polo SA, Hilton Wiener and a host of smaller customers. Pals clothing also exports into Africa for customers such as the Defence and Police Forces.

Pals clothing manufactures a wide range of Formal wear, jackets, blazers, trousers, shorts, shirts, school uniforms, corporate wear, security uniforms and other clothing, some manufacturing being contracted out to approved South African Manufacturers. Its modern factory utilizes a fully computerized planning and cutting system and also uses production capacity in Mauritius and China on a regular basis with approved long term suppliers (www.pals.co.za).

1.11 Retail Sector in South Africa

Retail traders are defined by Statistics South Africa (StatsSA) as the “enterprises registered in the taxation system that are mainly engaged in the resale (sale without transformation) of goods and the rendering of services incidental to the sale of goods. Retailing is the final step in the distribution of goods. Retailers typically sell goods to the general public for personal or household consumption, but some also serve businesses and institutions.”

The retail sector in South Africa has shown good growth over the past decade and a number of major retailers have expanded into Africa. Shoprite is Africa's largest food retailer and has one of the most extensive networks of African supermarkets. A number of the other major food retailers also have a presence in Africa, with Pick n Pay, Spar and Massmart being three companies of particular note. Massmart has a presence in 14 African countries outside of South Africa and is in the process of being taken over by the giant multinational Walmart. WalMart Stores Inc. in late 2010 made a cash offer for 51% of South African discount retailer Massmart Holdings Limited (Massmart), although final approval awaits a court of appeal process, which will further increase pressure on retailers across the sector.
Other major clothing and footwear retailers include Truworths, Woolworths, Ackermans, Foschini, etc. Truworths has 250 stores in South Africa and 14 franchise operations in Africa and the Middle East. Woolworths goods are sold at 149 corporate stores, 51 international franchise stores throughout the rest of Africa and the Middle East and 69 South African franchise stores nationwide.

Statistics South Africa reported on 16 March 2011 that seasonally-adjusted growth in South Africa's retail sales increased slightly, by 1.5% year-on-year in January, 2011, compared with a 1.6% increase in December, 2010. However, retail sales grew by 7.7% in real terms for the three months to January, 2011, compared with the same period a year ago. The main contributors to growth over this period were general retailers (up 5.7%), textiles, clothing, footwear and leather goods retailers (up 7.9%) and household furniture, appliances and equipment retailers (up 17.3%), whilst food retailers reported an increase of only 0.4%, hampered by weak demand conditions during 2010 (www.fastmoving.co.za).

1.12 Large Clothing Retailers of South Africa

Woolworths was founded in 1931 by Max Sonnenberg, whose belief that success lies in providing customers with superior quality merchandise at reasonable prices has been instrumental in establishing Woolworths as one of South Africa’s leading retail chains, with an enviable reputation for quality and innovation.

Woolworths Holdings Limited is a South African chain of retail stores and one of the largest in the country, modelled on Marks and Spencer of the United Kingdom. Various store formats include full-line stores, food stand-alone stores, food and home ware lifestyle stores, stores
offering textiles (clothing, footwear and home ware). Only a selection of merchandise is also available online.

Woolworths was the first major South African retailer to offer a range of clothing incorporating organically grown cotton. Its men’s, women’s and children’s clothing is known for its exceptional quality and durability, and all items have labels that indicate materials used and country of manufacture (www.fastmoving.co.za).

“google.com”

Truworths is one of South Africa's leading fashion retailers (premier fashion chain), with over 250 stores in South Africa and 14 franchise operations in Africa and the Middle East, catering in particular for youthful quality conscious consumers. Truworths forms part of Truworths International, an investment holding company listed on the JSE, its companies are engaged in the retailing of fashion clothing and accessories. Collectively, Truworths International has more than 400 stores in South Africa. The Truworths International Retail Group also incorporates Identity, YDE and Uzzi.

Truworths womenswear offers a collection of leisure wear, formal wear, evening wear, lingerie, shoes and accessories designed for the modern fashion-aware woman. Truworths Man offers a wide range of exclusive menswear brands, Truworths Man, Hemisphere, Hemisphere Sport, Studio and Exstream, encompassing formal wear, leisure lifestyle fashion as well as shoe and accessory choices (www.truworths.co.za).
The Foschini Group (TFG) is an investment holding company operating in the retail and financial services segments within southern Africa. The Group trades primarily in South Africa, comprising 14 trading brands in over 1,700 stores. TFG Clothing Supply Company manages the supply of locally made clothing and co-ordinates the merchandise sourcing, shipping and quality assurance activities. The retail divisions retail clothing, jewellery, accessories, cosmetics, sporting and outdoor clothing and equipment and home ware to the broad, middle income group throughout southern Africa, mainly as a credit retailer. The Foschini brand is positioned as a destination of choice for women seeking good value, fashionable, current clothing and footwear. It is a ladies wear retail store offering contemporary clothing, footwear and cosmetics targeted at the 18 – 35 year old (www.fastmoving.co.za).

The first Edgars store was opened in 1929 and today Edgars Consolidated Stores Limited (Edcon) is considered the leading clothing, footwear and textiles (CFT) retailing group in South Africa, trading through a range of retail formats, encompassing retail brands trading in over 900 stores in South Africa, Botswana, Namibia, Swaziland and Lesotho.

Defined by the target markets served, all retail business is structured under two divisions: Department Stores Division, including Edgars, CNA, Boardmans, Prato, Red Square and Temptations, serving middle and upper income markets, and Discount Division including Jet, Jet Mart, Jet Shoes, Legit and Blacksnow, serving middle to lower income markets. Jet is a discount clothing and footwear retailer created to serve a huge and important lower cost market, the people of Africa who want a choice of good quality, affordable fashion. Legit is a retail format in
the Discount Division, aimed at young, fashionable women. The Legit customer is between the ages of 16 and 24, fashion conscious and works on a very tight budget. The store design is young and trendy with merchandise displayed to present the latest looks and trends (www.edcon.co.za).

“google.com”

PEP, established in 1965 with just one store, is today the biggest single brand store network retailer in Southern Africa, operating over 1 600 clothing stores in 10 southern African countries: South Africa, Botswana, Lesotho, Namibia, Swaziland, Zambia, Mozambique, Angola, Malawi and Zimbabwe. PEP also owns and runs the largest clothing factory in Southern Africa, Pepclo (PEP Clothing), which manufactures many of the clothing and school wear items that are sold in PEP. PEP’s buyers source merchandise from local and international markets. Pep's target market is the mass lower to middle end of the market. As such it seeks to sell low cost clothing. Pep is a subsidiary of Pepkor (www.Pepkor.co.za and www.pepstores.com).

“google.com”

Mr Price Group Limited and its subsidiaries operate over 750 stores across southern Africa, consisting of four retail chains, focusing on clothing, footwear, accessories and home ware. These chains are divided into two operational divisions, namely; the clothing and home divisions. Brands include: Mr Price, Mr Price Sport, Miladys, Mr Price Home and Sheet Street.
Mr Price is about casual and relaxed, fun and affordable fashion for the whole family, offering casual clothing, intimate wear and accessories for kids and adults at affordable prices, combining price value and fashion value

**Fashion value = right fashion + everyday low prices**

(www.theretailer.co.za)

---

**Ackermans**

“google.com”

Ackermans was established in 1916 when Gus Ackerman opened the very first store in Wynberg, Cape Town. Today, with more than 450 stores in southern Africa, including Botswana and Namibia, the business is set to exceed R4billion in turnover.

As one of South Africa’s leading family retailers, Ackermans aims to provide quality clothing at affordable prices, offering the latest trends in men’s clothing and footwear. Ackermans women’s clothing is stylishly designed for comfort, functionality and durability – and of course, with a fashionable flair. Ackermans women’s, girls’ and teens’ clothing offers **excellent value**. They cater for the whole family, from cute, safe quality products for babies and toddlers, to elegant and sporty styles for parents and the latest trends in fashion for teenagers and kids. Top quality brands include Disney, Spiderman, Batman, WWE, Bata Shoes, Waverley Blankets, as well as airtime, cell phones and starter packs from leading companies like Vodacom, MTN, Cell C and Telkom (www.ackermans.co.za).
OBJECTIVES OF THE STUDY
2. Objectives of the Study

The topic of this study is “Quality issues related to apparel merchandising in South Africa”. Quality is the backbone of any clothing manufacturing, exporting and trading company, a quality pipeline process and product being essential for the timely delivery of goods so as to impress the buyer and secure future orders.

The South African garment industry is facing fierce competition within the global market, where price is often the main order qualifier, with transparency in the system (for example: cleaner production), excellent service, good quality and timely delivery being real winners. Local garment manufacturing companies are facing many risks, especially related to quality issues, which create delays in delivering the fashion merchandise to the store on time, on specification and on price. The pre-production process networks are unique for every single enterprise, every single buyer, even sometimes for every single order, the input of one process being the output of another process, so quality monitoring (testing) at each stage of the manufacturing pipeline, notably at the fabric stage, is essential for manufacturing companies prior to sending fabrics for bulk production.

In apparel merchandising, price, quality and fashion represent key elements and which need to be optimised if a company is to survive in this highly competitive global market environment. The objectives of this study are therefore to investigate and develop an understanding of the quality related issues and gaps relevant to apparel merchandising within the South African context, with a specific focus on Fabric Objective Measurement (FOM), a relatively new technology and one which could fruitfully be applied in South Africa, but which appears to have been largely neglected to date here in South Africa. FOM represents a new generation of instrumentally measured parameters which provide a more complete picture of fabric quality, tailorability and clothing performance. In this respect, FOM technology provides a ‘fingerprint’ of the fabric, implying that any two non-identical fabrics will differ, at least to some extent, in their objectively measureable characteristics.
The problem to be addressed revolves around the quality testing and control measures applied by local apparel manufacturers and retailers, what the common practice are and what constraints and gaps exist in this regard and in terms of their quest to be more globally competitive. A specific focus in this regard is the application and potential value of the relatively new technology of fabric objective measurement.

To achieve the objectives of this study, quality related questionnaire surveys and interviews will be undertaken at key selected clothing manufacturers and retailing companies. The worldwide distribution and application of FOM will also be determined, with a view to its application in South Africa. The data and information so captured will be presented graphically, statistically analysed and interpreted, to arrive at the appropriate conclusions and recommendations.
LITERATURE REVIEW
3. Literature Review

One of the most important consumer needs regarding clothing or clothing is that of well-fitting garments. Sieben and Chen-Yu (1992) states that consumers often use garment fit and feel as a means of evaluating the quality of the garment. Brown and Rice (1998) agree with this view and state that fit affects the comfort, as well as the wear life of a garment. When a garment is ill-fitting, the consumer is dissatisfied, irrespective of the quality of the material or the workmanship, or the fashionability of the garment (Winks, 1997). Ill-fitting garments will probably also have negative consequences for clothing retailers and manufacturers because the only true competitive advantage that the clothing industry has is keeping their present customers satisfied, since it is much more cost-effective for the retailer and manufacturer to retain loyal customers than to seek new customers all the time (Brown and Rice, 1998). In order to succeed in the above, the manufacturers follow proper merchandising processes along with quality considerations, which can help them to retain their present customers and also attract new ones.

3.1 Merchandising

The term merchandising means simply to buy and sell commodities for a profit. The role of merchandising varies depending upon whether it is performed within the retail or manufacturing context. Merchandising involves conceptualization, development, procurement of raw materials, sourcing of production and delivery of products to buyers. The merchandiser must combine logical and analytical thinking with initiative and expressive creativity, and merchandisers represent a critical component in the success of any garment retail business. They play an important role in ensuring the right products are produced at the right time, cost and quality, enabling a company to match the latest market trends and to meet market demands within the merchandising concept. Time management implies managing time properly, so that effort and attention can be focussed on value adding actions. In garment merchandising, there are, however, no specific rules, so it's important to be able to think on one's feet.

Today's garment merchandisers have to keep pace with frequent changes in demand and the developing technologies utilized in manufacturing and production. To keep in touch with
customer requirements, they regularly visit retail outlets, and come up with the latest updates from frontline staff. In order to keep an eye on developments in sourcing, site visits are made to factories to meet suppliers and study production.

The Main Functions and Responsibilities of Merchandisers are as follows:

- Understanding Sample Order

Merchandisers have to understand the buyer's requirements after receiving the specifications with the sample order. In many cases, modifications of the specifications are necessary in order to dispatch products on time and at the right quality and price. The merchandiser needs to talk to the in-house experts on the execution problems associated with sample orders, as the correct information is required in decision making (www.fibre2fashion.com).

- Managing order route card and production timetable

Merchandisers have to manage every single production schedule and order route card that helps to follow-up the execution in the planned way, involving various aspects, such as design, number of modules and operators, how many processes, date of dispatch, quantity, output capacity, and deadlines in the schedules. Sub-ordinates are normally assigned to follow-up with the execution of the plan. Merchandisers plan the various activities according to what is essential and what is non-essential, priority being given to the most essential tasks. It is customary that the essential activities are handled by the merchandisers personally, possibly with the support of junior merchandisers/sub-ordinates (www.fibre2fashion.com).

- Using route cards to reschedule activities

To get updated on the current status of an order, route cards should be utilized and the latest status can be fed into a computer. Where the buyer asks for the goods prior to the agreed upon deadline, the merchandiser has to appropriately reorganize the schedules in terms of tasks, output
capacity, number of pieces to be produced daily, substitute arrangements, time availability, supply time, scheduling critical ratio, etc (www.fibre2fashion.com).

- Submitting pre-production samples

The pre-production samples should be provided on time to the relevant buyers and the quality of the samples must be verified. If required, revised samples should be made available to the buyers. The merchandiser should adjust according to the required changes demanded by the buyer. The execution of bulk orders should only take place after samples have been approved by the buyer. In-process inspection occurs between any tasks during the order-execution. In cases of non-conformation, it is better to focus on those concerns relating to quality. Merchandisers that work on completed orders have to check on any deviations so that any amendments can be done timeously to avoid non-conformities (www.fibre2fashion.com).

- Solving shortage problems

The merchandiser should know timeously about a potential shortage of any commodity, such as fabric, yarn, etc. Action should be taken immediately to arrange for the required materials to be sourced and obtained. It is expected that the merchandisers should verify the quality of such goods prior to the execution of the order. If the required material is not available, the superior should be informed about the problem (www.fibre2fashion.com).

- Communicating with relevant persons and buyers

It is essential to communicate on an ongoing basis with the buyers regarding the order, with sufficient time allowed for the buyer to read sent messages. Merchandisers should read the messages received from the buyers and reply as soon as possible. In many cases, merchandisers have to provide order status reports to the buyers. The merchandiser also has to communicate with the people that are in-house, vendors, contractors and production staff. Only through proper communication can the deadline for the orders be met (www.fibre2fashion.com).

The merchandising workflow and processflow are illustrated in Figures 5 and 6, respectively.
MERCHANDISING WORKFLOW

Make contact with buyer

↓

Obtain order

↓

Do costing for that particular style

↓

Negotiation with buyer

↓

Order fabric and trims

↓

Receiving bulk fabrics and trims

↓

Send samples to production

↓

Supervising the order till shipment

Source: www.gogoindia.com

Figure 5: Merchandising Workflow
Figure 6: Merchandising Process flow

Figures 6 and 7 are explained in detail under the heading 3.1.1.
3.1.1 Merchandising Process

The merchandiser is the person who interacts with the buyer and whose main job is to get the work done as per the requirements of the buyer and to deliver the finished goods to the buyer’s destination on time (See Figures 5 and 6). The merchandiser interacts and co-ordinates various activities which are discussed in detail.

Order Enquiry:

This is the first stage where the buyer will make enquiries with the merchandiser about a new order.

Forwarding Tech Pack:

When the order enquiry has been addressed then the buyer will send a “tech pack” or specification sheet to the merchandiser. Tech packs include all relevant details of a style, including the following:

- Product style design
- Measurements
- Fabric
- Style code
- Surface ornamentation details (if any) etc.

