Fibre Substitution in the Chinese Textile Industry

by

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Declaration

This dissertation was written while I was studying at the Australia-Japan Research Centre at the Australian National University. The opinions expressed are my own, unless otherwise indicated.

LU Weiguo
July 1994
Acknowledgments

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This thesis examines the dramatic changes that have taken place in fibre substitution trends in China's rapidly growing textile industry. It presents a systematic analysis of a wide range of factors that may have affected textile mills' choice of fibre inputs. The empirical study is greatly facilitated by a survey of Chinese textile manufacturers conducted by the author in 1992.

Mills' demand for fibres is derived from domestic and foreign demand for textile and clothing products. The thesis uses both descriptive and statistical tools to define the fibre substitution path at end-use level as the Chinese economy grows. It is shown that demand for wool products, especially in the textile and clothing markets, is highly responsive to income growth, and that the changes that have taken place in the fibre composition of exported products conform closely with the relative strength of comparative advantage developed by China since the adoption of an open door policy.

Technological change affects fibre substitution mainly through diffusion. Application of the standard logistic diffusion model to data on aggregate wool and cotton shares indicates that chemical fibres have already gained most of their potential market share in the wool sector, while cotton may be subject to tougher competition from synthetics in the years ahead.

Once the impact of technological diffusion loses its momentum, price competition becomes important, especially as Chinese firms have indeed become more profit- and market-oriented as a result of economic reform. With behavioural change in state firms, the development of fibre markets and the hardening of firms' budget constraint, neoclassical demand models can be applied to the measurement of price responsiveness and competition between fibres in the Chinese textile industry.

A dynamic translog cost model is applied to mills' consumption data to analyse price-induced fibre substitution in the Chinese wool textile industry. The results indicate that mills' demand for wool is responsive to a change in prices. The price elasticity of demand for wool is found to be -0.2 in the short run, but higher in the long run (-0.52). There is also heavy price competition between wool and chemical fibres, with cross-price
elasticity of demand for chemical fibres estimated at 0.53 in the short run and 1.37 in the long run.

Attention is also given to the impact of policy on fibre demand and substitution. The focus is on the fibre self-sufficiency policy, from which many other policies are derived. Analysis has shown that fibre self-sufficiency inevitably falls as an economy grows in the case of a resource-poor and/or densely populated country such as China. The faster decline in China's wool than cotton self-sufficiency increased the government's determination to impose a fibre substitution policy on the wool textile industry, thereby contributing to a heavier substitution of chemical fibres into wool than cotton. The study also shows that the relative importance of various trade and foreign exchange restrictions has varied over time and that wool has borne the brunt of these restrictions.

In an attempt to gain a fuller understanding of fibre substitution in the Chinese textile industry, the dissertation takes a further step: identifying all the factors that could possibly be considered influential in manufacturers' choice of fibres. This is achieved mainly through a survey of selected Chinese textile manufacturers. Although some of the survey results merely confirm previous empirical findings, others provide fresh information of value to foreign supplying countries.

Some important strategic implications can be drawn from the study for fibre supplying countries, and especially for Australia as a major wool supplier. Both challenges and opportunities exist. If appropriate action is taken at this critical time, it may be possible for wool to realise its market potential in China.
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1 Perspectives

Over the past decade or so, there has been a significant increase in China’s demand for textile fibres and a dramatic change in the fibre mix. A distinct feature of these changes has been the widespread use of man-made fibres, especially synthetics, in textile production. Despite this, the key parameters of the variables influencing fibre substitution remain unknown. This has made it difficult for suppliers of fibres such as Australia to design appropriate marketing strategies. As wool is a major export commodity for Australia, and in view of the continuing adjustment in the Australian wool industry, the importance of studying fibre consumption and substitution in a large and promising market like China is self-evident.

Studies of fibre substitution in the Chinese textile industry have tended to be general in nature and are, therefore, of limited value. They have mostly been confined to discussion of income effects (Byron 1992; Anderson and Park 1992) and issues surrounding the supply of raw materials (Findlay and Watson 1992; Garnaut 1989). Other important factors — such as the impact of technological diffusion, the role of relative prices in fibre substitution, and the effects of government policy on all of these — have received little attention in the literature, either because of the lack of an explicit analytical framework or because detailed and consistent data were simply not available.

This dissertation provides a consistent analytical framework within which the issue of fibre substitution can be addressed effectively. The empirical study is largely facilitated by a survey of selected Chinese textile mills. The survey was designed by the author and carried out by the former Ministry of Textile Industry in 1992 (Appendix 1.1). The study gives, for the first time, a set of estimates for the key substitution parameters of interest. These estimates may prove crucial in the formulation of effective policy and marketing strategies.

1 These are called chemical fibres in the Chinese literature. Broadly speaking they consist of two types of fibres, cellulosics and non-cellulosics (synthetics). The former are produced from plant matter and the latter by polymerisation of chemical substances derived from coal and petroleum oil.
TRENDS IN FIBRE DEMAND AND SUBSTITUTION IN CHINA

Since the late 1970s, when far-reaching reform to economic policy was initiated, China has experienced a significant increase in demand for textile fibres. Much of this growth can be attributed to a rapid rise in household income and a surge in demand from abroad for textile and clothing products. In China, per capita consumption of fibres (cotton, wool, man-made fibres and other fibres such as silk, flax and ramie) rose from 2.88 kg in 1978 to 5.70 kg in 1991 (Table 1.1). Consumption of man-made fibres more than trebled during the period. There was also a noticeable increase in per capita consumption of wool, which more than doubled. The rate of growth of cotton consumption was much slower, leading to a large fall in cotton’s share of total per capita fibre consumption.

Table 1.1  Per Capita Consumption of Fibres\(^a\), 1978-91

<table>
<thead>
<tr>
<th>Year</th>
<th>Cotton (kg)</th>
<th>Share (%)</th>
<th>Wool (kg)</th>
<th>Share (%)</th>
<th>Man-made fibres (kg)</th>
<th>Share (%)</th>
<th>Other(^b) (kg)</th>
<th>Share (%)</th>
<th>Total (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>2.33</td>
<td>80.90</td>
<td>0.08</td>
<td>2.78</td>
<td>0.43</td>
<td>14.93</td>
<td>0.04</td>
<td>1.39</td>
<td>2.88</td>
</tr>
<tr>
<td>1980</td>
<td>2.63</td>
<td>75.36</td>
<td>0.10</td>
<td>2.87</td>
<td>0.73</td>
<td>20.92</td>
<td>0.03</td>
<td>0.86</td>
<td>3.49</td>
</tr>
<tr>
<td>1985</td>
<td>2.69</td>
<td>66.09</td>
<td>0.16</td>
<td>3.93</td>
<td>1.09</td>
<td>26.78</td>
<td>0.13</td>
<td>3.19</td>
<td>4.07</td>
</tr>
<tr>
<td>1990</td>
<td>3.52</td>
<td>63.54</td>
<td>0.19</td>
<td>3.43</td>
<td>1.69</td>
<td>30.51</td>
<td>0.14</td>
<td>2.53</td>
<td>5.54</td>
</tr>
<tr>
<td>1991</td>
<td>3.56</td>
<td>62.45</td>
<td>0.23</td>
<td>4.04</td>
<td>1.73</td>
<td>30.35</td>
<td>0.18</td>
<td>3.16</td>
<td>5.70</td>
</tr>
</tbody>
</table>

Notes: \(^a\) This is equivalent to “per capita fibre allocation” in the Chinese official publications.
Exported fibres and fibre products were included.
\(^b\) ‘Other’ fibres include silk, flax and ramie.


The textile industry’s demand for fibres is derived from domestic and foreign demand for textile and clothing products. During 1978-92, the value of domestic retail sales of textile and clothing products in China rose from 27.9 billion RMB yuan to 158.2 billion RMB yuan, an average annual increase of 13 per cent (Statistical Yearbook of China 1993, p. 616). Textile and clothing exports expanded at an even faster rate,
recording an average annual growth rate of more than 16 per cent during the same period. It has been estimated that in 1992 total textile and clothing exports were worth US$24 billion, making China the world’s largest textile and clothing exporter (Far Eastern Economic Review 4 February 1993, p. 55). Surging domestic consumer demand and exports have stimulated the growth of the Chinese textile industry. From 1978 to 1990, the average annual growth rate of textile output (in constant price) was well above 8 per cent, leading to enormous increases in textile mills’ demand for fibres. As Table 1.2 shows, in the second half of the 1980s total textile mill fibre consumption (excluding the “other” category of fibres) averaged 4.62 million tons annually, an 80 per cent increase compared with the mid 1970s. Fibre composition has also changed. Whereas the share of man-made fibres rose significantly in 1970-92, wool improved its market share only marginally. The share of cotton recorded a continuous decline, although it remains a major fibre for the Chinese textile industry.

Table 1.2 Textile Mills’ Consumption of Cotton, Wool and Man-made Fibres, 1970-92

<table>
<thead>
<tr>
<th>Year</th>
<th>Cotton (’000 tons)</th>
<th>Share (%)</th>
<th>Wool (’000 tons)</th>
<th>Share (%)</th>
<th>Man-made Fibres (’000 tons)</th>
<th>Share (%)</th>
<th>Total (’000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-74</td>
<td>1,839.5</td>
<td>89.5</td>
<td>58.5</td>
<td>2.8</td>
<td>157.6</td>
<td>7.7</td>
<td>2,055.6</td>
</tr>
<tr>
<td>1975-79</td>
<td>2,134.8</td>
<td>85.2</td>
<td>76.1</td>
<td>3.0</td>
<td>295.4</td>
<td>11.8</td>
<td>2,506.3</td>
</tr>
<tr>
<td>1980-84</td>
<td>2,712.5</td>
<td>73.4</td>
<td>125.9</td>
<td>3.4</td>
<td>857.4</td>
<td>23.2</td>
<td>3,695.8</td>
</tr>
<tr>
<td>1985-89</td>
<td>3,425.8</td>
<td>74.2</td>
<td>162.1</td>
<td>3.5</td>
<td>1,030.8</td>
<td>22.3</td>
<td>4,618.7</td>
</tr>
<tr>
<td>1990</td>
<td>3,202.6</td>
<td>71.1</td>
<td>114.7</td>
<td>2.5</td>
<td>1,188.6</td>
<td>26.4</td>
<td>4,505.9</td>
</tr>
<tr>
<td>1991</td>
<td>3,297.5</td>
<td>71.5</td>
<td>144.3</td>
<td>3.1</td>
<td>1,170.5</td>
<td>25.4</td>
<td>4,612.3</td>
</tr>
<tr>
<td>1992</td>
<td>3,273.8</td>
<td>71.7</td>
<td>144.0</td>
<td>3.2</td>
<td>1,150.0</td>
<td>25.2</td>
<td>4,567.8</td>
</tr>
</tbody>
</table>

Note: Figures for 1970-74 and 1992 are estimates.

Changes in the broad patterns of fibre substitution observed in the Chinese textile industry since the early 1970s would seem to follow earlier trends experienced in Japan, Korea and Taiwan. This is best illustrated with triangular graphs. Figure 1.1 shows changes in fibre composition in China for 1970-91 and in Japan, Korea and Taiwan for 1959/61-1989, based on a threefold classification comprising wool, cotton and man-made fibres. The point corresponding to 1991 (1989 for countries other than China) is shown by the head of the arrow, whereas that corresponding to 1970 (1959/61 for other

Figure 1.1 Patterns of Mills’ Fibre Consumption in China and Other Major East Asian Textile Economies

![Triangle Graph](image)


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2 Triangular graphs are a quick screening device used for expository and pedagogic purposes (Latham 1976). They are especially helpful in dealing with the three-component mixture problem. The basic idea of triangular graphs is that any three shares summing to unity can be represented by a single point on an equilateral triangle graph. Time trends can also be shown by plotting a series of points. In our three-fibre mixture problem, a single point on the graph tells the full story of the relative importance of three fibres. A series of points plotted against a time horizon shows the time path of fibre substitution.
countries) is represented by the tail of the arrow. It is clear from the location of the heads on the graph that fibre composition in the Chinese textile industry is quite different from that in Japan, Korea and Taiwan. Textile production in China is based more on natural fibres (especially cotton) than is the case within these countries. But, as the direction of the arrow indicates, China is moving in the direction of other major East Asian economies.

One interesting question that arises is whether China, as its economy grows, will follow the Korean and Taiwanese pattern of rapid substitution into synthetics, or whether, like Japan, it will substitute into synthetics more slowly (Findlay and Watson 1992). Extrapolating from present trends, it is not difficult to see that fibre substitution in the Chinese textile industry is more likely to follow the path of substitution experienced in Korea and Taiwan. But this leaves unanswered the more fundamental question of what the underlying factors generating this outcome are.

PREVIOUS STUDIES

The intensity of the effort to find an answer to this question can be appreciated from a recently published book edited by Findlay (1992) and an earlier work by Garnaut (1989). In the introductory chapter to Findlay (1992), Findlay and Watson argue that China’s choice of fibre substitution path will depend in part on the resolution of issues surrounding the supply of natural fibres. Failure to make appropriate supply arrangements, both within China and on the world market, may well add to the pressure on the Chinese textile industry to shift to man-made fibres in textile production.

“This supply-side story has its underpinning in the differences in supply conditions between fibres and over time. Perhaps the most important difference in this respect is the constant or declining long run cost for chemical fibre production and rising cost for production of natural fibres. Because of more or less constant costs in the chemical fibre industry, the potential for increases in the supply of chemical fibres in the

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3 The book is titled *Challenges of Economic Reform and Industrial Growth: China’s Wool War*. Its eight important papers present the results of recent research on the Chinese textile industry carried out at the Australia-Japan Research Centre, the Australian National University and at the Chinese Economy Research Unit at the University of Adelaide.
long run may be higher than natural fibres. This adds another dimension to the explanation of fibre substitution in the textile industry."

Garnaut’s answer to the question places more emphasis on official policy with respect to investment in the production and utilisation of synthetic fibres. He says:

Shortages of capital would argue against China following the Republic of Korea and Taiwan into heavy use of synthetics. Shortages of foreign exchange would exert pressure in the opposite direction. Cotton may pose a larger threat than synthetics to wool’s market share (Garnaut 1989, p. 183).

On the demand side, evidence presented by Byron (1992) suggests that the potential for growth in fibre consumption in China is high. In urban areas, household demand for clothing is expected to grow at the same pace as incomes. More importantly, within household clothing budgets, the income elasticity of demand for wool is found to be higher than that for synthetics or cotton.

Trade and foreign exchange policy issues are examined in a number of previous studies (Martin 1990; Whalley 1992; Morris et al. 1993; Sun et al 1993; Wool Industry Review Committee [WIRC] 1993). These studies show that the various trade barriers currently in place restrict the growth of the Chinese textile industry and hence reduce the demand for fibres, particularly wool.

Although these studies highlight some important aspects of the fibre substitution problem in China, both from a supply and a demand perspective, none addresses exclusively or systematically the central question of this thesis. A better understanding of the underlying factors that have affected fibre substitution in the Chinese textile industry can be gained from further and more comprehensive research.

**SCOPE OF THE ANALYSIS**

Fibre substitution is a complex phenomenon having its roots in both processing and final demand. As statistical information on the latter is very scarce in China, this study essentially has to focus on the former. This limitation is qualified to some extent by the fact that there is a high correlation between fibre substitution at the processing stage and final demand; generally speaking, fibre substitution at the processing stage will reflect
changes in consumer preferences and tastes. There may even be an advantage in focusing on demand from processors. For instance, in examining the impact of technological change, it has been argued that “in the early stage of adoption of chemical fibres, it is essentially the manufacturers’ initiative rather than consumer’s choice between alternative textile fibres which governs the pattern of fibre usage” (Polasek and Powell 1964). In addition, analysis of cost structure and inter-fibre substitution in mills — the direct consumers of fibres — is of most immediate concern to foreign raw material suppliers.

As mentioned earlier, mills’ demand for fibres is derived from final demand, which is made up of domestic and foreign consumer demand for finished clothing and textiles. One important determinant of domestic final demand is income. Currently, China’s per capita income and fibre consumption are low by world standards. There is huge potential for fibre demand to grow as income rises. In addition, rising incomes are expected to lead to changes in fibre preferences. In terms of the major objectives of this study, a key concern is to examine the evolution of the pattern of demand for fibres as income rises. Although this issue was examined by Byron (1992), it was not given sufficient attention. In addition, Byron’s analysis excluded price variables for specific fibre products from the demand model due to lack of data, and the income elasticity estimates that he obtained could therefore be biased.

Export growth depends to a large extent on the competitiveness of the textile industry, although foreign demand can also exert an influence. In recent decades, there has been a major shift in comparative advantage among the East Asian countries. China now has strong comparative advantage in labour-intensive products such as textiles and clothing (Song 1993). China’s textile and clothing exports have grown rapidly, and the share of exports in total domestic textile and clothing production (in terms of fibre content) has risen significantly. As one-third of China’s textile and clothing production is exported (Kong 1992), any change in the fibre composition of exported products is bound to have an effect on the overall pattern of fibre consumption in China.

Technical change and its diffusion are also partly responsible for the changes in mill fibre consumption patterns revealed in Figure 1.1. Before major breakthroughs took
place in the manufacturing of synthetics, fibre substitution occurred mainly between
cotton and wool in a three-fibre world (cotton, wool and man-made fibres). A rise in
income almost always meant a rise in wool’s share in total fibre consumption. With the
advent of synthetics, man-made fibres with a wider range of characteristics have become
more readily available. The fibre substitution path has changed. Much of the increase in
demand for fibres as a result of a rise in income now goes to synthetic fibres. Analysis of
the impact of technological change upon fibre substitution may give some indication of
how much momentum remains to influence future fibre substitution in the Chinese textile
industry.

The effect of changes in relative prices has always been a central issue in studies
of fibre substitution. Under the previous planned economy, the role played by relative
fibre prices in fibre substitution was minor; with the development of a more market-
oriented economic system, it has increased significantly.

So far, no study has focused on price responsiveness or the degree of price
competition between fibres in the Chinese textile industry. This has made it difficult not
only for policy makers to judge policy effects (for instance, the impact on wool demand
of import tariffs and deregulation of the foreign exchange market), but also for supplying
countries to design an appropriate strategy for the fast growing Chinese market.

The technological and economic factors affecting fibre substitution are heavily
influenced by policy variables. In China, government policy has been directed at
accelerating the technological diffusion of chemical fibres and restricting fibre imports
(particularly of wool) in order to prevent fibre self-sufficiency from falling. The
government’s special concern over falling wool self-sufficiency helps explain why
chemical fibres have made a greater progress in penetrating wool than cotton market.
The effects of import restrictions (including import tariffs and quotas, and foreign
exchange controls) on the industry are, however, far less clear. For instance, whereas
Morris et al. (1993) argue that ‘the quota system acts more as a planning mechanism
than as a direct import restriction’ (Morris et al. 1993, p. 3), Sun et al. (1993) emphasise
the binding effects of quotas. These issues are relevant to our discussion of the factors
underlying fibre substitution, and there is obviously a need to re-examine them in a more comprehensive way.

Studies of fibre substitution indicate that a number of other factors may also affect manufacturers' choice of fibres. For instance, the changes in textile production technology that have accompanied the invention of new fibre materials could have an important bearing on manufacturers' ability to substitute between fibres. Textile production technology in China used to be heavily natural-fibre based, and the substitution possibilities between natural fibres and man-made fibres were limited. With the introduction of man-made fibres, technical developments in the textile production process seem to have favoured man-made fibres, and substitution possibilities between fibres appear to have increased significantly.

The instability of natural fibre prices is also identified in the literature as an important factor influencing fibre substitution. Prices of natural fibres, and particularly of wool, have varied greatly since economic reform, and this has apparently created a considerable degree of uncertainty for Chinese textile manufacturers. It is therefore of interest to provide evidence on the attitudes of yarn and fabric manufacturers to price instability and how they would react to a more stable wool price.

Analysis of the relationship between cost and output also has implications for fibre substitution. In a study of fibre substitution in the Australian wool textile industry, Tisdell and McDonald (1979) found that a majority of the firms they surveyed experienced falling direct per-unit costs as full capacity was approached. The survey also revealed that relatively more man-made fibre than wool users experienced falling direct costs per unit as full capacity was reached. As China's mills are not operating at full capacity, an examination of the industry's cost structure should prove informative about the future direction of fibre substitution.

THE ISSUES

This discussion of the determinants of fibre substitution in the Chinese textile industry forms the basis of the following more specific research questions.
• What is the general relationship between the patterns of fibre consumption and economic development? More specifically, how have changes in income affected the pattern of demand for fibres in China; and are changes in the fibre composition of exported textiles and clothing consistent with the comparative advantage that China has developed since 1978 when the open door policy was initiated?

• What has been the impact of technological change and technological diffusion upon fibre substitution in the Chinese wool and cotton textile industries, and to what extent will these continue to influence fibre substitution in the Chinese textile industry?

• What is the role of relative prices in fibre substitution and how has this been affected by economic reform? What are the price-induced substitution parameters, and what are the implications of these for marketing strategies in countries supplying natural fibres?

• How have policy variables affected fibre demand and substitution in China?

• Are there any other major factors apart from those mentioned above influencing manufacturers in their choice of fibres?

STRUCTURE OF THE THESIS

The dissertation consists of nine chapters. Chapter 2 sets out a consistent and systematic methodological framework to deal with the questions raised above. Particular attention is paid to behavioural change in Chinese textile mills as a result of economic reform and also to changes in the economic and institutional environment within which textile mills operate.

Chapter 3 relates changes in the pattern of fibre consumption to income growth and export expansion, both of which are associated with the development process. It is argued that any change in final demand for fibre products will be reflected in mills' demand pattern for fibres.
Chapter 4 investigates the impact of technological change and technological diffusion on fibre substitution in the Chinese textile industry. An S-shaped growth function is fitted to aggregate fibre share data for both the wool and cotton textile industries. This enables us not only to measure past changes in fibre usage, but also possibly to predict the future fibre consumption path of the industry.

Chapter 5 discusses three basic conditions associated with the neoclassical demand model. The key issue addressed in the chapter is whether the neoclassical demand model can be applied to a partially reformed economy. The assertion that post-reform textile mills exhibit profit maximising behaviour is restated and checked using the author's 1992 survey results. The detailed discussion that follows on the development of fibre markets and the effects of changes in budget constraint on textile enterprises in recent years also incorporates survey results.

Chapter 6 carries out an empirical investigation of price-induced fibre substitution in the Chinese wool textile industry. A dynamic translog cost model is formulated and applied to wool data collected in the 1992 survey. Both short-run and long-run price elasticities are derived.

Chapter 7 discusses at length the effects of China's self-sufficiency policy on fibre demand and substitution. The chapter examines in particular the impact of fibre substitution policy as well as trade and foreign exchange restrictions on wool demand.

Chapter 8 identifies, and ascertains the relative importance of, all the factors that could have a significant influence on manufacturers' choice of fibres, based mainly on the results of the author's 1992 survey. Although some of the results merely confirm earlier empirical findings, others provide fresh information which should be of value to supplying countries such as Australia in formulating comprehensive and successful wool marketing strategies.

The final chapter outlines the strategic implications for the international wool market of the main findings of earlier chapters.
Researchers interested in the issue of fibre substitution in China are often faced with a lack of detailed data. While some consumption data both at end-use and intermediate levels have been published, they tend to be highly aggregated. In an attempt to overcome these data limitations and facilitate empirical investigation, in 1992 I initiated a survey of selected Chinese wool textile manufacturers. This was made possible by the generous financial support of the Australian Wool Corporation and the Australia-Japan Research Centre.

The aims of the survey were: first, to study the impact of economic reform on the Chinese wool textile industry, including the development of a fibre market and changes in firms' objectives and behavioural constraint; second, to obtain evidence on factors affecting wool yarn and fabric manufacturers' choice of fibres; and third, to collect quantity and price data on mills' fibre inputs, to be used in analysing price-induced fibre substitution in the Chinese wool textile industry.

The questionnaire designed by the author, called *Questionnaire for Typical Textile Enterprises on Management and on Input-Output*, consisted of three parts, each corresponding to one of the objectives outlined above. Questions asked in the first part were based mainly on the *Enterprise Questionnaire* distributed to 400 enterprises by the State Statistical Bureau in February 1989 and a set of questionnaires used by the Joint Research Team of Chinese Township and Village Enterprises in March 1986. The second part of the questionnaire contained questions about the factors influencing yarn and fabric manufacturers' choice of fibres. Many of these questions were drawn from the *Questionnaire for Australian Yarn and Fabric Manufacturers* designed by Tisdell and McDonald (1979). The last part of the questionnaire asked for data on mills' inputs and output and associated prices.

The wool survey (which was in fact part of a larger survey including cotton textile manufacturers as well) mainly took the form of mail-outs. It was officially

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4 Also includes some manufacturers of knitted wool products.
conducted in 1992 by the Chinese Textile Industry Economics Society and the Textile Commission of the Chinese Township and Village Association under the auspices of the former Ministry of Textile Industry, with which the author had a cooperative venture.

In 1990, there were around 3,700 wool textile mills across the country, of which 600 were state-run and 3,100 were township and village enterprises. The limited availability of financial resources meant that only a small number of these firms could be included in the survey. Altogether 100 wool textile manufacturers (half of them state firms and the remaining half township and village enterprises) were sent copies of the questionnaire. Manufacturers were selected mainly from the three most important wool textile producing regions in China — Shanghai, Shandong and Jiangsu. The wool spindles installed in these regions accounted for over 40 per cent of the national total in 1990, and so it was felt that sample firms should have a certain degree of representativeness.

Of the 100 manufacturers surveyed, 46 responded. The return rate for state and rural firms was uneven, with state firms returning a higher proportion (76% or 38 firms) than rural enterprises (12% or 8 firms). Because of the low response from rural enterprises, this study concentrates on state firms. An attempt has been made, though, to include analysis of rural enterprises wherever possible.

Most returned questionnaires provided valid answers, but there were missing or invalid responses in one part of the questionnaire or another. Therefore the actual response rate for the returned questionnaires varied for different parts of the questionnaire. As Table A1.1 shows, the response rate for Part 1 was highest (92.1 per cent), followed by Part 3 (60.5 per cent). The relatively low response rate for Part 2 is in part due to the failure of many textile mills making both yarn and fabrics to respond to both of the relevant sections.

A more detailed description of the data processing procedure is given when the survey results are reported in the thesis.
<table>
<thead>
<tr>
<th>Part</th>
<th>Valid responses</th>
<th>No. of questionnaires returned</th>
<th>Response rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>35</td>
<td>38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>92.1</td>
</tr>
<tr>
<td>Part 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yarn manufacturers</td>
<td>19</td>
<td>42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.2</td>
</tr>
<tr>
<td>Fabric manufacturers</td>
<td>23</td>
<td>44&lt;sup&gt;c&lt;/sup&gt;</td>
<td>52.3</td>
</tr>
<tr>
<td>Part 3</td>
<td>23</td>
<td>38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>60.5</td>
</tr>
</tbody>
</table>

Notes:  
<sup>a</sup> State firms only.  
<sup>b</sup> Includes rural firms. Of 46 respondents, four were firms producing fabrics or knitted products only. The total number of questionnaires returned is therefore 42, rather than 46.  
<sup>c</sup> Includes rural firms. Of 46 respondents, two were firms producing yarn only. The total number of questionnaires returned is therefore 44, rather than 46.

Source: Author's 1992 survey.
In order to give a clear understanding of trends in fibre substitution in the Chinese textile industry, the key issues set out in the previous chapter are now illustrated in Figure 2.1. The upper part of Figure 2.1 gives a schematic representation of the major factors affecting final demand. Domestic demand is stipulated as a function of income, price and some other factors. Export demand is determined by the relative strength of comparative advantage and possibly also by changes in foreign consumer demand.

The lower part of Figure 2.1, which is the focus of this study, shows the major determinants of mills’ demand for fibres. This is derived first from final consumer demand for fibre products. Changes in consumer preferences as a result of, say, income growth or export expansion will affect mills’ fibre consumption patterns. Demand is
affected by technical change in the manufacture of chemical fibres, operating either independently or in conjunction with price and other factors such as policy variables. Another determinant of mills’ demand for fibres is relative prices. Changes in relative prices could lead to substitution between fibres. A fourth determinant is policy variables, which influence fibre demand and substitution in a number of ways. Other factors influencing mills’ demand for fibres include price instability and cost structure.

The main purpose of this chapter is to set up a consistent and systematic framework within which these issues can be addressed. The theoretical and methodological issues involved are discussed below.

FIBRE SUBSTITUTION AND ECONOMIC DEVELOPMENT

The experience of major East Asian textile economies suggests that changes in levels of income and in the degree of involvement in international trade are two important underlying factors influencing the path of fibre substitution. Both are associated with the development process.

Economic development in its narrowest sense means growth in income. In its early stages, economic development is often accompanied by a rapid expansion in labour-intensive manufacturing exports, such as textiles and clothing (Anderson 1992). As income rises and exports increase, demand for fibre products also increases. This in turn leads to an increase in mills’ demand for fibres.

Consumer preferences for different types of fibre products are likely to change as incomes rise. The traditional path of alteration in the fibre mix following a rise in income is a shift away from staple fibres like cotton and towards luxury fibres such as wool and silk. However, the advent of man-made fibres, especially synthetic fibres, has complicated the picture. Substitution out of cotton and even wool into synthetic fibres is now evident as income grows. These changes will be reflected in mills’ demand patterns for fibres.

The experience of development in major East Asian countries suggests that economic development necessitates, and is facilitated by, the opening up of a country to international trade. Moreover, according to standard trade and development theory, in
the early stages of industrialisation countries tend to specialise in labour-intensive goods, such as textiles and clothing products (Anderson 1992). The fibre composition of exported clothing and textiles will depend to a large extent on a country’s comparative advantage in particular fibre products.