Product Development:

Once the tech pack is received, the merchandiser will arrange the tech pack details in a format by dividing the various styles and their details. After this the merchandiser will advise a junior merchandiser about the style and its details so that the junior can assist the sample co-ordinators and get the development samples ready from the sampling department.
Approval of Development Samples:

Once the development samples are ready, 2-3 samples are sent to the buyer for approval. From development sample, the main objective is to understand what the garment style looks like with its specific details. Here samples are made with the available fabric in store which closely resembles the specified requirements. For the development sample, surface ornamentations and fit are as per tech pack. If some correction is to be done the buyer will provide the details, and further samples are made until such time that they are approved.

Costing:

Once the development sample is made and approval is received from the buyer, the costing is done, by calculating various costs incurred in making the particular garment style, such as:

- Fabric cost
- Trims and accessories cost
- CMT
- Washing or finishing cost
- Bank charges
- Buffer value
- Miscellaneous costs, e.g.: rejection costs, wastage, etc.

Order Placement:

Once costing is done and is accepted by the buyer, then the buyer will place the order with the merchant, specifying the required quantity and other main details.

Ordering of Fabric and Trims:

Once the order is placed by the buyer, the merchandiser will place the order for the required fabric as per colour, weight, weave, etc which is required for the style. The merchandiser will forward the requirement sheet to the purchase department which will place the necessary orders with the suppliers.
**Fit Sample:**

After approval of the development sample from the buyer, a fit sample is made. This sample is usually made in a medium size so as to check the fit. All measurements are checked for correctness as per the specifications. The buyer returns the fit approval sheet which contains all the actual measurements and required measurements and how much deviation has occurred for the purpose of correction, if any. This sample is made from the original, or if that is not available, then from a proxy fabric. Three pieces are generally made, all of which are sent to the buyer and returned to the merchandiser again, after approval. Once it is approved, the order is confirmed.

**Pre-production Samples:**

Once the fit samples are approved, the pre-production samples or the “red seal” samples are made. The pre-production (PP) sample will have all the specific details of the style, with the exact fabric, colour, trims, surface ornamentations, etc. This represents a major step, where the sample has to exactly match as per the buyer’s requirement. Around 2-3 samples (in 4 sizes each) are sent to the buyer for approval and the buyer can advise on any corrections which may be required.

**Size Set Samples:**

From this stage onwards, samples are made in respective units. Size set samples are made for the purpose of checking the different sizes of the same style in terms of fit, measurements, styling, etc. It is also made to check whether the assigned unit is able to produce that style as per the specifications. Three sets are generally made for all the sizes, using the original fabric.
Pre-production Meeting (PPM):

Once all the samples are approved and all raw materials are ready in the store, the bulk production has to start. Before that, merchandisers will conduct a pre-production meeting with the production manager and other departmental heads to plan the process, so that delays can be avoided. Here the merchandisers will discuss with the production heads how the production can
be scheduled and executed within the required time frame. Hence this meeting is important and inevitable.

**Forwarding of Production Files to Production Planning and Control (PPC)**

The production file is a document which includes all the details of a particular style. This document is prepared by the merchandisers. The production file, together with the approved PP sample, is forwarded to the PPC, once the PP sample is approved. Some of the details contained in the production file are as follows:

- Measurements
- Export order sheet
- Colour details
- Style description
- Packing type
- Print/embroidery instructions
- Material requirement sheet (category, item, position, colour, size, consumption, unit in kg, quantity, total quantity)
- Job details for fabric order
- Marker plan
- T&A (Time and Action) order sheet
- Trims
- Packaging information

**Checking the Availability of Fabrics and Trims:**

Once the file is received by the PPC, they will check and study each and every aspect of the file and in parallel they will check the availability status of the fabric and trims in the store and will follow up the same if not yet in stock.
Checking the Surface Ornamentation of the Particular Style:

Surface ornamentation may include embroidery, printing or appliqué and these are done as per the buyer’s requirements, hence the PPC will check the ornamentation details and plan according to that, and in parallel arrange for all the required items.

Checking the Status of Stitching Materials In-house

Stitching materials are those which are used for sewing, such as threads and accessories, and which assist production, therefore, in parallel arrangements will be made for the stitching materials in-house.

Checking the Patterns with the Pattern Master:

The production file includes all the details concerning the patterns and the merchandiser will forward the original patterns, along with the production file, to the PPC. Once they receive the patterns they will forward them to the pattern master who will cross check the pattern against the actual and confirm.

Grading and Final Cross Check:

Once everything is checked and confirmed by the pattern master, the pattern is forwarded to the CAD department for Grading. Grading is a process of making different sizes from a basic size. When the file is forwarded to the PPC, only one centre pattern is provided and grading is done for the other sizes. Finally, the graded pattern will be cross checked and confirmed with the pattern master.

Laying and Cutting:

Laying is a process in which a large length of fabric is laid flat in several plies as per the marker plan’s length. Laying is done carefully, avoiding any wrinkles. Once laying is done, the patterns are laid on it as per the marker plan and the main concern is to minimize waste. The patterns are marked and the plies are cut. Once the plies are cut, they are separated and tied as bundles.
Printing/appliqué/embroidery:

The cut bundles will be sent for printing/appliqué/embroidery according to style demands. Surface ornamentation is done on cut pieces rather than on the full garment, since this reduces the risk of spoiling the whole garment if some defects occurred during printing etc. If a defect occurs in a cut piece, the piece can be replaced, resulting in less fabric wastage.

Loading in line:

When surface ornamentation is done on the cut pieces, the whole bundle moves to the sewing lines as per plan. Here bundles are loaded for each worker as per his/her work schedule and the sewing process moves from one end to the other end where the whole garment is stitched. One worker generally does the same job. For example, if a worker’s job is to stitch a collar with collar bone then he/she always does the same when he/she receives the material as it moves from his/her co-worker after he/she completes his/her part. In this way, sewing takes place in a chain format.

Garment Wash:

After sewing, the garment goes for washing as per the specifications given by the buyer.

Finishing:

Once the whole garment is stitched and washed and collected at the end of the process, it will be forwarded to the finishing section, where workers will do the finishing of the garment, including:

- Checking, here the whole garment is checked
- Trimming, trimming is the process in which all the protruding threads are cut, giving a good appearance to the garment
- Ironing, in this process, a steam iron is applied to the garment to remove wrinkles
- Packing, This is the process in which the garment is folded and packed in polythene covers.
Dispatch:

Dispatch is the end process in which the garments are packed in cartons and shipped. There are many procedures and documents which have to be checked and processed when the goods are moved out of the factory.

3.1.2 Some Important Documents which the Merchandiser is required to draft are:

- **Production Order: (PO)**

  There is a PO for every single style for every buyer. The PO is a form that communicates all the details required by the production planning department in order to generate a loading plan. The merchandising department issues a PO for every fabric that is to be processed. It contains:

  - style number
  - style description
  - order quantity
  - sizes
  - quantity for each size
  - fabric consumption
  - interlining details
  - trims description
  - packing instructions
  - label specifications etc.

- **Bill of Materials: (BOM)**

  From the production order, the quantity of fabric and trims is calculated for a single unit, and this is multiplied according to the number of garments being produced in a certain style. These quantities are issued as a BOM for various trims, such as buttons, threads, collarbones and cuff links. BOMs are also produced for packing materials and wash care labels. These are issued to the trims store. Accordingly, the store issues the required number of trims. Each BOM is
identified by its issue number and date. A copy of the above details is maintained by the accounts department for the purpose of costing.

- **Tech Pack:**

  This is the file which is considered the most important during the execution of an order. It contains all the relevant technical information regarding the style, fabric, process, tolerances, interlining details and the settings of the various machines used in processing the style. There is information regarding all departments i.e. for cutting, documents like marker planning, consumption etc.; for sewing, construction details, measurements, etc. even comments from buyers during the sourcing and sampling stage are recorded to clarify and avoid any doubts and mistakes. This tech pack, along with the PO file, is transferred to all the sections as the style is passed on from section to section.

- **Order Status Report:**

  This is a report in which all the styles and the various associated activities are updated in an Excel sheet. This is maintained by the senior merchandisers so that he/she can easily track the current status of a particular style. The status information is given by the merchandisers and is updated once a week.
3.2 Quality

Merchandising and quality complement each other very well (Chapman, 2003; Kumar, 2009; Speer, 2003). For consumers, the aesthetic value, cover, comfort, strength and durability, appearance and handle are all perceived as aspects of quality and part of their “value for money” assessment. There are many excellent scientific and technical books dealing with apparel fabric quality in general and which can be consulted for a more detailed and in-depth treatment of the subject (Behery, 2005; Das, 2009; Fan & Hunter, 2009; Fan et al, 2004; Purushothama, 2010;)

Quality means different things to different people, for example:-

- The best money can buy
- Meeting a specification or conformance to specifications
- Craftsmanship
- The degree of excellence that an item possesses

“Quality is the ability to exceed a customer’s expectations while maintaining a cost competitive market position” (Linking quality to business results, 1994)

Quality can be product based, user based, manufacturing based or value based (Garvin, 1988).

A product based definition of quality, views quality as a precise and measureable variable.

A user based definition of quality means that quality is whatever the customer says or wants – which goes back to meeting or exceeding customers’ requirements and expectations.

A manufacturing based definition of quality means meeting specifications, conformance to requirements, etc (Crosby, 1972). Any deviation from meeting requirements means poor quality.

A value based definition of quality takes into consideration the cost or price of a product or service. Quality is defined by ISO as “the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs” (ANSI/ASQC, 1994).
Studies by Fiore and Damhorst (1992) indicate that quality is a multidimensional construct that cannot be equated with, or measured by, a single cue or attribute.

Garvin (1988) proposed that there are eight dimensions of quality. They are: Performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality.

- Performance is based on the primary operating characteristics of a product.
- Features of a product are those secondary characteristics that supplement a product’s basic functioning.
- Reliability refers to the probability of a product malfunctioning or failing within a specified period of time.
- Conformance refers to the degree or extent to which a product’s design and operating characteristics meet pre-established standards.
- Durability means length of time a product will last, or product life.
- Serviceability refers to the speed, competence and ease of repair of a product.
- Aesthetics refers to how a product looks, feels, sounds, tastes or smells.
- Perceived quality refers to what customers perceive to be the quality of a product, based on image, advertising and brand image reputation.

By influencing or varying any one or more of these eight dimensions of quality, a company can position itself in the market place, so quality is then a strategic variable.

The following are some of the common quality related defects seen in a garment manufacturing unit:

- Broken buttons
- Broken snaps
- Broken stitching
- Defective snaps
- Different shades within the same garment
- Dropped stitches
- Exposed notches
- Exposed raw edges
- Fabric defects
- Holes
- Inoperative zipper
- Loose/hanging sewing threads
- Misaligned button/button holes
- Missing buttons
- Needle cuts/chews
- Open seams
- Pulled/loose yarn
- Stains
- Unfinished button holes
- Zipper too short

(Mehta and Bhardwaj, 1998)

Timeous fabric testing prevents poor quality garments from being marketed that might otherwise have resulted in damage to the brand image of the companies involved. Thus, if fabric testing is done beforehand, and in good time, it might act as a turning point in terms of the fate of the garment. Testing is a very important aspect of quality management. Whether testing is done in-house or by an outside laboratory is immaterial, as long as it is done properly and timeously. Testing in itself will not be of any help, but the interpretation of the numbers generated (test results) will help identify problem areas, if any.

Although it is up to the buyer and seller to mutually arrive at performance specifications for various properties of an end item (garment) under consideration, some retail store chains and government agencies have their own standards for various clothing items, and also, the test methods to be used are indicated by them. In such cases, it would be easy for a garment manufacturer to interpret test results and come to a conclusion regarding the quality of the product. Whenever such clear-cut guidelines are not available, the interpretation of test results could be based on comparative data or past experience and sometimes it is a matter of intuitive judgement. In spite of all the standard test methods and available test data, the interpretation of
test results is not exactly a science, and sometimes a quality decision, though backed by numbers, remains a gut decision.

There are certain basic, fabric and garment tests/inspections that need to be done before a particular fabric is sent for garment manufacturing. It eases the whole manufacturing process as well as reaching the desired specifications i.e. conformance to requirements.

### 3.2.1 Fabric Strength

Fabric strength can be divided into three areas: Resistance to tensile force (breaking strength), resistance to bursting force (bursting strength) and resistance to tearing/shearing force (tear strength). Whether the strength of a fabric is measured in all these three areas depends on the type of fabric and its end use.

The breaking strength of a fabric normally refers to its resistance to a tensile force, this being commonly measured for woven fabrics (Denton and Daniels, 2002). The breaking strength of a fabric can be tested in length and/or width directions. The force and elongation at the point of rupture are recorded, and are termed strength and elongation at break.

The tear strength of a fabric refers to its resistance to a tearing or shearing force (Denton and Daniels, 2002). This is of importance in clothing fabrics, such as those used for shirtings, blouses, interlining etc. Tear tests are not suitable for knit fabrics, felts or non-woven fabrics. Bursting strength tests are commonly used for knitted fabrics, lightweight woven fabrics and non-woven fabrics. Bursting strength is the force, uniformly distributed over a given area, needed to rupture a fabric when applied at right angles to the fabric (Mehta and Bhardwaj, 1998).

### 3.2.2 Seam Strength

Seam failure in a garment can occur because of either the failure of the sewing thread, leaving the fabric intact, or the fabric rupturing, leaving the seam intact, or both occurring at the same time. Seam strength is tested in almost the same manner as fabric breaking and bursting strength. The strength of a seam or stitching should equal that of the material it joins in order to have a
balanced construction that will withstand the forces encountered in the use of the garment of which the seam is a part.

The elements affecting the strength of a seam or stitching type include:

- Stitch type
- Thread strength
- Stitch density (for example, stitches/cm or /inch)
- Thread tension
- Seam type

The stronger the sewing thread, the stronger the seam. The elasticity of a seam or stitching depends on the stitch type and thread elasticity (Mehta and Bhardwaj, 1998).

3.2.3 Yarn Slippage in Fabrics

In some garments, before seam failure occurs, enough yarn slippage develops to render the garment unusable, because such failure is not readily repairable by seaming. Therefore, measuring resistance to slippage of yarns in woven fabrics is of importance in quality control. According to Lyle (1977), seam slippage may occur in a garment or household item because of:

- Too shallow seam allowances (any strain on the fabric at the seams causes the yarns to shift)
- Too tight a fit (undue strain during wear may cause yarns to shift at the seam line) and
- Improper seam construction eg: Too low a stitch density

3.2.4 Fabric Stretch

Power or action stretch, as the name implies, provides a fabric with a high degree of extensibility and quick recovery. The stretch factor for such fabrics generally ranges from at least 30% to 50% or more, with no more than 5 - 6% loss in recovery. Such stretch fabrics are best for skiwear, swimwear, athletic clothing and professional sportswear. Comfort stretch applies to fabrics with
less than 30% stretch factor and no more than 2 - 5% loss in recovery. Such fabrics are used for everyday clothing that needs only a moderate degree of elasticity (Mehta and Bhardwaj, 1998).

### 3.2.5 Durable Press

Durable press is a term used to describe a fabric or garment that will retain its original shape, smoothness and sharpness of crease through wear and repeated laundering and not require ironing (Denton and Daniels, 2002). This means it will resist wrinkles and retain its creases and pleats for, it is hoped, the lifetime of the garment. It also means that seams will be free from puckering and remain flat, and the fabric will retain a smooth surface appearance (Mehta, 1998).