Apart from the distinction between domestic and foreign demand, textiles can be placed in three categories according to end use: apparel, home furnishings and industrial goods. With economic growth, the importance of the apparel market tends to decline and that of the other two to increase. In the early 1980s, the relative importance of these three markets in China was 80:7:13 (Lin 1989, pp. 54-5); by the end of the 1980s, the ratio had changed to 59:19:22 (Li 1990, p. 31). In developed countries, the average ratio is about 40:30:30 (Lin 1989, p. 56). Thus it can be anticipated that there will be further change in China’s textile market as economic development proceeds. Ideally, each of these markets would be analysed in this study. Because of a lack of information, however, only consumer demand for textiles for apparel use can be examined here.

Studies of consumer demand often assume a two-stage budget procedure (Deaton and Muellbauer 1980). In the first stage, total household expenditure is allocated across a broad group of goods (food, clothing, housing etc.), while in the second stage, expenditure is allocated to individual commodities within a group (for instance, an item of clothing). As China’s consumer demand for clothing in the first stage has been well documented by Byron (1992) and others, the focus of the present study is on examining the second stage, in this case the allocation of clothing expenditure. As lack of data prevents us from using a demand system derived from utility theory (such as the Linear Expenditure System adopted by Byron), we have instead to relate consumption of different fibre products directly with income and price variables on an *ad hoc* basis.

Both cross-sectional and time-series household survey data are available for empirical investigation of the relationship between income and fibre consumption. Past analysis based on these data has often yielded different estimates of income elasticity. It is important to understand what causes these differences. In cross-sectional analysis, price and demographic variables are often taken as being fixed. This can present
problems for demand forecasting because these variables in fact often change significantly over time (Byron 1992). Although income elasticity derived on a time-series basis provides a more reliable foundation for demand prediction, failure to include price and demographic variables due to scarcity of data can still lead to bias in the income elasticity estimates. One solution is to use retail sales data, which at least enables the researcher to include an additional price variable.

Because of the difficulty of obtaining data, the analysis in this study of the export market will necessarily be rather descriptive. The discussion will show that changes in the fibre composition of exported textile and clothing products have been consistent with comparative advantage in China since the late 1970s.

**IMPACT OF TECHNOLOGICAL DIFFUSION UPON FIBRE MIX**

Another important factor that has affected and will continue to affect fibre substitution trends is the greater availability and diversity of man-made fibres. These fibres have a wider range of characteristics than ever before as a result of technological diffusion prompted by China's fibre self-sufficiency policy.

Man-made fibres were once rare in China. Until 1960, there was virtually no production of non-cellulosic fibres (synthetic fibres), although some cellulosic fibres (rayon) were available at that time as a result of earlier research efforts. Since the 1960s, however, population growth and rising incomes have created an imbalance between fibre supply and demand. The government responded by promoting the development of a synthetic fibre industry as part of a strategy to attain overall self-sufficiency in fibres. Massive amounts of money were poured into purchasing the latest equipment, and new technologies were introduced from abroad on a large scale. It was not long, therefore, before increasing quantities of man-made fibres with various new characteristics became available for mill consumption. As Figure 2.2 shows, since the mid 1970s growth in production of non-cellulosics (synthetics) has become exponential. In 1991, total

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1 According to Chian (1989), from the early 1970s to 1986, investment in technology and equipment in the Chinese chemical fibre industry was more than 2 billion RMB yuan. This constituted half of the total investment in the Chinese textile industry during that period.
production of both cellulosics and non-cellulosics was more than ten times higher than in 1975.

Figure 2.2 Production of Cellulosic and Non-cellulosic Fibres, 1960-91
('000 tons)


The introduction of man-made fibres, especially synthetic fibres, revolutionised raw fibre consumption in the Chinese textile industry. Until the mid 1970s, the share of man-made fibres in the total fibre consumption of the wool and cotton textile industries was low and relatively stable. Since then, fibre competition and substitution have intensified, mainly due to the greater availability of synthetic fibres (Figure 2.3). By the early 1990s, the share of chemical fibres in the Chinese wool textile industry had reached a record high of over 60 per cent.

That technological change has a significant impact on raw fibre usage has long been recognised by fibre marketing analysts. Several earlier studies examining fibre substitution in other countries have found that technological development combined with alterations in the properties of man-made fibres has been a major factor influencing trends in fibre competition and substitution (Tisdell and McDonald 1979; Powell et al. 1963; Polasek and Powell 1964). The main thrust of the argument here is that any change in the properties of synthetics (resulting from technical progress), whether it be an improvement of an existing function or the invention of a new characteristic, will lead
to a series of new differentiated products, and that this will boost the market share of synthetic fibres as a group.

In the case of China, it is technological diffusion, whose speed is subject to the intensity of self-sufficiency programs, that has affected fibre substitution trends. To reveal the magnitude of this impact, an S-shaped diffusion curve can be fitted to data on mills’ consumption plotted in the form of shares (Figure 2.3). The estimated parameters will give some indication of the speed of diffusion in the market and also of the ceiling that man-made fibres can be expected to reach if current technical and market conditions continue.

Figure 2.3 Share of Man-made Fibres in Total Fibre Consumption of Wool and Cotton Sectors, 1975-91 (%)

![Graph of man-made fibres in total fibre consumption](image)


The choice of an S-shaped model is based on the belief that the process by which man-made fibres gain market share can be represented by a growth curve of sigmoid shape. This S-shaped growth curve stipulates that at the initial introductory stage the innovative impact of a new textile fibre will tend to be small, but that as time goes on the rate of adoption will show signs of acceleration until it approaches the market saturation point (Polasek and Powell 1964).²

² The general theoretical justifications for adopting an S-shaped growth curve can be found in Rogers (1962), Bass (1969, 1980), Dodson and Muller (1978), Bonus (1973) and Russell (1980).
A number of S-shaped curves are potentially useful in describing the diffusional process, and choosing between competing curves is by no means an easy empirical task. The choice of model becomes easier if the process of diffusion is complete, as we can then let the data determine which curve produces the best fit (including the determination of symmetry or asymmetry). Usually, however, the researcher has to deal with an incomplete diffusion process, that is, a limited number of observations at the beginning of the diffusion process. This makes the determination of the position of the point of inflection rather difficult, as both symmetric and asymmetric curves fit equally well with the data observed.

Although techniques have been suggested for choosing between alternative curves (Gregg 1964; Bewley and Fiebig 1988), in the end it is largely a matter of speculation and educated guesswork, building on the work of similar studies (Mar-Molonero 1980). In this study the working hypothesis is that the diffusion of chemical fibres in China follows a symmetrical logistic trend, unless other competing trends can be shown to be statistically superior. The main reasons for choosing a logistic trend is that it is probably the most common S-shaped growth curve and that it has been successfully applied in previous analysis of fibre substitution (Polasek and Powell 1964; Powell et al. 1963). The logistic curve is also simple to use and, in the present context, its parameters are easier to interpret.

The impact of technological change and diffusion on the cotton and wool markets can be expected to be different in each market. As logistic trends are descriptive in nature, it is important to ask why this should be so. One possible way to account for differential impacts is to incorporate relative prices into the diffusion model, as price relativities can both accelerate the rate of adoption of new technology and affect the long-run market share of new products (Powell et al. 1963). However, in China the role of relative prices was very limited up until the mid 1980s, mainly due to the absence of a fibre market and the lack of incentives for firms to respond to changes in prices.
The issue of relative prices has become significant since 1985, when far-reaching economic reform of the Chinese industrial sector began to take effect. Reform measures allowed state enterprises greater freedom in purchasing inputs. Government also created incentives to encourage enterprises to economise on the use of inputs and to produce products for which there was a demand from consumers and other firms (Dollar 1990). According to the author’s 1992 survey of selected Chinese textile mills, textile manufacturers now place great importance on relative prices when choosing fibres.\(^3\)

Obviously, there is a need for detailed analysis of the cost-saving behaviour of textile mills and the impact this has had on fibre usage in post-reform China.

According to standard demand theory, demand for inputs will respond to changes in relative price, assuming that income (or expenditure) and all other factors influencing the buyer’s decision are given. This is shown in Figure 2.4. \(QQ'\) is the isoquant representing the substitution possibility between inputs, say wool and man-made fibres, or what we call the technical rate of substitution. The initial budget constraint is represented by a straight line, labelled \(B'\). Given budget constraint \(B'\), a firm’s cost-minimising behaviour will lead it to choose the optimal combination of fibre

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\(^3\) Refer to chapter 8 for details.
inputs at \( d_0 \). As the price of man-made fibres falls, the budget line shifts from \( B' \) to \( B'' \). Accordingly, the tangency point moves from \( d_0 \) to \( d_1 \). Demand for wool declines, and demand for man-made fibres rises.

The neoclassical model of demand assumes implicitly that a firm’s behaviour is characterised by profit maximisation (or cost minimisation). It also assumes that the supply side will present no obstacle to the satisfaction of demand (that is, that there will be no physical shortages of inputs) and that the firm’s budget constraint is hard (Kornai 1980). But how do these assumptions fit the post-reform Chinese economy?

**Firm behaviour**

For price-induced substitution to exist, firms must before all else be profit maximisers or cost minimisers. As state firms in pre-reform China were not profit maximisers, there is no point in analysing price-induced substitution during that period. With economic reform of the industrial sector, however, the situation has changed. The question is to what extent economic reform has succeeded in directing firms’ behaviour away from output maximisation and towards profit maximisation, and whether the change that has taken place is of an extent to justify study of price-induced fibre substitution in the Chinese textile industry.

Among researchers, Chinese firms’ behaviour in the post-reform era is a controversial subject. It is commonly believed that state firms have become more profit-oriented due to increases in autonomy and market orientation (Rawski 1992; Jefferson and Xu 1991; Groves et al. 1991; World Bank 1990; Perkins 1988). Evidence to support this assertion can readily be found in the results of several previous surveys, which show that there has been a significant re-ordering of firms’ objectives, with profit maximisation coming out on top. For instance, in a survey conducted in 1986 by the Chinese Institute for Economic System Reform, 359 out of 429 responding enterprises listed “improvement of efficiency and benefits” as the firm’s number one objective. “Fulfilment of production quotas” ranked eleventh (Perkins 1988, p. 616).

But researchers are less sure about whether profit maximisation is the ultimate goal of Chinese state firms; it seems that the pursuit of profit may serve more as an
avenue for increasing benefits to firm employees (Byrd and Tidrick 1987; Perkins 1988; Granick 1990; Tisdell 1993). This has led to the attempt to characterise Chinese firms’ behaviour as enterprise-welfare maximisation (Lin 1990; Hua et al. 1988). For instance, Lin (1990) describes firms’ behaviour in the post-reform economy as wage plus profit maximisation. He argues as follows. Although firms are state-owned, they are managed by workers or, more specifically, by managers elected by workers (in most cases these appointments are ratified by the state). Managers have to put workers’ interests first because they rely on them both for their positions and to carry out the goals set in the firm’s contract with the state. Thus the primary objective of the firm tends to be to provide economic benefits to workers, namely wages and profit. The reason that managers and workers are interested in profit as well as wages is that they receive a share of the firm’s profit under the present profit retention system.

Despite the differing interpretations of state firms’ behaviour, one thing is evident: the profit mechanism is operating in the Chinese industrial sector. Incentives exist for firms to respond to price signals and to economise on production inputs, at least on raw materials (Kalirajan and Cao 1993; Jefferson and Xu 1991; Lin 1990).

**Shortage and the market**

The second assumption of the neoclassical model relates to the absence of physical shortage of the type described by Kornai (1980). In an economy experiencing shortage, forced substitutions are frequent, making the neoclassical demand model impotent.

According to Kornai (1980), the input demand function of a shortage economy is formed quite differently from the neoclassical demand function. This distinction can easily be seen in an illustration of a shopping algorithm for a particular firm (Figure 2.5). For simplicity, we assume that there is only one supplier. The firm departs from the field labelled START. We assume that there are two goods, A and B, where B is a bundle of goods that can substitute for A. We also assume that income and all other factors influencing the firm's decision on inputs are given and invariant over time. The only factor to be considered at this stage is relative price $P$, which is $P_A/P_B$. This leads to the firm’s initial demand for A. Notice that if both A and B are available, this reduces to the
The neoclassical demand model requires that observed demand be consistent with initial demand. However, in the shortage economy, observed demand usually differs from initial demand. If the neoclassical model is applied to the revised (observed) demand, the derived estimates are likely to be biased.

Shortage is a relative concept. In an economy where the market mechanism is missing, shortage develops. Shortage may be reduced or eliminated altogether using the price mechanism (Hare 1989). Therefore, a key issue to be addressed is whether the development of a fibre market in recent years has essentially eliminated physical shortages of fibres in China.

Under the highly centralised system of pre-reform China, there was no fibre market. Inputs were allocated through national planning and prices played virtually no
role in resource allocation; they were used merely for accounting purposes. Economic reform initiated in the industrial sector since the mid 1980s together with earlier reform in the rural sector has led to a significant decline in the role of the state in the production, supply and marketing of agricultural and industrial products. The market is now increasingly used as a way of allocating resources.

The introduction of the dual price system is of particular importance to resource allocation. Much discussion has focused on how the dual price system operates in China and its likely effects on resource allocation. According to Diao (1987), the two-tier price system permits the coexistence of two prices for the same commodity, one the list price set by the state and the other the fluctuating market price determined by market forces or agreed upon by the parties engaged in the transaction. The proportion of inputs and output that changes hands under the state plan is allocated, purchased, sold or distributed at prices set by the state. Any output in excess of the quota set in the state plan is sold at the market price. In this context, nearly all previous studies point to the high marginal effect of prices prevailing on the free market (among them, Jefferson and Xu 1991; Martin 1992; McMillan and Naughton 1991; Sicular 1988; Wu and Zhao 1987; Diao 1987; Byrd 1987; Tisdell 1993). This means that when incremental input or output decisions are made, what matters to the decision-makers is the market price and not the state price.¹

One implication for the present study of the development of the dual price system is that physical shortage should in theory be eliminated, because any excess demand will be cleared at the price prevailing on the secondary market. This point can be illustrated with the help of a simple supply and demand curve analysis (Figure 2.6).

In Figure 2.6, S and D represent respectively the supply and demand curves of a commodity. In a typical planning system, the state sets a quota $Q_s$ for producers paying a price $P_s$. Consumer price is set at $P_c$ for quantity $Q_c$. Excess demand, or what we call physical shortage, thus exists between $Q_s$ and $Q_c$. However, if a secondary market is allowed, the free market price will be driven up to $P_c$ for the quantity produced and

¹ Recently, Lin (1993), in examining rice supply response in China, showed that the state price is also important in determining output supply if the quota is endogenously determined.
consumed at \( Q_e \). This price has no distorting effect since it does not affect resource allocation, though it does generate a revenue transfer (Martin 1992).

**Figure 2.6** Supply and Demand in a Dual Price System

![Graph showing supply and demand in a dual price system](image)

**Budget constraint**

The last condition, which is not essential but which will affect the degree of price responsiveness, is associated with budget constraint. Standard microeconomic theory stipulates that two effects result from a change in prices: an income effect and a substitution effect. Kornai (1980) argues that under soft budget constraint "the income effect does not materialise" (1980, p. 325). This point is illustrated in Figure 2.7. Suppose a firm uses two inputs to produce output \( Q \). Given the initial budget constraint \( B_0 \), the cost-minimising point for producing \( Q_0 \) is \( A \). At point \( A \), demand for \( X \) is \( x_o \) and demand for \( Y \) is \( y_o \). When the price of \( X \) increases, the budget constraint shifts inward to \( B_I \) with a new equilibrium found at \( A_I \). At \( A_I \), demand for \( Y \) has increased from \( y_o \) to \( y_I \) and that for \( X \) has decreased from \( x_o \) to \( x_2 \). The corresponding Marshallian demand curve for \( X \) \((D_m)\) is shown in the lower diagram.
Movement from the initial cost-minimising point $A$ to the new point $A_1$ can be seen as comprising two separate effects. The substitution effect is depicted as a movement from point $A$ to point $C$ on the initial isoquant $Q_0$. The price increase would, however, create a loss of purchasing power and a consequent movement to a lower isoquant. This is the income effect.\(^5\) In the diagram, the substitution effect is represented by the distance between $X_0$ and $X_1$ and the income effect by the distance between $X_1$ and $X_2$.

In contrast to a market economy, budget constraint in planned economies is typically soft. This means that budget constraint is not binding. Suppose that, following

\(^5\) "It is assumed that firms are price takers in the output market, that is, they cannot shift the rise in costs to consumers by charging a higher price on the output market."
an increase in price, the budget constraint line shifts outward to, say, $B_s$, due to subsidies or some other form of assistance. As a consequence, the income effect following a price increase will be totally offset and the demand curve would rotate to $D_s$, which in fact becomes in this instance a Hicksian (compensated) demand curve. From the lower diagram in Figure 2.7, it is apparent that the demand curve under soft budget constraint is more inelastic than it would be under hard budget constraint.

It is worth mentioning that budget constraint also affects firm behaviour, as discussed earlier. If the budget constraint were perfectly soft then firms would probably not be attempting to maximise profits, and it is unlikely that there would be any substitution effect at all. It is thus apparent that for firms to respond to price signals, their budget constraint cannot be perfectly soft. This leads us to ask whether the budget constraint of state firms has hardened as a result of economic reform.

It would seem this has indeed been the case. Although studies have indicated that the post-reform budget constraint of state firms in China is still relatively soft, mainly due to the impossibility of bankruptcy (World Bank 1990; Perkins 1988; Tisdell 1993), there are signs that it has become harder. This is because some of the conditions which contribute to the soft budget constraint have changed. For instance, with the introduction of market forces and the Contract Management Responsibility System, the price-setting power of state firms in the sense that firms are in time able to pass on cost increases to customers (Kornai 1980) has declined significantly. State firms are now compelled to respond to price signals, even though their level of responsiveness may still be low.

In summary, the three assertions that have been made are: 1) state firms have become more profit-oriented; 2) ‘physical shortage’ has in theory been eliminated by the introduction of a secondary market; and 3) budget constraint has hardened to some extent. In order to find out whether these general assertions hold for the case of the Chinese textile industry, my 1992 survey of selected textile mills included a number of questions on firms' behaviour, market development and budget constraint. A closer look at the results of the survey adds weight and conviction to these three propositions.
RELATIVE PRICES AND FIBRE SUBSTITUTION

Having discussed the possibility of price-induced substitution, the next step is to model firms’ responses to a change in prices.

The traditional approach to determining price-induced substitution between inputs is to model producer behaviour by specifying a production function and then to set up a profit maximisation or cost minimisation problem. In early empirical research, the Cobb-Douglas production function with constant returns to scale was widely used. A limitation of this approach is that the Cobb-Douglas production function imposes \textit{a priori} restrictions on patterns of substitution among inputs. In particular, the elasticity of substitution among all inputs must be equal to one. There seems to be no particular reason to impose such a restriction on \textit{a priori} grounds.

The Constant Elasticity of Substitution (CES) production function adds flexibility to the traditional approach by treating elasticity of substitution as an unknown parameter. It is, however, still restrictive in its representation of technology, requiring the elasticity between any pair of factors to be the same. Minford (1975) investigated elasticity of substitution between textile fibres within a CES production function framework. He assumed that all firms in the industry had a CES production function that was identical in each case except for differing multiplicative “efficiency parameters”. The production function had two components; fibres and labour-capital, which had a very low elasticity of substitution between them. The problem could then be reduced to optimisation within the fibre component. Using US mill consumption data separated into 74 different end uses, Minford concluded that, while technical change and diffusion might have explained changes in fibre share for most end uses, relative price change was also an important factor.

The innovation of duality has made it possible to overcome the limitations of the traditional approach to econometric modelling. The key features of dual formulation are first that the production function is characterised by means of a dual representation such as cost function, and second, that an explicit demand function is generated as a derivative of the cost function (Jorgenson 1986). Based on the dual approach, several attempts have been made in recent years to use flexible functional forms in the analysis.
of inter-fibre substitution. These studies include Harris (1988), Budsayavith and Byron (1988) and Ball et al. (1989). Using the theory of the duality between production and cost, these authors derived a system of factor share equations based on cost minimisation. More efficient estimates of cross-price elasticities can be obtained through the use of symmetry restrictions, if factor demand is estimated within a system.

Models of demand for fibres can be grouped into two categories. The first comprises static models that consistently account for substitution among different fibres, with or without imposing strong *a priori* restrictions on the production structure (Minford 1975; Harris 1988; Budsayavith and Byron 1988). The second category comprises dynamic models that incorporate costs of adjustment. Ball et al. (1989) argued that substitution between fibres implies adjustment by textile producers, which is inherently a dynamic process. To quote: “In the near term, cost of adjustment may be high, leading to a limited set of substitution possibilities. Over a more extended time, a greater adjustment is possible, expanding the set of substitution possibilities” (Ball et al. 1989, p. 2). Ball et al. developed a dynamic system of fibre demand at the manufacturing level for the United States, Japan and Europe on the basis of a partial adjustment cost model. They adopted a translog specification which has both linear and quadratic terms with an arbitrary number of inputs. Estimates were presented of both short-run and long-run own- and cross-price elasticities of demand. For the present purpose the dynamic approach is particularly appealing because a lengthy time lag between a rise in the price of fibres and a change in demand for fibres has also been observed in China.

In investigating price-induced fibre substitution in the Chinese textile industry, this study follows Minford (1975), Budsayavith and Byron (1988), Harris (1988) and Ball et al. (1989) in assuming weak separability between capital and labour, and fibre inputs. This puts the focus solely on the fibre component of the total cost function. In view of the limitations of the Cobb-Douglas and CES specifications, I have chosen on *a priori* grounds to use a translog cost function, mainly to allow for non-restrictiveness of substitution parameters. As the Translog, Cobb-Douglas and CES models can be nested, specification tests are duly performed. To capture the dynamic nature of price-induced substitution, the partial adjustment hypothesis is introduced to both cost and share
equations. The dynamic cost model is then estimated against wool survey data, and various hypotheses are tested empirically. The results have important implications for policy makers as well as fibre promoters.

POLICY ISSUES

As discussed earlier, fibre substitution trends are also influenced by policy variables. In China, the most influential policy has been that of fibre self-sufficiency. The policy has its origins in political considerations and foreign exchange constraints. The means of achieving the self-sufficiency goal was to restrict domestic consumption (for example, through the use of rationing coupons before 1983), increase domestic production of fibres (especially chemical fibres) and restrict imports of fibres.

A notable feature of China’s fibre self-sufficiency policy has been reliance on chemical fibres. This strategy dates back to the 1960s, when the government adopted a policy of “equal attention to natural fibres and chemical fibres, with the latter as the long-term strategic solution” (Almanac of China’s Textile Industry 1990, p. 10). The implementation of this strategy led to a greater substitution of chemical for natural fibres than would otherwise have been the case.

Demand for wool has been particularly affected by the fibre self-sufficiency policy. For the past decade or more, self-sufficiency in wool has been falling at a faster rate than has self-sufficiency in cotton. In order to slow the rate of decline in wool self-sufficiency, the Chinese government accelerated the technological diffusion of chemical fibres in the Chinese wool textile industry. The diffusion rate of chemical fibres is therefore likely to be higher in the wool than cotton textile industry.

Under the previous purely planned economy, economic planning was a powerful vehicle to promote chemical fibres. China lacked comparative advantage in chemical fibres, which is a capital intensive industry. Despite this, the central planning authority was able to mobilise the resources necessary to accelerate the development of an indigenous chemical fibre industry. In order to ensure increased use of chemical fibres, planning authorities also supplied mills with the necessary inputs.
As central planning has given way to market forces, the system through which the self-sufficiency policy affects fibre demand and substitution has become increasingly complex. The government is now far more reliant on indirect control mechanisms to achieve its long-run fibre self-sufficiency goal. These mechanisms have mainly involved setting up price-raising trade barriers to depress demand for particular natural fibres, such as wool, and encouraging the use of substitutes by providing more competitively-priced chemical fibres.

The history of protection shows that import restrictions are very detrimental to demand for wool, especially in the longer run. This is evident in the case of the United States, where per capita wool consumption remains low at 0.48 kg (1992) compared with 1.45 kg in the UK, 1.61 kg in Japan and 0.76 kg in Korea (Wool Industry Review Committee 1993). It is therefore of special importance to examine the changing import regime in China, including the nature and significance of various import restriction policies.

In examining the effects of policy on fibre demand and substitution in the Chinese textile industry, the analysis will be positive rather than normative. Specifically, the study will examine how various import restriction policies (such as import quotas, tariffs and foreign exchange controls) have interacted with each other to affect fibre demand, and what the likely outcome of relaxing these policies would be.

MANUFACTURERS' CHOICE OF FIBRES

So far, some basic technological and economic factors have been discussed, along with the role of policy issues. The reality is that when textile firms select fibres, they consider a great many other factors as well. It is important to identify these if we wish to obtain a full understanding of fibre substitution in the Chinese textile industry.

Based on earlier studies of fibre substitution, Tisdell and McDonald (1979) pointed out some of the factors that significantly affect a firm's choice of fibres, including those already mentioned. They cited such factors as technological developments, relative fibre prices, relative stability of prices, promotional efforts of synthetic fibre producers, changes in consumer preferences and fashion trends, and cost.
advantages in production. Tisdell and McDonald conducted a survey of Australian textile manufacturers which, when supplemented by earlier findings, provides a clear picture of the nature of and reasons for fibre substitution in the Australian textile industry.

Tisdell and McDonald’s work establishes a firm basis for analysis of the Chinese market. My 1992 survey of selected Chinese wool textile manufacturers incorporates many questions derived from Tisdell and McDonald’s earlier questionnaire. The results will highlight the relative importance of various factors affecting fibre demand and substitution.

**SUMMARY**

This chapter has discussed the main factors likely to affect trends in fibre substitution in the Chinese textile industry. A framework for analysing these issues has been laid out.

The factors that can be considered to have the greatest impact on fibre demand and substitution at the processing level are: changes in final demand for fibre products; technological diffusion of chemical fibres; changes in relative price; and government policy. These and some other factors will be analysed in more detail in Chapters 3 to 8.
This chapter examines the relationship between mills' fibre consumption patterns and changes in income and export demand. This is done mainly by analysing the end-use market for Chinese textile products, as any changes in demand for final products will be reflected in mills' demand patterns for fibres.

One way to examine how patterns of fibre consumption change as economies develop is to compare per capita fibre consumption and per capita GNP on either a cross-country or time-series basis. Cross-country comparison is helpful in understanding how fibre consumption increases as economies grow; time-series comparison is useful in depicting trends in fibre consumption in a particular country over time.

Further insight can be gained by analysing separately the domestic and foreign markets for fibre products. In analysing the domestic market for fibre products in China, the focus is necessarily on textiles for apparel and clothing only, as information on the home furnishings and industrial goods markets is unavailable. Both household survey data and retail sales data are used to estimate various income elasticities. These elasticity estimates, when supplemented by the findings of previous researchers, provide evidence on how changes in income have affected the demand pattern of various fibre products.

Some information on the export market is available in *China's Customs Statistics*, a government publication that provides data on the fibre composition of textile and clothing exports. It will be shown that changes in fibre composition are consistent with the development of comparative advantage in China since its open door policy was initiated.

**THE RELATIONSHIP BETWEEN FIBRE CONSUMPTION AND INCOME LEVEL**

Changes in the broad pattern of fibre consumption as an economy develops are best described by comparing changes in per capita fibre consumption with changes in per
capita GNP. A cross-country comparison suggests that there is a strong relationship between fibre consumption and income (Figure 3.1); generally speaking, the higher a country's income, the higher its fibre consumption. Income elasticity of demand for fibres also differs according to income level. At lower income levels, income elasticity of demand for fibres tends to be higher, while at higher income levels, the income elasticity tends to be lower. In other words, as countries attain a certain level of income, increases in fibre consumption tend to level off.

Figure 3.1 Cross-country Comparison of Per Capita Fibre Consumption and Per Capita Income

Source: MacPhee 1989, p. 89.

China's per capita income is low by world standards. In 1991, per capita GNP was US$323, compared with US$223 in 1978. This slow growth in per capita GNP in US dollar terms has mainly been a result of adverse movements in the RMB Yuan-US dollar exchange rate during the 1980s. According to Ma and Garnaut (1992), current Chinese GNP needs to be adjusted upward by a factor of two or three based on a comparative analysis of food consumption patterns in China and Taiwan. When this adjustment is taken into account, China would follow more closely the fibre consumption path revealed in Figure 3.1, the implication being that income elasticity of demand for fibres in China may already have started to decline.
The evidence suggests that this is indeed so. Gong (1990) found that in 1970-80 the per capita income elasticity of demand for fibres was 0.94. A comparable exercise in this study finds that income elasticity declined to 0.63 in 1980-90. It can be anticipated that income elasticity will decline further as the Chinese economy grows.

A thorough understanding of fibre substitution as income grows requires disaggregation of total income elasticity into elasticities for particular fibres. Figure 3.2 correlates per capita consumption of different types of fibres with per capita real income. As both the consumption and income variables are measured in logarithm scale, slopes can be interpreted in elasticity terms. It is immediately apparent from Figure 3.2 that chemical fibres are most elastic with respect to income growth, followed by wool and cotton. A simple regression based on double log specifications using the same data

Figure 3.2 China's Per Capita Fibre Consumption and Per Capita Real Income, 1978-90

![Graph showing per capita consumption of different fibres vs. per capita real income](image)

**Note:** Real per capita income is obtained by deflating per capita GNP using a GNP deflator. Both variables are measured in the logarithm scale.

**Sources:** *Statistical Yearbook of China* 1991; *Almanac of China's Textile Industry* 1982-92.

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1 The method that Gong (1992) used was percentage change in consumption divided by percentage change in real income for two different points in time.

2 Apparent fibre consumption (including exported products) divided by total population.
set confirms this finding statistically: income elasticity is 1.31 for chemical fibres, 1 for wool and 0.45 for cotton. In other words, if this relationship holds in the future, every 1 per cent increase in real per capita GNP will result in a 1 per cent increase in per capita wool consumption.

The above approach, though useful in giving a broad picture of the relationship between fibre consumption and income, obscures the distinction between domestic and foreign markets. Obviously, it is more informative to treat these two markets separately, as the determinants of each are different.

**APPAREL TEXTILE AND CLOTHING CONSUMPTION**

The domestic end-use market for textiles can be classified into three submarkets: apparel, home furnishings and industrial goods. As information about the latter two is very limited, our analysis has to be confined to apparel textiles and clothing only.

**Review of previous studies**

In analysis of consumer demand, a two-stage budgeting procedure (Deaton and Muellbauer 1980) is often assumed. In the first stage, total expenditure is allocated among a broad groups of goods (for instance, food, clothing and housing); in the second stage, group expenditure (for instance, on clothing) is allocated among individual commodities. Most empirical studies on consumer demand for fibre products in China have focused on the first stage. For instance, Gong (1990) found that the income elasticity of demand for clothing in urban China declined from 1.46 in 1957-78 to 1.18 in 1978-83. Another study was carried out by Byron (1992), who applied the Linear Expenditure System to a panel of Chinese urban household survey data for 1982-87. Byron found that the income (expenditure) elasticity for clothing in China had declined further to about one, indicating that increases in demand for fibre products had kept pace with rises in income. Lu (1989), who made a similar attempt to estimate the income elasticity of demand for clothing in rural China, obtained an income elasticity estimate of 0.66 for the period 1978-87. This estimate is relatively low compared with Gong’s
estimates for rural areas of 0.77 for 1978-83 and 0.86 for 1957-78. These findings are consistent with the trend for income elasticity to decline on a per capita basis.

It is worth noting that the absolute value of income elasticity of demand for clothing in rural areas of China is lower than that in urban areas. This seems to be at odds with our earlier assertion that at lower income levels income elasticity tends to be higher. The explanation may lie in distortions in the welfare system in urban China. In urban areas many items (such as health care, education and housing) were either free or subsidised. However, these items were subject to allocation. A higher proportion of increases in disposable income was therefore likely to be spent on other items including clothing, and this could have led to an overestimated income elasticity of demand for clothing in urban China. Thus when predicting future changes in income elasticity of urban household demand for clothing, researchers will need to consider how substitution between different commodity groups has been and will be affected by reform of the urban welfare system (Gong 1990), while maintaining income as an important explanatory variable. “In the case of rural areas, the absence of a welfare system such as that in place in urban areas means that there is no bias effect on demand pattern for clothing. Moreover, there are possibly some data problems in analysing clothing purchases since peasants may purchase textile and clothing products during visits to urban centres and it is quite popular to have fabrics and clothing home made in some of the rural areas.”

A more interesting and relevant topic for this study is how consumers allocate their clothing budget to different types of fibre products. Unfortunately, lack of systematic information has so far made it difficult for researchers to employ demand models derived directly from utility functions. Instead, household purchases of individual items have been related directly to total expenditure (income) on an ad hoc basis. For example, Byron (1992) undertook a descriptive analysis of the relationship between clothing consumption by fibre type and income level, based on survey data provided by Lu et al. (1985). Byron found that purchases of wool clothing by households were most

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3 These were 1982 survey data on the average monthly commodity purchases on a per capita basis of Beijing staff-and-worker households (Lu et al. 1985, p. 23).
responsive to changes in income level, followed by synthetic fibres and cotton. Byron (1992) also attempted to estimate income elasticities for different fibre products in urban China based on a pooled regression analysis. His conclusion was that:

... the income elasticities for wool cloth, woollen fabric clothes and knitted wool items are high, and in fact it is fairly safe to conclude they are greater than one. Cotton items appear to have low income elasticities, synthetics somewhat higher, and silk and satins rank with wool in elasticity terms (Byron 1992, p. 33).

Some new evidence

The main purpose of this section is to examine how consumers allocate their clothing budget to different types of fibre products. The sketchy nature of Chinese data means that we will have to relate household purchases of specific fibre products directly to household income, as did Byron.

Demand analysis can be based either on cross-sectional or time-series/pooled survey data. As Byron used pooled household survey data, the present study will focus on single cross-sectional and time-series household demand analysis. The results will then be compared with those of Byron.

An examination of earlier empirical demand studies shows that analysis based on cross-sectional and time-series data is likely to yield different elasticity estimates. In order to understand the sources of these differences, we need to examine carefully the assumptions involved in household demand analysis. In cross-sectional analysis, it is often assumed that prices are constant, that is, that households in different income groups pay the same prices. The demographic characteristics of different income groups are also assumed to be the same. These assumptions are generally considered to be reasonable and are accepted in empirical studies on household demand.

However, the introduction of these assumptions into time-series or pooled time-series demand analysis may cause serious problems if prices and demographic factors have changed greatly over time. In many earlier studies of household demand (Byron’s, for instance), the introduction of these assumptions was a matter more of necessity (due to lack of data) than of ignorance of the potential problems involved. The consequences,
however, are the same: the derived estimates of income elasticity are likely to be biased, creating potential problems for demand forecasting.

There is some evidence to show that demand for fibre products in China is sensitive to changes in price, although the demographic effects are hard to assess. Li (1992), for instance, demonstrated that rural demand for fibre products is fairly responsive to changes in prices. As Li showed, in 1978-90 the general price index for cotton fabrics in China more than doubled, while per capita annual consumption of cotton fabrics in rural areas decreased from 5.66 metres to 0.9 metres. Another example is chemical fibre fabrics. In 1978-87, the price of chemical fibre fabrics declined, especially in the last three years of the period. Annual per capita consumption of chemical fibre fabrics, meanwhile, rose from 0.41 metres to 2.28 metres. Since 1988, the price of chemical fibre fabrics has risen and per capita consumption has dropped to 1.74 metres in 1990.

The above discussion indicates that, when using time-series data to estimate income elasticities, we should at least take into account changes in the prices of fibre products; derived income elasticities could otherwise be seriously biased. Unfortunately, as price variables compatible with household survey data are not available, we will have to resort to using other forms of data. Retail sales data would seem to be a good alternative.

Evidence from cross-sectional survey data

Cross-sectional analysis has proved a rich source of information about the market segments defined by income groups, although it is less useful in predicting changes in demand over time.

Cross-sectional household survey data is available only for urban areas of China. The data show that there was a strong positive relationship between per capita household purchases of different types of fibre products and household income levels in 1990 (Figures 3.3a and 3.3b). In particular, per capita purchases of wool fabric and clothing rose relatively faster than their cotton and chemical fibre counterparts as per capita
Figure 3.3a  Annual Per Capita Fabric Purchases of Urban Households by Fibre Type and Household Income Level, 1990

Note: Annual per capita purchases are measured on a logarithm scale; chemical fibre fabrics include cotton-chemical fibre blends.

income increased. A plot of household survey data for earlier years reveals basically the same pattern.

More detailed information on urban income groupings obtained from Statistical Yearbook of China allows us to identify the above relationship statistically. Table 3.1 shows the income elasticity for different types of fibre products based on a simple double log specification. It is clear from the estimation results that the income elasticity of demand for wool fabrics and clothing is highest among the three fibre products. In terms of elasticity ranking, this finding is consistent with Byron's (1992) results, although the income elasticity of demand for wool fabrics has become smaller than one. Another interesting feature of Table 3.1 is that the income elasticity of demand for clothing by fibre type is higher than that for fabrics. This may well reflect changes in consumer behaviour as income increases. During 1978-89 the share of fibres sold on the domestic market in the form of finished clothing rose from 10 per cent to around 45 per cent (Shen 1990, p. 159). Fewer people were making their own clothes, probably because of a greater emphasis by consumers on lifestyle and fashion.

Table 3.1 Income Elasticities of Demand for Fibre Products in China, 1990

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Income elasticity</th>
<th>t ratio</th>
<th>$\bar{R}^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton fabrics</td>
<td>0.21</td>
<td>1.82</td>
<td>0.1203</td>
</tr>
<tr>
<td>Wool fabrics</td>
<td>0.86</td>
<td>4.85</td>
<td>0.5699</td>
</tr>
<tr>
<td>Chemical fibre fabrics (including blends)</td>
<td>0.46</td>
<td>3.27</td>
<td>0.3633</td>
</tr>
<tr>
<td>Cotton clothing</td>
<td>0.92</td>
<td>9.45</td>
<td>0.8387</td>
</tr>
<tr>
<td>Wool clothing</td>
<td>1.24</td>
<td>10.80</td>
<td>0.8718</td>
</tr>
<tr>
<td>Chemical fibre clothing</td>
<td>0.82</td>
<td>8.59</td>
<td>0.8108</td>
</tr>
</tbody>
</table>

Note: The independent variable is household income level. Total number of observations is 18. As both dependent and independent variable are in log form, the coefficients can be interpreted in elasticity terms.
Evidence from time-series survey data

Time-series household survey data are available for both urban and rural China. Urban consumer demand for fabrics and clothing shows a quite different pattern from the cross-sectional case (Figures 3.4a and 3.4b). It is also interesting to note that there are wide variations in purchases of the three types of fabrics and clothing, even though income seems to have increased steadily during the period under study, 1981-91. This suggests that there could be other variables — such as price and demographic factors — influencing the demand pattern. Even so, lack of data forces us to exclude these variables from the regression analysis reported below.

Table 3.2 presents the income elasticities for a number of fibre products in 1981-91 based on time-series household survey data. In the textile market, the income elasticities for cotton and wool fabrics are not statistically different from zero. The relationship between household purchases of chemical fibre fabrics and income has become negative. In the clothing market, chemical fibre clothing has the highest income elasticity, followed by wool clothing. The income elasticity for cotton clothing, however, turns out to be negative. These results are in sharp contrast with those obtained above using cross-sectional data and also with those of Byron (1992).

China’s rural areas constitute a large market for textiles and clothing. Although annual per capita household expenditure on textiles and clothing in rural areas is only one-quarter that of urban areas, because of the larger rural population, the absolute size of the rural market is still greater than that of the urban market. In 1991, the rural market was estimated to account for about 58 per cent of the total textile and clothing market in China.

China’s rural household survey data include information on only a few textile products, namely cotton, wool and chemical fibre fabrics, and wool yarns. Figure 3.5 shows that there is a negative relationship between cotton fabric consumption and income, with an income elasticity estimate of -1.33 (see also Table 3.3).

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4 Whereas in 1991 per capita household expenditure on clothing in urban China was 199.6 RMB yuan, it was only 51 RMB yuan in rural China (Statistical Yearbook of China, p. 284 and p. 311).

5 In 1991, the rural population accounted for about 74 percent of China’s total population (Statistical Yearbook of China, p. 77).
Figure 3.4a  Annual Per Capita Fabric Purchases of Urban Households by Fibre Type and Household Income Level, 1981-91

Figure 3.4b  Annual Per Capita Clothing Purchases of Urban Households by Fibre Type and Household Income Level, 1981-91

Note: Annual per capita purchases are measured on a logarithm scale; chemical fibre fabrics include cotton-chemical fibre blends.

Table 3.2 Income Elasticities of Demand for Fibre Products in Urban China, 1981-91

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Income elasticity</th>
<th>t ratio</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton fabrics</td>
<td>-0.25</td>
<td>-0.9694</td>
<td>-0.0061</td>
</tr>
<tr>
<td>Wool fabrics</td>
<td>0.03</td>
<td>0.1781</td>
<td>-0.1072</td>
</tr>
<tr>
<td>Chemical fibre fabrics (including blends)</td>
<td>-0.23</td>
<td>-2.8101</td>
<td>0.4082</td>
</tr>
<tr>
<td>Cotton clothing</td>
<td>-0.38</td>
<td>-6.7133</td>
<td>0.8151</td>
</tr>
<tr>
<td>Wool clothing</td>
<td>0.35</td>
<td>2.7975</td>
<td>0.4057</td>
</tr>
<tr>
<td>Chemical fibre clothing</td>
<td>0.48</td>
<td>5.4658</td>
<td>0.7428</td>
</tr>
</tbody>
</table>

Note: The independent variable is household income level. Total number of observations is 11. As both dependent and independent variables are in log form, coefficients can be interpreted in elasticity terms.

Figure 3.5 Changes in Annual Per Capita Textiles Consumption of Rural Households by Fibre Type and Household Income, 1980-91

Note: Annual per capita consumption and income are measured on a logarithm scale. Wool yarns are measured in kilograms.

Table 3.3 Income Elasticities of Demand for Fibre Products in Rural China, 1980-91

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Income elasticity</th>
<th>t ratio</th>
<th>$\bar{R}^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton fabrics</td>
<td>-1.33</td>
<td>-13.3550</td>
<td>0.9416</td>
</tr>
<tr>
<td>Wool fabrics</td>
<td>0.53</td>
<td>2.1484</td>
<td>0.2474</td>
</tr>
<tr>
<td>Wool yarns</td>
<td>0.39</td>
<td>3.1506</td>
<td>0.4480</td>
</tr>
<tr>
<td>Chemical fibre fabrics</td>
<td>0.39</td>
<td>1.9977</td>
<td>0.2138</td>
</tr>
<tr>
<td>(including blends)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The independent variable is household income level. Total number of observations is 12. As both dependent and independent variable are in log form, the coefficients can be interpreted in elasticity terms.

However, a positive relationship is found between income and the consumption of wool fabrics, wool yarns and chemical fabrics, the income elasticities being 0.53, 0.39 and 0.39 respectively.

Evidence from retail sales data

Clothing is the second largest commodity group (after food) in total retail sales of consumer goods in China. The general trend has been for the share of clothing in total retail sales to decline, from 22 per cent in 1978 to 16.4 per cent in 1991 (See Statistical Yearbook of China 1992, p. 610). This is consistent with the trend revealed by household survey data.

Statistical Yearbook of China reports the annual retail sales of major textile products, including cotton fabrics, wool fabrics, wool yarns and chemical fibre fabrics, as well as corresponding price data. This information for 1978-91 is set out in Table 3.4. The income level is proxied by total consumption.

In estimating the demand model, we also need to ascertain real income and price series for various fibre products. This is done by deflating nominal income and price series by the total retail price index for consumer goods.
Table 3.4 Retail Sales Data Set, 1978-91

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
<th>Price</th>
<th>PI</th>
<th>CI</th>
<th>Total consumption level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cotton fabrics</td>
<td>Wool fabrics</td>
<td>Wool yarns</td>
<td>Chemical fibre fabrics</td>
<td>Cotton fabrics</td>
</tr>
<tr>
<td>1978</td>
<td>6,370</td>
<td>81</td>
<td>27</td>
<td>1,320</td>
<td>1.6</td>
</tr>
<tr>
<td>1979</td>
<td>6,680</td>
<td>106</td>
<td>37</td>
<td>2,000</td>
<td>1.6</td>
</tr>
<tr>
<td>1980</td>
<td>7,190</td>
<td>142</td>
<td>45</td>
<td>2,650</td>
<td>1.6</td>
</tr>
<tr>
<td>1981</td>
<td>7,100</td>
<td>170</td>
<td>50</td>
<td>3,150</td>
<td>1.6</td>
</tr>
<tr>
<td>1982</td>
<td>6,700</td>
<td>184</td>
<td>51</td>
<td>3,380</td>
<td>1.6</td>
</tr>
<tr>
<td>1983</td>
<td>6,100</td>
<td>208</td>
<td>61</td>
<td>4,440</td>
<td>1.8</td>
</tr>
<tr>
<td>1984</td>
<td>6,350</td>
<td>264</td>
<td>80</td>
<td>4,790</td>
<td>1.6</td>
</tr>
<tr>
<td>1985</td>
<td>7,130</td>
<td>306</td>
<td>96</td>
<td>4,990</td>
<td>1.7</td>
</tr>
<tr>
<td>1986</td>
<td>6,860</td>
<td>296</td>
<td>109</td>
<td>4,920</td>
<td>1.8</td>
</tr>
<tr>
<td>1987</td>
<td>7,400</td>
<td>297</td>
<td>133</td>
<td>4,730</td>
<td>1.9</td>
</tr>
<tr>
<td>1988</td>
<td>8,230</td>
<td>318</td>
<td>154</td>
<td>5,020</td>
<td>2.4</td>
</tr>
<tr>
<td>1989</td>
<td>8,050</td>
<td>278</td>
<td>123</td>
<td>4,730</td>
<td>3.2</td>
</tr>
<tr>
<td>1990</td>
<td>7,840</td>
<td>265</td>
<td>89</td>
<td>4,190</td>
<td>3.4</td>
</tr>
<tr>
<td>1991</td>
<td>7,550</td>
<td>301</td>
<td>95</td>
<td>4,300</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Note: Cotton, wool and chemical fibre fabrics are measured in million metres, wool yarns in thousand tons. Prices are given in RMB Yuan/metre for cotton, wool and chemical fibre fabrics, and in RMB Yuan/kilogram for wool yarns. Consumption levels are in billion RMB Yuan.


Table 3.5 reports the estimation results based on retail sales data. Although there is only one equation (namely demand for wool fabrics) in which the price variable is statistically significant, this alone indicates the importance of including the price variable. The income elasticities derived from time-series retail sales data are all positive and statistically significant. This is in sharp contrast to findings derived from time-series household survey data, which contain negative income elasticities. The income

---

6 This is in contradiction to Li's (1992) observation. Two possible explanations are: (1) Li's observation was based on the rural market only, while that here is based on urban and rural markets as a whole; and (2) as Li did not carry out a statistical analysis, his direct observations may not be correct.
elasticities of demand for wool fabrics and yarns are quite high at 1.59 and 1.42 respectively. This result is in agreement with Byron’s earlier findings. The income elasticity for chemical fibre fabrics is also high; in fact, it is greater than one. In our earlier cross-sectional analysis and in Byron’s results, the corresponding income elasticity was smaller than one. The result for cotton demand is in close agreement with Byron’s and that derived from cross-sectional analysis.

### Table 3.5 Expenditure and Own-Price Elasticity for Main Fibre Products, 1978-91

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Expenditure elasticity</th>
<th>t ratio</th>
<th>Price elasticity</th>
<th>t ratio</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton fabrics</td>
<td>0.19</td>
<td>3.12</td>
<td>0.11</td>
<td>0.50</td>
<td>0.37</td>
</tr>
<tr>
<td>Wool fabrics</td>
<td>1.59</td>
<td>7.29</td>
<td>-1.61</td>
<td>-1.93</td>
<td>0.89</td>
</tr>
<tr>
<td>Wool yarns</td>
<td>1.42</td>
<td>6.74</td>
<td>-0.53</td>
<td>-0.60</td>
<td>0.87</td>
</tr>
<tr>
<td>Chemical fibre fabrics</td>
<td>1.25</td>
<td>4.33</td>
<td>-0.34</td>
<td>-0.98</td>
<td>0.69</td>
</tr>
<tr>
<td>(including blends)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** As both the dependent and independent variables are in log form, the coefficients can be interpreted in elasticity terms.

**Summary of results**

Table 3.6 summarises the main results of the preceding analysis and also those of Byron (1992). A number of key points emerge from the table.

First, the results of cross-sectional analysis indicate that the income elasticity estimates for wool, both fabrics and clothing, are highest among the three types of fibres. This means that as urban households move into higher income groups, they can be expected to spend more on wool products than on cotton or chemical fibres.

Second, it was expected that changes in the pattern of household expenditure over time would be similar to those revealed in the cross-sectional analysis, because over time households tend to move into higher income groups. The empirical evidence from time-series household survey data does not uphold this expectation, however. On the whole, the income elasticity estimates derived from the data are lower than those obtained from cross-sectional data. Furthermore, in the case of urban household demand,
some estimates of income elasticity have become either insignificant or negative. In the case of rural household demand, the income elasticity for cotton fabrics is also found to be negative. These results are suspicious given that current levels of per capita fibre consumption are low and that there should be potential for increases as income grows. The explanation for this empirical outcome probably lies in misspecification of the demand model.

Table 3.6  Income Elasticities of Demand for Textiles and Clothing by Fibre Type, China

<table>
<thead>
<tr>
<th></th>
<th>Byron (1992)</th>
<th>Present study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton fabrics</td>
<td>-</td>
<td>L</td>
</tr>
<tr>
<td>Wool fabrics</td>
<td>-</td>
<td>H*</td>
</tr>
<tr>
<td>Chemical fibre fabrics</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td>Cotton clothing</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Wool clothing</td>
<td>H*</td>
<td>H*</td>
</tr>
<tr>
<td>Chemical fibre clothing</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

Note: H, M and L stand respectively for a high, medium and low relative magnitude of income elasticity; * indicates an income elasticity greater than one; - after a letter indicates a negative income elasticity; 0 indicates an insignificant income elasticity estimate; and - means not available.


Third, the empirical results, based on a demand model using time-series retail sales data and including price variables, indicate that demand for both wool and chemical fibre fabrics is highly responsive to income growth. The ranking of income elasticity estimates also conforms closely to Byron's findings and those of this study's cross-sectional analysis. In the case of the clothing market, although no additional evidence...
was derived from the retail sales data, Byron’s earlier findings together with the results of cross-sectional analysis in this study support the view that the income elasticity of demand for wool clothing is high.

CHANGING FIBRE COMPOSITION OF EXPORT PRODUCTS

Owing to trade reform and China’s open door policy, as well as an international relocation of textile and clothing production activities, exports of textiles and clothing have grown rapidly since 1978. In 1992, the total value of textiles and clothing reached US$24 billion (Far Eastern Economic Review 4 February 1993, p. 55), almost nine times the value in 1978. The share of exported fibres in total domestic production of textiles and clothing rose from 16 per cent in 1980 to 34 per cent in 1990 (Kong 1992).

China’s exports of textiles and clothing have expanded more rapidly in value than in quantity terms. During 1981-89, while the total value of textile and clothing exports increased by 188 per cent, the quantity of fibres contained in those exports increased by only 87.5 per cent. This means that less fibre is now used for every US dollar earned from textile and clothing exports.

In 1989, China exported a total of 2.4 million tons of textiles and clothing, compared with 1.28 million tons in 1981 (Table 3.6). One interesting feature of China’s exports of textiles and clothing has been the heavy dependence on natural fibres. In 1989, natural fibres (cotton, wool and other natural fibres) accounted for about 70 per cent of total textile and clothing exports, with the remaining 30 per cent being taken up by chemical fibres. The dominant natural fibre was cotton, which had a market share of 57.6 per cent in 1989; this share has been increasing since 1981 mainly at the expense of the ‘other’ fibres category. The market share of wool has remained relatively stable.

The fastest growing area of China’s textile and clothing exports has been clothing products. Exports of fibres in the form of clothing products increased 211 per cent from 1981 to 1989. This accords with the general assertion that as the clothing industry is labour intensive, it is subject to higher growth if a country is well endowed with labour resources. However, in this prosperous and expanding market, wool’s market share
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Textiles, total (000 tons)</td>
<td>1,075.77</td>
<td>1,767.39</td>
<td>+64.5</td>
</tr>
<tr>
<td>Cotton</td>
<td>49.9</td>
<td>56.6</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>1.4</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres</td>
<td>25.5</td>
<td>27.5</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>23.2</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>Yarns (000 tons)</td>
<td>268.69</td>
<td>406.66</td>
<td>+51.3</td>
</tr>
<tr>
<td>Cotton</td>
<td>64.0</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>0.6</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>13.8</td>
<td>29.3</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>21.6</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td>Fabrics (000 tons)</td>
<td>493.80</td>
<td>838.02</td>
<td>+69.7</td>
</tr>
<tr>
<td>Cotton</td>
<td>58.6</td>
<td>58.5</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>0.7</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>36.6</td>
<td>35.9</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>4.1</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>Textiles for home and industrial use</td>
<td>313.28</td>
<td>524.71</td>
<td>+67.5</td>
</tr>
<tr>
<td>Cotton</td>
<td>24.1</td>
<td>61.7</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>3.2</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>18.2</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>54.5</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>Clothing, total (000 tons)</td>
<td>200.99</td>
<td>625.96</td>
<td>+211.4</td>
</tr>
<tr>
<td>Cotton</td>
<td>49.8</td>
<td>60.5</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>3.8</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>44.8</td>
<td>34.7</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>1.6</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Clothing, woven (000 tons)</td>
<td>94.76</td>
<td>286.83</td>
<td>+202.7</td>
</tr>
<tr>
<td>Cotton</td>
<td>63.3</td>
<td>50.5</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>0.9</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>32.5</td>
<td>42.5</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>3.3</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Clothing, knitted (000 tons)</td>
<td>78.07</td>
<td>285.20</td>
<td>+265.3</td>
</tr>
<tr>
<td>Cotton</td>
<td>61.1</td>
<td>76.4</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>9.6</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>29.0</td>
<td>19.9</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>0.3</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Other clothing (000 tons)</td>
<td>28.17</td>
<td>53.93</td>
<td>+91.4</td>
</tr>
<tr>
<td>Fibre products, total (000 tons)</td>
<td>1,276.76</td>
<td>2,393.35</td>
<td>+87.5</td>
</tr>
<tr>
<td>Cotton</td>
<td>49.9</td>
<td>57.6</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>1.8</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Chemical fibres (including blends)</td>
<td>28.7</td>
<td>29.5</td>
<td></td>
</tr>
<tr>
<td>Other (silk, flax, ramie and jute)</td>
<td>19.6</td>
<td>11.0</td>
<td></td>
</tr>
</tbody>
</table>

Sources: China Fibre Yearbook 1990; China's Customs Statistics 1981-90, Customs of China.
dropped by 1.2 per cent, a quite significant percentage considering wool is a minor fibre. The main source of decline seems to have been in the knitted clothing market, where the market share of wool fell from 9.6 per cent to 3.3 per cent. The increase in the market share of wool in the woven clothing market has not been strong enough to compensate for this decline.

The export market share of cotton clothing grew, mainly at the expense of chemical fibres. The chief source of growth has been the knitted clothing market. In the woven clothing market, cotton’s market share actually fell.

China’s textile exports grew at a much slower rate than its clothing exports. In 1989, China exported 1.77 million tons equivalent of textile products, compared with 1.07 million tons in 1981. The market share of wool in the textile market improved slightly from 1981 to 1989. The increase in the market share of cotton was mainly at the expense of the ‘other’ category of fibres.

Within the textile market, the submarkets of fabrics and textiles for home and industrial use grew at a relatively faster pace than the submarket for yarns. Wool again performed relatively poorly in the former two submarkets, although its market share in the yarns market increased by a good 2 percentage points.

As argued previously, changes in fibre composition in the export market depend largely on the relative competitiveness of specific sectors of the Chinese textile industry. Strong competitiveness in a particular product line could create demand for these products and squeeze the market share of competitors. One of the most important determinants of competitiveness in the textile industry is the intensity of labour use. Findlay and Li (1992) found that in China the cotton textile industry is more labour intensive than the wool textile industry. This explains in part why the export performance of the former is better than that of the latter.

The availability of cheap raw materials is another important determinant of competitiveness. During the 1980s, success in securing increased cotton production as a result of rural economic reform greatly facilitated the development of the Chinese cotton textile industry and also its export activities. The wool textile industry, on the other hand,
was placed at a disadvantage by tight domestic supply and various restrictions on imports. This issue will be taken up in more detail in chapter 7.

**CONCLUDING REMARKS**

In this chapter, I have examined changing fibre composition of the end-use markets for textiles, both domestic and foreign. It was argued that changes in demand in the end-use market would influence mills’ demand patterns for fibres.

The analysis started by comparing per capita fibre consumption and real per capita income. It was found that the income elasticity of fibres as a whole has been declining, a trend confirmed by observations based on international comparison. The income elasticity of wool demand was found to be one, indicating that, if this relationship holds in the future, growth in per capita wool consumption will keep pace with growth in real per capita income.

A detailed analysis was also made of both domestic and foreign demand for fibre products. Because of lack of data, only the market for apparel textiles and clothing was analysed in the case of the domestic market. The central interest was in examining how demand for specific fibre products changes when household incomes change. It was argued that the time-series demand model including a price variable was a more appropriate model than the cross-sectional demand model for projecting future demand for fibre products. The empirical results derived from retail sales data were that the income elasticities for wool fabrics and wool yarns were fairly high. Demand for wool fabrics also appeared to have been quite responsive to changes in prices. These estimates are indispensable in projecting the future development of the Chinese wool market.

Among fibres for export, changes in market share during the 1980s seem to have favoured cotton. While the market shares of wool and chemical fibres remained relatively constant, the ‘other’ category of fibres lost a substantial amount of its market share. These changes conform closely with the relative strength of comparative advantage that has developed in China since its adoption of an open door policy.
4 The Diffusional Impact of Technological Change on Fibre Substitution

The introduction into China of the technology for making man-made fibres, especially synthetic fibres, has had a profound impact on patterns of fibre usage in the Chinese textile industry. The process by which man-made fibres have penetrated markets traditionally held by natural fibres has been very much like that experienced earlier in the United States, Japan and some European countries. A common approach in describing this diffusional process is to fit an S-shaped growth curve to historical share data. This enables us not only to measure past changes in fibre usage but also to make useful projections of mills’ future fibre consumption.