### 3.2.6 Sewability of Fabrics

Sewability is that characteristic of a fabric that allows it to be seamed at the full limit of high-speed sewing machinery, without the fabric suffering degradation (Denton and Daniels, 2002). The strength of many woven fabrics can be considerably reduced by the seaming operation. The result of such reduction is the shortening of the overall life of the garment. Needle cutting or yarn severance can occur due to the stiffness of the fabric and yarns and a lack of mobility of the yarns. Instead of moving and/or deforming when the needle penetrates the fabric structure, the yarns remain taut and are ruptured or burned (heat damaged). Some damage may also result from excessive heat generated due to the friction of the sewing needle and the fabric. Also, using wrong size and types of needles will result in sewing damage (Mehta and Bhardwaj, 1998).

### 3.2.7 Moisture Absorbency

Moisture absorbency refers to the ability of a material to take in or absorb moisture (Denton and Daniels, 2002). For example, the absorbency of a cotton towel is related to the amount of water the cotton fibres absorb, as well as that trapped within the fabric. Moisture absorption in general includes the ability of a material to retain a liquid, such as water, in its interstices, pores and within the fibres. It is one measure of a material’s performance in terms of comfort (Kadolph, 2011).
3.2.8 Bow and Skewness (Bias) in Woven and Knitted Fabrics

Filling yarns in woven fabrics and courses in knitted fabrics usually appear as straight lines perpendicular to the selvedge of the fabrics. When there is a deviation from this perpendicularity, the fabric is said to have a bias or bowed condition. Skewness is a fabric condition resulting when filling yarns or knitted courses are angularly displaced from a line perpendicular to the edge or side of the fabric, in the case of knitted fabrics it is popularly termed spirality.

Bow or skewness can be induced during fabric manufacturing, dyeing, tentering, finishing, or other operations where a potential exists for the uneven distribution of tensions across the fabric width. Bow and skewness are more visually displeasing in coloured patterned fabrics than in solid colours because the colour contrasts make the distortion more prominent. Bow or skewness in a fabric will sometimes cause a garment to twist in laundering, such as a twisted leg on a pair of jeans or a twisted sleeve on a long sleeve knit-shirt.

3.2.9 Fabric Thickness

Fabric thickness is not measured as a routine quality control procedure; however, various properties, such as warmth and bulk, are dependent on fabric thickness. Thicker fabrics generally entrap more air within the fabric structure, creating a thicker shield between the skin and the environment, thereby providing more warmth. According to Lyle (1977), the garment manufacturer relies mostly on a fabric thickness measurement in calculating the number of fabric lays in cutting garments and determining settings to use for stitching on sewing machines.

3.2.10 Pilling

According to the Textile Terms and Definitions of The Textile Institute (1991) pilling is defined as ‘the entangling of fibres during washing, dry cleaning, testing or in wear to form balls or pills which stand proud of the surface of a fabric and which are of such density that light will not pass through them’. These are formed during wear and washing by the entanglement of fibres that are loose or protrude from the fabric surface. Under the influence of a rubbing action, these loose or surface fibres develop into small spherical bundles anchored to the fabric by a few unbroken fibres. Such pills are usually evident on the areas of garments where some abrasion takes place.
during normal wear. Most staple fibres have a tendency to pill. The pilling of garments is a very complex property because it is affected by various factors, such as fibre length and fineness, fibre mechanical properties (e.g. bending and flexibility), yarn twist level, fabric construction, fabric finishing treatments and the nature and activity of the person wearing the garment (Mehta and Bhardwaj, 1998).

3.2.11 Snagging

Snagging is defined as a defect caused by the pulling or plucking of yarns from a fabric surface (Denton and Daniels, 2002). The snagging of a specific fabric in actual wear varies with the individual wearer and general condition of use, it being mostly confined to fabrics containing continuous filament yarn (Mehta, 1998).

3.2.12 Colourfastness

Colourfastness is the property of a dye or print that enables it to retain its depth of shade throughout the wear life of a product (Denton and Daniels, 2002). Dyes are generally considered fast when they resist the deteriorating influence (such as laundering, dry-cleaning and sunlight) to which they will be subjected during the use for which the fabric is intended. Garments are often in contact with other items while being worn or cleaned. The migration of colour from one item to another (such as from coat lining to shirt, from pants to upholstery, from night clothes to sheets, etc) can result in an article becoming unwearable/unusable.

3.2.13 Stiffness

Stiffness affects fabric handle, drape, resistance to roll, such as in waistbands, resistance to wrinkling, and other aspects related to comfort and aesthetics. Fabric stiffness is a measure of a fabric’s resistance to bending or flexing (Denton and Daniels, 2002). More force or energy is required to bend a material that is described as being stiff compared to that required to bend a material that is described as being pliable (Kadolph, 2011).
3.2.14 Drape

According to the Textile Terms and Definitions of The Textile Institute (1991/95) drape is defined as ‘the ability of a fabric to hang limply in graceful folds’. Cusick (1965) defined the drape of a fabric as ‘a deformation of the fabric produced by gravity when only part of the fabric is directly supported’. Drape appearance depends not only on the way the fabric hangs in folds, etc., but also upon the visual effects of light, shade and fabric lustre at the rounded folds of the fabric as well as on the visual effects of folding on colour, design and surface decoration. In practice, drape is usually assessed visually, or subjectively, and its actual assessment greatly depends often upon changing factors, such as fashion, personal preference, human perception, etc. (Fan and Hunter, 2009).

3.2.15 Wrinkling

Wrinkling is best defined by Denby (1982), as “the unwanted residual bending deformation, largely random in nature, which occurs during wear and which does not disappear spontaneously, resulting in wrinkles or creases which can make the fabric appear unsightly”. All textile clothing fabrics bend and fold with remarkable ease during wear and laundering, often to relatively high curvatures. Wrinkles are normally confined to small areas and specific locations in the garment, like trouser and skirt seat areas, sleeves of coats, laps of trousers, back of shoulders etc. (Fan and Hunter, 2009).
3.3 Fabric handle, Tailorability and Objective Measurement

3.3.1 Introduction

Handle and making-up performance (tailorability) are interrelated and represent key quality parameters for clothing manufacturers and consumers, handle (or hand) being defined by the Textile Terms and Definitions of The Textile Institute (1991) as the ‘subjective assessment of a textile material obtained from the sense of touch’. Clothing manufacturers require that the fabric is easy to tailor, passes through the making-up (garment manufacturing) process easily and without undue problems and that the finished garment is ready to wear.

For consumers, the aesthetic value, cover, comfort, strength and durability, appearance and handle are perceived as quality and part of their value for money assessment. On the other hand, experts traditionally, largely assessed the quality of a fabric on the basis of its handle. Nevertheless, their assessment, though expert, was subjective, and not infrequently lead to complications during manufacturing and the wear of the garment. Hence an objective (instrument) measurement system was developed to overcome weaknesses in the subjective assessment, and such systems are referred to as Fabric Objective Measurement (FOM) systems.

As a result of these systems, the quality and manufacturing performance of fabrics improved significantly, much to the relief of the garment manufacturers and merchandisers alike.

The fabric is the basic raw material for the clothing industry. Fabric characteristics can also be considered from the point of view of the consumer, fabric manufacturer and clothing manufacturer. In developing objective evaluation methods, the subjective evaluation of fabric tailorability is essential so as to obtain the fabric properties which are relevant to the finished-garment quality and necessary for control in the garment manufacture process and which therefore need to be objectively measured.

The concept of fabric objective measurement can be defined as a necessary and sufficient set of instrumentally measurable parameters which are required to specify the fabric quality, tailorability and clothing performance. In this way, fabric objective measurement technology provides a ‘fingerprint’ of the fabric quality, tailorability and performance, implying that any two
fabrics will generally differ, at least to some extent, in their objectively measureable characteristics (Fan and Hunter, 2009).

Fabric objective measurement technology provides the key for:

- Optimization of fabric properties and engineering new fabrics of desirable quality and performance attributes for particular end use
- Development of new finishes, finishing agents and finishing machinery for textile materials
- Control of fabric finishing/refinishing to meet fabric mechanical, surface and dimensional property goals
- Fabric specification and process control for clothing manufacture
- Total fabric development, from raw material to tailored garments.

Measurement of all the properties that determine important aesthetic characteristics of fabrics is not feasible for industrial users. However, fabric or garment makers require a system that measures only the necessary properties to achieve satisfactory quality control (Postle, 1989).

Two developments have raised the status of FOM from a research tool to one suitable for use in industry:

1. The availability of a set of instruments that is relatively inexpensive and simple to use (Ly et al, 1998).
2. The co-ordination of background information needed to interpret the large amount of data produced by the instruments and use it to predict fabric performance.

(CSIRO, Australia)

The most important development in this area was when Kawabata and Niwa developed and commercialised the Kawabata Evaluation System with appropriate and vast inputs from experts from the Japanese clothing industry. This pioneering work laid a solid foundation for the accurate and routine measurement of those fabric properties that determine fabric handle and garment making up and appearance. This system was, however, fairly complicated and expensive and not entirely suitable for routine application in industry, which lead to the
development, by the CSIRO in Australia, of a simplified and less expensive system, namely the FAST (Fabric Assurance by Simple Testing), this system now being referred to as SiroFAST. According to Ly et al (1998), FAST was designed to meet the industrial need for a simple and robust system to predict fabric performance.

According to Fan and Hunter (2009), Kawabata and FAST systems measure similar low-stress fabric mechanical properties (compression, bending, extension and shear), although they differ somewhat in the measurement principles that they use, there being a good correlation between similar parameters measured on the two systems and also on other systems. The Kawabata system was essentially aimed at predicting the feel, handle and appearance of fabrics, whereas the FAST system was essentially aimed at predicting fabric tailorability. Sule and Bardhan (2000) have summarised the differences between the two systems, stating that the Kawabata system does not include the measurement of relaxation shrinkage and hygral expansion, which are important for tailorability, while the FAST system does not measure the linearity of tensile properties as well as tensile, bending and shear hysteresis, to which the Kawabata system attaches considerable importance. Initially Kawabata was restricted to research application only, but later it became available for industrial preventive quality control and performance prediction.

3.3.2 Kawabata Evaluation System (KES)

The Kawabata system is based on the general agreement that the stimuli leading to the psychological response to a fabric are entirely determined by the physical and mechanical properties of the fabric. In this regard, these properties are considered only at low loads and extensions and not at the level of load and extension at which fabric failure occurs (Kawabata, 1982). The mechanical properties (Table - 5) important in the assessment of hand were also important in the manufacture of high quality garments (Kato Tech Co. Ltd).
KES – FB instruments are:

- KES – FB1  Tensile and Shearing Tester
- KES – FB2  Bending Rigidity Tester
- KES – FB3  Compression Tester
- KES – FB4  Frictional Property Tester

Table – 5: The Parameters Describing Fabric Mechanical and Surface Properties

<table>
<thead>
<tr>
<th>Tensile</th>
<th>KES – FB1</th>
<th>LT</th>
<th>Linearity of load/extension curve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>WT</td>
<td>Tensile energy in N/m (gf.cm/cm²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RT</td>
<td>Tensile resilience (%)</td>
</tr>
<tr>
<td>Shear</td>
<td>KES – FB1</td>
<td>G</td>
<td>Shear rigidity in N.m/degree (gf.cm/degree)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2HG</td>
<td>Hysteresis of shear force at 0.5° shear angle (gf/cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2HG5</td>
<td>Hysteresis of shear force at 5° shear angle (gf/cm)</td>
</tr>
<tr>
<td>Bending</td>
<td>KES – FB2</td>
<td>B</td>
<td>Bending rigidity in 10⁻¹ N.m (gf.cm²/cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2HB</td>
<td>Hysteresis of bending moment in 10⁻² N (gf.cm/cm)</td>
</tr>
<tr>
<td>Lateral compression</td>
<td>KES – FB3</td>
<td>LC</td>
<td>Linearity of compression/thickness curve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WC</td>
<td>Compressional energy in N.m (gf.cm/cm²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RC</td>
<td>Compressional resilience (%)</td>
</tr>
</tbody>
</table>

Page | 66
<table>
<thead>
<tr>
<th>Surface characteristics</th>
<th>KES – FB4</th>
<th>MIU</th>
<th>Coefficient of friction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MMD</td>
<td>Mean deviation of MIU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMD</td>
<td>Geometrical roughness (µm)</td>
</tr>
<tr>
<td>Fabric construction</td>
<td></td>
<td>W</td>
<td>Fabric weight per unit area (mg/cm²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T</td>
<td>Fabric thickness (mm)</td>
</tr>
</tbody>
</table>

Source: Postle, 1983 and Harlock, 1989
This automated tester is designed for the purpose of measuring the tensile and shearing property of fabrics, paper, nonwovens, and film-like materials. Tensile energy and tensile strain, resilience, the stiffness and hysteresis in shear property can be measured by this tester.

This automated tester is designed for the purpose of measuring the bending property under pure bending condition for fabrics, paper, nonwovens, yarns, hairs, or film-like materials. This property is valuable for determining bending stiffness and hysteresis of specimens.

This automated tester is designed for the purpose of measuring the compressional property for fabrics, paper, nonwovens, and film-like materials. Compressional energy, compressibility, resilience and thickness of specimen can be obtained by this tester.

This automated tester is designed for the purpose of measuring the surface property for fabrics, paper, nonwovens, and film-like materials. Frictional properties, and geometrical surface roughness can be measured by this tester.

Source: www.keskato.co.jp

Figure 8: KES FB - Auto – A System
These above instruments can test fabrics automatically and provide continuous stress-strain curves. An automatic version of the Kawabata system, called KES – FB AUTO (Figure 8), is also available (Fan and Hunter, 2009).

The three Primary Handle Values (PHV) arrived at were Koshi (stiffness), Numeri (smoothness) and Fukurami (fullness) and further handle values, Shari (crispness) and Hari (‘anti – drape stiffness’), were added for men’s summer suitings and women’s fabrics. Each of the Primary Handle Values rank from 1 to 10 (Table 6) (Fan and Hunter, 2009).

An outcome of the above development is that fabric handle can be objectively graded in terms of the ‘Total Handle Value’ (THV) and garment (suit) appearance in terms of the ‘Total Appearance Value’ (TAV) (Kawabata, 2000), both on a scale 1 to 5. THV is a combined measure of smoothness, softness and stiffness (Fan and Hunter, 2009).

The test results from the Kawabata system, although primarily aimed at defining handle, can show which fabrics will go through a clothing factory easily and efficiently, which ones will need special care (with indicated adjustment of machine settings) and which will cause serious problems (Fan and Hunter, 2009).

As already mentioned, Kawabata and Niwa (1998) stated that an ideal suiting fabric should satisfy the following three conditions:

- Good handle value (high THV)
- Good suit appearance (high TAV)
- Mechanical comfort conditions (shaded zone on control chart)

Values of THV and TAV above 4 (on a scale from 1 to 5) constitute a perfect winter suiting fabric (Anon, 2000). Behera and Mishra (2007) found that, of all the wool and wool blend fabrics tested, wool/linen blend fabrics had the highest winter THV (of 4.34) and wool/tussah silk fabrics had the highest THV for summer suitings. Table 7 gives some typical hand values for fabrics produced in Japan for suitings.
Table – 6: Hand Values. Samples are divided into three groups A, B and C following the intensity of the hand feeling and then the samples of each of those groups are again divided to three groups. The XH and XL are picked out from A-A and C-C respectively. Finally the eleven groups are obtained and labeled by numbers 10, 9, 8 …0. This number is named Hand Value (HV) and the higher value corresponds to strong feeling of the hand.