SOME ISSUES REGARDING THE USE OF S-SHAPED DIFFUSION MODELS

Since Griliches’ (1957) and Mansfield’s (1961) seminal papers, the use of S-shaped growth curves to describe various economic phenomena has become widespread. They have been used to examine such diverse topics as the television market in the United Kingdom (Bain 1963), the synthetic fibres market in the United States (Powell et al. 1963; Polasek and Powell 1964), the telephone market in the United States (Chaddha and Chitgopekar 1971) and the tractor market in Spain (Mar-Molinero 1980), among others.

Probably the most widely used S-shaped growth curve is the logistic model, given as:

\[ y_t = \frac{\delta}{1 + e^{-(\alpha + \beta t)}} \]

where \( y_t \) is the trend value of the relevant economic variable measured in percentage form, \( t \) is a time variable, and \( \delta, \alpha \) and \( \beta \) are parameters. More specifically, the estimated value of \( \delta \) is interpreted as market saturation level, \( \alpha \) as the constant of integration that positions the function in the time space and \( \beta \) as speed of adjustment.
The first application of the logistic model to the problem of fibre substitution was carried out by Powell et al. (1963), who fitted a logistic substitution curve to quarterly US mill data for 1954-62. They also introduced relative price into the logistic model, assuming that it could both accelerate the rate of adoption of and affect the long-run market share enjoyed by synthetic fibres. However, based on the empirical results they obtained, they were forced to conclude that the role of price in the adjustment of the US textile market to synthetic substitutes for wool had been of minor importance.

In view of this finding, Polasek and Powell (1964) in a subsequent work focused solely on the technological side of the adjustment process in the United States. The authors fitted a logistic curve to 33 end uses as well as to aggregate final demand and mill consumption data. This enabled them to make a fairly accurate assessment of the differential impacts of synthetics in the US market for a range of final products.

The logistic model imposes an S-shaped, symmetrical diffusion trend with an inflection point that occurs when $y = \delta/2$ and with upper and lower bounds of $\delta$ and zero. The symmetrical property of the logistic model has often been criticised as being too restrictive, as the actual diffusion process may exhibit growth rates that are higher early on and later decline gradually (Chow 1967; Dixon 1980). One alternative is to use the asymmetrical Gompertz model, in which the maximum diffusion rate occurs when 37 per cent of potential cumulative adopters have adopted the new product (Dixon 1980).

The Gompertz model has also been criticised in more recent studies as being too rigid. In order to accommodate different patterns of diffusion and let the point of inflection and degree of symmetry be determined by the data, Bewley and Fiebig (1988) developed a flexible logistic growth model (FLOG). The FLOG class of models allows for a range of possible inflection points, growth that is either symmetrical or asymmetrical, and the possibility of the existence of an internal saturation level.

In my analysis, I make a prior assumption that diffusion of chemical fibres in China has followed a symmetrical logistic growth curve.¹ This model will, however, be

¹ As mentioned in chapter 2, in a situation of incomplete diffusion process — in which it is often not possible to sort out the best model by relying on the data — choosing the most appropriate model becomes a matter of educated guesswork. The reasons for settling on a logistic model are also given in chapter 2.
tested against variants of the FLOG model. Unless any other competing trend is found to be statistically more plausible, the logistic model will form the basis for measuring the diffusional impact of technological change on fibre substitution in the Chinese textile industry.

THE FLOG MODEL

Following Bewley and Fiebig (1988), a more general form of the logistic model is given by:

$$y_t = \frac{\delta}{1 + \exp(f(t))}$$

(4.2)

where $y_t$ is the trend value of chemical fibres' share of the market, $\delta$ is defined as market saturation level and $f(t)$ is some non-linear function of time. A number of variants of this general logistic model arise depending on how $f(t)$ is specified. For instance, $f(t)$ may be specified as:

$$f(t) = -\alpha - \beta \log(1+kt)$$

if $k > 0$ and $k \neq 1$  

(4.3)

$$= -\alpha \beta \log(t)$$

if $k = 1$  

(4.4)

$$= -\alpha \beta t$$

if $k = 0$  

(4.5)

where $t = 0, 1, 2, \ldots$. Equations 4.2 and 4.3 together provide a general log-logistic model, free from the problem of arbitrary time scale. Equation 4.4 is a standard log-logistic formulation and has been used by Tanner (1978), Defries and Fiebig (1984) and Poznanski (1990). Formulation (4.5) corresponds to the standard logistic model.

According to Bewley and Fiebig (1988), the specification of equation 4.3 is in fact the log of IPT (inverse power transformation) discussed in Gaudry (1981). The IPT function is given by:

$$(1+kt)^{1/k} - 1$$

(4.6)

Bewley and Fiebig (1988) referred to equation 4.3 as the log-IPT model and to equation 4.6 as the IPT model.
Alternatively, as shown by Bewley and Fiebig (1988), we may take the Box-Cox transformation of the IPT model, namely:

\[
t(\mu, k) = \left\{ \left[ (1 + kt)^{\frac{\mu}{k}} \right] - 1 \right\} / \mu
\]

if \( \mu \neq 0, k \neq 0 \) (4.7)

\[
= (1/k) \log(1 + kt)
\]

if \( \mu = 0, k \neq 0 \) (4.8)

\[
= (e^\mu - 1) / \mu
\]

if \( \mu \neq 0, k = 0 \) (4.9)

\[
= t
\]

if \( \mu = 0, k = 0 \) (4.10)

In differential form, equation 4.7 is given as:

\[
dy_i / dt = \beta \left[ (1 + kt)^{(1/k)} \right]^{(\mu - k)} y_i(1 - y_i)
\]

The solution to equation 4.11 is expressed as:

\[
y_i = \left\{ 1 + \exp[-\alpha - \beta t(\mu, k)] \right\}^{-1}
\]

(4.12)

That is, \( \delta = 1 \) and \( t(\mu, k) \) is as given by equation 4.7. Moreover, if the estimate of \( \mu \) is negative,\(^2\) the internal saturation level is:

\[
y_i^* = \left\{ 1 + \exp[-\alpha + \beta / \mu] \right\}^{-1}
\]

(4.13)

One obvious advantage of equation 4.12 is that it has a number of useful models nested within it, both symmetric and asymmetric. The variants of the FLOG model, summarised in Bewley and Fiebig (1988) are reproduced in Table 4.1 with slight changes in notation.

Table 4.1 provides a useful basis for model selection. The usual likelihood ratio test can be performed to differentiate competing models. However, as mentioned earlier, the main purpose of the ongoing specification test is to ensure that no competing trends outperform the standard logistic model; otherwise, our original assumption would need to be reconsidered.

---

\(^2\) According to Bewley and Fiebig (1988), \( \mu \) affects curvature to the extent that an internal saturation level can be predicted.
Table 4.1 Variants of FLOG model

<table>
<thead>
<tr>
<th>Model</th>
<th>$\mu$</th>
<th>$k$</th>
<th>$t(\mu, k)$</th>
<th>Eq. No.</th>
<th>Location of inflection point ($\delta/2$) times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear*</td>
<td>1</td>
<td>1</td>
<td>$t$</td>
<td>(4.5), (4.10)</td>
<td>1</td>
</tr>
<tr>
<td>Log</td>
<td>0</td>
<td>1</td>
<td>$\log(t)$</td>
<td>(4.4)</td>
<td>$[1-1/\beta]$ if $\beta&gt;1$</td>
</tr>
<tr>
<td>IPT</td>
<td>1</td>
<td>0</td>
<td>$(1+k\mu)/(1/k)_{-1}$</td>
<td>(4.6)</td>
<td>**</td>
</tr>
<tr>
<td>Log-IPT***</td>
<td>0</td>
<td>-</td>
<td>$(1/k) \log(1+k\mu)$</td>
<td>(4.3), (4.8)</td>
<td>$[1-k/\beta]$ if $\beta&gt;k$</td>
</tr>
<tr>
<td>Box-Cox</td>
<td>-</td>
<td>1</td>
<td>$[(1+\mu)_{-1}]\mu$</td>
<td>-</td>
<td>**</td>
</tr>
<tr>
<td>ELOG</td>
<td>-</td>
<td>0</td>
<td>$(e^{\mu} - 1)/\mu$</td>
<td>(4.9)</td>
<td>**</td>
</tr>
<tr>
<td>FLOG</td>
<td>-</td>
<td>-</td>
<td>$\left{\left[(1+k\mu)^{1/k}\right]^{-1} - 1\right}/\mu$</td>
<td>(4.7)</td>
<td>**</td>
</tr>
</tbody>
</table>

* $\mu=k$ or $\mu=k=0$ will also produce a linear function. In the former case, the parameters for $\beta$, $\mu$ and $k$ are not identified.

** According to Bewley and Fiebig (1988), the point of inflection, if it exists, can occur anywhere between $y=0$ and $y=1$ depending on the values of $\alpha$, $\beta$, $\mu$ and $k$. It can be shown that a point of inflection occurs at the solution to $(1 - 2y_i)\log\left\{\left[(y_i)^{-1} - 1\right]/((y_i)^{-1} - 1)\right\} = (k - \mu)/\mu$.

*** If $k=1$, Log-IPT reduces to log-logistic.


ESTIMATION PROCEDURE

There are several methods of fitting FLOG models. One classic way proposed by Griliches (1957) is to transform equation 4.12 into:

$$
\log[y_i/(1-y_i)] = \alpha + \beta t(\mu, k) + \epsilon_i
$$

(4.14)

and to apply the least-squares criterion. This approach has been criticised by Meade (1984, p. 438), who says: “the reasoning leading to the choice of transformation is usually that of expediency rather than a convincing hypothesis about the error structure”.

An alternative suggested in some of the literature (Dixon 1980; Mar-Molinero 1976; Fishelson 1984; Poznanski 1990) is to use untransformed data and apply the non-linear iterative method. However, Bewley and Fiebig (1988) recently showed that the stochastic specification embodied in equation 4.14 is probably the most appropriate transformation. In fact, the log-transformation, as will be seen later, has the additional

---

3 Two other transformations mentioned by Bewley and Fiebig (1988) are:
advantage of finding \( \delta \) (ceiling) when none of the variants of the FLOG model can find an internal saturation level.

As the independent variable in equation 4.14 involves non-linear terms, the non-linear estimation method, a maximum likelihood procedure (Davidon-Fletcher-Powell algorithm) available on SHAZAM, is used for estimation.

**DATA**

Data for the estimation of the FLOG model are tabulated in Table 4.2. These data were also used to create Figure 2.2. The time-series data run from 1975 to 1991.

Table 4.2 Share of Chemical Fibres in Total Fibre Consumption of the Chinese Cotton and Wool Industries, 1975-91 (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cotton Sector</th>
<th>Wool Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>7.10</td>
<td>27.00</td>
</tr>
<tr>
<td>1976</td>
<td>8.10</td>
<td>27.50</td>
</tr>
<tr>
<td>1977</td>
<td>9.20</td>
<td>25.80</td>
</tr>
<tr>
<td>1978</td>
<td>12.60</td>
<td>35.40</td>
</tr>
<tr>
<td>1978</td>
<td>15.60</td>
<td>39.80</td>
</tr>
<tr>
<td>1980</td>
<td>18.90</td>
<td>40.30</td>
</tr>
<tr>
<td>1981</td>
<td>21.80</td>
<td>43.60</td>
</tr>
<tr>
<td>1982</td>
<td>17.08</td>
<td>41.70</td>
</tr>
<tr>
<td>1983</td>
<td>22.10</td>
<td>44.10</td>
</tr>
<tr>
<td>1984</td>
<td>25.70</td>
<td>39.10</td>
</tr>
<tr>
<td>1985</td>
<td>25.10</td>
<td>43.03</td>
</tr>
<tr>
<td>1986</td>
<td>21.11</td>
<td>50.67</td>
</tr>
<tr>
<td>1987</td>
<td>19.20</td>
<td>47.70</td>
</tr>
<tr>
<td>1988</td>
<td>16.50</td>
<td>55.10</td>
</tr>
<tr>
<td>1989</td>
<td>19.26</td>
<td>59.10</td>
</tr>
<tr>
<td>1990</td>
<td>23.50</td>
<td>64.10</td>
</tr>
<tr>
<td>1991</td>
<td>22.65</td>
<td>58.68</td>
</tr>
</tbody>
</table>


(1) \[ y_i = \left(1 + \exp[-\alpha - \beta r(\mu, k)]\right)^{-1} + \epsilon_i \]

(2) \[ \left(1 - y_i / y_i \right) = \exp[-\alpha - \beta r(\mu, k)] + \epsilon_i \]

For more details, see Bewley and Fiebig, pp. 182-4.
In official Chinese statistics, chemical fibres are defined as consisting of synthetic fibres and other man-made fibres. In 1991, synthetic fibres accounted for 85 per cent and 88 per cent respectively of total chemical fibres consumed by the Chinese cotton and wool textile industries, up from 49 per cent and 39 per cent in 1975. Obviously, synthetic fibres have constituted the main source of change in the use of manufactured inputs in the wool and cotton textile industries.

It is important to note that there is evidence that the total fibre consumption of the cotton and wool textile industries as reported by the former Ministry of Textile Industry has been underestimated due to the growing fibre consumption of non-state-owned enterprises, which are not under the control of the ministry. As this could lead to some bias in the results, caution is needed when using data supplied by the Ministry to obtain a general picture of the diffusional impact of technology on fibre substitution.

SPECIFICATION TESTS

Following the estimation procedure described above, the FLOG model and its six special cases were estimated using the share data on chemical fibres for 1975-91 reported in Table 4.2. The results are presented in Table 4.3.

It is immediately apparent from Table 4.3 that the log-logistic model is the least promising model for the wool industry, as the associated log-likelihood function is much lower than that of other competing models. Although the FLOG model enjoys the highest log-likelihood function, the coefficients for $\mu$ and $k$ are both statistically insignificant. This implies that $\mu = k = 0$, leading to the standard logistic function, that is equations 4.7 to 4.10. In the case of the FLOG model, as $\mu$ is not significantly different from zero, the model also reduces to the linear logistic trend — equations 4.9 to 4.10. In the case of the IPT model, the $k$ value is very close to one, and a likelihood ratios (LR) test\(^4\) indicates that there are no significant differences between the IPT and the

\[ \chi^2 \]

\(^4\) The likelihood test (Pindyck and Rubinfeld 1991) is given by:

\[ -2 [ L(\beta_k) - L(\beta_{\text{LR}}) ] \sim \chi^2 \]
Table 4.3 Specification Tests

### Wool Sector

<table>
<thead>
<tr>
<th>Model</th>
<th>( \mu )</th>
<th>( k )</th>
<th>( \alpha )</th>
<th>( \beta )</th>
<th>Log-likelihood function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>1</td>
<td>1</td>
<td>-1.0480</td>
<td>0.0876</td>
<td>9.0894</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-14.4350)</td>
<td>(12.4300)</td>
<td></td>
</tr>
<tr>
<td>Log</td>
<td>0</td>
<td>1</td>
<td>-1.3013</td>
<td>0.5287</td>
<td>3.7129</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-10.0510)</td>
<td>(8.6490)</td>
<td></td>
</tr>
<tr>
<td>IPT</td>
<td>1</td>
<td>1.0831</td>
<td>-1.0809</td>
<td>0.1044</td>
<td>9.1134</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.7047)</td>
<td>(1.2462)</td>
<td></td>
</tr>
<tr>
<td>Log-IPT</td>
<td>0</td>
<td>-0.0060</td>
<td>-1.0326</td>
<td>0.0929</td>
<td>9.0989</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-0.1477)</td>
<td>(2.4995)</td>
<td></td>
</tr>
<tr>
<td>Box-Cox</td>
<td>0.9247</td>
<td>1</td>
<td>-1.0796</td>
<td>0.1035</td>
<td>9.1127</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.7360)</td>
<td>(1.3369)</td>
<td></td>
</tr>
<tr>
<td>ELOG</td>
<td>0.0050</td>
<td>0</td>
<td>-1.0358</td>
<td>0.0838</td>
<td>9.0969</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.1218)</td>
<td>(2.6416)</td>
<td></td>
</tr>
<tr>
<td>FLOG</td>
<td>35.6400</td>
<td>37.8580</td>
<td>-1.0825</td>
<td>0.1225</td>
<td>9.1223</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.1135)</td>
<td>(1.5314)</td>
<td></td>
</tr>
</tbody>
</table>

### Cotton Sector

<table>
<thead>
<tr>
<th>Model</th>
<th>( \mu )</th>
<th>( k )</th>
<th>( \alpha )</th>
<th>( \beta )</th>
<th>Log-likelihood function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>1</td>
<td>1</td>
<td>-2.2083</td>
<td>0.0698</td>
<td>-3.2734</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-14.6260)</td>
<td>(4.6217)</td>
<td></td>
</tr>
<tr>
<td>Log</td>
<td>0</td>
<td>1</td>
<td>-2.6008</td>
<td>0.5180</td>
<td>2.5943</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-18.8200)</td>
<td>(7.9151)</td>
<td></td>
</tr>
<tr>
<td>IPT</td>
<td>1</td>
<td>179.920</td>
<td>-5.2223</td>
<td>89.6000</td>
<td>2.5653</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.6084)</td>
<td>(-7.0759)</td>
<td>(0.6084)</td>
<td></td>
</tr>
<tr>
<td>Log-IPT</td>
<td>0</td>
<td>-</td>
<td>Failure to converge</td>
<td>3.8244</td>
<td></td>
</tr>
<tr>
<td>Box-Cox</td>
<td>-0.6618</td>
<td>1</td>
<td>-3.8959</td>
<td>2.0890</td>
<td>3.8244</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-2.1286)</td>
<td>(1.9288)</td>
<td></td>
</tr>
<tr>
<td>ELOG</td>
<td>-</td>
<td>0</td>
<td>Failure to converge</td>
<td>3.8244</td>
<td></td>
</tr>
<tr>
<td>FLOG</td>
<td>-</td>
<td>-</td>
<td>Failure to converge</td>
<td>3.8244</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Numbers in parentheses are \( t \) ratios.

where \( L(\beta_r) \) represents the maximum value of the log-likelihood function when the restriction(s) apply and \( L(\beta_{unr}) \) the maximum value of the log-likelihood function when the restriction(s) do not apply. The number of restrictions is \( m \). The LR statistic in this case is 0.048, which is apparently below the critical value of \( \chi^2_{1,0.05}=3.84 \).
linear logistic model; that is, the former cannot reject the latter. The insignificant value of \( k \) in log-IPT suggests that this model can also be reduced to a standard logistic curve, that is, equations 4.8 to 4.10. It appears now that the only model competing with the linear logistic model is the Box-Cox model. Again, though, a careful examination of the estimation results for these two models does not suggest any wide difference. If we treat the linear logistic model as a restricted model \((k=1)\), and Box-Cox as an unrestricted model, a likelihood ratio test\(^5\) cannot reject the hypothesis that the restriction is not true.

Turning to the estimation results for the cotton sector, we find that generally the fits are poorer than is the case with the wool sector. Moreover, the system seems to have become very unstable in a number of cases, both in terms of convergence and parameter estimates. There are three cases (log-IPT, ELOG and FLOG) where the model estimations fail to converge. The value of the log-likelihood function in both Log and IPT models is lower than the linear logistic trend. Although the value of the likelihood function is higher in the Box-Cox model than in the standard logistic model, it cannot reject the latter.\(^6\) In addition, the estimate of diffusion speed \( \beta \) is unrealistically high.

To sum up, the above specification test shows that none of the competing models can outperform the standard two-parameter logistic model. Furthermore, nearly all the estimates of \( \mu \) are greater than zero (except in the case of the Box-Cox model for the cotton sector),\(^7\) thus failing to find an internal saturation level as suggested by some variants of the FLOG model. Therefore, in the analysis below, I shall focus on the standard logistic model and introduce an alternative way of finding the saturation level.

**AN ALTERNATIVE WAY OF FINDING SATURATION LEVEL**

One of the most interesting aspects of a fitted diffusion model is the estimated saturation level. The saturation level (\( \delta \)) for the standard logistic trend in FLOG models, however, is fixed at one. This is certainly not plausible, as chemical fibres will never fully replace natural fibres.

---

\(^5\) The LR statistic is 0.0466. The critical value is \( \chi^2_{1,0.05} = 3.84 \).

\(^6\) The LR statistic is 1.102. The critical value is \( \chi^2_{1,0.05} = 3.84 \).

\(^7\) The Box-Cox model is the only variant that predicts an internal saturation level. However, the calculated value is nearly one, which is certainly not plausible in the usual sense.
An alternative way of determining saturation level is to follow Griliches (1957) and Polasek and Powell (1964) in transforming equation 4.1 into the following log-linear form:

\[
\log\left[\frac{y_i}{(\delta - y_i)}\right] = \alpha + \beta t + \epsilon_i, \tag{4.15}
\]

In this form, the parameters can be estimated by the least-squares method, and \(\delta\) can be chosen by visual inspection so as to yield, by trial and error, the highest degree of linear association with equation 4.15.

The iterative least-squares approach is not free of problems, as sometimes (especially when dealing with an incomplete diffusion process) no minimum sum of squared residuals can be obtained for \(\delta\) between zero and one. A remedy suggested by Polasek and Powell (1964) is to use restricted least-squares (RLS), the constraint being that the absolute value of the cross-product (CP) term does not exceed 5 per cent of the total sum of squares.\(^8\)

In terms of model performance, although the conventional measure, \(R^2\), can be used to give some indication of goodness of fit, it is not really appropriate for models dealing with non-linear relationships (Polasek and Powell 1964). An alternative way of analysing prediction errors is to use Theil’s \(U\) statistics, given by:

\[
U = \frac{\left\{\sum_{i=1}^{N} (y_i - \hat{y}_i)^2 / N \right\}^{1/2}}{\left(\sum_{i=1}^{N} y_i^2 / N\right)^{1/2} + \left\{\sum_{i=1}^{N} y_i^2 / N \right\}^{1/2}} \tag{4.16}
\]

where \(0 < U < 1\). If \(U = 0\), the estimated values coincide with actual values. When \(U = 1\), the degree of deviation reaches its maximum. According to Theil, the \(U\) statistics can be decomposed into \(U^m\), \(U^s\) and \(U^c\), which are respectively bias, variance and co-variance proportions. The bias proportion \(U^m\) is an indication of systematic errors, since it measures the extent to which the average values of predicted and actual shares deviate from each other. The variance proportion \(U^s\) measures the contribution to inequality made by unequal variance. The co-variance proportion \(U^c\) measures unsystematic error.

\(^{8}\) \(CP = 2\sum_{i=1}^{N} (\hat{y}_i - \bar{y})(y_i - \hat{y}) / \sum_{i=1}^{N} (y_i - \bar{y})^2 < 0.05\). For more details, see Polasek and Powell (1964, p. 27).
For any value of $U>0$, the ideal distribution of inequality over three sources is $U^m=U^s=0$ and $U^c=1$ (Pindyck and Rubinfeld 1991, pp. 340-1).

In estimating logistic trends for the cotton and wool sectors, as no minimum sum of squared errors (SSE) existed when $\delta$ varied between its lower and upper bounds, a RLS approach is adopted. The RLS parameter estimates are reported in Table 4.4. The performance of the model can be judged from the summary of results presented in Table 4.5. Forecasts for trend values up to 2010 together with actual and estimated values are plotted in Figures 4.1 and 4.2.

Table 4.4  Estimates of Logistic Trends in Chemical Fibres in Cotton and Wool Sectors, 1975-91

<table>
<thead>
<tr>
<th>Sectors</th>
<th>OLS estimates</th>
<th>( R^2 )</th>
<th>Mean consumption %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saturation level ($\delta$)</td>
<td>Origin-fixing parameter</td>
<td>Rate of adoption</td>
</tr>
<tr>
<td>Cotton</td>
<td>0.38</td>
<td>-1.0273</td>
<td>0.0992</td>
</tr>
<tr>
<td>Wool</td>
<td>0.72</td>
<td>-0.7126</td>
<td>0.1354</td>
</tr>
</tbody>
</table>

Table 4.5  Analysis of Prediction Error: Logistic Trend Fitted to Cotton and Wool Sectors, 1975-91

<table>
<thead>
<tr>
<th>Sector</th>
<th>Coefficient of inequality $U$</th>
<th>Analysis of inequality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$U^m$</td>
<td>$U^s$</td>
</tr>
<tr>
<td>Cotton</td>
<td>0.1057</td>
<td>0.0019</td>
</tr>
<tr>
<td>Wool</td>
<td>0.0399</td>
<td>0.0044</td>
</tr>
</tbody>
</table>
It seems from Figures 4.1 and 4.2 and the corresponding prediction errors given in Table 4.5 that the observed market share of chemical fibres conforms better to the assumed adjustment process in the wool than in the cotton sector. The relatively poor performance of the logistic model for the cotton sector is perhaps due to the use of logarithmic transformation. Although the use of untransformed data (which tend to put greater emphasis on recent observations) produces a better fit, the results indicate that a saturation level of 0.21 has already been attained; judging from the experience of other countries, this is unlikely to be the case.
It is interesting to note from Table 4.4 that there is a considerable difference in the revealed long-run equilibrium use (saturation level) of chemical fibres between the wool and the cotton sectors: 0.72 for wool compared with 0.38 for cotton. These predictions are based on the assumption that past technological and market conditions will continue to prevail in the future.

Diffusion (adoption) rates are of course not directly comparable between the two sectors, as the fitted logistic trends do not have the same origin or saturation level. However, if we allowed for the scale effect, the estimated diffusion rate in the cotton sector would be even lower.9

CONCLUDING REMARKS

The chapter measured the diffusional impact of technological change on fibre substitution in the Chinese textile industry. The approach followed was to fit a standard logistic trend to data on mills' fibre consumption data for the period 1975-91. A set of other possible trend curves was also presented, but none was found to be statistically superior to the standard logistic trend.

Based on standard logistic analysis, it was found that the diffusional impact of chemical fibres on fibre substitution was differential for the Chinese wool and cotton textile industries. The revealed equilibrium use of man-made fibres (saturation levels) and the rate of approach to equilibrium (slopes) were higher for wool than for cotton. The results also indicated that, if current market conditions prevail and there is no adverse technological change, the speed of displacement of wool by chemical fibres will slow down and end in the not-too-distant future. This suggests that the Chinese wool textile industry could ultimately be expected to absorb chemical fibres and wool in a ratio of about 3:1.

It is worth noting that the preceding analysis concentrated only on the technological side of adjustment. In fact, the time pattern of the diffusion process is not

9 The difference between the origin and the estimated saturation level is 0.45 for wool and 0.31 for cotton. If the saturation level in the cotton sector were raised to 0.52, which effectively results in the same difference as in the wool sector, the estimated diffusion rate would be even lower because an inverse relationship exists between saturation level and diffusion rate.
immune to economic and policy conditions. Griliches' (1957) classic study related interstate differences in adopting "hybrid corns" to "profitability" variables. Powell et al. (1963) argued that relative prices could both accelerate the rate of adoption and affect the long-run market share enjoyed by a new product. However, these arguments do not apply in the case of China, where economic variables such as profitability and relative prices have played a very limited role in technological adjustment. Their importance has of course increased in the post-reform period (chapter 2).

Casual observation suggests that the differential impact of technological diffusion upon fibre substitution has much to do with changing fibre self-sufficiency in China. It seems that the tighter supply and demand are in a particular market, the greater is the innovative impact of technological diffusion upon fibre substitution in that market. It is therefore crucial to understand changes in supply and demand in China's natural fibre markets. Specifically, the effects of China's longstanding self-sufficiency policy need to be examined, as the success or failure of aspects of this policy has substantial implications for fibre substitution in the Chinese textile industry. This issue will be dealt with in more detail in chapter 7, which examines policy issues.
5 The Role of Prices in Fibre Substitution

In previous chapters we have looked at the impact of economic growth and technological diffusion on fibre demand and substitution. The issue examined now is the role of prices in fibre substitution.

In analysing price-induced fibre substitution in China’s partially reformed textile economy, we cannot automatically adopt the neoclassical approach; its basic assumptions must first be checked and proven to be met. Chapter 2 pointed out that there are three basic conditions associated with the neoclassical demand model, namely: 1) firms should be either profit maximisers or cost minimisers; 2) there should be no physical shortage, that is, a fibre market exists; and 3) firms’ budget constraint should be hard or at least not perfectly soft.

The purpose of this chapter is to examine these conditions in the specific context of the Chinese wool textile industry. Findings of previous studies are restated and the results of my own survey presented. The results indicate that neoclassical demand models are potentially useful in examining price-induced fibre substitution in the Chinese wool textile industry.

BEHAVIOURAL CHANGE IN STATE FIRMS

An essential condition for the existence of price-induced substitution between production inputs is that firms be profit maximisers or cost minimisers. Prior to the introduction of economic reform in the late 1970s, state firms’ behaviour in China was characterised by neither of these. Managers were more concerned with filling the production quota than with making a profit. State enterprises were above all production entities (Mao and Hare 1989) and took no responsibility for their profits and losses. Furthermore, because competition was very limited and prices played virtually no role in economic activities, there was no need for enterprises to make any economic decisions about input demand or output supply.
This situation began to change in the late 1970s with the introduction of a number of economic reforms. Greater autonomy was granted to state-owned enterprises: managers were given the right to choose their own structure and style of management; enterprises were allowed to keep a percentage of their profits; firms began to purchase some inputs and sell goods produced in excess of the quota on the free market; and the power to decide what to produce, how much to produce, and how to produce it was transferred to a large extent from the state to enterprises (Groves et al. 1991).

The broadening of enterprise autonomy in the early reform period was reinforced in the mid 1980s by price reform and the development of product and factor markets. The key innovation in industrial reform was the creation of a dual track price system (Rawski 1992), which not only permitted greater competition but also further strengthened the autonomy of enterprises.

With increases in firm's managerial autonomy and market orientation, many analysts believed that state enterprises, though still burdened with all the trappings of socialist planning, would be able to move in the direction of market-oriented and entrepreneurial behaviour (Jefferson and Rawski 1992). They would produce, for profit, goods in short supply, and cut costs by using raw materials available in ample supply at low prices (Mao and Hare 1989).

But to what extent has the actual behaviour of the now largely autonomous state enterprises fulfilled these expectations? Recent research suggests that state enterprises in China have indeed become more profit-oriented. Groves et al. (1991, p. 20), using data from surveys conducted by the Institute of Economics in the Chinese Academy of Social Science (CASS), found that “increases in enterprise autonomy have induced measurable change in behaviour at the enterprise level”. Within the framework of the structure-conduct-performance paradigm of the industrial organisation literature, Jefferson and Xu (1991) examined the degree to which state enterprises in transition mimic the behaviour of the canonical neoclassical firm. Based on survey data collected from industrial

---

1 The data covered 769 enterprises in four provinces (Sichuan, Jiangsu, Jilin and Shanxi) in 1980-89.
enterprises in Wuhan, Jefferson and Xu found that Chinese enterprise managers tend to economise on factor inputs in response to increases in managerial autonomy and market orientation. More recently, Rawski (1992) concluded after an examination of the CASS survey data set\(^2\) and that of the Institute for Economic System Reform\(^3\) that “firms do have a clear incentive to pursue profit and avoid loss” (Rawski 1992, p. 16).

Although most economists agree that state enterprises have become more profit-oriented, opinion differs as to whether it is the profit-seeking motive that dominates managerial behaviour. Many researchers believe that the pursuit of profits, rather than being the ultimate goal of state enterprises, is more likely to serve as an avenue for increasing benefits to firm employees (Byrd and Tidric 1987; Perkins 1988; Granick 1990; Ishihara 1990; Lin 1990). Byrd and Tidrick (1987 p. 52), for example, stated that “the identification of workers with the interests of managers means that maximising worker benefits is frequently the dominant motive of enterprises”.

The characterisation of Chinese firms’ behaviour as enterprise-welfare maximisation was first made explicit by Lin (1990), who stated that the firm’s objective function in the post-reform economy was wage + profit maximisation, expressed as:

\[
\text{Max } R = V(y) + \alpha(py - C(y))
\]  \hspace{1cm} (5.1)

where:

- \(R\) is total receipt of income by workers;
- \(V(y)\) is wage bill, \(V'(y) > 0\);
- \(\alpha\) is profit retention rate, \(0 < \alpha < 1\);
- \(p\) is output price;
- \(y\) is output, \(y \geq 0\); and
- \(C(y)\) is production cost, including \(V(y), C'(y) > 0, C''(y) > 0\)

\(^2\) The data covered 453 firms, including 363 in the state sector and 278 large and medium sized firms, for the years 1980 and 1983-86.

\(^3\) The data covered 852 enterprises, including 736 in the state sector and 617 large and medium sized firms, for the years 1986-89.
This may look peculiar at first sight because although $V(y)$ appears in $C(y)$, which should be minimised, it is also a positive element in the objective function, which should be maximised. However a careful examination will reveal the rationale of the characterisation. If we assume that there is no institutional control over wages, $V(y)$ is likely to be driven up to the point where $py = C(y)$. In this instance, all factor remuneration goes to labour. However, the government usually tries to control wages, making $V(y)$ a variable exogenous to the firm’s economic decision. Incentives, then, are derived exclusively from the profit retention rate $\alpha$. In the pre-reform period, when $\alpha$ was equal to zero, a firm had no incentive to maximise profits or minimise costs. In the post-reform period, however, $\alpha$ has become greater than zero, and the incentive certainly exists for firms to maximise profits or minimise costs. Generally speaking, the higher $\alpha$ is, the greater is this incentive (Groves et al. 1991).

Lin’s model has an important implication: although the behaviour of Chinese state firms in the post-reform era is still far from that of neoclassical firms, the profit mechanism is embedded in firms’ objective function. So long as the profit retention rate $\alpha$ is greater than zero, autonomous state firms have an incentive to economise on production inputs, or at least on the use of raw materials.

Putting aside discussion of the general impact of reform on state firms’ behaviour, what is the evidence for behavioural change in firms in the Chinese wool textile industry? The industry has undergone extensive reform, especially since the mid 1980s. One important reform measure, aimed at increasing enterprises’ financial accountability, was the introduction of the Contract Management System (CMS). Under the CMS, state enterprises establish a contract with their supervisory bodies that governs mutual responsibilities, rights and benefits associated with the management of enterprises. A key feature of the CMS is that enterprises are provided with clear incentives for seeking increases in profit or a reductions in losses. A survey conducted by the author in 1992 of state-owned wool textile enterprises in Shanghai, Jiangsu and Shandong found that 32 of 35 responding enterprises had adopted the CMS. This suggests that an overwhelming majority of state enterprises in the Chinese wool textile industry are now under various institutional constraints to behave more like profit-seeking firms.
Various forms of the CMS have been adopted in the Chinese wool textile industry. The most popular of these is the base figure contract in which state enterprises are contracted to transfer quotas of taxes and profits to the state and profits derived from above-quota output is split between enterprise and state according to a pre-specified distribution ratio. Of the 32 enterprises in my survey adopting the CMS, 20 had signed a base figure contract with their supervisory bodies (Table 5.1).

The quota system — in which a fixed proportion of profit is turned over to the state and any remaining profit is retained by the enterprise — is usually adopted by enterprises generating either a small loss or a small profit. This system has a zero marginal tax rate and hence provides a greater incentive for enterprises. Of the enterprises surveyed, five had adopted the quota system.

Other forms of the CMS include the progressive increase and reduction of loss contracts. In the former, progressive increases in taxes and profits are transferred to the state while above-quota portions of profits are either retained by enterprises or shared by the enterprises and the state in a contracted ratio. In the latter, an enterprise which chronically generates a loss guarantees that its annual losses will be held under a definite ceiling. Four of the firms which adopted CMS held progressive increase contracts and three reduction of loss contracts.

Table 5.1 Types and Adoption Rate of Contract Management System (CMS)

<table>
<thead>
<tr>
<th>Contract form</th>
<th>No. of firms</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quota contract</td>
<td>5</td>
<td>15.63%</td>
</tr>
<tr>
<td>Base figure contract</td>
<td>20</td>
<td>62.50%</td>
</tr>
<tr>
<td>Progressive increase contract</td>
<td>4</td>
<td>12.50%</td>
</tr>
<tr>
<td>Reduction of losses contract</td>
<td>3</td>
<td>9.38%</td>
</tr>
<tr>
<td>Total enterprises adopting CMS</td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Author’s 1992 survey.
In all its forms, the CMS stresses the importance of total remitted tax and profits. As Table 5.2 shows, Chinese wool enterprises now place great emphasis on total remitted tax and profits, the incentive for doing so being that if contract norms are met, they are entitled to increases in retained profit. In contrast, the volume of output has become the least attractive goal sought by enterprises.

Table 5.2 Importance of Tax and Profits in CMS

<table>
<thead>
<tr>
<th>Contract items</th>
<th>No. of enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of output</td>
<td>14</td>
</tr>
<tr>
<td>Volume of output</td>
<td>7</td>
</tr>
<tr>
<td>Assortment</td>
<td>9</td>
</tr>
<tr>
<td>Total remitted tax and profit</td>
<td>26</td>
</tr>
<tr>
<td>Retained profit</td>
<td>9</td>
</tr>
<tr>
<td>Export and earn foreign exchange</td>
<td>15</td>
</tr>
</tbody>
</table>

Notes: In my questionnaire, I asked enterprises to select items in order of importance. Unfortunately, few did. Nevertheless, the responses provided do give some indication of enterprises’ priorities.

Source: Author’s 1992 survey.

Given that profit affects the wellbeing of enterprises, what is the link between profit and material benefits to workers? Of the 32 enterprises adopting the CMS, 24 acknowledged that the total wage bill of workers (wages plus bonuses) is linked to the rate of increase in profit and tax remitted to the government. However, when questioned about the elasticity of this link only a few firms responded. The low response rate may have reflected the sensitivity of the question being asked, as most Chinese enterprises are keen to keep some discretion from their supervisory bodies. This in itself indicates that actual incentive payments to workers by sample firms may have been higher than the government normally allows.
MARKET DEVELOPMENT

Pre-reform China was a “classic” shortage economy (Kornai and Daniel 1989). There were serious shortages of nearly everything, from intermediate goods to consumer goods. Both producers and consumers frequently engaged in forced substitution.

Chronic shortages in socialist countries have often been attributed to the emphasis on expansion and quantity, which in turn can be traced to the persistence of soft budget constraint (Kornai 1980; Wong 1986). A number of other economists view the lack of a flexible price mechanism as a key explanatory variable generating shortage (Mao and Hare 1989; Hare 1989). In many cases, they argue, shortage may merely be the outcome of distorted prices, which are pervasive in planned economies.

The introduction of a price mechanism in the Chinese economy proved effective in eliminating or reducing shortages of many products. So far, although price reform has proceeded in a piecemeal way, the cumulative effects have been large. In just over a decade, the Chinese have been successful in converting the market for many consumer products from a sellers’ into a buyers’ market. A typical example is textile and clothing products. Since 1983, when the ration system was abolished, the market for textile and clothing products in China has become increasingly prosperous (Kong 1992).

A puzzling phenomenon, however, has been the continued existence of shortage of many producer goods, including raw materials. In the case of the wool textile industry, shortage has been reflected in low levels of capacity utilisation (Zhang et al. 1991). Because of this, some believe that producers are still facing the type of shortage described by Kornai (1980).

While it is true that soft budget constraint is an ongoing cause of the short supply of many producer goods in China, the notion of shortage in the post-reform economy differs from that under the traditional planned economy. In the pre-reform economy, prices were fixed and markets were often in a non-clearing state. When forming their initial demand for inputs, producers had to consider non-price signals such as queue length, waiting time and so on. Forced substitution was also a common phenomenon. In the post-reform economy secondary markets are allowed, and any excess demand or shortage will be cleared by prices prevailing on the open market (chapter 2).
Although it can be argued in theory that the existence of a secondary market will eliminate “physical shortage”, the extent to which the secondary market has actually developed is important. If the portion subject to regulation by market prices is small, any argument about the absence of “shortage” would still be weak in practical terms. This necessitates separate analysis of the extent to which fibre markets have developed over the past decade.

**Wool Market**

Up to 1984 the market for wool was tightly controlled, with the Unified Purchasing and Selling System (UPSS) playing a dominant role. Under this system, producers sold all their products to the state at a specified price, and their consumption requirements for wool were met by means of state allocation. Because UPSS set a low price for wool, shortage of wool was a persistent phenomenon (Du 1992).

The UPSS was formally abandoned by the state in 1985 in favour of a new marketing and pricing system called “Contract Purchasing”. Under this system, the state purchased a proportion of wool growers’ output at a price stipulated in the contract. After fulfilling the contract, wool growers were allowed to sell their products on the free market. This has effectively resulted in a dual price system in the wool market.

As wool was liberalised at a time of excess demand for wool and before an organised market was set up, free market prices were under pressure to increase. Farmers and herdsmen were reluctant to sign contracts with the state, whose prices were lower than the free market price, and tried to move as much wool as possible on to the market. The state, finding it increasingly difficult to obtain wool, was forced to increase its purchasing price substantially. In 1984-88, the mixed average state purchasing price of wool\(^4\) rose from 3.7 RMB yuan per kilogram to a record level of 10.8 RMB yuan per kilogram (Figure 5.1).

\(^4\) The mixed average purchasing price is calculated as: total value of purchased wool / total quantity of purchased wool.
Sharp increases in the state purchasing price did not, however, prevent competition in the purchase of wool. In fact, during 1985-88, the so-called 'Wool War' developed. Actors in the battle for raw wool supplies included various types of enterprises (both state and non-state), various levels of government and various kinds of private dealers (Watson et al. 1989). The origin of the ‘Wool War’ was a relaxation of central control over wool marketing at a time when regional governments in major producing provinces (Gansu, Qinghai, Xinjing and Inner Mongolia) were anxious to develop their own wool processing industries under the new policy of ‘own production, own use and own sales’ (Watson and Findlay 1992). A direct consequence of the ‘Wool War’ was a significant decline in the role of the state in wool distribution in China. By 1989, the share of state purchases in total wool production had fallen to less than 50 per cent (Figure 5.2).

The ‘Wool War’ also spread from China to overseas wool producing countries. Wool textile enterprises in coastal provinces and cities, deprived of their traditional sources of supply, turned to the international market for their supplies of raw wool.

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5 Another major consequence of the ‘Wool War’ was the decline in the quality of wool sold and purchased. For an excellent discussion of China’s ‘Wool War’, see Watson and Findlay (1992).
Competition for foreign wool was intense, leading to enormous increases in the world wool price. In 1988, when the ‘Wool War’ was at its height, the average price per kilogram paid for wool imported into China was twice that of 1984 (Zhang 1990).

Figure 5.2  Share of State Purchases in Total Wool Production in China, 1981-91


In response to the ‘Wool War’, the government tightened controls from 1989 onwards. Wool moved back into a single government-controlled marketing channel (Shi 1990). A minimum delivery quota on wool production was re-imposed in major wool growing provinces. Controls over wool imports were also tightened, with import quotas and centralised import arrangements being reintroduced. There was concern that these policy changes would cause new supply restrictions for the wool industry (Zhang et al. 1991).

However, the tightening of control over domestic wool did not involve total elimination of the secondary market. For instance, in the major wool producing region of Inner Mongolia, where tougher controls are believed to have been imposed, farmers and herdsmen could still sell around 20 per cent of their production to Supply and Marketing Cooperatives at a negotiated price determined basically by supply and demand forces. Furthermore, because of the slump in consumer demand for wool products that began in late 1988 and accelerated in early 1989, the negotiated price began to move closer to the
official price, which has itself declined since 1988 (Figure 5.1). In 1990, the negotiated price fell to the same level as the official price (Fisher et al. 1990).

Changes in the wool distribution system brought about by economic reform had a profound influence on the wool processing sector. Wool requirements were no longer automatically allocated in full by the state. Instead, the wool processing sector had to become reliant on the market for its wool requirements.

According to the survey of selected wool mills conducted by the author in 1992, purchases of wool on the market have been increasing steadily since 1987. By 1991, the share of wool purchased on the market by these mills had reached over 70 per cent (Figure 5.3), more than the national average. This is probably because these regions rely a great deal on imported wool, an increasing part of which is procured outside the traditional state planning channels.6

Figure 5.3 Market Purchase versus State Allocation: the Case of Wool

Source: Author's 1992 survey.

6 Traditional planned imports are often associated with explicit and/or implicit import subsidies. Until the end of 1988, there was a direct subsidy equivalent of 4 RMB yuan per kilogram for planned wool imports. There was also an implicit subsidy in that wool processors could buy imported wool at the official, overvalued, exchange rate.
The market for chemical fibres was once heavily controlled by the government, with the state plan dominating both production and distribution. Domestic prices for chemical fibres and chemical fibre products were high, mainly due to tight restrictions on imports.

Although with technological diffusion chemical fibres had become increasingly popular, their high prices began to meet strong resistance from consumers. This was felt first in the early 1980s, when the supply of domestic fibres (particularly cotton) increased greatly due to the success of rural economic reform. The government, faced with sluggish domestic sales of chemical fibre products, had to adjust prices downward several times, thus putting pressure on both producers and processors to become competitive.

Market reform in the chemical fibre sector was slow compared with reform in other sectors of the Chinese textile industry. Even today a substantial part of chemical fibre production is subject to state control. There has, however, been some relaxing of the state’s grip on prices. Unlike in the pre-reform period, when production quotas were always accompanied by a fixed quota price, the state can no longer secure through the state allocation system the chemicals required for the quota production. Consequently, that part of production which uses high-priced chemicals was allowed to be transferred at the market price.

The development of a chemical fibre market was also facilitated by the growing number of chemical fibre manufacturers operating outside the state planning system, Township and Village Enterprises (TVEs) for example. By 1990, the total number of TVEs had reached 547 — nearly 2.5 times the number of state owned chemical fibre producers — though the value of their output accounted for only about 10 per cent of the national total in that year. These TVEs relied mainly on the market to acquire raw materials and sell their output.

Markets in which free transactions of chemical fibres can be made have also been set up. Three major textile markets (for all textiles including chemical fibres) now operate in China: in Shanghai (for East China), Shandong (for North China) and Fu Shan (for South China). Although these markets are subject to a floating price range, it
appears that the government-set price ceiling has rarely been binding and that firms' marginal demand has usually been met on these markets. In cases where the price ceiling has been binding, it has been reported that premiums over the state ceiling were paid by users price for chemical fibres sourced in these open markets (China's Textile News January 1992, p. 4).

My survey provides important information about the degree of dependence on market purchases of chemical fibre consumers. Figure 5.3 shows that in 1987-91 the average proportion of chemical fibres purchased on the market by sample wool mills rose from 50 per cent to over 70 per cent.

Figure 5.4  Market Purchase versus State Allocation: The Case of Chemical Fibres

Source: Author's 1992 survey.

HARDENING BUDGET CONSTRAINT

As stated earlier, for state firms in socialist countries to respond to price signals, the budget constraint needs be hard or at least not perfectly soft (chapter 2). In particular, firms should not have price-making power, that is, they should not be able to impose cost increases on their customers. At the same time, the financial accountability of firms needs to be such that they are compelled to take real action in response to a change in input prices.
The budget constraint of state firms in the pre-reform Chinese economy was typically soft. This was mainly reflected in the lack of entry and exit from the market, the negotiability of prices, the availability of soft credit and free grants, and most of all the absence of financial accountability. Under these conditions, it would surprising if firms reacted at all to a change in input prices.

These conditions have since altered as a result of economic reform, though to a varying degree. Although the continuing existence of loss-making firms propped up by subsidies inclines many economists to believe that post-reform budget constraint remains soft (Wong 1986; Perkins 1988; World Bank 1990), some aspects of the budget constraint have hardened. First, the price-making power of state firms has been greatly curtailed, mainly because in the second half of the 1980s a buyers’ market began to emerge in the trade of many consumer products including textiles and clothing. With excess supply, in the late 1980s the market prices of many textile products fell well below state-planned prices (Economic Daily 20 March 1991, p. 1). This made it no longer sensible for enterprises to bargain with the state authority for higher output prices to compensate for increases in input prices. State firms were thus compelled to pay more attention to marketing, lowering prices and costs, and improving the quality of their products.

Second, conditions for obtaining investment funds have hardened. Perkins (1988) observed that “the Chinese in the 1980s have been moving steadily away from provision of investment funds on a grant basis from the government budget” (Perkins 1988, p. 616). This means that both working capital and investment financing now come at a cost. Under the present incentive structure, firms need to be more cautious with their spending on various production inputs including raw materials.

Third, state firms have become more financially accountable. This has mainly been a result of the widespread adoption of the CMS, as discussed earlier. For loss-making firms, there is now a limit on allowable losses. Furthermore, losses can no longer be written off, although the present arrangement for debt repayment still tends to make the budget constraint soft.
There is some evidence in my survey to show that the budget constraint of state enterprises in the wool textile industry has hardened as a result of economic reform. In the questionnaire, I asked enterprises whether the prices of state-allocated raw materials have increased in recent years. The unanimous answer was "yes". And what measures did enterprises take to deal with this situation? Four choices were given: (a) influence the government to increase the output price; (b) absorb rising costs internally; (c) apply for government subsidies; and (d) reduce output. Of 32 firms, 22 selected (b), five selected (a), three selected (d) and two selected (c). From this result, it is apparent that most wool textile enterprises in China no longer rely on the government to compensate them for increases in cost, preferring instead to strive to minimise the impact of price increases on their operating costs.

Many enterprises in the Chinese wool textile industry have made losses in recent years. Of 35 wool enterprises surveyed, 21 experienced operating losses in one year or another. Surprisingly, my survey results show that no firm asked for a reduction of debt in difficult years. Rather, they sought to accommodate repayments by extending the period of the loan, rolling over loans and asking for permission to repay debt before paying taxes. Although these sorts of arrangement do tend to soften the budget constraint, they are certainly a step forward from the previous situation in which the government was directly responsible for any losses incurred.

**IMPLICATIONS**

The discussion so far has raised a number of points. First, post-reform enterprises have become more profit oriented, although their behaviour still deviates from that of "orthodox" neoclassical enterprises (Ishihara 1990). The characterisation of enterprises' behaviour as workers' welfare maximisation means that Chinese firms' cost behaviour with respect to labour differs from that of typical neoclassical firms. A neoclassical cost function including labour may therefore not be a valid approach to characterising firm behaviour in China. The cost minimisation assumption of the neoclassical model is, however, now clearly applicable to a sub-cost function consisting only of raw materials. Under the present incentive scheme and due to the disposability of raw materials, firms
can be considered to have every incentive to seek the best combination of raw material inputs and to economise on the use of fibres.

Second, the dual price system has provided China with an evolutionary means of reform as the country progresses towards a complete market system (Tisdell 1993). By 1991, the extent to which state firms' demand for fibres was subject to market regulation had already become overwhelming. Because of the development of fibre markets, the nature of shortage has changed. In the pre-reform period, although prices of raw materials were low, demand from firms could not always be met and firms often had to engage in forced substitution. In the post-reform period, any shortage would be reflected in higher free market prices and firms' marginal decisions would be made on the basis of these prices.

Third, there is evidence that the budget constraint has hardened to some extent as a result of economic reform. Basically, though, it remains soft in comparison with the hard budget constraint of firms in a market economy. The response of Chinese firms to a change in prices, then, could be expected to be weak.

In summary, in view of the changes that have taken place in the post-reform Chinese economy, it appears that the neoclassical demand model is to some degree applicable to measurement of fibre demand and substitution in the Chinese wool textile industry.
Price-induced Fibre Substitution in the Chinese Wool Textile Industry

In chapter 5, we examined behavioural change in Chinese textile mills brought about by economic reform and also changes in the market environment in which mills operate. It was argued that because of these changes textile mills in China now have an incentive to respond to price signals, at least in the case of raw material use.

The objective of this chapter is to examine empirically the degree of price responsiveness and price competition between wool and chemical fibres in the Chinese wool textile industry. To this end, a translog cost model allowing for free variation of the parameters of inter-fibre competition is applied to my survey data on wool (1992). The lag structure in textile producers' responses is also investigated; it is possible that in the short run textile producers may not respond fully to price changes because of institutional and technological rigidities or because of inertia in their behaviour. 'Bootstrapping' is performed to ensure that elasticity estimates are robust. The results have important policy and marketing implications.

METHODOLOGY

As general methodological issues have already been discussed in some detail in chapter 2, this section will concentrate on considering the specification of an econometric model for fibre demand in the Chinese wool textile industry.

Basic model

We assume that there exists in the Chinese wool textile industry a continuously twice differentiable production function of the following:

\[ y = f(K, L, F(f_s, f_w)) \]  \hspace{1cm} (6.1)

where \( y \) is output, \( K \) is capital, \( L \) is labour and \( F \) is fibre materials which are in turn a function of chemical fibres and wool. It is further assumed that: (i) the production
function is linearly homogeneous (that is, constant returns to scale), increasing and quasi-concave in inputs; (ii) there is strong separability between $K$ and $L$, and $F$; and (iii) technical progress is Hicks neutral. Corresponding to the production function is a cost function reflecting the production technology. This can be written as:

$$C = g(y, p_K, p_L, p_F)$$  \hspace{1cm} (6.2)

where $p_K$: rental price of capital  
$p_L$: price of labour  
$p_F$: price of fibres  

The homothetic separability equivalence theorem (Blackorby et al. 1977; Oum 1979) implies that, if the production function is increasing and satisfies conditions for continuity, monotonicity and quasi-concavity, the homothetic separability of $F$ from $(K, L)$ in the production function is equivalent to the separability of $p_F$ from both $(p_K, p_L)$ in the cost function. This allows us to construct a sub-cost function (6.3) that is independent of the price of inputs other than the price of fibres, that is, $p_K$ and $p_L$:

$$C_F = g(y, p_s, p_w)$$  \hspace{1cm} (6.3)

where $p_s$ is the price of chemical fibres and $p_w$ is the price of wool.

For the purpose of the estimation, we need to employ a specific functional form for sub-cost function (6.3). For a two-input cost model, although Cobb-Douglas and Constant Elasticity of Substitution (CES) are convenient ways of representing the production technology, they prove to be too restrictive. We therefore resort to more flexible functional forms.

Following Christensen, Jorgenson and Lau (1973), we choose to specify a highly general functional form that allows for free variation of Allen partial elasticities of substitution and that can be interpreted as a second order approximation. Although there are a number of functional forms that satisfy this requirement, the popular translog specification is chosen in this study. To apply our two-input model to the panel data, we

---

1 The specification tests show that more flexible functional forms, such as translog, are preferable to both Cobb-Douglas and CES.
write the translog cost function, with symmetry and constant returns to scale imposed, as:

\[
\ln C_{ht} = \alpha_0 + \ln y_{ht} + \alpha_s \ln p_{sh} + \alpha_w \ln p_{wh} + \frac{1}{2} \alpha_{ss} (\ln p_{sh})^2 + \frac{1}{2} \alpha_{sw} (\ln p_{sh}) (\ln p_{wh}) + \alpha_{ww} (\ln p_{wh})^2 + \ln p_{wh} + v_{ht} \tag{6.4}
\]

where \(C_{ht}\) is total fibre cost for firm \(h\) (= 1, 2, ..., n), observed at each of \(T\) time periods, \(T = 1, 2, ... 5\), \(\alpha\)'s are coefficients to be estimated and \(v_{ht}\) are random errors.

If we assume that sample firms minimise costs, treating fibre prices and the level of output as conditionally predetermined, we can obtain the following share equations by differentiating (6.4):

\[
S_s = \alpha_s + \alpha_{ss} \ln p_{sh} + \alpha_{sw} \ln p_{wh} + \mu_{sh} \tag{6.5}
\]
\[
S_w = \alpha_w + \alpha_{sw} \ln p_{sh} + \alpha_{ww} \ln p_{wh} + \mu_{wh}
\]

where \(S_s\) is the value share of chemical fibres, \(S_w\) is the value share of wool, and \(\mu_{sh}\) and \(\mu_{wh}\) are random error terms in cost minimising behaviour.

Linear homogeneity in prices imposes the following restrictions on (6.4) and (6.5):

\[
\alpha_s + \alpha_w = 1 \quad \text{or} \quad \alpha_s = 1 - \alpha_w
\]
\[
\alpha_{ss} + \alpha_{sw} = 0 \quad \text{or} \quad \alpha_{ss} = -\alpha_{sw}
\]
\[
\alpha_{sw} + \alpha_{ww} = 0 \quad \text{or} \quad \alpha_{sw} = -\alpha_{ww}
\tag{6.6}
\]

This results in the deletion of one of the two share equations. To gain efficiency in estimates of interest, equation (6.4) can be estimated simultaneously with one of the share equations in (6.5) using any multivariate regression technique, say, iterative Seemingly Unrelated Regression (SUR). The iterative SUR estimators have the same asymptotic properties as maximum likelihood estimators. The estimates are invariant to the equation deleted (Barten 1969).

Since fibre substitution in the processing stage is closely linked to final demand, a set of proxy dummy variables allowing for change in output composition (in terms of fibre content), \(D_i\), was added to (6.4) and (6.5) to identify whether these variables affect
total fibre cost and fibre shares. This gives us the following static system of equations describing firms' demand behaviour for fibres:

$$\ln C_{ht} = \alpha_{c} + \ln y_{ht} + \alpha_{y} \ln \left(\frac{p_{shl}}{p_{wht}}\right) + \frac{1}{2} \alpha_{s} \left[\ln \left(\frac{p_{shl}}{p_{wht}}\right)\right]^2$$

$$+ \tau_1 \ln D_{1ht} + \tau_2 \ln D_{2ht} + \tau_3 \ln D_{3ht} + \nu_{ht}$$

(6.7)

$$S_{shl} = \alpha_{s} + \alpha_{ss} \ln \left(\frac{p_{shl}}{p_{wht}}\right) + \phi_1 \ln D_{1ht} + \phi_2 \ln D_{2ht} + \phi_3 \ln D_{3ht} + \mu_{shl}$$

where $D_1$, $D_2$ and $D_3$ are respectively the share of pure chemical fibre products, the share of pure wool products and the share of blended products in total output.

**Dynamic specification and alternative cost and share model**

The translog cost function and associated cost share equations considered up to this point have been static in the sense that cost and share variables are taken to be a function of a set of explanatory variables observed at the same point in time, implying that the pattern of demand adjusts to changes in prices instantaneously. However, there are good reasons for believing that economic behaviour often involves a time lag during which costs and shares are adjusted to their optimal levels. For instance, a firm which finds that its current fibre shares are inconsistent with the long-run equilibrium implied by current relative fibre prices will generally spread the planned adjustment to long-run equilibrium over a period of time. If that is the case, our cost model and share equations should incorporate this adjustment process, especially when having panel data at hand.

There are a number of ways to model the lagged adjustment behaviour of firms, including the partial adjustment model, Error Correction Model (ECM) and autoregressive model. ECM is a more generalised version of the partial adjustment model. Although empirical evidence and economic interpretation are more in favour of ECM than the restricted partial adjustment hypothesis (Maddala 1992), there is a trade-off between the use of a more desirable hypothesis and the loss of scarce observations.