<table>
<thead>
<tr>
<th>Group</th>
<th>XH</th>
<th>A (Strong)</th>
<th>B (Medium)</th>
<th>C (Weak)</th>
<th>XL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A-A</td>
<td>A-B</td>
<td>A-C</td>
<td>B-A</td>
</tr>
<tr>
<td>HV</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: Kawabata (1980 b)

Table - 7: Mean and Standard Deviation of the Hand Values of the Fabrics Produced in Japan

<table>
<thead>
<tr>
<th>Hand</th>
<th>Mean Value</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KOSHI</td>
<td>4.94</td>
<td>1.46</td>
</tr>
<tr>
<td>NUMERI</td>
<td>5.08</td>
<td>1.83</td>
</tr>
<tr>
<td>FUKURAMI</td>
<td>4.96</td>
<td>1.68</td>
</tr>
<tr>
<td>Summer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KOSHI</td>
<td>4.81</td>
<td>1.43</td>
</tr>
<tr>
<td>HARI</td>
<td>5.39*</td>
<td>1.30*</td>
</tr>
<tr>
<td>SHARI</td>
<td>4.98</td>
<td>1.61</td>
</tr>
<tr>
<td>FUKURAMI</td>
<td>4.92*</td>
<td>1.02*</td>
</tr>
</tbody>
</table>

Source: Kawabata (1980 b)

*The above data were taken from the samples collected for the development of basic mechanical properties – HV translation formula. The values are similar to those of randomly sampled fabrics. The fingerprint chart (Figure 9) shows the properties of a man’s winter suit by plotting its mechanical properties. This examines the hand property of the fabric. The higher value corresponds to a stronger feeling of the hand.
Source: Kawabata (1980 b)

Figure 9: Fingerprint Chart of a Man’s Winter Suit Obtained using KES – FB Instruments
Application of KES – FB Instruments

- The largest application of the KES – F instruments has been in the area of the prediction of the performance of woven fabric in garment manufacture, particularly in men’s and ladies suitings and formal or corporate wear.
- In addition to its application for worsted and other types of suiting fabrics for which it was originally developed, the applications of the KES – FB system have been diverse, including terry towels, warp and weft knitted fabrics, non-wovens, blankets for example interliner materials, towelling, silk clothes, knitted underwear and for washed clothing. The measurement of the residual couple in knit fabrics can be used as a measure of their tendency to curl and the effectiveness of finishing operations.
- Modifications of the original test procedures developed for woven fabrics on the KES – F instruments have been described for the testing of shirtings, women’s thin dress fabric, outerwear knitted fabric for underwear.
- The KES – FB instruments have also been widely used to measure the effect of softening, hand modifying and mechanical finishes.
- The KES System is also widely used in those industries which place importance on hand-feeling aspects, including the tissue paper and diaper industries.

Source: www.keskato.co.jp

3.3.3 SiroFAST

SiroFAST is a set of instruments and test methods for measuring mechanical and dimensional properties of wool fabrics. These measurements allow the prediction of fabric performance in garment manufacture and the appearance of the garment during wear (Ly, 1970). The instruments were developed by the Australian CSIRO Division of Wool Technology. The system was designed to be relatively inexpensive, reliable, accurate, robust and simple to operate. A simple method of interpreting the data to predict fabric performance is an integral part of the system (De Boos and Tester, 1997). FAST instruments are similar in operation to conventional measuring instruments, except that measurement is carried out using sensors, and test results are
displayed digitally. The FAST system measures the mechanical, dimensional and pressing performance related propensities of fabrics and is used to assess the fabric tailorability, appearance and handle properties (Fan and Hunter, 2009).

This measurement system can provide an edge to merchandisers who use it when competing with retailers or manufacturers of different countries and organisations, in terms of quality and the overall performance of a fabric.

Source: www.itec-innovation.com

**Figure 10: SiroFAST - 1, -2 and -3 Instruments**

SiroFAST consists of three instruments and a test method: (De Boos and Tester (1997))

(a) SiroFAST – 1 is a compression meter that measures fabric thickness at loads of 2g/cm² and 100g/cm². The surface layer thickness is defined as the difference in thickness measured at the two loads, and is calculated from these measurements (De Jong, 1986). The measurements are normally made on the (conditioned) fabric and then repeated after the fabric has been relaxed in steam. From these measurements, the released thickness and released surface layer thickness are obtained. Comparison of the original surface thickness and the released surface thickness can be
used to assess the stability of the finish on the fabric under the conditions of garment manufacture, such as pressing and steaming (De Jong and Tester, 1988).

(b) **SiroFAST – 2** is a bending meter that measures the fabric bending length, using the cantilever bending principle. From the values of bending length obtained, the bending rigidity of the fabric is calculated. Bending rigidity is a measure of the stiffness of a fabric and is related to handling in garment making. SiroFAST – 2 uses a photocell to detect the leading edge of the sample, which is done by eye in some other test methods. The elimination of this source of operator error makes the SiroFAST bending meter more reliable and simpler to use than alternative instruments (Allen et al, 1990).

(c) **SiroFAST – 3** is an extension meter that measures fabric extensibility under three different loads (5, 20 and 100g/cm of width). The loads are chosen to simulate the level of deformation the fabric is likely to undergo during garment manufacture. SiroFAST–3 is also used to measure the bias extensibility of the fabric (at 45° to the warp direction) under a low load (5g/cm width). Bias extensibility is not used directly but instead is used to calculate shear rigidity (Kilby, 1963). Shear rigidity is a measure of the ease with which a fabric can be deformed into a three-dimensional shape.

Formability is derived from measurements made using SiroFAST – 3 in combination with data from SiroFAST – 2 (Table - 8).

\[
\text{Formability} = \text{Bending Rigidity} \times (\text{Extension (20 g/cm)} - \text{Extension (5 g/cm)}) / 14.7
\]

(d) **SiroFAST – 4** is a test procedure for measuring the dimensional properties of a fabric, namely hygral expansion and relaxation shrinkage. SiroFAST–4 is a modification of the conventional “wet - dry” test (Shaw, 1978) and as per the SiroFAST Instruction Manual it can be completed in less than two hours. Another advantage of SiroFAST – 4 is that the fabric does not require conditioning. With SiroFAST – 4 the fabric is dried in a convection oven at 105°C and its dry dimensions measured. The fabric is then relaxed by wetting in water and its wet dimensions measured. Lastly, the fabric is dried again at 105°C and its final dry dimensions measured.
Table – 8: List of Fabric Properties Measured using the SiroFAST

<table>
<thead>
<tr>
<th>Properties Measured</th>
<th>SiroFAST Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fabric Weight</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Compression:</strong></td>
<td>SiroFAST -1</td>
</tr>
<tr>
<td>Fabric thickness at 2g/cm²</td>
<td></td>
</tr>
<tr>
<td>Fabric thickness at 100g/cm²</td>
<td></td>
</tr>
<tr>
<td>Released thickness at 2g/cm²</td>
<td></td>
</tr>
<tr>
<td>Released thickness at 100g/cm²</td>
<td></td>
</tr>
<tr>
<td><strong>Bending:</strong></td>
<td>SiroFAST -2</td>
</tr>
<tr>
<td>Bending length</td>
<td></td>
</tr>
<tr>
<td><strong>Tensile:</strong></td>
<td>SiroFAST -3</td>
</tr>
<tr>
<td>Warp Extensibility</td>
<td></td>
</tr>
<tr>
<td>Weft extensibility</td>
<td></td>
</tr>
<tr>
<td>Bias extensibility</td>
<td></td>
</tr>
<tr>
<td><strong>Dimensional stability:</strong></td>
<td>SiroFAST -4</td>
</tr>
<tr>
<td>Relaxation shrinkage</td>
<td></td>
</tr>
<tr>
<td>Hygral expansion</td>
<td></td>
</tr>
</tbody>
</table>

Source: De Boos and Tester, 1997

Table – 9: List of Fabric Properties which can be derived from measurements made using SiroFAST

<table>
<thead>
<tr>
<th>Derived properties</th>
<th>Calculated from</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface thickness</strong></td>
<td>Thickness at 2g/cm² and 100 g/cm²</td>
</tr>
<tr>
<td></td>
<td>Released surface thickness</td>
</tr>
<tr>
<td></td>
<td>Released thicknesses at 2g/cm² and 100 g/cm²</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Finish stability</td>
<td>Fabric surface thickness</td>
</tr>
<tr>
<td></td>
<td>Released surface thickness</td>
</tr>
<tr>
<td>Bending rigidity</td>
<td>Bending length</td>
</tr>
<tr>
<td></td>
<td>Weight</td>
</tr>
<tr>
<td>Shear rigidity</td>
<td>Bias extensibility</td>
</tr>
<tr>
<td>Formability</td>
<td>Bending rigidity</td>
</tr>
<tr>
<td></td>
<td>Extensibility at low loads</td>
</tr>
</tbody>
</table>

Source: De Boos and Tester, 1997

**Sampling for SiroFAST tests**

SiroFAST – 1, -2, -3 test samples are 150mm x 50mm. The tests are performed in the order SiroFAST – 1, -2 and -3, respectively. This avoids deformations that would affect later results. The SiroFAST manual recommends:

- SiroFAST - 1 Compression – 5 replicates
- SiroFAST - 2 Bending – 3 warp and 3 weft replicates
- SiroFAST - 3 Extension – 3 warp, 3 weft and 6 bias replicates (3 left - bias and 3 right - bias)

The samples are then steam released and the SiroFAST – 1 tests repeated. The dimensional stability test (SiroFAST - 4) requires a separate sample (300 x 300mm).

**Interpretation of SiroFAST data**

As quoted by De Boos and Tester (1997), the SiroFAST system uses a control chart (fingerprint) as an aid to interpreting the data. According to the Test Manual of the Australian Wool Textile Objective Measurement Evaluation Committee and Ito and Kawabata (1986) this approach is not new and has been recommended for other objective measurement systems.
The fingerprint is formed by plotting properties of the fabric on appropriate scales and then joining the points. A wide range of information can be obtained from direct observation of the fingerprint’s position in relation to the ‘grey zones’ on the SiroFAST chart.

Figure 11 shows the FAST control chart on which measured fabric properties are plotted as a ‘fingerprint’, for easy diagnosis and corrective action.

Source: Anonymous

**Figure 11: FAST Control Chart for Light-weight Suiting Fabrics**
Niwa et al (1983) and Postle and Mahar (1982) reported that the use of a fabric fingerprint is preferred over alternative techniques for interpreting objective measurement data because the fingerprint makes it easier for the garment maker to categorize different garment-making problems and to identify, and possibly correct (by re-finishing for example), the property or properties associated with poor fabric performance.

Slightly different zones would be used for other applications, such as women’s dress goods or pleated skirts. Software is available for use with the SiroFAST that allows users to adjust limits to meet changing garment designs and skill levels in their factory. The limits shown on the SiroFAST chart are derived from published information, research at CSIRO during the development of SiroFAST, the experience of users of SiroFAST and other forms of FOM.

Shirting fabrics have been found to be more difficult to rate for handle than suiting fabrics (Yick, 1995), with shear rigidity, formability and bending rigidity having the main effect on their handle. Yick et al (1995), have established FAST control charts for shirting material, based on 104 commercial shirting materials ranging in weight from 93 to 258 g/m², high correlations being found between FAST and Kawabata results for fabric formability, bending rigidity and shear rigidity. Although originally developed for men’s and women’s worsted type suiting fabrics, the SiroFAST system has been applied in other fabric fields. The FAST system has also found applications, in fused interlinings. The grey zones on the chart Figure 12, indicates where potential problems can be anticipated in the manufacture of suits or structured jackets using fused interlinings (i.e. fused composites). The ‘grey zones’ on the SiroFAST chart are not intended for use only as ‘accept or reject’ zones. De Boos and Tester (1997) suggested that they should be used as indicators that forewarn the garment maker that problems can be anticipated and these problems should be considered in garment manufacture.
Source: Fan, 1993

Figure 12: Control Chart for Fused Composites Showing Various Zones
**Application of SiroFAST**

The trend towards increased use of lighter-weight fabrics and greater levels of automation by garment manufacturers, among other reasons, means that FOM is becoming a necessary part of garment manufacturing. The conversion of increasingly light-weight fabrics into high quality garments is more difficult because of the inherent properties of such fabrics.

SiroFAST is used at various stages in garment manufacturing (De Boos and Tester, 1997) including:

- Evaluation of sample fabrics – sample lengths can be evaluated for potential tailoring problems.
- Checking bulk deliveries – the properties of bulk deliveries, particularly the first bulk delivery, can either be monitored or checked against specification.
- Problem solving – SiroFAST can be used to locate the cause of fabric related difficulties in garment manufacture and garment appearance. In many cases, garment manufacturers can identify the symptoms of a problem, but for action to be taken it is essential that the cause of the problem (rather than the symptom) is determined.
- SiroFAST is used by garment manufacturers to predict performance in garment manufacture and to compare the properties of the incoming fabric against specifications. Normally, the major emphasis of testing is on identifying fabrics most likely to cause problems. This can only be done using experience gained from measurements of existing fabrics and by testing and categorizing new fabrics (Uemura, 1982) (Nitta, 1982).
- SiroFAST gives the finisher the tool by which the properties of the fabric can be monitored to ensure that they are ‘on track’ to meet the final specifications. As finishers gain experience of these measurements they can considerably reduce the time needed for new fabric development. Finishers have used SiroFAST to:
  - Optimise individual and sequences of processes
  - Ascertain new alternative finishing machinery
  - Evaluate new chemical processes
- FAST fabric measurements have been used to develop models to classify and predict the handle of cotton, linen, wool and silk fabrics (Fan and Hunter, 2009).
Table – 10: Summary of the CSIRO FAST System

<table>
<thead>
<tr>
<th>Instrument and test</th>
<th>Measures</th>
<th>Predict problems in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAST – 1</td>
<td>Thickness</td>
<td>Pressing</td>
</tr>
<tr>
<td></td>
<td>Compression</td>
<td>Finish stability</td>
</tr>
<tr>
<td>FAST – 2</td>
<td>Bending</td>
<td>Cutting, automated handling</td>
</tr>
<tr>
<td>FAST – 3</td>
<td>Extensibility</td>
<td>Laying up, pattern matching,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>overfed seams, moulding</td>
</tr>
<tr>
<td></td>
<td>Shear</td>
<td>Laying up, moulding, sleeve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>insertion</td>
</tr>
<tr>
<td>FAST – 2 and -3</td>
<td>Formability</td>
<td>Seam pucker</td>
</tr>
<tr>
<td>FAST – 4</td>
<td>Relaxation shrinkage</td>
<td>Size, seam pucker and</td>
</tr>
<tr>
<td></td>
<td>Hygral expansion</td>
<td>pleating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Looks, pleating</td>
</tr>
</tbody>
</table>

Source: Sule and Bardhan, 1999

Table - 11: Fabric Properties Associated with Problems in Garment Making

<table>
<thead>
<tr>
<th>Property</th>
<th>Potential problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low relaxation shrinkage</td>
<td>Bubbling of fused panels</td>
</tr>
<tr>
<td></td>
<td>Delamination of fused panels</td>
</tr>
<tr>
<td></td>
<td>Bubbling in pleating</td>
</tr>
<tr>
<td></td>
<td>Difficulty shrinking out fullness</td>
</tr>
<tr>
<td>High relaxation shrinkage</td>
<td>Excessive fusing press shrinkage</td>
</tr>
<tr>
<td></td>
<td>Excessive steam press shrinkage</td>
</tr>
<tr>
<td></td>
<td>Variation in size of cut panels</td>
</tr>
<tr>
<td>Property</td>
<td>Potential problem</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Excessive hygral expansion     | Excessive shrinkage during manufacture  
Bubbling of fused panels        |
|                                | Bubbling of pleated panels                                                       |
| Low formability                | Difficulty in sleeve setting                                                      |
| Low extensibility              | Difficulty with sewing overfed seam  
Difficulty in pressing             |
|                                | Difficulty shrinking out fullness                                                 |
| High extensibility             | Difficulty matching checks                                                        |
|                                | Difficulty sewing unsupported seams  
(Warp) Easy to stretch in laying up, leading to shrinkage problems |
| Low bending rigidity           | Difficulty to cut and sew                                                         |
|                                | Automated handling problems                                                      |
| High bending rigidity          | Difficult to mould and press                                                      |
| Low shear rigidity             | Easy to distort in laying up, marking and cutting                                |
| High shear rigidity            | Difficulty in garment moulding                                                    |
|                                | Difficult to form smooth 3D shapes                                                |

Source: Anonymous

Table – 12: Fabric Properties Associated with Potential Poor Garment Appearance in Wear

<table>
<thead>
<tr>
<th>Property</th>
<th>Potential problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low relaxation shrinkage</td>
<td>Bubbling/waviness in fused panels</td>
</tr>
<tr>
<td></td>
<td>Delamination of fused panels</td>
</tr>
<tr>
<td></td>
<td>Seam pucker</td>
</tr>
<tr>
<td>High relaxation shrinkage</td>
<td>Size variation</td>
</tr>
<tr>
<td></td>
<td>Seam pucker</td>
</tr>
<tr>
<td>Excessive hygral expansion</td>
<td>Bubbling/waviness in fused panels</td>
</tr>
<tr>
<td>Property</td>
<td>Characteristics</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>Poor shape retention</td>
<td></td>
</tr>
<tr>
<td>Seam pucker</td>
<td></td>
</tr>
<tr>
<td>Low formability</td>
<td>Puckering of seams</td>
</tr>
<tr>
<td></td>
<td>Difficulty in pressing</td>
</tr>
<tr>
<td>Low bending rigidity</td>
<td>Poor shape retention</td>
</tr>
<tr>
<td></td>
<td>Soft drape of sleeves</td>
</tr>
<tr>
<td>Low shear rigidity</td>
<td>Poor garment shape retention</td>
</tr>
<tr>
<td></td>
<td>Soft drape of sleeves</td>
</tr>
<tr>
<td>Excessive increase in surface thickness</td>
<td>Poor appearance retention (fabric)</td>
</tr>
<tr>
<td></td>
<td>Re-emergence of running marks or cracking</td>
</tr>
<tr>
<td></td>
<td>and distortion of fabric</td>
</tr>
</tbody>
</table>

Source: Anonymous

Table 10 provides a summary of the FAST system. Table 11 summarises the FAST fabric properties associated with problems in garment making while Table 12 lists those FAST fabric properties associated with potentially poor garment appearance.