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2 The inclusion of these proxy dummies can also be considered a way of capturing the so-called “fabric substitution effect” (Blau 1946), which basically relates to the indifference maps of the final consumers of fibre products. Ferguson and Polasek (1962) argued that fabric substitution caused, for example, by a shift in consumer preferences at a given level of prices in favour of a fabric containing less wool and more synthetic fibres, would also influence mill consumption patterns. It is therefore important to remove this effect when dealing with price-induced fibre substitution.
the case of the autoregressive model, the hypothesis was rejected by a pre-test with our data. The partial adjustment model was, therefore, selected.

The partial adjustment hypothesis has often been used in applied economics to describe firms’ optimal behaviour in the face of an adjustment cost. Suppose that there is a desired level of some variable that an agent would like to achieve at time $t$, denoted as:

$$y_t^* = \alpha + \beta x_t + \varepsilon_t \quad (6.8)$$

However, because of friction, delays, cost of adjustment and so forth, the desired level of $y$ cannot be achieved within a single period. Starting from the previously existing level $y_{t-1}$, the change required to attain the desired level is $y_t^* - y_{t-1}$, but the actual change $y_t - y_{t-1}$ is only a fraction of this. Assuming that the proportion achieved is $(1-\lambda)$, where $0 < \lambda < 1$, the partial adjustment hypothesis can be written as:

$$y_t - y_{t-1} = (1-\lambda)(y_t^* - y_{t-1})$$

or

$$y_t = \alpha (1-\lambda) + \beta (1-\lambda) x_t + \lambda y_{t-1} + (1-\lambda) \varepsilon_t \quad (6.9)$$

Small values of $\lambda$ imply relatively quick adjustment, and if $\lambda=0$, adjustment is complete, not partial, in a single period. Larger values of $\lambda$ imply that the past value of the variables concerned exerts a greater influence, and if $\lambda=1$, nothing changes.

Applying the above partial adjustment hypothesis to (6.7) leads to the following dynamic system of cost function and share equation to be estimated:

$$\ln C_{ht} = (1-\lambda)(\alpha_0 + \ln y_{ht}) + (1-\lambda)\alpha_s \ln (p_{shl} / p_{whl}) + (1-\lambda)\frac{1}{2} \alpha_s \ln (p_{shl} / p_{whl})^2$$

$$+(1-\lambda)\tau_1 \ln D_{1ht} + (1-\lambda)\tau_2 \ln D_{2ht} + (1-\lambda)\tau_3 \ln D_{3ht} + \lambda \ln C_{ht-1} + (1-\lambda)\nu_{ht}$$

$$S_{shl} = (1-\lambda)\alpha_s + (1-\lambda)\alpha_{ss} \ln (p_{shl} / p_{whl}) + (1-\lambda)\phi_1 \ln D_{1ht}$$

$$+(1-\lambda)\phi_2 \ln D_{2ht} + (1-\lambda)\phi_3 \ln D_{3ht} + \lambda \ln S_{shl-1} + (1-\lambda)\mu_{shl} \quad (6.10)$$

It should be pointed out that since the adjustment speed for cost and share needs to be consistent, $\lambda$ should be restricted so that it is equal across the two equations in (6.10). To determine whether a static or dynamic cost model is to be used, a simple $t$ test or a log likelihood ratio test can be performed.
It is often argued that the partial adjustment hypothesis is rather *ad hoc*, but it can be justified in terms of a cost minimisation procedure. Ball et al. (1989) offered a more rigorous derivation of the partial adjustment model toward the translog specification, leading to basically the same result as (6.10). The authors started with a cost minimisation problem for a fixed level of a single output:\(^3\)

$$\min C_t = P_t^T F_t + g(F_t; F_{t-1}), \quad \text{Subject to: } Y_t = f(F_t) \quad (6.11)$$

where \(C_t\) and \(P_t\) are vectors of cost and fibre prices, \(F_t\) is a vector of fibre inputs and \(Y_t\) is a vector of output. The function \(g(F_t; F_{t-1})\) is intended to represent the cost of adjusting the level of inputs, while \(f(F_t)\) represents the firm’s production function. First-order conditions for a minimum are:

$$p_i + g_i(F_t; F_{t-1}) - \lambda f_i(F_t) = 0 \quad i = 1, 2, ..., n. \quad (6.12)$$

$$y_t - f(F_t) = 0$$

where \(f_i\) and \(g_i\) denote the partial derivatives of \(f\) and \(g\) with respect to \(F_t\). If a smooth, increasing, strictly quasi-concave production function is assumed, then obviously the second-order sufficient conditions will always be satisfied. This ensures the existence of an optimal cost function:

$$C_t = C_t(P_t, y_t, F_t, F_{t-1}) \quad (6.13)$$

Ball et al. (1989) select a multiplicative form of the cost function incorporating the adjustment cost as it is consistent with the translog functional form. The partial adjustment model is written as:

$$C_t = C_s(P_t, y_t) C_o^\lambda \quad (6.14)$$

where \(C_s\) is the long-run optimum cost of production defined as \(C_s=C_s(P_t, y_t)\), \(\lambda\) is a partial adjustment parameter and \(C_o\) is the cost of production given that no adjustment is made to the level of inputs (that is, \(C_o = P_t^T F_{t-1}\)). It can be shown that this cost function

---

\(^3\) The following section draws heavily from Ball et al (1989), with only some modifications in notation.
has desirable properties of homogeneity of degree one, weak concavity in prices and symmetry with respect to its price derivatives.\(^4\)

The partial adjustment specification also leads to a system of share equations. Taking the derivative of the natural log of the partial adjustment cost function with respect to the log of price yields:

\[
\frac{\partial}{\partial} \ln C_i / \partial \ln p_{it} = S_{it} = (1-\lambda) S_{it}^+ (P_t, y) + \lambda S_{io}
\] (6.15)

where \(S_{it}\) is the value share of the \(i^{th}\) fibre in the total cost in period \(t\), and:

\[
S_{it} = \frac{\partial}{\partial} \ln C_i / \partial \ln p_{it} = \frac{S_{it}^+ F_{it}^1}{P_i \tilde{F}_{i,t-1}}
\]

The generalisation of this result towards the translog specification is straightforward. For a dynamic translog cost function such as (6.10), Ball et al. (1989) derived both short-run and long-run own- and cross-price elasticities.\(^5\) The short-run price elasticities are given by:

\[
\eta_i = (1 - \lambda) (\alpha_{ii} S_i + S_i^2) / S_i
\] (6.16a)

\[
\eta_{ij} = (1 - \lambda) (\alpha_{ij} + S_i S_j) / S_i
\] (6.16b)

Long-term own- and cross-price elasticities are given by:

\[
\eta_i^* = (\alpha_{ii} S_i + S_i^2) / S_i
\] (6.17a)

\[
\eta_{ij}^* = (\alpha_{ij} + S_i S_j) / S_i
\] (6.17b)

To evaluate the elasticities at any point in time \(t\) requires an explicit solution to the system of differential equations. However, equating \(C_t, C^*\) and \(C_o\) yields approximate formulas for the own- and cross-price elasticities at time \(t\):

\[
\eta_{i}^t = (1 - \lambda^t) (\alpha_{ii} S_i^t + S_i^2) / S_i
\] (6.18a)

\[
\eta_{ij}^t = (1 - \lambda^t) (\alpha_{ij} + S_i S_j) / S_i
\] (6.18b)

---

\(^4\) For a more detailed derivation, see Ball et. al. (1989).

\(^5\) For derivation, see Ball et al. (1989), Appendix A.
DATA AND MODEL ESTIMATION

The data to be used for empirical analysis are from the author’s 1992 survey (Appendix 1.1). After checking the questionnaires, only 23 of the 38 returned by state firms were found to be useable. Fifteen were excluded either because the firm failed to provide the required information or simply because the firm was not involved in spinning activities.

"The data presented in Appendix 6.1 showed the wide difference in prices faced by firms. This reflected in part the difference in the quality of fibres that were used in textile production (for example, the higher quality of imported wool and lower quality of domestically produced wool). Given data limitations, an assumption has to be made that all firms use the same quality of wool. In future studies, if data become available, it would be interesting to explore the different price responsiveness of demand for imported (high quality) and domestic (low quality) wool."

The variables required for fitting the cost system (6.10) are: wool input quantity; wool price; chemical fibre input quantity; chemical fibre price; output; and output composition. The complete data are presented in Appendix 6.1 in an unbalanced panel form, a combination of cross-sections over time (1987-91). Market prices are used for the price variables. For the few firms who failed to provide information about prices, we use the average market price paid by manufacturers in the same region. Output data are more problematic. While most manufacturers reported their yarn production in tons, some only provided data on final output in metres of fabric. Data were converted where necessary to obtain a consistent data set.

In applying a cost system such as (6.10) to panel data, two potential problems — technical change and efficiency differences among cross-sectional units — require careful treatment. If technical change is not neutral and differences in efficiency exist among units, direct estimation of system (6.10) will lead to biased parameter estimates (Binswanger 1974). A time variable (as a proxy for technical change) and regional

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6 This is mainly because some firms failed to provide data on a full five-year basis, but also because other firms were established after 1987.

7 Here, technical change refers to change in textile production technology, as distinct from technological change as discussed in chapter 4.
dummies (to allow for regional efficiency differences) were therefore added to the system (6.10).

The cost function and share equation in (6.10), incorporating technical change and regional difference, were jointly estimated using a system approach. Since system (6.10) involves non-linear terms in the parameters to be estimated, the Non Linear (NL) estimation method, a maximum likelihood procedure, was used.\(^8\) This was the Davidon-Fletcher-Powell (DFP) algorithm available on SHAZAM. The DFP algorithm is extremely effective and is among the most widely used gradient methods (Greene 1991). To verify that the global maximum had probably been achieved, the model was re-estimated several times with a different initial starting value.\(^9\) There were no significant changes in the estimation results.

The initial empirical results show that none of the coefficients associated with technical change and cross-sectional efficiency difference are statistically significant. This suggests that omission of these variables will not cause bias in the estimated parameters.

Elasticity estimators in the translog model are non-linear transformations of the parameter estimators and factor cost shares. Conventional formulas for estimating standard errors are too optimistic, particularly when applied to the finite sample problem (Freedman and Peters 1984a). It is therefore crucially important, if we are to make inferences for policy making purposes, to check the accuracy of the asymptotics. The method used, ‘bootstrapping’, permits the assessment of variability in an estimation using just the data at hand (Efron 1979).

Since Efron’s pioneering work on bootstrapping, the procedure has been extended to cater for different kinds of regression models. Freedman and Peters (1984a), Nainar (1989) and McNown et al. (1991) used bootstrapping for the translog model in order to get consistent standard errors for price elasticities. In another paper by Freedman and Peters (1984b), the bootstrapping methodology was applied to the panel data including

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\(^8\) Ball et al. (1989) used a Seemingly Unrelated Regression technique to estimate the dynamic translog derived demand system. This seems inappropriate as the parameters to be estimated are apparently non-linear.

\(^9\) This was suggested by Greene (1991), as a way of checking for several local extrema.
dynamics. These studies provide a sound foundation for shaping our bootstrapping strategy.

Following Freedman and Peters (1984a), our bootstrapping procedure can be described as follows. To simplify our illustration, we consider a general dynamic linear model of the form:

\[
Y_{ht} = Y_{h,t-1} B + X_{ht} C + \varepsilon_{ht}
\]  

(6.19)

In this system of equations, \(B\) and \(C\) are coefficient matrices of unknown parameters (to be estimated from the data) subject to identifying restrictions. \(Y_{ht}\) and \(X_{ht}\) are respectively vectors of endogenous and exogenous variables for firm \(h\) observed at time \(t\). We may expect that the endogenous variables on both the left and right hand sides of the equation will be correlated with \(\varepsilon\), while exogenous variables will not. The assumption on the stochastic disturbance terms \(\varepsilon_{ht}\) is as follows:

\[
E(\varepsilon_{ht}) = 0 \text{ for all } h \text{ and } t
\]

where \(\varepsilon_{ht}\) is independent and identically distributed across sectional units and in time.

We take the model (6.19) as specified and estimated to be true. By a well-defined statistical procedure (a non-linear estimation technique is suggested for estimating dynamic translog share equations), the coefficient matrices \(B\) and \(C\) can be estimated. Elasticities and the asymptotic variances of the cost shares are calculated. The residuals are then defined as:

\[
\varepsilon_{ht} = Y_{ht} - Y_{h,t-1} \hat{B} + X_{ht} \hat{C}
\]  

(6.20)

Now consider a model like (6.19), but where all ingredients are known:

- \(Y_{ho}\) and \(X_{ht}\) are fixed;
- parameters are set at their estimated values \(\hat{B}\) and \(\hat{C}\); and
- disturbance terms are independent with a common distribution \(\mu\).

A random sample is drawn from each residual series for each cross-sectional unit across time. Thus certain observations may be sampled more than once and others not at
all. These are taken as pseudo residuals and used to construct pseudo data for the
dependent variable $Y_{ht}^*$, which is:

$$Y_{ht}^* = Y_{ht}^{k,-1} B + X_{ht}^* C + \varepsilon_{ht}^*$$  \hspace{1cm} (6.21)

The same estimation method is then applied to (6.21) to get $B^*$ and $C^*$. The
above step is repeated 200 times; consequently, the distribution of pseudo errors $B^* - \hat{B}$,
$C^* - \hat{C}$ can be computed and used to approximate the distribution of real errors $\hat{B} - B$, $\hat{C} - C$
(Freedman and Peters (1984b). The formulas for bootstrap estimates of the standard
errors of each parameter are calculated in McNown (1991) as:

$$\left[ \frac{1}{200} \sum_{i=1}^{200} (B_{i}^* - \hat{B})^2 \right]^{1/2} \quad \text{and} \quad \left[ \frac{1}{200} \sum_{i=1}^{200} (C_{i}^* - \hat{C})^2 \right]^{1/2}$$  \hspace{1cm} (6.22)

where $\hat{B}$ and $\hat{C}$ are the calculated parameter estimates based on the actual data and $B_{i}^*$ and $C_{i}^*$ are the corresponding estimates using pseudo data of the $i$th replication. The
average standard errors based on conventional asymptotics can be calculated as:

$$\left[ \frac{1}{200} \sum_{i=1}^{200} SE_i(\hat{B}_{i}^*) \right]^{1/2} \quad \text{and} \quad \left[ \frac{1}{200} \sum_{i=1}^{200} SE_i(\hat{C}_{i}^*) \right]^{1/2}$$  \hspace{1cm} (6.23)

where $SE_i(\hat{B}_{i}^*)$ and $SE_i(\hat{C}_{i}^*)$ denote the formula standard errors. It is found that average
standard errors tend to be biased downwards, as do asymptotic standard errors obtained
from estimation of the original data set. Freedman and Peters (1984a) and McNown et
al. (1991) argue that analysis of bias in standard errors should be based on comparison of
(6.22) and (6.23), since these are based on the same pseudo-data. The resulting
differences indicate the magnitude of the biases in the formula standard errors.

**ESTIMATION RESULTS**

Table 6.1 presents the NL estimation results of cost system (6.10) and summary statistics
of the bootstrapping experiment. The NL estimates of the translog cost parameters and
their respective standard errors from the asymptotic formulas are reported in the first two
columns. An inspection of these two columns reveals that while the parameter estimate
for partial adjustment ($\hat{\lambda}$) is highly significant, the coefficient associated with the price variable in the cost share equation is only marginally significant. In order to ensure that the parameter estimates are statistically robust, we need to check test statistics from the bootstrapping experiment based on 200 replications. These are reported in the last three columns of Table 6.1. Column (3) contains the sample mean of the 200 replications of the bootstrap process and can be compared with column (1) as an indication of bias in the NL estimates. The difference between columns (1) and (3) is acceptably small.
The last two columns of Table 6.1 require special attention as they represent the focus of the bootstrapping experiment. Column (4) shows standard errors calculated according to formula (6.22). As expected, these are biased downward in comparison with formula standard errors. Column (5) is average standard deviation, calculated using formula (6.23). Surprisingly, the figures in column (4) are much smaller than those in column (2). This is in sharp contrast to earlier bootstrapping experiments (Freedman and Peters 1984a; Freedman and Peters 1984b; Nainar 1989; McNown et al. 1991), which tended to find that the standard deviation was higher than the formula standard error. However, as mentioned earlier, a valid analysis of bias in formula standard errors should be based on a comparison of columns (4) and (5). The difference between the figures in each column is exceptionally small, suggesting that in this case there is little danger in using formula standard errors. We can therefore have reasonable confidence in the various price elasticities derived from NL parameter estimates. These are set out later in this chapter.

Before turning to the derivation of price elasticity of demand, a few more comments need to be made on the results reported in Table 6.1. First, the coefficient associated with the price variable in the share equation is still statistically significant at the 0.10 significance level after allowing for bias in conventional standard errors. This indicates that price-induced fibre substitution does exist in the Chinese textile industry.

Second, the estimate of the partial adjustment coefficient ($\lambda$) is 0.63 and is statistically significant, suggesting that the static cost model (6.7) is not an appropriate one for modelling Chinese textile manufacturers’ demand behaviour with respect to choice of fibres. The relatively high value of $\lambda$ indicates that the rate of adjustment is quite slow; that is, only about one-third of deviation of observed from optimal shares noted at the beginning of the year is adjusted during the year. Assuming a geometric lag, the mean lag (Griliches 1967, pp. 16-49) can be calculated as:

$$\text{Mean lag} = \frac{(1 - \lambda)}{\lambda} = 0.58 \text{ year}$$

$$\text{Variance} = \frac{(1 - \lambda)}{\lambda^2} = 0.92 \text{ year}$$
This tells us that wool textile manufacturers’ response has exhibited a geometric lag distribution with a mean of 0.58 years and a variance of about 0.92 years.

Alternatively, as shown by Stewart and Wallis (1989), we can calculate how many time periods are required to accomplish a full adjustment. In general, after \( n \) periods, \( 1 - \lambda^n \) of the adjustment will have been accomplished. If this expression is set to be equal to some value of \( p \), which is a proportion of the desired adjustment, we may solve for \( n \) to obtain the number of periods required for adjustment to be complete:

\[
p = 1 - \lambda^n
\]

therefore

\[
n = \frac{\log(1 - p)}{\log \lambda}
\]

If we assume full adjustment and set \( p \) asymptotically as nearly equal to one, say 0.99, the number of years required to accomplish the adjustment will be 10, given the estimated \( \lambda \). This information is crucial to our understanding of the various elasticities derived later in this chapter.

Third, the signs of the three proxy dummy variables for changes in output composition are as expected, but only the coefficients associated with \( D_2 \) in both cost and share equations are statistically significant. The positive sign for \( D_2 \) in the cost equation indicates that increasing the share of pure wool textile products in total output will generally result in an increase in total cost. On the other hand, the negative sign for \( D_2 \) in the share equation indicates that an increase in the pure wool share in total output will lead to a reduction in the share of the chemical fibre input.

**OWN- AND CROSS-PRICE ELASTICITIES**

Given estimates of the model’s parameters, and for a given vector of shares, we can obtain substitution and demand elasticities as defined in equations (6.16) to (6.18). The limited time period covered by the panel data is a complicating factor. Taking a four-year period, during which an adjustment of over four-fifths (assuming geometric lag) is accomplished, allows us to calculate approximate long-run price elasticities. Short-run price elasticities, can be obtained straightforwardly from (6.16). Point elasticities are not
calculated, as Anderson and Thursby (1986) demonstrated that point estimates of elasticities often provide no information about the structure of technology or factor demand.

Table 6.2 presents both short-run and long-run price elasticities of demand for sample firms. As is obvious from the table, the derived own-price elasticities of fibre demand have the correct signs. The short-run own-price elasticities are -0.20 and -0.60 respectively for wool and chemical fibres. The four-year (approximating long-run) elasticities are much higher at -0.52 for wool and -1.37 for chemical fibres.

Elasticities of substitution and cross-price elasticities of demand are found to be positive, indicating that there is price competition between wool and chemical fibres. Furthermore, the cross-price elasticity of demand for chemical fibres is higher than that for wool. This means that demand for wool responds more to a change in chemical fibre prices than does demand for chemical fibres when the wool price changes.

<table>
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**Note:** Long-run price elasticities are calculated according to the formula: \( (1 - \lambda^4) \eta_y \).
Turning to the calculated yearly own- and cross-price elasticities, we find that firms have become increasingly responsive to changes in the wool price and less responsive to changes in chemical fibre price.

CONCLUDING REMARKS

In this chapter an attempt has been made to provide an econometric analysis of price-induced fibre substitution in the Chinese textile industry using data from my 1992 survey of selected wool textile manufacturers. A dynamic translog cost function was used and a partial adjustment hypothesis introduced. Bootstrapping was performed to ensure that the elasticity estimates were robust.

The short-run price elasticity of derived demand for wool was found to be inelastic. This finding is consistent with previous results for other countries (Harris 1988; Budsayavith and Byron 1989; Ball et al. 1989). However, it is inconsistent with the high price responsiveness of final demand discovered in chapter 3. This inconsistency may result in part from the continuing softness of the post-reform budget constraint and in part from the fact that consumers’ response to a change in price is higher at the lower income levels that at higher levels.

There was a lag in firm response to a change in prices. Although the short-run own-price elasticities of demand for both wool and chemical fibres were low, long-run elasticities were substantially higher. In fact, in the case of chemical fibres, the long-run elasticity was greater than one.

The cost structure of the Chinese wool textile industry is such that wool is under heavy price competition from chemical fibres. Although a relatively low own-price elasticity has provided wool with market power, the relatively higher price responsiveness of chemical fibres puts wool at a disadvantage in terms of expanding its market share, particularly in the longer term.

Some qualifications need to be made to the above results. First, it has been assumed that mills produce a homogenous product. This assumption is questionable; a wool-rich product is very different from a wool-poor one. This problem was overcome by introducing three output composition dummies. Second, it was assumed that the
quality of wool and chemical fibres used by yarn manufacturers was the same. This is a crude assumption because it ignores potential competition between different kinds of wool (fine and coarse wool) and chemical fibres (synthetics and rayon). Although aware of this issue, I had to carry out my research on an aggregate level because of the difficulty of obtaining the required data and constraints on financial resources available for this research. Third, the study was confined to demand in selected state-owned enterprises in three areas. Care therefore needs to be taken when inferring mills’ total demand for wool throughout China.
<table>
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**Notes:** Fibre inputs and yarn output are measured in metric tons; fibre prices are in thousand RMB Yuan per metric ton.

**Source:** Author's 1992 survey.
7 The Effects of Policies on Fibre Demand and Substitution

In addition to the technological and economic factors discussed earlier, government policy also influences fibre demand and substitution. As stated in chapter 2, the Chinese government has a longstanding policy of fibre self-sufficiency. This policy has typically emphasised the development of chemical fibres as an important strategy to achieve the country’s long-term self-sufficiency goal, implying that China’s trade and foreign exchange policies with respect to natural fibre imports are likely to be restrictive. The purpose of this chapter is to provide a comprehensive analysis of the effects of China’s fibre substitution policy and related trade and foreign exchange policies on fibre demand and fibre substitution.

The effects of fibre substitution policy on fibre demand are examined in the context of changing fibre self-sufficiency. It will be shown that natural fibre self-sufficiency inevitably falls as an economy grows, especially in the case of a resource-poor and/or densely populated country (Anderson 1992; Garnaut and Anderson 1980); in China the faster decline in wool than in cotton self-sufficiency increased the government’s determination to impose its fibre substitution policy on the wool textile industry, contributing to a heavier substitution of chemical fibres into wool than into cotton.

Analysis of the impact of trade and foreign exchange policies on fibre demand and substitution is made in the context of continuous changes brought about by reform in the economic, trade and foreign exchange systems. It will be shown that the relative importance of various trade and foreign exchange restrictions has varied over time and that wool imports have borne the brunt of these restrictions.
FALLING FIBRE SELF-SUFFICIENCY
AND THE FIBRE SUBSTITUTION POLICY

The tendency for fibre self-sufficiency to fall as economies grow is a common phenomenon, especially among East Asian countries. This phenomenon was analysed by Anderson (1992), who drew on standard trade and development theory to suggest the following:

A poor country opening up to international trade will tend to specialise in the production and export of primary products, though less so the more densely populated the country. If its domestic incomes grow more rapidly than the rest of the world’s, its export specialisation will gradually move away from primary products (in raw or lightly processed form) to manufactures. The manufactured goods initially exported will be more labour intensive the more resource-poor or densely populated the country. Since many processes in textile and clothing production tend to be intensive in the use of unskilled labour, they would be among the items initially exported by a newly industrialising, densely populated country. And as the demands for textile raw materials by that country’s expanding textile industry grow, so the country’s net exports of natural fibre would diminish, or net imports of natural fibres would increase, ceteris paribus (Anderson 1992, p. 6).

In essence, Anderson identifies three conditions that need to be met for fibre self-sufficiency to fall: first, the economy must be an open one; second, domestic incomes should grow more rapidly than the rest of the world’s; and third, the country must be densely populated.

China is, of course, a densely populated country. Since 1978, when an outward-oriented policy was adopted and economic reform began, the Chinese economy has grown rapidly. According to official statistics, the average annual growth rate of real GNP for 1978-91 was 8.6 per cent, which is well above any other country’s performance during the same period. On the basis of the theory presented above, then, one may expect that China’s self-sufficiency in natural fibres would have begun to fall.

This is indeed the case, though the trend is less apparent in the case of cotton. Tables 7.1 and 7.2 present some basic data on China’s production, trade and self-
sufficiency in wool and cotton. As seen in Table 7.1, there has been a steep decline in wool self-sufficiency in China since 1975. This decline was initially slow under the previous autarky type of planned economy, but accelerated after the country adopted an open door policy. By 1992, the wool self-sufficiency rate in China had dropped to only 55 per cent, compared with 97 per cent in 1975.

Table 7.1 China’s Production, Trade and Self-sufficiency in Raw Wool

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Note: Imported wool is a mixture of greasy and clean wool. Because of the lower yield of domestically produced wool, the calculated self-sufficiency rate may be overestimated.

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<td>230.15</td>
<td>-162.05</td>
<td>4799.05</td>
<td>96.62</td>
</tr>
<tr>
<td>1984</td>
<td>6258</td>
<td>202.50</td>
<td>39.75</td>
<td>162.75</td>
<td>6095.25</td>
<td>102.67</td>
</tr>
<tr>
<td>1985</td>
<td>4147</td>
<td>349.50</td>
<td>0.16</td>
<td>349.34</td>
<td>3797.66</td>
<td>109.20</td>
</tr>
<tr>
<td>1986</td>
<td>3540</td>
<td>527.50</td>
<td>0.19</td>
<td>527.31</td>
<td>3012.69</td>
<td>117.50</td>
</tr>
<tr>
<td>1987</td>
<td>4245</td>
<td>754.58</td>
<td>5.98</td>
<td>748.60</td>
<td>3496.40</td>
<td>121.41</td>
</tr>
<tr>
<td>1988</td>
<td>4148</td>
<td>468.99</td>
<td>34.77</td>
<td>434.22</td>
<td>3713.78</td>
<td>111.69</td>
</tr>
<tr>
<td>1989</td>
<td>3788</td>
<td>272.48</td>
<td>519.04</td>
<td>-246.56</td>
<td>4034.56</td>
<td>93.89</td>
</tr>
<tr>
<td>1990</td>
<td>4508</td>
<td>167.28</td>
<td>416.73</td>
<td>-249.45</td>
<td>4757.45</td>
<td>94.76</td>
</tr>
<tr>
<td>1991</td>
<td>5675</td>
<td>199.98</td>
<td>370.52</td>
<td>-170.54</td>
<td>5827.54</td>
<td>97.38</td>
</tr>
<tr>
<td>1992</td>
<td>4508</td>
<td>144.62</td>
<td>280.00</td>
<td>-135.38</td>
<td>4643.38</td>
<td>97.08</td>
</tr>
</tbody>
</table>

**Sources:** *Statistical Yearbook of China* 1982-92.  

The trend with respect to cotton self-sufficiency is less clear. The period 1980-87 saw a reversal of an earlier declining trend (Table 7.2). Anderson (1992) argued that this reversal would be short-lived, for the following two reasons. First, the surge in China's cotton output in the first half of the 1980s was connected with changes in producer incentives, which were biased toward cotton growers. The response of producers to

2 According to Anderson (1992, p. 42), 'average prices received by cotton producers increased 50% between 1978 and 1984, as did prices for grains and many other farm products ... The marginal producer price for cotton — for over-quota deliveries or sales to the free market — increased even faster than for grain. Moreover, producers of cotton received preferential access to grain and fertiliser during 1978-1982, and by switching from grain to cotton production farmers were able to avoid fulfilling their grain quota at the relatively low quota price (quoted from Sicular 1988)'.
these incentives was unlikely to last long because of the likely long-term bias in China’s agricultural prices in favour of ensuring food-grain self-sufficiency. Second, even if China’s production of natural fibres did continue to expand, demand for fibres could grow at an even faster rate as a result of the rapid expansion of both domestic and export markets. Thus Anderson predicted that the trend for cotton self-sufficiency to decline would resume in the mid 1980s. This prediction has proved to be correct; since 1987, the general trend has been for cotton self-sufficiency once again to decline.

Although it has been shown that a downward trend in natural fibre self-sufficiency is inevitable as economies grow, more important for policy is the speed at which self-sufficiency in a particular fibre falls. Figure 7.1 compares the trends for self-sufficiency in wool and cotton. As is evident from the figure, until 1980 the self-sufficiency rates of both wool and cotton were falling and the difference between the two fibres in absolute levels of self-sufficiency was small. However, since that time trends in self-sufficiency for the two fibres have diverged widely. The main reasons for this divergence have been that the income elasticity of demand for wool has been much higher than that for cotton (chapter 3) and, on the supply side, that bias in incentives appears to have led to a greater increase in cotton than raw wool production. From 1980 to 1991, the average annual growth rate of cotton production was 7 per cent, compared with 2.9 per cent for raw wool production.