Other FOM type methods

Although the Kawabata and FAST systems dominate the Fabric Objective Measurement market, various alternative or complementary systems have been developed (Kawabata and Niwa, 1998; Fan et al, 2002), such as a portable system (Fan et al, 2002), universal tensile testers (Pan et al, 1993; Lord et al, 1989; Bereck et al, 1997; Alamdar-Yazdi, 2004; Sule and Gurudutt, 2000; Ramkumar, 2000 a) and LSU (Chen et al, 2001) tensile tester, a polymeric human finger sensor (artificial finger) (Ramkumar, 2000 b; Ramkumar et al, 2003), etc.
Summary

Fabric is the basic raw material of the clothing industry and the quality of the fabric influences not only the quality of the garment but also the ease with which a shell structure out of a flat (two dimensional) fabric can be produced for conversion into a three dimensional garment. The fabric specifications for different end use requirements are different and the selection of an appropriate fabric is one of the most difficult tasks for clothing manufacturers. Fabric characteristics can also be considered from the point of view of the consumer, and the apparel and fabric manufacturers. Thus the selection of fabric directly or indirectly influences the apparel making-up process and finished clothing product performance (Kothari, 1999).

The satisfactory design of a garment involves the selection of a satisfactory fabric, which will not only be attractive but will perform well and remain serviceable throughout the life of the garment. Garment makers must be clear about their objectives in producing a particular garment style, what market is being targeted, what functions the garment will be expected to perform, and therefore what requirements the fabric needs to meet. Whether the fabric in fact is suitable can be discovered by tests to stimulate the conditions of wear, when wear tests themselves are not appropriate (Lowe and Lowcock, 1975).

The literature review clearly indicates the importance and relevance of the various tests involved in fabric and garment quality, describing their role in controlling and ensuring garment quality, appropriate to the specific garment type and end use. This formed the basis for formulating the research objectives and methodology of the present study, namely to determine the status quo in South Africa and any gaps and scope for improvement.
Research Methodology

and

Experimental
4. Research Methodology and Experimental

The study researches the various quality related processes, procedures and systems adopted in different companies to ensure that specifications and standards are met, with a specific focus on Fabric Objective Measurement. This involves the collection of appropriate data and information from key selected clothing manufacturers and retailers in the country, so as to understand the nature of the various quality testing procedures and systems which they follow and the possible gaps which exist in this respect. Therefore on the basis of the initial responses from the main apparel retail and manufacturing companies particularly with respect to their willingness to co-operate in the study, a number of key retailers and manufacturers were selected to form part of the study.

The most important and largest apparel manufacturers and retailers in South Africa were approached for collaboration in this study and all but one agreed to do so and were therefore included in the questionnaires. Because of time and cost constraints, only those in Gauteng and Western Cape as well as Trubok in Newcastle (KZN) were visited for the personal interviews. In so doing a representative cross section of apparel manufacturers and retailers was covered, thereby providing meaningful and representative results for the apparel retailing and manufacturing sector of South Africa.

The research included direct interaction and discussion with the relevant company employees. A set of interview questions was framed based on the types of testing that are being followed by the retailers and manufacturers and how the results are applied in final garment making, as well as how they affect the quality of the final garment with/without the use of FOM. Each question had multiple options which facilitated the answering to the questions. Sampling of specific staff was on the basis of the recommendations of the senior management. On the basis of the outcomes from the questionnaires and interviews, the data were to be analysed, graphically presented and interpreted, and the appropriate conclusions and recommendations made.

The questionnaire was framed with a specific focus on quality testing procedures and quality in relation to apparel production and merchandising, it being so developed, framed and structured that the responses could provide information on, and interpreted in terms of, the quality control
testing, system etc. of the apparel manufacturing and retailing sectors in South Africa, and enable
gaps to be identified, with a specific focus on fabric objective measurement. The questionnaire
was of a multiple choice nature, enabling the company employees to tick one or more blocks
appropriate to their organisation. The questionnaire is given in the ‘Annexure’.

As mentioned above, certain key manufacturers and retailers, considered relevant to the study,
were selected and contacted telephonically or by e-mail to outline the study and secure their co-
operation, after which the questionnaires were sent to them. Some of the recipients requested
clarifications on a few questions in the questionnaire, which were provided and which facilitated
completion. The completed questionnaires were analysed and the information generated was
captured in graphs. Questionnaires were completed by all but one of the companies which were
approached, the following companies having completed them; Woolworths, Edcon, Foschini, Mr
Price, Pep Stores, Trubok, Pals Clothing, Rex Trueform, Cecil Aron & Sons, Pregroup,
Kingsgate Clothing and House of Monatic.

In addition, the following retailers and manufacturers were visited and the appropriate staff
interviewed personally - Woolworths, Edcon, Foschini, Mr Price, Pep Stores, Trubok, Pals
Clothing, Rex Trueform, Cecil Aron & Sons, Pregroup, Kingsgate Clothing and House of
Monatic. Staff interviewed included the factory managers, sourcing and technical managers and
quality executives. The personnel interviewed, and who were all directly involved in quality
related aspects, openly shared information relating to testing and quality and the study objective
in general.

In addition to the questions listed in the questionnaire, there were also certain other quality and
related questions and issues which were raised and discussed during the interviews, including the
following:

1. What are the main quality related problems you experience and how can they be solved or
   addressed?
2. Are there any gaps or problems in terms of in-house or external quality testing facilities,
   competence, skills, etc. if so, what are they?
3. When quality problems occur, which cannot be solved “in-house”, which testing facilities do you use, and are you satisfied with what is available and the level of problem solving/troubleshooting services provided?
4. Where are the bulk of your fabrics and/or garments sourced from, i.e. locally or overseas?
5. What are the main obstacles in terms of achieving cost effective quality products in South Africa?
6. Which proportion of your sourcing (fabrics/garment) is done locally and which overseas?
7. How is quality monitoring done by retailers?
8. What is the size and importance of retailing to the South African industry?

Many different views and comments were expressed freely during the interviews. The questionnaire responses were compiled and subjected to statistical analysis using the F and t-tests, being appropriate for assessing the significance of responses and any differences in this respect. An F - test involves two samples compared to two independent sets of test data and helps to determine if the variances are the same or different from each other. A t- test involves two samples compares the two sets of test data. If the two data sets are independent of each other, a two-sample t-test, assuming unequal variances, is done. It helps to determine whether the means (i.e. averages) are the same or different from each other.

**Trubok**

Trubok in Newcastle, is at present the only manufacturer that uses the FAST system of FOM for quality control purposes before sending the fabric for bulk production. Hence, a special visit was paid to Trubok, to gain an understanding of their application of this system of testing. Detailed discussions were held with laboratory and management staff directly involved in quality control and the application of the FAST system. In addition, in order to obtain hands-on experience with the FAST system as operated in the mill quality control laboratory, two different types of fabrics, in process at the time, were taken and tested on the three FAST instruments, FAST -1, FAST -2 and FAST- 3. The fabrics tested were a 100% polyester fabric, a 65% polyester and a 35% wool...
blended fabric. Each fabric was cut in the warp-wise, weft-wise and diagonal directions and the appropriately cut pieces placed on the FAST-1, -2 and -3 instruments and the tests conducted as per the FAST Instruction Manual. The FAST instruments automatically recorded and processed the test data. Sets of readings were taken for each fabric on each instrument. The quality parameters obtained from the three instruments, included compression, bending and elongation. The software installed in the system automatically recorded and processed the readings, and the results generated will be discussed under ‘Results and Discussion’ (Chapter 6).

**FOM Application and Distribution**

The global manufacturers and suppliers of FAST and Kawabata systems, with headquarters in Australia and Japan, respectively, were contacted and information and data requested in terms of the application of their respective FOM systems and the global sales and distribution of their systems to date.
RESULTS AND DISCUSSION
5. Results and Discussion

5.1 Analysis of Questionnaire Responses

5.1.1 Introduction

An example of the questionnaire is given as Annexure 10.1. The actual responses each respondent captured in tabular form as Annexure 10.2. The responses to the questionnaire from both the retailers and manufacturers have been compiled and presented as graphs for each individual question. On the basis of the responses, 18 out of the 20 questions in the questionnaire could be presented graphically. The other 2 questions (13 and 16) are discussed, but not presented graphically. It should perhaps be noted that whereas all the retailers responded to virtually all the questions, this was not the case for the manufacturers, as will be evident from Annexure 10.2.

The graphs are plotted with the individual retailers (R1 to R5) and manufacturers (M1 to M7) indicated along the X axis and their individual responses, given as a percentage, presented on the Y axis. In addition, the overall response of all 12 respondents to a particular option, expressed as a percentage, is also indicated alongside the graphs of the individual respondents with the options for each question from the questionnaire on the X axis and the overall percentage responses of both the retailers and manufacturers, on the Y axis. For each question and each respondent, the response to each of the options is shown as a percentage. Therefore, as an example, if a respondent to question 1 only ticked option ‘a’, then ‘a’ is shown on the graph as 100% for that particular respondent. If another respondent ticked two options, say ‘a’ and ‘b’, both would be shown as 50%. If no tick (i.e. no response) then the response is indicated as 0. A similar approach is followed for all the questions as discussed below.

In addition to the graphical analysis, a statistical analysis of the questionnaire responses was carried out (see 6.1.3), by grouping the retailer responses together and those of the manufacturers together. For the purpose of this analysis, certain related questions were grouped together, as shown in tabular form (see Tables 13 to 16) with the retailers and manufacturers’ column wise
and their responses row wise. The percentage was calculated for the retailers and manufacturers, respectively. For example, in Table 13 the responses of the two groups i.e. ‘retailers’ and ‘manufacturers’, have been calculated on the basis of the number of respondents, expressed as a percentage, opting for a particular option. For example, in question 1, 5 out of 5 retailers (R1 to R5) and 7 out of 7 manufacturers (M1 to M7) selected option ‘c’, which comes to 100%, in both cases i.e. all the retailers and manufacturers selected the same option. Similarly, in question 2, 4 out of 5 retailers (80%) selected option ‘a’, only one selecting option ‘d’, while 6 out of 7 manufacturers (86%) selected option ‘a’, only one selecting option ‘c’. For the statistical analysis, the percentage taken for each question, for a particular retailer/manufacturer, is according to the highest number of retailers/manufacturers agreeing on a particular option. For example, option ‘a’ in case of question 2, giving 80% for the retailers and 86% for the manufacturers, respectively. Where there are common responses on multiple options for the retailers and manufacturers, the option with most responses is selected and calculated as a percentage. For example, in question 18, 4 out of 5 retailers (80%) selected option ‘a’, and 6 out of 7 manufacturers (86%) also selected option ‘a’. Therefore, although 17% of the retailers and manufacturers also selected option ‘c’, 80% and 86% are taken to be the responses of the retailers and manufacturers, respectively, for the purpose of the statistical analysis. In Table 13, questions 1, 2, 17 and 18 have been grouped together for analysis because they collectively reflect on quality, merchandising and product benchmarking. A similar approach is followed for the other tables.
All the respondents (i.e. 100%) chose only option ‘c’, namely quality means conformance to requirements and meeting customer needs. Some retailers added comments to the effect that quality means “fit for use”, or “fit for purpose”.

Figure 13: Individual and Overall Responses to Question 1: “Quality means” …..
Figure 14: Individual and Overall Responses to Question 2: “What is the role of quality in product benchmarking”?

The majority of the responses (80%) favoured option ‘a’, namely that quality in product benchmarking is a major criteria, only a few felt it is supplier dependent. A few of the retailers commented that quality is the first criteria when benchmarking a product. Quality can be broken down into many components, such as fabric quality, quality of workmanship, etc.
Figure 15: Individual and Overall Responses to Question 3: “Where is the fabric and garment testing done, for your company”?

Some 50% of the responses were for the option that fabric testing was done by the supplier; with the standards being set by the customer (i.e. manufacturers and retailers) for the testing procedures, hence the supplier follows the standards as set. If, however, garment testing is done, especially related to laundering, then it is always done in-house. Both retailers and manufacturers largely agreed to the fact that testing related to the fabric is done by the supplier, whereas some retailers also mentioned that testing houses, like SGS or ITS, or in-house testing, are the preferred options for them.
Figure 16: Individual and Overall Responses to Question 4: “Which quality testing is done by the company and those by the supplier”?

The majority of the responses (almost 50%) were in favour of the option that quality testing is done by both the company and the supplier. This is clearly reflected in the overall response as illustrated in Figure 16. Four of the companies did not respond to this question, therefore their responses were taken as zero, in calculating the overall response as reflected in Figure 16. From a few of the responses it can be deduced that fabric testing is done by the supplier only, while the rest indicated that other types of tests are done by the company itself.
Figure 17: Individual and Overall Responses to Question 5: “Which independent/accredited outside laboratory are used for quality testing and to what extent”?

According to the responses, the most often used laboratories are SGS and ITS. Some of the retailers have their preferred laboratories which do their testing or else it is done by the supplier. For the manufacturers, testing is mainly done outside, mostly by ITS and SGS, some of them occasionally do it through other organizations, such as the CSIR. Over 20% of the responses were for “other”, most of which represented the “suppliers” or another testing house or laboratory where the tests were carried out.
Figure 18: Individual and Overall Responses to Question 6: “Which methods do you follow during testing”?

Some 36% of the responses were for SABS and almost 30% for ISO, with colourfastness, shrinkage, fabric weight tests etc. being conducted most of the time. Certain of the top-end retailers follow their own testing methods which they also tend to perform in-house.
Figure 19: Individual and Overall Responses to Question 7: “Which fabric and garment quality attributes are monitored on a regular/routine basis and by whom”?

In all, some 67% of responses to this question were that strength, colourfastness, care labels and dimensional stability are all monitored on a routine basis, indicating the critical importance of quality in garment making and that retailers and manufacturers are very particular about the quality of the product they sell to their target market. Only a very small percentage of the responses were for only one specific test, such as dimensional stability (option ‘d’). Other than the above mentioned tests, some manufacturers also conduct tests for abrasion, shrinkage, bond strength, width variation, shade variation etc. The quality oriented retailers have a documented system which verifies basic fabric suitability before placing orders, thereafter bulk attributes are tested before garment manufacture. A full final AQL procedure is applied to all garments, one of the aspects checked being care label accuracy.
Figure 20: Individual and Overall Responses to Question 8: “Which fabric strength tests do you undertake”?

Some 50% of the responses opted for all four strength related tests listed, with almost 30% selecting seam strength/slippage (option ‘d’) specifically. These tests are of particular importance for fabrics destined for shirtings, blouses and interlinings. Bursting strength tests are commonly used for knitted fabrics, lightweight woven fabrics and non-woven fabrics. The strength of seams are very important in garments and should ideally equal that of the material it joins in order to provide a balanced construction that will withstand the forces encountered during use of the garment, of which the seam forms an important part. Some of the retailers commented that the fabric strength tests performed, especially tearing and bursting strength, depend on the styling and end use of the product.
Garments often come into contact with other items while being worn or cleaned. The migration of colour from one item to another (such as from coat linings to shirts, pants to upholstery, night clothes to bedsheet, etc.) can result in a garment becoming unwearable or unusable. In all, 33% of the responses were for all the colourfastness tests listed. Some 32% of the responses conduct the colourfastness to rubbing test most of the time because it represents an important indication of the proneness (propensity) of a fabric or garment to develop shine or lose colour, and thereby become unwearable.)
Figure 22: Individual and Overall Responses to Question 10: “What other tests are performed”?

Some 37% of the responses were for all the listed tests i.e. dimensional stability, abrasion resistance and pilling, certain of these tests also being selected on an individual basis. Therefore, in total, close on 80% of the responses selected one or more of these tests as being performed. Pilling and abrasion tests are product specific for some retailers. In addition to the above, a few manufacturers also commented that they conduct tests on linings, such as shrinkage to steam press and fusing – shrinkage and bond strength.
Figure 23:- Individual and Overall Responses to Question 11: “Which quality management systems do you apply”?

Some 50% of the responses represented the option of “own quality management system” and not the quality management systems listed, such as TQM or Six Sigma. Two of the manufacturers, however, apply TQM to all aspects of quality, from raw material to monitoring customer returns. A few of the retailers have developed their own system which monitors all aspects of quality from the raw material to monitoring customer returns.
Only 2 manufacturers (17% of the responses) use FOM, namely the FAST system, for fabric quality evaluation, with some 50% of the responses not being even aware of this form of quality testing. It is rather surprising to learn that so many companies haven’t even heard of either the FAST or Kawabata system of FOM, since they represent a new generation of instrumentally measured parameters which provide a more complete picture of fabric quality, tailorability and performance. FOM is a relatively new technology and one which could fruitfully be applied in South Africa but this has largely been neglected to date. If used, it can improve the quality and competitiveness at the international level, which are currently lacking in the South African clothing sector.

**Question 13:** This question was viewed in conjunction with question 12, since it deals with which types of garments were tested using FOM. The two manufacturers which apply FAST for quality control purposes, use it for testing mostly suitings. As could be deduced from the responses to question 12 the other responses were nil. It is worth mentioning that, worldwide, FOM as yet finds little application for knitted fabrics.
Figure 25: Individual and Overall Responses to Question 14: “Which is the most common fabric you employ in garment making”?

All the respondents, except one, employ (or manufacture) either woven or knitted fabrics, or both, with 10 employing woven fabrics (2 of which employing only woven fabrics), 7 employing knitted fabrics (1 of which employing only knitted fabrics) and two manufacturers employing both non-woven and woven fabrics. In terms of the overall percentage responses, woven fabrics scored 50%, knitted fabrics 33% and non-wovens 8%. Non-wovens find very little utility in garment manufacture, being almost solely used in interlinings for suitings, jackets etc.
Figure 26: Individual and Overall Responses to Question 15: “Which type of garment do you mostly manufacture”?

All the retailers responded that they cover all the types of garments listed, as well as accessories. All of the manufacturers, except one, were involved in menswear, three in children’s wear (kidswear), five of the manufacturers also being involved in ladieswear. In terms of the overall percentage responses, 41% (representing all the retailers) were for all types, 30% for menswear, 17% for ladieswear and 10% for children’s wear. Only one manufacturer is involved in accessories.

Question 16: The responses of the retailers and manufacturers to question number 16,

“**The role of quality in merchandising**”, can be summarized as follows:

- Satisfying consumer expectations in terms of the end product
- Increasing sales and customer satisfaction
- Best portraying and positioning their products during visual merchandising in stores, in the media and magazines etc.
Quality is a major criterion in merchandising, particularly where the brand is being so positioned (e.g. Woolworths). If the brand is not so positioned, then obviously this factor would not play a dominant role. Nevertheless, quality always plays a role, basically in terms of “value for money”.

Figure 27: Individual and Overall Responses to Question 17: “Does the merchandising process benefit from the quality assessments of garments”?

The above graph shows the overwhelming “yes” responses of both retailers and manufacturers, in terms of the merchandising process benefiting from the quality assessment of garments. All the respondents, i.e. 100%, agreed to the fact that merchandising and quality complement each other, and that with proper quality assessment, the merchandising workflow process becomes smooth and easy, resulting in the timely delivery of products of the desired quality. Therefore, quality plays a vital role in the apparel merchandising process and clothing pipeline in their entireties.
Figure 28:- Individual and Overall Responses to Question 18: “Are merchandising and quality interdependent in satisfying customer requirements”?

Only 17% of the overall responses reflected merchandising and quality as being independent of each other, the majority (83%) reflecting that merchandising and quality are very much interdependent in satisfying customer requirements. With proper quality control, the chances of defective garments being produced are considerably less and can products be produced of the required standards, and also result in the timely delivery of quality products, thereby minimizing claims and costs.
Figure 29: Individual and Overall Responses to Question 19: “Your customers buy these garments mainly in terms of”

All the responses (100%) selected option ‘d’, namely that consumers buy garments mainly in terms of price, quality, design and appeal of the product. All these are inter-related and affect the choices exercised by the customers.
Figure 30: Individual and Overall Responses to Question 20: “Do you plan to introduce any new fabric/garment tests within the near future”?  

Half (50%) of the respondents indicated that they plan to introduce new tests in the near future, while the other half did not plan to do so. Five out of the seven manufacturers, but only one out of the five retailers, planned to introduce new tests within the near future. Although not explicitly stated, the tests they plan to introduce in future could be FAST, which is fairly simple, reliable and productive, and could enhance the quality of the fabric and garment. By introducing this test they can improve their competitiveness, locally as well as internationally. The fact that retailers did not plan to introduce any new tests may be because they largely rely on their suppliers to do the relevant tests necessary for a particular fabric and/or garment and to introduce any new tests when deemed necessary. A few of the retailers commented on this question, stating they would introduce a new test if a new fabric is required or if the market demands for a different product results in a different end result.
5.1.3 Statistical Analysis

Terminologies:

Two statistical tests, namely the F-test and the t-test, were applied in the analysis of certain grouped question responses. The F-test, where F is the variance ratio, is any statistical test in which the test statistic has an F-distribution under the null hypothesis. It is most often used when comparing statistical models that have been fitted to a data set, in order to identify the model that best fits the population from which the data were sampled.

The t-test is a statistical examination of two population means (the mathematical averages of the two sets of numbers). A two-sample t-test examines whether the two samples are different in terms of their mean values and is commonly used when the variances (the sum of the squares of the deviations from the mean value) of two normal distributions are unknown and when an experiment uses a small sample size.

The number of independent pieces of information that go into the estimate of a parameter is called the degrees of freedom (df).

Null Hypothesis: A type of hypothesis used in statistics that proposes that no statistical significance exists in a set of given observations. The null hypothesis attempts to show that no variation exists between variables, or that a single variable is no different from zero. It is presumed to be true until statistical evidence nullifies it for an alternative hypothesis.
Table 13: Quality, Merchandising and Product Benchmarking

In Table 13 the responses of the two groups have been calculated on the basis of the number of respondents expressed as a percentage, opting for a particular option. In question 1, 5 out of 5 retailers and 7 out of 7 manufacturers selected option ‘c’, which comes to 100% in both cases i.e. all the retailers and manufacturers selected the same option. Similarly, in question 2, 4 out of 5 retailers (80%) selected option ‘a’, only one selecting option ‘d’ while 6 out of 7 manufacturers (86%) selected option ‘a’ only one selecting option ‘c’. For the statistical analysis, the percentage taken for each question, for a particular retailer/manufacturer is taken according to the highest number of retailers/manufacturers agreeing on a particular option, i.e. option ‘a’ for question 2, giving 80% for the retailers and 86% for the manufacturers, respectively. Where there are common responses to multiple options for the retailers and manufacturers, then the option with the most responses is selected and calculated as a percentage. In question 18, 4 out of 5 retailers (80%) selected option ‘a’, and 6 out of 7 manufacturers (86%) also selected option ‘a’. Therefore, although 17% of the retailers and manufacturers also selected option ‘c’, 80% and 86% are taken to be the responses of the retailers and manufacturers, respectively, for the purpose of the statistical analysis.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Percentage of responses from retailers and manufacturers, in favour of quality and merchandising being interdependent and playing a role in, and of benefit to, product benchmarking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>Question 2</td>
</tr>
<tr>
<td>Retailers</td>
<td>100</td>
</tr>
<tr>
<td>Manufacturers</td>
<td>100</td>
</tr>
</tbody>
</table>
F-test Two-Sample for Variances  \( \alpha = 0.05 \)

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>90</td>
<td>93</td>
</tr>
<tr>
<td>Variance</td>
<td>133.3</td>
<td>65.3</td>
</tr>
<tr>
<td>Observations</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>df</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>( P(F&lt;=f) ) One-tail</td>
<td>0.286</td>
<td>0.573</td>
</tr>
<tr>
<td>F Critical One-tail</td>
<td>9.28</td>
<td>15.44</td>
</tr>
</tbody>
</table>

One-tail  Accept Null Hypothesis because \( p > 0.05 \) (Variances are the same)

Two-tail  Accept Null Hypothesis because \( p > 0.05 \) (Variances are the same)

Since \( F < F_{crit} \) (2.04 < 9.28) and \( P \text{ value} > \alpha \) (0.286 > 0.05), we accept the null hypothesis that the variances in the responses are essentially the same for the retailers and manufacturers.

**t-test: Two-Sample Assuming Equal Variances**  \( \alpha = 0.05 \)

Equal Sample Sizes

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>90</td>
<td>93</td>
</tr>
<tr>
<td>Variance</td>
<td>133.3</td>
<td>65.3</td>
</tr>
<tr>
<td>Observations</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Pooled Variance</td>
<td>9.3</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>t-Stat</td>
<td>-0.426</td>
<td></td>
</tr>
<tr>
<td>( P(T&lt;=t) ) One-tail</td>
<td>0.343</td>
<td>Accept Null Hypothesis because ( p &gt; 0.05 ) (Means are the same)</td>
</tr>
<tr>
<td>T Critical One-tail</td>
<td>1.943</td>
<td></td>
</tr>
<tr>
<td>( P(T&lt;=t) ) Two-tail</td>
<td>0.685</td>
<td>Accept Null Hypothesis because ( p &gt; 0.05 ) (Means are the same)</td>
</tr>
<tr>
<td>T Critical Two-tail</td>
<td>2.447</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion: Since the t-statistic < t critical (-0.426 < 1.943) and P value > α (0.685 > 0.05), we accept the null hypothesis that the means (i.e. responses) are the same for the retailers and manufacturers.

On the basis of the results of the above statistical analysis it can therefore be concluded that the responses of the retailers and manufacturers did not differ statistically significantly, both retailers and manufacturers agreeing that quality and merchandising are interrelated and help in achieving product benchmarking.

Table 14: Fabric and Garment Testing as per Standards

In Table 14, for question 3, 2 out of 5 retailers (40%) and 5 out of 7 manufacturers (70%) agreed on option ‘c’. Similarly, in question 4, 2 out of 5 retailers (40%) and 4 out of 7 manufacturers (57%) selected option ‘c’. In question 5, 2 out of 5 (i.e. 40%) retailers and 4 out of 7 (57%) manufacturers selected option ‘a’. Similarly, in question 6, 3 out of 5 retailers (i.e. 60%) and 4 out of 7 manufacturers (i.e. 57%) selected option ‘c’. Although in these four questions retailers and manufacturers selected multiple options, the majority responses were considered for the purposes of the statistical analysis.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Percentage of responses relating to where fabric and garment testing is done, for example, in-house or by the supplier or outside laboratories as per the relevant standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Question 3</td>
</tr>
<tr>
<td>Retailers</td>
<td>40</td>
</tr>
<tr>
<td>Manufacturers</td>
<td>70</td>
</tr>
</tbody>
</table>
F-test Two-Sample for Variances

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>45</td>
<td>60.25</td>
</tr>
<tr>
<td>Variance</td>
<td>100</td>
<td>42.25</td>
</tr>
<tr>
<td>Observations</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>df</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>2.37</td>
<td></td>
</tr>
<tr>
<td>P(F&lt;=f) one-tail</td>
<td>0.249</td>
<td>0.498</td>
</tr>
<tr>
<td>F Critical one-tail</td>
<td>9.28</td>
<td>15.44</td>
</tr>
<tr>
<td>One-tail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-tail</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Accept Null Hypothesis because p > 0.05 (Variances are the same)

Since F < Fcrit (2.37 < 9.28) and P value > α (0.249 < 0.05), we accept the null hypothesis that the variances in the responses are essentially the same for the retailers and manufacturers. On the basis of this result, the next step was to undertake the appropriate t-test.

t-test: Two-Sample Assuming Equal Variances

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>45</td>
<td>60.25</td>
</tr>
<tr>
<td>Variance</td>
<td>100</td>
<td>42.25</td>
</tr>
<tr>
<td>Observations</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>df</td>
<td></td>
<td></td>
</tr>
<tr>
<td>df</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pooled Variance</td>
<td>71.125</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>t-Stat</td>
<td>-2.557</td>
<td></td>
</tr>
</tbody>
</table>
P(T<=t) one-tail 0.022 Reject Null Hypothesis because p < 0.05 (Means are Different)
T Critical one-tail 1.943
P(T<=t) two-tail 0.043 Reject Null Hypothesis because p < 0.05 (Means are Different)
T Critical two-tail 2.447

**Conclusion:** Since the t - statistic < t critical (-2.557 < 0.043) and P value < α (0.043 < 0.05), we reject the null hypothesis, namely that the means are different (at a 95% confidence level).

Since the types of testing and test methods are different for the retailers and manufacturers, depending on product price and quality, and since the testing can also be done in-house and/or by outside laboratories according to the need of the fabric or garment, most of the responses are different with no particular testing method or laboratory being used for the same. Therefore, getting a uniform response from the retailers and manufacturers was difficult, hence the reason for the above hypothesis being rejected, the responses of the retailers and manufacturers differing statistically significantly in this respect.