The relatively rapid decline in wool self-sufficiency caused the Chinese government particular concern. This reflected the government’s perception that wool is a luxury commodity; consumption of increasing quantities of imported wool was viewed as inappropriate at China’s present stage of development. Knowing that there was little scope for overall domestic wool production to increase — self-sufficiency in other items such as food and cotton had a higher priority — the Chinese government chose to accelerate the adoption of chemical fibres in the wool textile industry in order to slow the

---

3 Growth in domestic wool production has lagged far behind consumption. During 1978-92, while consumption recorded an average annual growth rate of 7.8 per cent, growth in production achieved only 2.8 per cent.
Figure 7.1  Cotton and Wool Self-sufficiency Rates in China, 1975-91

Notes: The self-sufficiency rate is defined as:

\[
\text{Rate} = \left( \frac{\text{Domestic production}}{\text{Domestic production} + \text{imports} - \text{exports}} \right) \times 100
\]

Stocks are not taken into account due to lack of data. Thus calculated rates jump around a lot over the years, which should not be the case. In order to have a clear view of trends in fibre self-sufficiency, a three-year moving average was taken of the actual series.


decline in self-sufficiency. This policy is likely to have contributed to a faster diffusion rate and higher saturation level of chemical fibres in the Chinese wool textile industry than in the cotton textile industry (chapter 4).

Until the start of industrial reform in the mid 1980s, economic planning provided a powerful means to implement fibre substitution policy. The typical planning process involved using chemical fibres to make up any shortfall between supply and demand for a particular fibre and then to fill any remaining gap with imports. As the amount of chemical fibres used in the wool textile industry accounted for only a small proportion of the total chemical fibres consumed in the Chinese textile industry, the supply constraint of chemical fibres was less of a problem for the wool textile industry than, say, for the cotton textile industry. Planners therefore had considerable room to promote the use of chemical fibres in the wool sector.
Since 1985, when economic reform of industrial sectors began, the Chinese government has gradually lost the use of the economic planning tool in implementing its fibre substitution policy. Despite this, the Chinese government seems to be no less ambitious in its plans for future substitution. This is particularly true in the case of the wool textile industry, for which a new substitution plan was recently set out. Table 7.3 shows current recommendations on the structure of wool products in China. The proportion of pure wool products is to be reduced to around 10 per cent while the shares of blended and pure chemical fibre products will increase to 80 and 10 per cent respectively. In the case of blended products, more emphasis is to be placed on developing wool-poor products.

Table 7.3 Target Structure of Wool Products

<table>
<thead>
<tr>
<th>Types of Products</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure wool products</td>
<td>10</td>
</tr>
<tr>
<td>Blended products</td>
<td>90</td>
</tr>
<tr>
<td>Wool rich (over 70% wool)</td>
<td>na</td>
</tr>
<tr>
<td>Wool medium (30%–70% wool)</td>
<td>na</td>
</tr>
<tr>
<td>Wool poor (under 20% wool)</td>
<td>na</td>
</tr>
<tr>
<td>Pure chemical fibre products</td>
<td>10</td>
</tr>
</tbody>
</table>

*Source: Li 1992, p. 75.*

With the declining ability of the government to influence the fibre consumption pattern directly through economic planning, it appears that policy makers in China have become increasingly aware of the necessity of using indirect mechanisms, such as trade and foreign exchange policy instruments. These issues are discussed in detail below.
THE EFFECTS OF TRADE RESTRICTIONS
ON FIBRE DEMAND AND SUBSTITUTION

The pursuit of fibre self-sufficiency implies that trade policy is likely to be restrictive. Currently, all fibre imports into China are subject to restrictions of one form or another. "China imposes tariffs on imports of all major fibres and quotas on wool and chemical fibres." Tariffs have a direct price-raising effect; import quotas, when binding, further raise the domestic price of fibres. The effect of these trade barriers is to encourage the use of a greater quantity of domestically produced fibres and substitution into other fibres.

In recent years wool imports have provided over one-half of the wool consumed in China's mills. Policies to restrict fibre imports have therefore had a more severe impact on demand for wool than on demand for cotton and chemical fibres, which are largely domestically produced (Connolly et al. 1991). It is of importance, then, to examine how various trade restrictions have affected wool demand in China and to draw some implications for fibre substitution.

Tariff restrictions

Historically, tariffs on imports of raw wool and wool products have been high. Even today, after several reductions in the last decade or so, tariffs on wool imports and wool products remain significant. This can be seen in Table 7.4, which shows the current structure of tariffs on fibre imports in China, Japan, South Korea and Malaysia. As is evident from Table 7.4, tariffs imposed by China on imports of wool and wool products are substantially higher than those imposed by other countries such as Japan and South Korea.

The table also shows that China imposes higher tariffs on wool than on cotton, but lower tariffs on wool than on chemical fibres up to the yarn stage. Over the past decade or so China has been almost self-sufficient in cotton. A tariff on importables such as wool thus disadvantages wool further. The policy of higher tariffs on chemical fibres requires a closer examination. A higher tariff imposed on chemical fibres than on wool will, of course, result in a higher relative price for chemical fibres, which in turn will make chemical fibres less competitive on the market. But this does not mean at all that
the Chinese government hopes to discourage the use of chemical fibres. It simply reflects the Chinese government's desire to increase domestic production and processing of chemical fibres in the longer run, given that there is scope for China to expand its domestic production of chemical fibres (Morris et al. 1993).

"High tariffs (and quotas) on imports of chemical fibres increased domestic output of this activity. However, the effect on mill's consumption varies with the changes in economic system. Under the planning system, because all the materials are allocated and prices served only as accounting devices, the state can still effectively promote the use of chemical fibres. With the declining role of state planning after reform, the effect of trade restrictions on the use of chemical fibres has become more obvious and more important."

Table 7.4 Import Duties on Textile Fibres, Yarns and Fabrics (%)

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Japan</th>
<th>South Korea</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greasy wool</td>
<td>15</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Scoured wool</td>
<td>15</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Wool tops</td>
<td>20</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Wool yarns</td>
<td>50</td>
<td>0-10</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Wool fabrics</td>
<td>100</td>
<td>0-12</td>
<td>9</td>
<td>2-7</td>
</tr>
<tr>
<td>Cotton</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0-2</td>
</tr>
<tr>
<td>Cotton yarns</td>
<td>30</td>
<td>0-15</td>
<td>9</td>
<td>5-20</td>
</tr>
<tr>
<td>Cotton fabrics</td>
<td>50</td>
<td>0-15</td>
<td>9</td>
<td>30-55</td>
</tr>
<tr>
<td>Acrylic fibres</td>
<td>25</td>
<td>0-25</td>
<td>9</td>
<td>0-2</td>
</tr>
<tr>
<td>Other synthetic fibres</td>
<td>50</td>
<td>0-25</td>
<td>9</td>
<td>0-5</td>
</tr>
<tr>
<td>Cellulosic fibres</td>
<td>25</td>
<td>0-25</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Synthetic yarns</td>
<td>70</td>
<td>0-25</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Manufactured fibre fabrics</td>
<td>100</td>
<td>0-25</td>
<td>9</td>
<td>30-55</td>
</tr>
</tbody>
</table>

Source: Morris et al. (1993, p. 18).
Another feature of the tariff structure is that it discriminates against the import of wool for domestic consumption. Tariffs paid on imported wool which is subsequently re-exported in the form of semi-processed or processed wool products can be reclaimed. As around two-thirds of imported wool is used for domestic consumption, however, a tariff on wool will particularly dampen the domestic consumption of wool.

While import tariffs on wool and wool products have been imposed for many years, the nature of these tariffs and their significance in affecting wool demand have varied greatly with changes in the Chinese economic system. Prior to economic reform, when prices merely performed an accounting function, tariffs did not usually have any real economic impact on mills’ demand for wool, though they did affect consumer demand. This is no longer the case. With the behavioural change and market orientation brought about by economic reform, firms in China have become more responsive to price signals (chapter 5). The effects of tariffs have thus become increasingly significant.

Figure 7.2  Impact of Tariffs on Wool Demand

The impact of import tariffs on mills’ demand for wool is shown in Figure 7.2. It is assumed that domestic and imported wool are perfect substitutes. The vertical axis represents the price of wool in domestic currency. The domestic short-run supply curve is a vertical line, represented by $S_d$. The world supply curve of wool is assumed to be horizontal. The industry’s aggregated demand curve for wool, which is downward-
sloping, is represented by $DD$. $P_d$ is the domestic autarky price. As shown in the figure, given a world price of $P_w$, the amount of wool that firms will import is $AC$. With a tariff, however, their import requirements would be reduced to $AB$.

The specific effects of tariffs on wool demand will depend on the relevant price elasticity of demand. Usually, the larger the price elasticity, the greater the negative effects on wool demand. According to the price elasticity estimated in chapter 6 (-0.2 in the short run), a 15 per cent tariff on greasy and scoured wool could result in a 3 per cent reduction in wool demand. In the longer run, because of a higher price elasticity, the reduction in wool demand would be even greater (7.8 per cent in four-year time).

The above analysis is based on the assumption that domestic and imported wool are perfect substitutes. In fact, there is a quality difference between domestic and imported wool. China mainly produces coarse wool more suited to non-apparel end-uses, such as carpet yarns, blankets, fabric for domestic production and knitted yarns (Cross and Spinks 1986). Although in recent years the share of fine wool in total raw wool production has increased to some extent, Chinese fine wool suffers from serious drawbacks, such as breaks in the fibre and high levels of dirt and vegetable matter (Findlay and Li 1992). Moreover, the domestic production of fine wool has lagged behind consumption. Therefore, a tariff on wool imports would have a greater impact on fine wool imports.

Import quota system

Under the previous planned economy, wool imports into China were strictly controlled by import plans. These plans, which put overwhelming emphasis on self-sufficiency, were very similar to quotas and enabled the self-sufficiency rate in wool to be maintained at high levels until 1978 (Table 7.1).

With the weakening of the central planning system, controls over wool imports were relaxed and the widening gap between domestic supply and demand could be accommodated by increasing imports. From 1978 to 1988, China’s wool imports

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4 In 1980, the share of fine wool in China’s total raw wool production was 39.3 per cent (Findlay and Li 1992, p. 113). It increased to 45.4 per cent in 1991 (Statistical Yearbook of China 1992, p. 370).
increased by 17 times (Table 7.1). While this greatly facilitated the development of the Chinese wool textile industry, it also brought about a steep decline in the wool self-sufficiency rate and worsened the terms of trade — China is a big buyer on the world wool market. In late 1988 the Chinese government therefore decided to introduce a quota system for wool imports up to the tops stage of processing. At the same time, wool imports were re-centralised.

A number of studies have examined the nature and significance of the newly introduced quota system. Morris et al. (1993) argued that China's quota system differs from those of other countries in that it acts more as an aid to planning than as a direct import restriction. Sun et al. (1993) placed greater emphasis on the binding effect of import quotas. Their argument was based mainly on their observation that illegal sales of import licences were occurring. In order to clarify these issues, there is a need to carry out a closer examination of how the system operates in China.

Unlike other countries where import quotas are usually centrally determined, the process by which import quotas are formed in China involves two stages: the formation of net import requirements by textile mills; and the submission of these requirements for central approval.

Net import requirements can be considered primarily to be a function of the relative prices of imported and domestic wool. Usually, the higher the relative price, the lower the net import requirement, and vice versa. Figure 7.2 shows how net import requirements are determined. It can be seen that for a given total level of wool textile output and given $P_t$ (world wool price plus tariff), firms' net import requirements will be the amount represented by $AB$.

But whether this amount will be approved by the central government depends on a number of factors. The first of these is foreign exchange allocation policy, which is in turn derived from China's industrial policy. As noted earlier, wool is viewed in China as a luxury commodity not essential to current economic development. The Chinese government is therefore reluctant to spend much of its precious foreign exchange on wool imports and so usually gives wool imports low priority.
A second factor is the availability of foreign exchange. The amount of wool imports represented by \( AB \) is most likely to be approved at times when foreign exchange reserves are ample. This was proved by Sun et al.'s (1993) study, which showed that there is a high correlation between China's wool imports and foreign exchange reserves. In practical terms, it appears that under the previous dual foreign exchange regime, so long as firms could source foreign exchange themselves, their import requests would usually be approved.

Another factor affecting the probability of approval is the changes in the world wool price. At times when the government believes it can take advantage of a low world price for wool, the amount of imports represented by \( AB \) is more likely to be approved. The sudden surge in Chinese wool imports in 1992 and 1993 was partly attributable to this. When world prices are very high, more restrictive quotas are likely to be endorsed.

The last factor concerns domestic supplies. When stocks of wool and wool products are large as was the case in 1990, a more restrictive quota is likely to be endorsed to protect domestic wool producers.

All the factors mentioned here could cause import quotas to be binding. But the extent to which they are in fact binding depends on the interaction of these factors at a given time. Although it has been shown that the import quotas have been reasonably flexible in meeting rising import demand (Morris et al. 1993), there are also indications to suggest that import quotas have been at times binding. One such indication is the illegal sales of import licences observed by Sun et al. (1993). Another is that in 1990 the excessively restrictive wool quota apparently overrode other restrictions on wool imports (Connolly et al. 1991).\(^5\)

The effect that import quotas could have on wool demand is still changing. As will be shown later, with the abolition of the dual foreign exchange system wool quotas could become a more important constraint on wool demand in the future.

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\(^5\) In 1990, the quota was set at 45 kt clean equivalent, well below the level of wool imports in 1988 and 1989 — 230 kt and 144 kt clean equivalent respectively, according to Connolly and Roper (1991).
THE EFFECTS OF FOREIGN EXCHANGE POLICY REFORM
ON FIBRE DEMAND

Demand for wool has also been severely affected by foreign exchange policy. Prior to 1978, all foreign exchange required for imports was allocated through the state planning system. These allocations served effectively as quotas on imports of all commodities including wool.

However, since 1979 there has been substantial reform of China's foreign exchange system. The three major components of reform may be identified as: devaluation of the official exchange rate; introduction of the foreign exchange retention system; and introduction of legal secondary markets for foreign exchange.

Reform of the foreign exchange system began with a substantial devaluation of the RMB yuan. This and later devaluations stemmed from the need to reduce mounting export subsidies and more importantly from the Chinese government's desire to boost export activities in line with its more outward-oriented policies. As Figure 7.3 shows, since 1981, when the first devaluation took place, there has been an almost continuous downward adjustment in the official exchange rate. Between 1980 and 1992, the official price of the RMB yuan declined by as much as 257 per cent.

Figure 7.3  China's Official and Market Exchange Rates (1978-92)

\[
\begin{array}{c}
\text{RMB Yuan/US$} \\
7.00 \\
6.00 \\
5.00 \\
4.00 \\
3.00 \\
2.00 \\
1.00 \\
0.00
\end{array}
\]

\[\begin{array}{c}
\text{1978} \\
\text{1979} \\
\text{1980} \\
\text{1981} \\
\text{1982} \\
\text{1983} \\
\text{1984} \\
\text{1985} \\
\text{1986} \\
\text{1987} \\
\text{1988} \\
\text{1989} \\
\text{1990} \\
\text{1991} \\
\text{1992}
\end{array}\]

\[
\begin{array}{c}
\bullet \text{ Swap Rate} \\
\circ \text{ Official Rate}
\end{array}
\]

\textbf{Note:}  Period average, RMB yuan / US$. \\
\textit{Sources: China Statistical Yearbook 1992; Yang 1993, p. 10.}
The second major component of reform was the introduction of the foreign exchange retention system. This system was designed to provide additional incentives for exporting enterprises. Initially the effectiveness of this system was hampered by heavy restrictions on the use of retained earnings and the lack of well-developed swap markets. However the system became increasingly more significant as restrictions on non-plan imports were relaxed and markets for foreign exchange developed.

The final component of reform was the introduction of legal secondary markets for foreign exchange. These markets, though occasionally subject to ceiling control, have expanded very rapidly due to increasing supply and demand for foreign exchange generated outside the state plan. Whereas in 1987 foreign exchange transactions in swap markets amounted to only US$4.7 billion (Wei 1992), they had increased to US$25.1 billion by 1992, or 31 per cent of the total import bill (Yang 1993). Moreover, the market exchange rate ran a substantial premium over the official rate (Figure 7.3), thereby providing additional incentives for export. The 'two-tier' foreign exchange system ended at the beginning of 1994 when the government decided to unify the two exchange rates.

Substantial devaluation of the RMB yuan together with the introduction of the foreign exchange retention system and swap markets provided a strong incentive for enterprises to export, leading to enormous increases in exports over the past decade or so. According to official statistics, in 1978-92 China’s total exports grew at an average annual rate of 16.7 per cent, rising from US$9.75 billion to US$85 billion. These increases in exports greatly enhanced China’s overall capacity to import goods, including wool.

While reform of the foreign exchange system has relaxed constraints on the availability of foreign exchange required for imports, this does not necessarily mean that

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6 With the introduction of a legal secondary market, a black market for foreign exchange also began to develop. Because of its limited scale, the black market does not have a significant impact at industry level (Sun et al. 1993) and can be ignored in this analysis.

7 The swap market in China was at times subject to price ceiling controls. In 1981-85, the ceiling was set at 3.08 RMB yuan per US dollar. There were, however, some upward adjustments after 1985 in response to changes in market conditions. From 1988 to 1993 (excluding the first five months of 1993), there was no price ceiling.
wool imports have been favoured. In fact, analysed from a comparative-static perspective, wool imports have been discriminated against in various ways by the distorted foreign exchange system.

The effects on wool demand of distortions in the two-tier foreign exchange system were analysed by Martin (1992) using the ‘short-side rationing model’ first proposed by Desai and Bhagwatti (1981). This model, though simple, provides a very useful framework for understanding the major consequences of China’s two-tier foreign exchange system. The main results derived from Martin’s model are shown in the Figure 7.4.

Figure 7.4  Short-side Rationing Model of Foreign Exchange Market

Price of foreign exchange

\[
\begin{align*}
&\text{Price of foreign exchange} \\
&D \quad S \quad e^*_1 \quad e^*_2 \quad e^*_3 \quad e^*_4 \\
&\text{Quantity of foreign exchange} \quad q^*_1 \quad q^*_2 \quad q^*_3 \quad q^*_4 \\
&S' \quad S' \quad q \quad q^* \quad q^*_1
\end{align*}
\]

In the figure, \( SS \) represents the supply of foreign exchange, which is assumed to be an increasing function of the price of foreign exchange. Demand for foreign exchange, which is stipulated as a downward-sloping function of price, is represented by \( DD \). As illustrated in the figure, in equilibrium, \( q^* \) units of foreign exchange is supplied and demanded at exchange rate \( e^* \).\(^8\) However, when the exchange rate is officially set at an

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\(^8\) Because of pervasive trade distortions, \( e^* \) should not be interpreted as being a long-run free trade equilibrium rate. However, for the purpose of examining the effects of foreign exchange distortions, \( e^* \) will be used later as a benchmark to decide whether the official rate is overvalued or whether the swap rate is undervalued.
overvalued rate, $e$, as in China, the supply of foreign exchange falls from $q^*$ to $q_1$ due to a reduction in exports.

A major consequence of the induced scarcity of foreign exchange is the higher scarcity value of foreign exchange in the economy (Martin 1990). This scarcity value would remain implicit if legal secondary markets did not exist. In this instance, the scarcity of foreign exchange would be manifested in varying degrees of shortage of foreign exchange in particular sectors of the economy (Martin 1990; Dervis et al. 1981). If, however, legal secondary markets were allowed, then the scarcity value would become explicit and would be represented by the price prevailing on secondary markets. As is evident from Figure 7.4, this price ($e_1'$) could not only be expected to be above the official rate, but would also be above the equilibrium exchange rate.

Before drawing any conclusions from the figure, we need to add some supplementary features of China’s foreign exchange system to the model. The first such feature is the foreign exchange retention scheme described earlier. According to Martin (1992), the impact of the scheme is to increase the incentive to export and hence to shift the supply curve of foreign exchange to the right over that portion of the curve for which foreign exchange remains in short supply, that is, from $SE$ to $S'E$. This increases the quantity of foreign currency available domestically to $q_2$, thereby reducing the swap rate to $e_2$. Generally speaking, the higher the retention rate, the greater the shift to the right in the foreign exchange supply curve and hence the less the distortion in the foreign exchange system.

The second feature, which was omitted in Martin’s study (1992) but which needs to be included in the model, is the price ceiling imposed on the secondary market during most of the years a dual foreign exchange system operated. The existence of a price ceiling means that the actual exchange rate prevailing on the secondary market would be lower than $e_2$, but whether it would also be below $e^*$ is difficult to judge. Although it is possible that $e_c$ could be below $e^*$, this would greatly increase the pressure for government to restrict firms’ access to the foreign exchange market or to intervene in the import trade directly in order to maintain the current account balance. Given the rapid expansion of the secondary market for foreign exchange and the falling trend of direct
intervention in trade in the 1980s, it seems unlikely that the price ceiling set by the government would be below $e^*$.

The imposition of a price ceiling on legal secondary markets for foreign exchange will have some offsetting effects for the foreign exchange retention system. As shown in Figure 7.4, the existence of a price ceiling will lower the average price received for exports and hence there will be less incentive to export. The total availability of foreign exchange is thus reduced from $q_2$ to $q_c$.

Another effect of the price ceiling is to create a need to intervene directly either in the foreign exchange market or in trade because of excess demand ($AB$) for foreign exchange at price $e_c^*$. This explains in part why under the two-tier foreign exchange regime restriction of access to the foreign exchange market and direct intervention in import trade were still widely observed.

Two important implications for wool demand can now be drawn from the short-side rationing model. First, the overvalued official exchange rate constituted a direct tax on exports, thereby reducing the amount of exports. Since the textile industry was a major export sector, it was particularly disadvantaged. Reduced export activity can be expected not only to have resulted in a reduction in the foreign exchange earnings available for imports, but also in lower demand from industry for fibres including wool because of lower production rates.

Second, the undervalued swap rate acted as an implicit tax on wool imports. Like import tariffs, it added to the costs of importing wool and hence reduced the firm’s net import requirements. Although the existence of a ceiling on secondary markets in most years of the two-tier system’s operation reduced the degree of undervaluation to some extent, it also created a shortage of foreign exchange, necessitating direct intervention in the foreign exchange market and import trade. As a result, wool import demand was affected not only by an undervalued swap market foreign exchange rate, but also by restricted access to the foreign exchange market and direct import restrictions.

This was also borne out by the empirical results of the author’s 1992 survey. Asked whether they could get access to the foreign exchange market and buy foreign exchange needed for importing the raw materials they required in textile production, 18
of the 29 responding wool textile firms replied 'no'. Quite a few of the remaining firms which could get access to the foreign exchange market indicated that they could not import because of quota restrictions.

Two studies have simulated the effects on wool of a depreciation of the official exchange rate. Using a CGE model of the Chinese economy, Martin (1992) found that a 10 per cent depreciation of the official rate would result in an 8-10 per cent increase in wool imports, primarily because of substantial increases in exports of textiles and clothing. Another study, carried out by Morris et al. (1993) and using a model of the Chinese wool textile industry, found that a 10 per cent depreciation of the official rate would initially lead to a 1.5 per cent reduction in wool imports due to an increase in yuan import prices. However, five years after devaluation, wool imports would show a net 3.2 per cent increase due to growth in the production of textiles for export.

After operating for over 10 years, the two-tier exchange system ended in 1993. From 1994, the official exchange rate was devalued to the level of the swap rate to form a so-called 'unitary and manageable floating exchange rate' (Wu 1994). At the same time, the system of foreign exchange retention and remittance of a specified amount of foreign exchange to the state was replaced with a system of settling accounts and selling foreign exchange.

Recent changes in the foreign exchange system are expected to lessen the disadvantage suffered by export sectors such as textiles, or even to give them an advantage in the short run due to the possible undervaluation of the RMB yuan. It will also make it easier for importers to gain access to the foreign exchange market and obtain the foreign exchange required for imports.

Still in question is the extent to which the Chinese textile industry, particularly the wool textile industry, can benefit from this reform. Although in the short run a substantial devaluation could stimulate exports, this does not necessarily mean that export sectors would have an advantage in the longer term. As China has stressed that the new unitary foreign exchange rate will be a managed one and given the recent rapid
economic expansion, it is highly likely that the new exchange rate could again become overvalued and once again constitute a disincentive for exports.\(^9\)

On the import side, although the demise of the foreign exchange approval system and increases in exports due to devaluation could lead to a growth in import demand, the existence of quotas means that wool imports will not benefit fully from recent reform of the Chinese foreign exchange system. Import quotas, if they remain in place, may become a more important measure to restrict wool imports in future.

**CONCLUDING REMARKS**

The chapter analysed the effects of government policies on fibre demand and substitution in China. Three major issues were discussed: fibre substitution policy; trade policy; and foreign exchange policy.

The policy of substitution of natural fibres with chemical fibres is directly related to the fibre self-sufficiency policy pursued by the Chinese government. Discussion of the effects of this policy therefore took place in the context of changing fibre self-sufficiency and growth of the Chinese economy. Because of the more rapid decline in wool self-sufficiency, it was argued that the fibre substitution policy has so far had a more severe impact on demand for wool than on demand for cotton.

China's fibre demand has also been influenced by trade and foreign exchange policies. It has been shown that the relative importance of various trade and foreign exchange restrictions in affecting fibre demand has changed since economic reform. Under the previous planned economy, while import tariffs usually did not have a direct effect on mills' demand for fibres, import planning and foreign exchange controls acted effectively as a quota on imports. Since reform, because firms in China have become more profit- and market-oriented, tariffs have become a more significant way of influencing mills' demand for fibres. Import quotas, which so far have not been a particularly significant factor in restricting mills' demand, will become more important as recent changes in the foreign exchange system take effect. Foreign exchange control —

\(^9\) According to the latest estimate, the clearing rate for the RMB yuan was at 9.3 yuan to one US dollar (compared with a regulated market rate of 8.7 yuan) as at mid-April 1994 (Zhang 1994).
specifically, restricted access to secondary markets — was a significant factor in constraining import demand under the previous dual foreign exchange system. The recent abolition of the system is expected to ease this constraint.

China's wool demand has been particularly hard hit by various trade and foreign exchange restrictions. This is because, first, wool imports are subject to both tariff and quota restrictions; and second, China's firms have been more heavily dependent on imports of wool than of cotton or chemical fibres.

Tariffs have a direct price-raising effect. Import quotas, when binding, further raise the domestic price of fibres. Given the limited potential for growth in domestic wool production, heavier restrictions on wool imports are likely to lead to the replacement of wool with other fibres such as chemical fibres and cotton.

Another important result is that derived from the analysis of distortions in the foreign exchange regime. It was shown that under the former two-tier foreign exchange system the official exchange rate was overvalued and the non-official rate undervalued. Because the Chinese wool textile industry is both an exporter of fibre products and an importer of fibre materials, it was doubly disadvantaged. Although the recent abolition of the two-tier foreign exchange system can be expected to have a positive impact on the industry, the continued existence of import quotas means that wool imports may be unable to benefit greatly from this reform.
So far, we have examined several key factors influencing fibre demand and substitution, including technological and economic factors as well as policy variables. There are, however, a number of issues yet to be explored. First, earlier discussion of the effects of technological change focused only on the diffusion of chemical fibre technology. In fact, though, technical change in textile production also has a bearing on fibre substitution between chemical and natural fibres. Second, although it was argued that changes in final demand for fibre products could affect mills’ demand for fibres, the extent to which textile mills responded to these changes was not empirically shown. Third, analysis of the price factor concentrated on the role of relative prices in fibre substitution and did not touch on the effects of price instability. Fourth, although policy issues were discussed at length, there is still a need to assess the relative importance of the various trade and foreign exchange restrictions that affect fibre demand and substitution. Fifth, little has yet been said about the nature of cost curves and their implications for fibre substitution.

This chapter will discuss these issues using information gathered from my 1992 survey. The relevant section is Part 2 of the Questionnaire for Typical Textile Enterprises on Management and the Input-Output Situation, which asked both wool yarn and fabric manufacturers to indicate the main factors determining their choice of fibres. The choices given were: 1) production technology; 2) consumer demand; 3) relative prices of fibres; 4) price instability; and 5) other factors. Textile manufacturers were asked further to specify the circumstances in which they would be prepared to use more wool in textile production. The choices offered to respondents included the effects of policy variables. The survey also yielded information about the cost curves of Chinese wool textile manufacturers, with implications for fibre substitution.

Useable responses were obtained from 19 yarn manufacturers and 23 fabric manufacturers (Table 8.1). The response rates of the survey are detailed in Appendix 1.1.
Table 8.1 Number of Respondent Firms by Manufacturing Process

<table>
<thead>
<tr>
<th>Manufacturing Firms</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn</td>
<td>11</td>
</tr>
<tr>
<td>Fabric$^a$</td>
<td>15</td>
</tr>
<tr>
<td>Yarn and Fabric</td>
<td>8</td>
</tr>
<tr>
<td>Total Firms</td>
<td>34</td>
</tr>
</tbody>
</table>

Note: $^a$ Also includes knitted product manufacturers.

Source: Author’s 1992 survey.

In my questionnaire, I asked enterprises to select items according to the order of their importance. Unfortunately few did, and so each choice has had to be given an equal weight in data processing. Although this may have caused some bias in the results reported below, they do give some indication of the relative importance of the factors affecting fibre substitution.

TECHNOLOGICAL PROGRESS IN TEXTILE PRODUCTION

Since the introduction of chemical fibres and especially synthetic fibres into China, great progress has been made in the development of wool textile production technology. This has had a significant impact on the extent to which wool textile manufacturers have been able to substitute chemical fibres for wool in the textile production process.