**Table 15: Fabric and Garment Tests done on Regular/Routine basis and new tests for future use**

In Table 15, question 7, 5 out of 5 retailers (100%) and 3 out of 7 manufacturers (43%) agreed on option ‘e’. Similarly, for question 8, 4 out of 5 retailers (80%) and 3 out of 7 manufacturers (43%) selected option ‘e’. In question number 9, 1 out of 5 retailers (20%) and 5 out of 7 manufacturers (71%) selected option ‘a’. Similarly, in question number 10, 4 out of 5 retailers (80%) and 1 out of 7 manufacturers (14%) selected option ‘d’. Again for question 20, 1 out of 5 retailers (20%) and 5 out of 7 manufacturers (71%) selected option ‘a’. Although for these five questions the retailers and manufacturers also selected multiple options, only the majority options were again considered for purposes of the statistical analysis.
<table>
<thead>
<tr>
<th>Categories</th>
<th>Percentage of responses relating to fabric and garment quality performance testing, such as strength, colourfastness and other tests, on a regular/routine basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Question 7</td>
</tr>
<tr>
<td>Retailers</td>
<td>100</td>
</tr>
<tr>
<td>Manufacturers</td>
<td>43</td>
</tr>
</tbody>
</table>

**F-test Two-Sample for Variances**

<table>
<thead>
<tr>
<th></th>
<th>α</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retailers</td>
<td>Mean</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>1400</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>df</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2.47</td>
</tr>
<tr>
<td></td>
<td>P(F&lt;=f) one-tail</td>
<td>0.201</td>
</tr>
<tr>
<td></td>
<td>F Critical one-tail</td>
<td>6.39</td>
</tr>
</tbody>
</table>

**One-tail**

Accept Null Hypothesis because p > 0.05 (Variances are the same)

**Two-tail**

Accept Null Hypothesis because p > 0.05 (Variances are the same)

Since F < Fcrit (2.47 < 6.39) and P value > α (0.201 > 0.05), we accept the null hypothesis that the variances in the responses are essentially the same for the retailers and manufacturers. On the basis of this result the next step was to undertake the appropriate t-test.

**t-test: Two-Sample Assuming Equal Variances**

<table>
<thead>
<tr>
<th></th>
<th>α</th>
<th>0.05</th>
</tr>
</thead>
</table>

Page | 117
Equal Sample Sizes

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>60</td>
<td>48.4</td>
</tr>
<tr>
<td>Variance</td>
<td>1400</td>
<td>565.8</td>
</tr>
<tr>
<td>Observations</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pooled Variance</td>
<td>982.9</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>t-Stat</td>
<td>0.585</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.287</td>
<td>Accept Null Hypothesis because p &gt; 0.05 (Means are the same)</td>
</tr>
<tr>
<td>T Critical one-tail</td>
<td>1.860</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.575</td>
<td>Accept Null Hypothesis because p &gt; 0.05 (Means are the same)</td>
</tr>
<tr>
<td>T Critical Two-tail</td>
<td>2.306</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:** Since the t - statistic < t critical (0.585 < 2.306) and P value > α (0.575 > 0.05), we accept the null hypothesis that the means are the same, at the 95% confidence level.

On the basis of the above statistical tests it can therefore be concluded that the responses of the retailers and manufacturers did not differ statistically significantly, both retailers and manufacturers agreeing that they conduct fabric and garment tests on a regular/routine basis.

Table 16: Fabric Types Used in Garment Making

In Table 16, question 11, 5 out of 5 retailers (100%) and 1 out of 7 manufacturers (14%) selected option ‘d’. Similarly, in question 14, 4 out of 5 retailers (80%) and 7 out of 7 manufacturers (100%) agreed on option ‘a’. For question 19, 5 out of 5 retailers and 7 out of 7 manufacturers selected option ‘e’. Although, for these three questions, retailers and manufacturers selected multiple options, only the majority response was once again used for the statistical analysis.
<table>
<thead>
<tr>
<th>Categories</th>
<th>Percentage of responses relating to the quality management system followed, use of a particular fabric type in garment making, on the basis of which, customers buy these garments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Question 11</td>
</tr>
<tr>
<td>Retailers</td>
<td>100</td>
</tr>
<tr>
<td>Manufacturers</td>
<td>14</td>
</tr>
</tbody>
</table>

F-test Two-Sample for Variances

\[ \alpha = 0.05 \]

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>93.33333</td>
<td>71.33333</td>
</tr>
<tr>
<td>Variance</td>
<td>133.3333</td>
<td>2465.333</td>
</tr>
<tr>
<td>Observations</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>df</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>P(F&lt;=f) one-tail</td>
<td>0.051</td>
<td>0.103</td>
</tr>
<tr>
<td>F Critical one-tail</td>
<td>19.00</td>
<td>39.00</td>
</tr>
</tbody>
</table>

One-tail Accept Null Hypothesis because \( p > 0.05 \) (Variances are the same)

Two-tail Accept Null Hypothesis because \( p > 0.05 \) (Variances are the same)

Since \( F < F_{crit} (0.05 < 19.00) \) and \( P \text{ value} > \alpha (0.051 > 0.05) \), we accept the null hypothesis that the variances in the responses are essentially the same for the retailers and manufacturers. On the basis of this result, the next step was to undertake the appropriate t-test.
**t-test: Two-Sample Assuming Equal Variances**

<table>
<thead>
<tr>
<th></th>
<th>Retailers</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>93.33333</td>
<td>71.33333</td>
</tr>
<tr>
<td>Variance</td>
<td>133.3333</td>
<td>2465.333</td>
</tr>
<tr>
<td>Observations</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pooled Variance</td>
<td>1299.333</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>t-Stat</td>
<td>0.747</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.248</td>
<td>Accept Null Hypothesis because p &gt; 0.05 (Means are the same)</td>
</tr>
<tr>
<td>T Critical one-tail</td>
<td>2.132</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.496</td>
<td>Accept Null Hypothesis because p &gt; 0.05 (Means are the same)</td>
</tr>
<tr>
<td>T Critical Two-tail</td>
<td>2.776</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:** Since the t-statistic < t critical (-0.246 < 2.776) and P value > α (0.818 > 0.05), we can accept the null hypothesis that the means are the same, at the 95% confidence level. Hence, both retailers and manufacturers follow their own developed quality management system and are involved in, or use, mostly knitted and woven fabrics in garment making.
5.2 Interview Feedback

Most of the companies replied that the basic quality problems they experience relate to distorted cloth (skew/bow), shading, shrinkage, seam pucker, cloth defects and incorrect length and width. When a fabric is assessed as defective, it is rejected and returned to the supplier. Sometimes fabrics from different rolls behave differently during production, and are therefore packed separately before sending to the retailers. Most companies liaise with both supplier and customer, to the mutual benefit of both.

When fabric testing is done in-house, there are times when the results don’t comply with the company’s set standards. In addition, bulk deliveries do not always match the original samples when tested or inspected. Where certain specialised testing cannot be done in-house, fabrics requiring such testing are submitted to outside, generally accredited, test houses, for independent testing.

When asked about the main obstacles preventing retailers from sourcing garments locally, most agreed that local labour costs are too high, productivity is not good and that there were gaps in terms of designing aspects when it comes to embroideries and other embellishments, which have become so popular for garments.

Most manufacturers are satisfied with the test houses and external testing facilities available, although the turnout times were often too slow and presented a problem in meeting deadlines. From the questionnaires and interviews, the lack of knowledge on FOM by almost all of the respondents was a matter of concern since this will most certainly impact on the quality and also competitiveness of locally produced apparel fabrics, more particularly that of high quality worsted type of fabrics in wool and mohair and their blends with synthetic fibres, such as polyester.

Even though the manufacturers and retailers do quality checks, faults still slip through both and find their way to the final customers, resulting in unnecessary customer complaints and returns.
5.3 FAST Test Results

FAST is a simple method of interpreting the data to predict fabric performance. It covers:

**Relaxation shrinkage**: The irreversible change in dimensions that occurs when a fabric is relaxed in steam or water. If the shrinkage is too high or too low it results in formation of irregular shaped garments during and after stitching, thereby impacting negatively on the quality of garments.

**Hygral expansion**: The reversible change in fabric dimensions that occurs in fabric dimensions when the moisture content of the fibres changes. Too high a hygral expansion can result in excessive fabric shrinkage, poor garment appearance, delamination of fusible interlinings and seam pucker.

**Formability**: The tendency of a fabric to buckle when subjected to an in-plane compressive load. If the formability is high, the fabric will accept the compression without buckling and the seam will usually have a good appearance. If the formability is too low, the fabric will buckle and the seam will pucker.

**Extensibility**: The extension of a fabric under a pre-defined load. Fabric extension helps to improve performance dealing manufacturing, handle and appearance in wear. If the extensibility is too high the garment loses its original shape and does not easily recover its pre-defined shape and if its too low, the garment becomes uncomfortable to wear because of its stiffness.

**Bending rigidity**: The couple required to bend unit width of fabric to unit curvature. If the bending rigidity is too high or too low it results in irregular sleeve setting.

**Shear rigidity**: The shear load required to deform a unit width of fabric to unit strain. If the shear rigidity is too high or too low it creates difficulty in manufacturing of side seams, arm holes and sleeve settings.
As per the readings taken at Trubok on the FAST set of instruments, two control charts were generated as shown in Figures 31 and 32. Figure 31 (65% polyester and 35% wool) shows low shear rigidity, which indicates that the lay may require pinning. Tailoring fabrics of this weight generally requires considerable care and precautions, particularly during cutting and sewing, and at the shoulder seams. Figure 32 (100% polyester) indicates a warning to the garment maker relating to the warp and weft hygral expansion values being low. Warp and weft formability being too low, makes the fabric more prone to seam puckering and poor seam performance, which could create difficulty during sleeve insertion. The low warp extensibility may create difficulties with overfed seams and moulding of the fabric. Potential cutting and sewing difficulties may also arise as the weft bending rigidity is low. The FAST test results of these two widely different fabrics serve as good examples of the unique, highly valuable and useful information generated by the FAST system and which could be utilised to great benefit by many links in the apparel retailing pipeline, from fabric manufacturer to retailer.
Figure 31: SiroFAST Control Chart for Tailorability (65% polyester and 35% wool)
Source: CSIRO, Australia

Figure 32: SiroFAST Control Chart for Tailorability (100% polyester)
5.4 Worldwide FOM Application and Distribution

The information and data supplied by the global manufacturers and suppliers of the Kawabata and FAST systems were compiled and classified according to the institutions which acquired them, as shown in Tables 17 and 18.

Table - 17: Number of Kawabata KES – FB1-4 users Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>No. of units sold</th>
<th>Educational Institution</th>
<th>Company</th>
<th>Research Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Czech</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>India</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>24</td>
<td>4</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>Korea</td>
<td>8</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Portugal</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>United States of America</td>
<td>11</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>37</td>
<td>31</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: www.keskato.co.jp
From Table 17 it can be seen that Kawabata systems are in place in 16 countries, with most systems being in Asia (45), followed by Europe (20). Most systems (47) are in place in research and educational institutions, clearly indicating that this system, which is rather sophisticated and expensive, mainly finds application in research and educational institutions, as opposed to commercial firms.

Table -18: Number of SiroFAST users Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of units sold</th>
<th>Educational Institutions</th>
<th>Company Research Organisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>6</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>8</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Egypt</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>France</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>10</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Israel</td>
<td>3</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>19</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Japan</td>
<td>9</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Jordan</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Korea</td>
<td>9</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Companies</td>
<td>Users</td>
<td>Subsystems</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------</td>
<td>-------</td>
<td>------------</td>
</tr>
<tr>
<td>New Zealand</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Portugal</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Slovenia</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>South Africa</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Spain</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sweden</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Taiwan</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Turkey</td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>17</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>United States of America</td>
<td>7</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Uruguay</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Total** 121 24 70 27

Upto 2011

Source: CSIRO, Australia and www.itec-innovation.com

According to the above table, there are some 121 FAST systems in place in 31 countries, most (47) being in Europe, followed by Asia (43). Most of the systems, 70 in all, are used by companies, which contrast with the Kawabata system, reflecting the practical usefulness (user friendly) and relatively low cost of the FAST, system compared to the Kawabata system.

The above data, collected from CSIRO, Australia, and itec, clearly show that South Africa, as a country, lags behind most other countries in terms of the use of the FAST system. Only two companies in South Africa own FAST instruments, one of which is no longer using their FAST system as they have changed their area of operation from manufacturing to retailing. Trubok is now the only company in South Africa, using the FAST system for quality control purposes (the only other FAST system is at the CSIR). As a result it is now able to manufacture for some of the major retailers in South Africa, because of the quality of its end product.
Companies in countries such as Japan, UK and Italy, are well known for producing fashionable and good quality suiting and similar types of fabrics, which is understandable if one considers their extensive usage of FOM, i.e. FAST and/or Kawabata systems. Similarly, China and India are becoming hubs for all national and international retailers, with their significant and increasing use of FOM systems helping them to attain their objectives.
SUMMARY
AND
CONCLUSIONS
6. Summary and Conclusions

Quality issues related to apparel merchandising in South Africa formed the basis of this study. In apparel merchandising, price, quality and fashion represent key elements which need to be optimised if a company is to survive in this highly competitive global market environment. The objectives of this study were to develop an understanding of the quality related issues and gaps relevant to apparel merchandising within the South African context, with a specific focus on Fabric Objective Measurement (FOM), a relatively new technology and one which could fruitfully be applied in South Africa to monitor and improve fabric quality, but which appears to have been largely neglected to date. Fabric Objective Measurement represents a new generation of instrumentally measured parameters which provide a more complete picture of fabric quality, tailorability and clothing performance, and is particularly relevant to the higher quality end of the market.

Background information on the global and South African textile and clothing sectors has been discussed in terms of their performance in sales, production, exports and imports. A literature review was undertaken on quality and merchandising in the retail and clothing industry. Various quality parameters, such as defects and performance properties, have been discussed. Merchandising covers the roles and responsibilities of a merchandiser, which incorporate the merchandising process flow and the associated parameters. Under FOM, both of the widely used systems, FAST and Kawabata, have been briefly discussed, including their applications in suitings, shirtings, interlinings, etc., as well as their advantages. The quality parameters relating to FAST and Kawabata have been covered.

A questionnaire was framed, with a specific focus on quality testing procedures and quality aspects relevant to apparel merchandising. Most of the top apparel manufacturers and retailers of the country, and which were considered to be particularly relevant to the study, were selected and contacted personally and through e-mail to secure their participation in the study, after which questionnaires were sent to them for completion. In addition to this, a number of these companies were visited, and the appropriate staff involved in quality control interviewed.
Most of the companies when interviewed, replied that the basic quality problems they experience are mostly related to distorted cloth (skew/bow), shading, shrinkage, seam pucker, cloth defects (faults), and unacceptable variations in fabric length and width. When a defective fabric is encountered, it is rejected. Sometimes, fabrics from different rolls behave differently during production, and are therefore packed separately during packaging prior to sending to the retailers. Most companies liaise with both supplier and customer, to the mutual benefit of both.

When asked about the main obstacles preventing them from sourcing garments locally, most retailers agreed that local labour costs are too high, productivity is not good and that there were gaps in terms of designing aspects when it comes to embroideries and embellishments, factors which are now so popular for garments.

On the basis of the responses to the questionnaires and interviews, the data were collated, integrated and statistically analysed, graphically presented and interpreted, drawing the appropriate conclusions and relevant recommendations. The individual responses were quantified as (converted into) percentages, on the basis of the option(s) selected for each question. The main conclusions that can be drawn from the responses to the questionnaires are as follows:

- All the respondents (i.e. 100%) expressed the view that quality means conformance to requirements and meeting customer needs with some retailers also commenting that quality can be taken as “fit for use” or “fit for purpose”.
- The majority of the responses agreed that quality represents a major, if not the main, criterion in product benchmarking, only a few felt it is supplier dependent. It was also noted that quality can be broken down into many factors, like fabric quality, quality of workmanship, etc.
- The responses of the retailers and manufacturers, in terms of the role of quality in merchandising can be summarized as follows:- Satisfying the consumer expectations in terms of the end product, increasing sales and customer satisfaction and best portraying
and positioning their products during visual merchandising in stores and in the media and magazines etc.

- All the respondents agreed to the fact that merchandising and quality complement each other, and with proper quality assessment, the merchandising workflow process becomes smooth and easy, resulting in the timely delivery of products of the desired quality. Therefore, quality plays a vital role in the apparel merchandising process and clothing pipeline in its entirety.

- Only 17% of the overall responses were in favour of merchandising and quality as being independent of each other, the majority (83%) response being that merchandising and quality are very much interdependent in satisfying customer requirements. With proper quality control, the chances of defective garments being produced and reaching the customer are considerably less and can products be produced of the required standard, and also result in the timely delivery of quality products, thereby minimising returns, claims and costs.

- All the respondents (100%) selected the option that consumers buy garments mainly in terms of price, quality, design and appeal of the product. All these are inter-related and affect the choices exercised by the customers.

- Some 50% of the responses reflected the fact that fabric testing was done by the supplier; with the standards being set by the customer (i.e. manufacturers and retailers) for the testing procedures, hence the supplier follows the standards. If, however, there is any garment testing done, especially related to laundering, then it is virtually always done in-house.

- The external laboratories most often used by retailers and manufacturers were SGS and ITS, some of the retailers having their preferred laboratories which do their testing; else it is done by the supplier. For the manufacturers, testing is done outside, mostly also by ITS and SGS, some of them occasionally do it through other organizations, such as the CSIR. Over 20% of the responses were for “other”, most of which represented the “suppliers” or another testing house or laboratory where the tests were carried out.

- In all, some 67% of responses indicated that strength, colourfastness, care labels and dimensional stability are all monitored on a routine basis, reflecting the critical importance of quality in garment making, and the fact that retailers and manufacturers are
very particular about the quality of the product they sell to their target market. Only a
very small percentage of the responses were in terms of a specific test only, such as
dimensional stability.

- Some 50% of the responses opted for all four strength related tests listed, namely as
tensile, tearing, bursting and seam strength, 30% selecting seam strength/slippage
specifically. These tests are of particular importance for fabrics destined for shirtings,
blouses and interlinings.

- In all, 33% of the responses perform all the colourfastness tests listed, namely
colourfastness to rubbing, perspiration, water and chlorine/sea water. Some 32% of the
responses regarded the colourfastness to the rubbing test as very important since it is an
important measure of the loss in appearance and wear life of a garment in practice,
indicating the propensity for a fabric or garment to lose colour or become shiny during
wear.

- Some 37% of the responses also favoured tests, such as dimensional stability, abrasion
resistance and pilling, certain of these tests also being selected on an individual basis.
Therefore, in total, close on 80% of the responses selected one or more of these tests as
being performed regularly.

- Some 50% of the responses indicated that their own quality management systems and
monitoring were followed and not those quality management systems listed, such as
TQM or Six Sigma. Two of the manufacturers applied TQM in all aspects of quality,
from raw material to monitoring customer returns. A few retailers reported that they have
developed their own specific system which monitors all aspects of quality, from raw
material up to and including monitoring customer returns.

- Only 17% of the respondents, representing 2 manufacturers, use, or have used, FOM,
namely the FAST system, for fabric quality evaluation, 50% of the respondents not even
being aware of this form of quality testing. It is very surprising to learn that so many
companies haven’t even heard of the FAST or Kawabata system of FOM. It is perhaps
worth mentioning that FOM as yet finds little application for knitted fabrics.

- All the respondents, except one, employ (or manufacture) either woven or knitted fabrics,
or both, with 10 employing woven fabrics (2 of which employing only woven fabrics), 7
employing knitted fabrics (1 of which employing only knitted fabrics) and two
manufacturers employing both non-woven and woven fabrics. In terms of the overall percentage responses, woven fabrics scored 50%, knitted fabrics 33% and non-wovens 8%. Non-wovens find very little utility in garment manufacture, being almost solely used in interlinings for suitings, jackets etc.

- All the retailers responded that they cover all the types of garments listed as well as accessories. All of the manufacturers, except one, were involved in menswear, three in children’s wear (kids wear), five of the manufacturers also being involved in ladieswear. In terms of percentage responses, 41% (representing all the retailers) were for all types of garments, 30% for menswear, 17% for ladieswear and 10% for children’s wear. Only one manufacturer is involved in accessories.

- Only 50% of the respondents consisting of five out of the seven manufacturers and only one out of the five retailers stated that they plan to introduce new tests in the near future. Although not explicitly stated, one of the new tests being contemplated could be FOM, such as the FAST, which is fairly simple, reliable and productive, and could enhance the quality of the fabric and garment. By introducing this test they could improve their competitiveness, locally as well as internationally, particularly in the higher quality end of the market. The fact that retailers did not plan to introduce any new tests may be because they largely rely on their suppliers to do and introduce the relevant tests necessary for a particular fabric and/or garment.

Trubok in Newcastle, is at present the only manufacturer in South Africa that actively uses FOM, namely the FAST system, for quality control purposes, before sending the fabric for bulk production. Hence a special visit was paid to Trubok, to understand their application of this system of testing and the value they derive from it. In order to obtain hands on experience with the FAST system as operated in their laboratory, two widely different types of fabrics, in production at the time, namely 100% polyester and a blend of 65% polyester and 35% wool, were selected and tested on the three FAST instruments, FAST -1, FAST -2 and FAST- 3. The blend fabric exhibited low shear rigidity, which indicates that the lay may require pinning, tailoring fabrics of this weight generally requiring considerable care, particularly in cutting and sewing, and shoulder seams. The 100% polyester fabric FAST fingerprint indicated potential problems during making up, as the warp and weft hygral expansion are low. Warp and weft
formability being low, makes the fabric more prone to seam puckering and poor seam performance, which could create difficulty during sleeve insertion. The low warp extensibility of the fabric indicates that difficulty may be experienced with overfed seams and moulding of the fabric. Potential cutting and sewing difficulties may also arise as the weft bending rigidity is low. The user friendly nature and most useful and valuable information and data generated by the FAST system were confirmed during the experimental work at Trubok.

The following conclusions were drawn from the statistical analysis of the questionnaire responses using the F-test and t-test:

- Both retailers and manufacturers agreed that quality and merchandising are interrelated and help in achieving product benchmarking.
- Since the types of testing and test methods are different for the retailers and manufacturers depending on product price and quality, and since the testing can also be done in-house and/or by outside laboratories according to the need of the fabric or garment, most of the responses are different with no particular testing method or laboratory being used by all. Therefore, getting a uniform response from the retailers and manufacturers was difficult, the responses of the retailers and manufacturers differing statistically significantly in this respect.
- Both retailers and manufacturers conduct fabric and garment tests as per the required standards, this being statistically significant at the 95% confidence level.
- Both retailers and manufacturers conduct fabric and garment tests on a regular/routine basis and their responses are statistically the same, at the 95% confidence level.
- Retailers and manufacturers mostly follow their own quality management systems and are involved in, or use, mostly knitted and woven fabrics in garment making.

What the above results of the statistical analysis imply, is that in most of the above mentioned factors, the responses of the retailers and manufacturers were similar and did not differ significantly at the 95% confidence level.
The information and data supplied by the global manufacturers and suppliers of the Kawabata and FAST systems were compiled and classified according to the institutions which acquired them. According to the FOM survey, it emerged that there are some 78 Kawabata systems in place in 16 countries, most (45) being in Asia, followed by Europe (20). Most of the systems (47) are in place in research and educational institutions, which could be ascribed to the high cost and sophistication (complexity) of this system of testing. There are some 121 FAST systems in place in 31 countries, most (47) in Europe, followed by Asia (43). Most (70) FAST systems are used by companies which reflects the relatively low cost, user friendly and practical industrial application of this system, in contrast to the Kawabata system. It emerged that, South Africa, as a country, lags behind most other countries in terms of the use of FOM. Only two companies in South Africa own FAST systems, one of which is no longer in use, since the company has changed its area of operation, from manufacturing to retailing.

From the questionnaire and interview responses it emerged that, although most of the relevant standard apparel quality related tests were being carried out, such as strength and colourfastness tests etc. by the retailers and manufacturers, only one company applies FOM. The latter is important for formal types of apparel fabrics and could be reflected in problems during garment making up, such as seam pucker and laying and cutting, as well as garment dimensional stability (e.g. hygral expansion) and appearance during wear.
RECOMMENDATIONS

AND

SCOPE FOR FURTHER STUDY
7. Recommendations and Scope for Further Study

Recommendations

- Where appropriate and desirable, companies need to become familiar with FOM, and its advantages as a quality control measure, and apply it as appropriate in terms of the apparel products.
- More technically trained employees should be brought onto the production floor, which would result in better quality product in minimum time.
- Strengthening the textile and clothing sector.

Scope for Further Study

- A more comprehensive study needs to be undertaken in each of the different clothing segments, namely menswear, ladieswear, children’s wear, etc. with a focus on the potential value of the application of FOM in each segment and each specific product line.
- A comparative study can be undertaken of the relative merits of the FAST and Kawabata systems, taking into account different fabric types e.g. suitings, shirtings and dress materials.
- An in-depth study can also be undertaken on the application and value of FAST in fabric finishing, particularly within the South African context.
- A more in-depth study of specific FOM related quality issues facing local fabric and clothing manufacturers, particularly also as identified by retailers, needs to be undertaken so as to identify and precisely define the potential application and value of FOM in improving the quality and quality consistency of locally produced fabrics and garments. This could serve to improve the global competitiveness of South African fabric and garment manufacturers, particularly in the less price sensitive, high quality, top end of the market, and which could also serve to further beneficiate and use the high quality wool and mohair produced locally.
REFERENCES
8. References


Cape Clothing and Textile Cluster (2009), Available from http://www.capeclothingcluster.org.za/index/contents/view/1


Fan J (1995), A guide for the selection and use of fusible interlinings for constructed wool garments, Division of Textile Technology, CSIR, South Africa.


Ito K and Kawabata S (1986), Objective measurement: applications to product design and process control (editors: S Kawabata, R Postle and M Niwa), The Textile Machinery Society, Japan, 175.


Kumar M K (2009), ‘Professional approach key to successful apparel merchandising,’ Text Mazi, 50(11), 53-55.


Mabugu R E (2004), South Africa: Dynamic effects on trade liberalization - Results from an Inter-temporal CGE model with Perfect Foresight, Centre for Environmental Economics and Policy in Africa, University of Pretoria.


Morris M, Barnes J and Esselaar J (2005), *An identification of strategic interventions at the Provincial Government level to secure the growth and development of the Western Cape Clothing and Textiles Industries*.


SiroFAST Instruction Manual (1989), CSIRO.


Test manual of the Australian Wool Textile Objective Measurement Evaluation Committee.

The RATES Center (2005), Cotton-textile-apparel value chain report South Africa, Nairobi, Kenya.


http://tradingeconomics.com/south-africa/indicators
http://www.asgisa-ec.co.za/
http://www.southafrica.info/news/
http://www.emergingtextiles.com/2010-11
http://www.eastafrica.usaid.gov/
http://www.mbendi.com/
http://www.agoa.info/, http://www.agoa.info/?view=country_info&country=za
http://www.capewools.co.za/index/annual statistics
http://www.cottonsa.org.za/
http://pals.co.za/, http://pals.co.za/products.htm,
http://www.cecilaron.co.za/, http://www.cecilaron.co.za/about-us
http://monatic.co.za/
http://www.tradeinvestsa.co.za/pls/cms/active_pages
http://en.wikipedia.org/wiki/AGOA
http://www.google.com/images
http://www.fastmoving.co.za/news/retailer-news-16
http://www.fastmoving.co.za/retailers/retailer-profiles-132/the-foschini-group-204
http://www.truworths.co.za/about-us
http://www.edcon.co.za/AboutEdcon/CompanyProfile.aspx
http://www.mrprice.com/
http://www.pepstores.com/, http://www.pepkor.co.za
http://www.ackermans.co.za/
http://www.fibre2fashion.com/
http://www.isc.hbs.edu/pdf/Student.../SouthAfrica_Textiles_2009
http://www.theretailer.co.za/
http://www.gogoindia.com
http://www.itec-innovation.com/
http://www.keskato.co.jp
http://npconline.co.za
ANNEXURE
9. Annexure

Questionnaire (Please mark one or more of the options provided for each question)

9.1 Sample Questionnaire

1. Quality means
   a) conformance to requirements
   b) meeting customer needs
   c) both
   d) none

   Comments (if any):

2. What is the role of quality in product benchmarking?
   a) Major criteria
   b) Minor criteria
   c) Supplier dependent
   d) Other

   Comments (if any):

3. Where is the fabric and garment testing done, for your company?
   a) In-house
   b) Testing house
   c) By supplier
   d) All
   e) Other
Comments (if any):

4. Which quality testing is done by the company and those by the supplier?

a) Fabric
b) Garment
c) Both
d) Other

Comments (if any):

5. Which independent/accredited outside laboratory are used for quality testing and to what extent?

<table>
<thead>
<tr>
<th></th>
<th>Regularly</th>
<th>Occasionally</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>ITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>SGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>CSIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Other *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Please name:

6. Which methods do you follow during testing?

<table>
<thead>
<tr>
<th></th>
<th>Generally</th>
<th>Monthly</th>
<th>Occasionally</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>ASTM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>ISO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>SABS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. Which fabric and garment quality attributes are monitored on a regular/routine basis, and by whom?

a) Strength
b) Colour fastness
c) Care labels
d) Dimensional stability
e) All
f) Other

Comments (if any):

8. Which fabric strength tests do you undertake?

a) Tensile strength
b) Tearing strength
c) Bursting strength
d) Seam strength/slippage
e) All

Comments (if any):

9. Which colourfastness tests are performed?

a) Colourfastness to rubbing
b) Colourfastness to perspiration
c) Colourfastness to water
d) Colourfastness to chlorine/sea water
10. What other tests are performed?

a) Dimensional stability
b) Pilling resistance
c) Abrasion resistance
d) All
e) Other*

*Please name:

11. Which quality management systems do you apply?

a) TQM (Total Quality Management)
b) Six Sigma
c) Kaizen
d) None
e) Other*

*Please name:

12. Do you utilise any Fabric Objective Evaluation tests?

a) Yes
b) FAST
c) Kawabata
d) No
e) Not familiar with such tests
Comments (if any):

13. If yes, to question no 12, for which garment types do you mostly do so?

a) Ladies wear
b) Kids wear
c) Menswear
d) Other

14. Which is the most common fabric you employ in garment making?

a) Woven
b) Knitted
c) Non-woven
d) Other

Comments (if any)

15. Which type of garment do you mostly manufacture?

a) Menswear
b) Kids wear
c) Ladieswear
d) Accessories
e) All of the above

16. The role of quality in merchandising –

17. Does the merchandising process benefit from the quality assessments of garments?
18. Are merchandising and quality interdependent in satisfying customer requirements?

a) Very much
b) To some extent
c) Independent of each other
d) No

19. Your customers buy these garments mainly in terms of –

a) Price
b) Quality
c) Design and appeal
d) All of the above

20. Do you plan to introduce any new fabric/garment tests within the near future?

a) Yes*
b) No

*If yes, please name them.
### 9.2 Individual Responses to Each of the Questions framed in the Questionnaire

<table>
<thead>
<tr>
<th>Qn 1</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 2</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 3</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 4</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 5</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>50</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>100</td>
<td>0</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Qn 6</td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
<td>R4</td>
<td>R5</td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
<td>M4</td>
<td>M5</td>
<td>M6</td>
<td>M7</td>
</tr>
<tr>
<td>------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>50</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>50</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td>0</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 7</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>33</td>
</tr>
<tr>
<td>e</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 8</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>33</td>
<td>0</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>e</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 9</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>33</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 10</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>Qn 11</td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
<td>R4</td>
<td>R5</td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
<td>M4</td>
<td>M5</td>
<td>M6</td>
<td>M7</td>
</tr>
<tr>
<td>-------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 12</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 13</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 14</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>b</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 15</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>33</td>
<td>33</td>
<td>50</td>
<td>33</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>33</td>
<td>33</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>33</td>
<td>33</td>
<td>50</td>
<td>33</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>e</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Qn 17</td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
<td>R4</td>
<td>R5</td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
<td>M4</td>
<td>M5</td>
<td>M6</td>
<td>M7</td>
</tr>
<tr>
<td>-------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>a</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 18</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 19</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qn 20</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>b</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

R: Retailer and M: Manufacturer