Until the 1960s, spinning and weaving technology in China was largely wool-based. Since the 1970s the growing availability of synthetic fibres has stimulated domestic R&D on synthetic fibre textile-processing and fibre-blending technology. Whereas R&D was initially concentrated on developing technology for processing wool-rayon blended products, later it was increasingly oriented toward wool-synthetic blending technology.$^1$ This orientation resulted from policy as well as technical considerations. Technically, blending enables textile mills to combine fibres so that the

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$^1$ Rayon is a cellulosic fibre and synthetics are non-cellulosic fibres. Since the mid 1970s, the main growth area in China has been synthetic fibres.
strengths of each are used to best advantage (Hollen and Saddler 1968). From a policy point of view, blending is an option for the government to implement its policy of substituting chemical fibres for wool.

Although domestic blending technology was relatively slow to develop when the economy was closed, development has accelerated since China started to import foreign technology in 1978. Through intensive research on, and assimilation of, the technology embodied in wool textile machinery imported from Japan, West Germany, France and Italy, in the early 1980s China was able to produce its third generation of wool textile machinery. The new technology has allowed greater variation in fibre composition as well as a better quality of blended fibre product.

Since then, outdated British or French wool spinning and weaving machines have gradually been replaced with the latest generation of domestically produced wool textile machinery. At the same time, the latest blending technology has been widely adopted in newly built textile mills. As a fairly large proportion of current wool spinning and weaving facilities was added during the 1980s, textile production technology now provides greater technical scope for Chinese wool textile mills to substitute chemical fibres for wool.

The 1992 survey provides some information on the technical capability of Chinese wool textile mills to alter the fibre mix. Of the 19 yarn manufacturers who responded to the questionnaire, 17 indicated that they could and actually did vary the fibre content of yarn production. The remaining two produced pure chemical fibre yarn only. Of 23 fabric manufacturers, 21 indicated that they could and did alter the mix of wool and chemical fibres in the production of fabrics. The remaining two manufactured pure chemical fibre products only.

In a study of fibre substitution in the Australian wool textile industry, Tisdell and McDonald (1979) considered four categories of fibre usage: zero wool usage; low wool

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2 The first generation of domestically produced wool textile machinery, which emerged in the 1960s, could process only wool. The second generation, mainly developed in the 1970s, was better able to process pure chemical fibre products.

3 In 1980, the total number of wool spindles and wool looms installed in the Chinese wool textile industry was 600,500 and 8,332 respectively. By 1990, this had increased to 2.66 million and 33,556.
usage (1-39 per cent); intermediate wool usage (40-79 per cent); and high wool usage (80-99 per cent). The authors found that firms altering the fibre mix tended to be intermediate to high wool users and low to intermediate users of man-made fibres. In the case of the Chinese wool textile industry, however, no such relationship can be established. It appears that fibre substitution occurs across the whole range of wool fibre use.

In order to ascertain whether production technology was still a constraint on fibre substitution, textile manufacturers were asked to identify the main factors determining their choice of fibres. Only three yarn manufacturers (excluding the two manufacturers of pure chemical fibre yarn) and one fabric manufacturer (excluding the two manufacturers of pure chemical fibre fabrics) indicated that production technology constrained their ability to substitute between fibres.

CONSUMER DEMAND

Domestic consumer demand has undergone great change over the past decade or so. Among the factors contributing to this, the most obvious is that strong economic growth has raised living standards and incomes, allowing consumers to express their preference for luxury fibres such as wool (chapter 3). A second factor is that an increase in the degree of urbanisation, again associated with economic growth, has reinforced demand for wool (Findlay and Watson 1990). This has also, however, led to greater demand for casual clothing, which would seem to favour chemical fibres and perhaps cotton.

Changes in the relative price of fibre products have also affected demand. The relative price of wool products has been adversely affected by government fibre policy, forcing consumers to shift from wool to substitutes such as wool blends. As consumers now seems to have become accustomed to wool blends, this trend would be difficult to reverse (Fisher et al. 1990).

A fourth factor concerns technological change. Technical change and diffusion have imparted to chemical fibres many new characteristics not possessed by natural

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4 The criteria for the content of wool is as defined by Tisdell and McDonald (1979).
fibres, such as easy care and superior wash and wear properties. These properties have proven highly desirable to consumers who increasingly value their leisure time.

Finally, demand has been affected by the increasing importance of fashion trends, associated partly with a higher standard of living and partly with greater freedom of choice. In the past decade or so, urban consumers have become more conscious of fashion, colour and the fibre content of the yarn, fabrics and clothing they purchase. This was highlighted by the results of a survey conducted in 1993 by Xingxing Market Research Company on the clothing market in Beijing. The survey identified the following features of changing consumer preferences (Economic Daily 13 October 1993):

- more emphasis on the style of clothing;
- preference for quality materials and harmonious colours;
- preference for more innovative and distinctive fashion;
- greater attention by young people to spring and autumn fashion;
- greater attention by consumers to the quality of men’s clothes, including workmanship, fit, comfort and fabric quality; and
- increased demand by young people for natural fibres such as silk, wool and cotton as a fashion component.

Patterns of consumer demand were cited by both yarn and fabric manufacturers as an important factor in their selection of fibres; 14 of 19 yarn manufacturers (74 per cent) and 16 of 23 fabric manufacturers (70 per cent) considered consumer demand to be a factor in fibre substitution.

CHANGES IN THE RELATIVE PRICE OF FIBRES

The importance of relative prices in fibre substitution has increased substantially in the past decade or so as Chinese firms have become more profit- and market-oriented (chapter 5). The empirical study carried out in chapter 6 showed that relative prices had a statistically significant effect on mills’ fibre demand and substitution. This result is also borne out by the analysis of qualitative data from the survey. Of the textile manufacturers
surveyed, seven yarn manufacturers (37 per cent) and eight fabric manufacturers (35 per cent) considered relative prices to be a factor in fibre substitution.

**THE ROLE OF PRICE STABILITY IN FIBRE SUBSTITUTION**

Another dimension of the role of prices in fibre substitution is price instability. Earlier studies on fibre substitution have suggested that the relative instability of prices for natural fibres has steered textile manufacturers towards substitution with man-made fibres (Tisdell and McDonald 1979; Hirsh and Ellis 1974; AWC 1973).

Price instability appears to have become increasingly relevant in the case of China, where prices of natural fibres, particularly wool, have varied greatly since the mid 1980s when economic reform began in the industrial sector. Table 8.2 presents the variance and coefficients of variation (between-year) for both the world\(^5\) and domestic\(^6\) prices of wool for the period 1970-91 based on a five-year moving average. The coefficients of variation for average annual wool prices are also graphed in Figure 8.1. Until 1983 the coefficient of variation for the world wool price was tending to fall. Since then it has risen dramatically. The coefficient of variation for the domestic wool price remained relatively small until 1984, then increased in line with the world wool price.

The instability of wool prices may create a considerable degree of uncertainty among manufacturers and make planning of the textile production process more difficult (Tisdell and McDonald 1979). In the survey, seven yarn manufacturers (37 per cent) and one fabric manufacturer indicated that price instability affects their choice of fibres in textile production. The higher number of yarn manufacturers choosing this factor reflects the fact that yarn producers are direct consumers of raw fibres.

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\(^5\) The Australian auction price is used as an indicator of the world wool price.

\(^6\) Due to lack of data, the mixed annual average purchasing price was used to indicate the variability of wool prices. Because calculation of the mixed price is based on both state and market purchase prices, variation may in fact be underestimated.
## Table 8.2 Between-year Variation in Average Annual World and Domestic Wool Prices (1970-91)

<table>
<thead>
<tr>
<th>Year</th>
<th>World Price $a$</th>
<th>Domestic Price $b$</th>
<th>Coefficient of variation</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aust. cents per kg</td>
<td>RMB yuan per kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean $c$</td>
<td>Variance</td>
<td>Mean</td>
<td>Variance</td>
</tr>
<tr>
<td>1970/74</td>
<td>126.37</td>
<td>3179.00</td>
<td>0.4462</td>
<td>2.99</td>
</tr>
<tr>
<td>1971/75</td>
<td>142.08</td>
<td>1990.16</td>
<td>0.3140</td>
<td>3.00</td>
</tr>
<tr>
<td>1972/76</td>
<td>163.58</td>
<td>708.89</td>
<td>0.1628</td>
<td>3.02</td>
</tr>
<tr>
<td>1973/77</td>
<td>164.25</td>
<td>745.18</td>
<td>0.1662</td>
<td>3.08</td>
</tr>
<tr>
<td>1974/78</td>
<td>169.07</td>
<td>1064.70</td>
<td>0.1930</td>
<td>3.18</td>
</tr>
<tr>
<td>1975/79</td>
<td>192.39</td>
<td>1330.03</td>
<td>0.1896</td>
<td>3.25</td>
</tr>
<tr>
<td>1976/80</td>
<td>214.93</td>
<td>1101.89</td>
<td>0.1544</td>
<td>3.33</td>
</tr>
<tr>
<td>1977/81</td>
<td>231.32</td>
<td>1125.82</td>
<td>0.1450</td>
<td>3.40</td>
</tr>
<tr>
<td>1978/82</td>
<td>247.86</td>
<td>666.86</td>
<td>0.1042</td>
<td>3.46</td>
</tr>
<tr>
<td>1979/83</td>
<td>265.58</td>
<td>348.61</td>
<td>0.0703</td>
<td>3.51</td>
</tr>
<tr>
<td>1980/84</td>
<td>280.60</td>
<td>649.42</td>
<td>0.0908</td>
<td>3.58</td>
</tr>
<tr>
<td>1981/85</td>
<td>297.82</td>
<td>1071.60</td>
<td>0.1099</td>
<td>3.90</td>
</tr>
<tr>
<td>1982/86</td>
<td>323.97</td>
<td>2326.17</td>
<td>0.1489</td>
<td>4.40</td>
</tr>
<tr>
<td>1983/87</td>
<td>396.54</td>
<td>18837.93</td>
<td>0.3461</td>
<td>4.95</td>
</tr>
<tr>
<td>1984/88</td>
<td>467.22</td>
<td>25670.96</td>
<td>0.3429</td>
<td>6.37</td>
</tr>
<tr>
<td>1985/89</td>
<td>514.37</td>
<td>19271.43</td>
<td>0.2699</td>
<td>7.44</td>
</tr>
<tr>
<td>1986/90</td>
<td>528.72</td>
<td>14118.42</td>
<td>0.2247</td>
<td>8.04</td>
</tr>
<tr>
<td>1987/91</td>
<td>521.39</td>
<td>16828.87</td>
<td>0.2488</td>
<td>8.71</td>
</tr>
</tbody>
</table>

**Notes:**

- $a$ Greasy wool, average annual Australian auction price for 1 July to 30 June.
- $b$ Greasy wool, mixed average annual domestic purchasing price.
- $c$ Five-year moving average.
- $d$ The coefficient of variation of prices is equal to their standard deviation divided by the mean and indicates the relative fluctuation of prices.

**Sources:** *Commodity Statistical Bulletin 1992, ABARE; Statistical Yearbook of China 1981-93.*
Figure 8.1  Between-year Variation in Average Annual World and Domestic Wool Prices (1970-91)

![Graph showing variation in wool prices](image)

Source: Based on Table 8.1.

**FACTORs INFLUENCING FIBRE SUBSTITUTION: SUMMARY AND FURTHER EVIDENCE**

Tables 8.3 and 8.4 summarise the empirical results on factors influencing Chinese yarn and fabric manufacturers' choice of fibres. It is clear from these tables that consumer demand is the overwhelming factor: it was mentioned by 73.4 per cent of yarn makers and 69.9 per cent fabric manufacturers. The second most important factor is the relative price of fibres, which was selected by 36.8 per cent of yarn manufacturers and 34.7 per cent of fabric manufacturers. Price instability ranks equal with relative prices in the case of yarn manufacturers but last in the case of fabric manufacturers. The least important factor for both groups is the availability of technology.

In addition to these general observations about the factors influencing fibre substitution in the Chinese wool textile industry, firms were asked to indicate under what circumstances they would be prepared to use more wool in textile production. Since changes in production technology and in consumer demand can either increase or decrease wool usage, these two factors were taken as given. Manufacturers were asked rather to choose between relaxation of foreign exchange controls and a lessening of import controls, among other things. Responses are summarised in Tables 8.5 and 8.6.
Table 8.3 Factors Influencing Fibre Substitution as Indicated by Yarn Manufacturers

<table>
<thead>
<tr>
<th>Factor influencing fibre substitution</th>
<th>No. of firms mentioning factor</th>
<th>Per cent$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production technology</td>
<td>5</td>
<td>26.3</td>
</tr>
<tr>
<td>Changes in consumer demand</td>
<td>14</td>
<td>73.4</td>
</tr>
<tr>
<td>Relative prices</td>
<td>7</td>
<td>36.8</td>
</tr>
<tr>
<td>Price instability</td>
<td>7</td>
<td>36.8</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note:  
$^a$ Number of firms mentioning a particular factor as a percentage of the total number of firms responding to the question on fibre substitution. Percentages do not sum to 100 because most respondents mentioned more than one factor.

Source: Author's 1992 survey.

Table 8.4 Factors Influencing Fibre Substitution as Indicated by Fabric Manufacturers

<table>
<thead>
<tr>
<th>Factor influencing fibre substitution</th>
<th>No. of firms mentioning factor</th>
<th>Per cent$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production technology</td>
<td>3</td>
<td>13.0</td>
</tr>
<tr>
<td>Changes in consumer demand</td>
<td>16</td>
<td>69.6</td>
</tr>
<tr>
<td>Relative prices</td>
<td>8</td>
<td>34.7</td>
</tr>
<tr>
<td>Price instability</td>
<td>1</td>
<td>4.3</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note:  
$^a$ Number of firms mentioning a particular factor as a percentage of the total number of firms responding to the question on fibre substitution. Percentages do not sum to 100 because most respondents mentioned more than one factor.

Source: Author's 1992 survey.
Table 8.5 Factors Influencing Mills' Use of Wool as Indicated by Yarn Manufacturers

<table>
<thead>
<tr>
<th>Factors influencing willingness to buy more wool</th>
<th>No. of firms mentioning factor</th>
<th>Per cent&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower relative wool price</td>
<td>10</td>
<td>52.6</td>
</tr>
<tr>
<td>More stable wool price</td>
<td>4</td>
<td>21.1</td>
</tr>
<tr>
<td>Availability of foreign exchange</td>
<td>9</td>
<td>47.4</td>
</tr>
<tr>
<td>Relaxation of import controls</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Other&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5</td>
<td>26.3</td>
</tr>
</tbody>
</table>

Note:  
<sup>a</sup> Number of firms mentioning a particular factor as a percentage of the total number of firms responding to the question on fibre substitution. Percentages do not sum to 100 because most respondents mentioned more than one factor.  
<sup>b</sup> Most firms mentioned consumer demand.

Source: Author's 1992 survey.

Table 8.6 Factors Influencing Mills' Use of Wool as Indicated by Fabric Manufacturers

<table>
<thead>
<tr>
<th>Factors influencing willingness to buy more wool</th>
<th>No. of firms mentioning factor</th>
<th>Per cent&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower relative wool price</td>
<td>15</td>
<td>65.2</td>
</tr>
<tr>
<td>More stable wool price</td>
<td>3</td>
<td>13.0</td>
</tr>
<tr>
<td>Availability of foreign exchange</td>
<td>5</td>
<td>21.7</td>
</tr>
<tr>
<td>Relaxation of import controls</td>
<td>1</td>
<td>4.3</td>
</tr>
<tr>
<td>Other&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10</td>
<td>43.5</td>
</tr>
</tbody>
</table>

Note:  
<sup>a</sup> Number of firms mentioning a particular factor as a percentage of the total number of firms responding to the question on fibre substitution. Percentages do not sum to 100 because most respondents mentioned more than one factor.  
<sup>b</sup> Most firms mentioned consumer demand.

Source: Author's 1992 survey.
Most firms (52.6 per cent of yarn manufacturers and 65.2 per cent of fabric manufacturers) indicated that they would be prepared to use more wool if the relative price of wool versus chemical fibres were lower. This result is important as at the time of the survey the relative price of wool had already dropped significantly from its previous level. Yet this fall in price still seems to have been insufficient to induce wool textile manufacturers to use more wool in textile production.

The next most frequently mentioned factor was restrictions on foreign exchange; yarn manufacturers were particularly likely to mention this. In contrast, import controls do not seem significantly to affect wool demand. These results confirm the earlier observation that under the dual foreign exchange system restrictions on access to the foreign exchange market act as a real constraint on wool demand.7

A number of firms also indicated that they would use more wool if a more stable wool price could be delivered. Although the number of firms mentioning this factor was small, it does suggest that instability of the wool price could be a problem in future for the Chinese wool textile industry in the absence of devices for stabilising the price.

Of responses in the ‘other’ category, many firms said that the slump in consumer demand for wool products was a major factor influencing their use of wool. This result again confirms the importance of consumer demand in mills’ selection of fibres.

THE NATURE AND IMPLICATIONS FOR FIBRE SUBSTITUTION OF DIRECT COSTS

The cost curves of different firms — for instance, heavy wool users versus heavy chemical fibre users — may have different characteristics. These characteristics matter in fibre substitution, as the following example shows. If a heavy wool user experiences excess capacity and rising per-unit direct cost as output expands, the higher cost of production may force the firm to shift into other fibres such as chemicals at the production stage or to face a decline in the competitiveness of its output on the end-use market.

7 Because the survey was carried out in 1992, the situation may change now as discussed in chapter 7.
The nature of the cost/output relationship in the short run for a typical manufacturing firm was analysed by Tisdell and McDonald (1979). The authors discussed a number of theoretically or empirically plausible shapes for the average cost curve and the average variable cost (per-unit direct cost or operating cost) curve of a particular manufacturing firm. These curves are summarised in Figure 8.2.

**Figure 8.2 Possible Shapes of Cost Curve**

![Possible Shapes of Cost Curve](image)

Source: Tisdell and McDonald 1979, pp. 143-45.

Figure 8.2(a) illustrates a U-shaped short-run average cost curve (AC) and average variable (AVC) cost curve. These U-shaped curves can be derived from a cost function of cubic form. This has been considered to be the most general case in cost analysis, since it allows for the entire range of returns to variable factors: it shows increasing returns to scale at first, then constant returns (momentarily, at the point of inflection), and finally diminishing returns, after the point of inflection.
In some production processes, however, it is not necessary for all these ranges to be present. One view expressed in the literature is to expect diminishing returns to set in immediately; that is, for the marginal product (marginal cost) to decline (increase) from the outset, as shown in Figure 8.2(b) (Douglas and Callan 1992). In this instance, the average variable cost curve increases in a linear fashion. Note that the short-run AC curve falls at first under the influence of falling average fixed costs, but later rises as the rising AVC outweighs falling average fixed costs.

There are also cases in which constant returns to the variable factors may prevail throughout, or at least over a substantial output range. This results in decreasing short-run average costs accompanied by constant marginal and average variable costs, as indicated in Figure 8.2(c). 8

A further case of the cost curve that could be faced by a typical manufacturing firm is decreasing short-run average costs of production. This was first suggested by Andrews (1951). A modification of Andrew’s model suggests that when full capacity is reached, average costs would become almost a vertical straight line to form an average curve like that depicted in Figure 8.2(d).

In a survey of Australian wool textile manufacturers, Tisdell and McDonald (1979) found that a majority of responding firms experienced falling direct per-unit costs as they approached full capacity. This result is consistent with the findings of other studies targeting the textile industry, such as that of Markham (1952). 9 Tisdell and McDonald also found that relatively more man-made fibre than wool users experienced a fall in direct per-unit costs as full capacity was approached.

My survey also asked Chinese yarn and fabric manufacturers to indicate the variation in their direct per-unit costs as production moved from surplus to full capacity. 10 As Table 8.7 shows, of 19 yarn manufacturers responding to this question, 11

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8 For the generality of this model, see Johnson (1960).

9 Markham (1952), in his book *Competition in the Rayon Industry*, said that the average costs of a typical US producer of rayon corresponded to the model depicted in Figure 8.2(d).

10 In their survey, Tisdell and McDonald (1979) avoided asking textile manufacturers about changes in marginal cost on the grounds that the concept would be unfamiliar to them and many firms would not be able to estimate these. As this is equally true of Chinese textile industry, I followed Tisdell and McDonald’s approach.
said they had excess capacity. Of these 11 firms, eight experienced rising per-unit direct costs as full capacity was approached; two experienced falling costs, and the remaining firm indicated that it did not know the direction of variation. A more interesting result in terms of fibre substitution was that of the eight firms that experienced rising costs, six were heavy wool users; the two that experienced falling costs were heavy chemical fibre users. This clearly indicates that the cost structure did not favour wool usage.

Seven of 23 fabric firms had excess capacity. Five of these experienced rising per-unit direct costs as full capacity was approached; of these, four were heavy wool users. One firm experienced falling costs and was found to be a heavy wool user.

Table 8.7 Per-unit Direct Costs of Firms with Excess Capacity

<table>
<thead>
<tr>
<th></th>
<th>Yarn manufacturers (n=11)</th>
<th>Fabric manufacturers (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of firms experiencing rising per-unit direct costs as full capacity was approached</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Heavy wool users(^a)</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Heavy chemical fibre users(^b)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>No. of firms experiencing falling per-unit direct costs as full capacity was approached</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Heavy wool users</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Heavy chemical fibre users</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>No. of firms not knowing direction of variation in per-unit direct costs</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes:  
\(^a\) Wool accounted for more than 50 per cent of total fibre inputs.
\(^b\) Chemical fibres accounted for more than 50 per cent of total fibre inputs.

Source: Author's 1992 survey.

In summary, the above analysis of the cost/output relationship suggests that the cost structure of the Chinese wool textile industry has discouraged wool usage. Heavy wool users face rising per-unit direct costs as output expands, possibly because they are
forced to use older and less efficient machinery. This suggests that the future prospects of wool usage will depend in part on the improvement of wool processing technology and equipment.

CONCLUDING REMARKS

In this chapter I have attempted to identify, and ascertain the relative importance of, all the factors that could possibly affect Chinese textile manufacturers’ choice of fibres, drawing from my survey. I also examined the implications of the cost/output relationship for fibre substitution.

Within the limits of the information provided by the survey, a number of conclusions can be drawn from the empirical results presented in this chapter. First, technical progress in textile production has provided greater scope for Chinese wool textile manufacturers to substitute chemical fibres for wool. It is clear from the survey that new technology has enabled most firms to alter the fibre mix in textile production. Some firms’ technology even enables the exclusive use of chemical fibres and this may threaten future wool consumption. Second, mills’ demand for fibres is highly responsive to changes in consumer demand. Many firms at the time of the survey considered weak consumer demand for wool products to be a significant factor restricting their use of wool. Third, changes in the relative price of fibres are also regarded as a factor in fibre substitution. This result is consistent with the findings of our earlier econometric analysis. Fourth, the price instability of wool appears to have become a factor influencing textile manufacturers’ choice of fibres. Finally, restrictions on access to the foreign exchange market are more important than import quotas in affecting wool demand.

Analysis of cost/output relationships revealed that most firms experienced rising per-unit direct costs as they approached full capacity. Moreover, relatively more wool than chemical fibre users experienced rising costs as they approached full capacity. This implies that when demand for wool picks up and mills’ operating rates rise, the cost of wool products will also increase; and this in turn may make wool products less competitive in end-use markets.
9 Conclusions

In concluding the study, this chapter first draws out the main features of this dissertation. It then summarises the major findings of the thesis before drawing some strategic implications. The final section outlines the directions for future research.

KEY FEATURES OF THE STUDY

The main purpose of this study has been to examine the dramatic changes in fibre substitution trends which have occurred in the Chinese textile industry and to seek out the driving forces behind these changes. The study differs from others of its type in two respects.

First, the study has provided a consistent and systematic framework for addressing effectively the issue of fibre substitution. The analysis began by relating trends in fibre substitution to income growth and export expansion. The fibre substitution path as the Chinese economy grew was described, and analysed further using a linear regression technique. I then examined the impact of the technological diffusion of chemical fibres on fibre substitution using a logistic diffusion model. The estimated results enabled us not only to measure past changes in fibre usage but also to assess the pattern of mills’ future fibre consumption. The study then touched upon the important question of price-induced fibre substitution. The three basic assumptions associated with neoclassical demand models were examined before turning to an empirical investigation of price-induced fibre substitution in the Chinese wool textile industry. Attention was also given to the effects of policies on fibre demand and substitution, with specific focus on the changing nature and significance of the various trade and foreign exchange restrictions that have accompanied economic reform. Finally, an attempt was made to identify and to rank the relative importance of major factors that were judged possibly to be important in manufacturers’ choice of fibres.

Second, analysis was greatly enriched by a unique survey serving the specific purposes of the study. The questions in the survey were formulated by the author, and
the survey was carried out by two professional organisations working under the guidance of the former Ministry of Textile Industry. Although the number of firms surveyed was small due to limited financial resources, the reasonably good return rate for state-owned textile mills allowed the results to be used with a fair degree of confidence.

The survey makes a significant contribution to understanding the effect of economic reform on firms' behaviour, market development and firms' budget constraint; it provided a unique data set on inputs, which allowed the author to carry out the first detailed empirical study of price-induced fibre substitution in the Chinese textile industry; and it revealed first-hand information about factors influencing mills' choice of fibres.

**MAJOR FINDINGS OF THE STUDY**

A number of important findings arise from this study.

**The pattern of fibre consumption changes as income grows and exports expand**

Mills' demand for fibres is derived from domestic consumer demand and foreign demand for fibre products. Both domestic and foreign demand have grown rapidly over the past 15 years or so as a result of increases in income and improvement in the competitiveness of Chinese textile products on the world market. Accompanying this growth have been dramatic changes in patterns of final demand for fibre products. Several key characteristics of these changes were identified in this study.

First, analysis of the relationship between per capita fibre consumption and per capita income revealed that the income elasticity of demand for fibres has been falling, a result which is consistent with cross-country comparisons. In 1980-90, the income elasticity of demand for fibres as a whole was found to be 0.63, compared with Gong's figure of 0.94 for 1970-80.

Second, disaggregation of total income elasticity into elasticities for particular fibres showed that chemical fibres enjoyed the highest income elasticity, followed by wool and cotton. The income elasticity of demand for wool was found to be one, indicating that, if this relationship holds true in the future, growth in per capita wool consumption will keep pace with growth in real per capita income. In view of China's
huge population and its potential for growth, the market for wool could be substantially larger than in any other country.

Third, a review of the literature on China's household expenditure system suggested that there was a trend for the expenditure elasticity of demand for clothing to decline. The latest studies pointed to an expenditure elasticity of one in urban China (Byron 1992) and 0.66 in rural China (Lu 1989). The higher expenditure elasticity in urban than in rural areas reflected primarily differences in the household welfare system and in consumer preferences. Reform of the urban welfare system, and especially of the urban housing system, may accelerate the trend of falling income elasticity of demand for fibres.

Fourth, within the category of household clothing expenditure, the expenditure elasticity of demand for wool fabrics and clothing was higher than for other types of fibre products; in many cases, it was greater than one.

Fifth, data on fibre composition in export products showed that cotton gained quite significantly in market share during the 1980s, mainly at the expense of silk, flax, ramie and jute. The market shares of wool and chemical fibres remained relatively stable. These changes accord with the relative strength of comparative advantage that China has developed since the adoption of an open door policy.

**Technological diffusion affects fibre substitution**

The introduction of chemical fibres, especially synthetic fibres, has had a profound impact on mills' fibre consumption pattern. In order to gauge the impact of the new technology on the market share enjoyed by traditional and new products, an S-shaped growth curve was fitted to historical share data. This demonstrated that the diffusional impact of chemical fibres on fibre substitution was different for the Chinese wool and cotton textile industries. Both the equilibrium use (saturation level) of chemical fibres and the rate of approach to the equilibrium (slopes) were found to be higher for the wool than for the cotton industry.

While the diffusional impetus of chemical fibres has so far had a stronger substitution effect on the wool market, a comparison of the current market share of
chemical fibres in the Chinese wool textile industry with the ultimate ceiling asymptote suggested that the momentum of this diffusional impact on future fibre substitution will not be as great as in the past. If current market conditions prevail and there is no further adverse technological change, the speed of displacement of wool by chemical fibres will slow down and end in the not-too-distant future.

It should be noted that while growth curve analysis is useful in documenting and summarising the observed shifts in fibre usage, it is not informative about why fitted growth curves assume their particular values (Polasek 1965). It would therefore be tempting to include some economic variables, such as relative prices, in the logistic model to account for the growth pattern of chemical fibre market share. However, this would probably not be justified in the case of China because relative prices were not relevant in most years of the sample period under study.

**Price now matters in fibre substitution**

Two events have recently brought relative prices to the fore as an important issue in fibre substitution in the Chinese textile industry. First and most importantly, economic reform in the industrial sector since the mid 1980s has made Chinese state-owned enterprises more profit-oriented or cost-minded. Second, chemical fibres have already made the quantum jump of penetrating the market for natural fibres, especially wool. International experience suggests that once this leap has been achieved, the progress of further market penetration depends primarily and directly on price movements (Minford 1975).

For a neoclassical demand model to be applied to the measurement of price responsiveness in the Chinese wool textile industry, three basic assumptions associated with the neoclassical approach were checked, and proven to be met in the case of a sub-cost function consisting of raw fibre inputs only. These assumptions were: 1) firms should be either profit maximisers or cost minimisers; 2) there should be no physical shortage, that is, a fibre market must exist; and 3) firms’ budget constraints should be hard, or at least not perfectly soft.

Significant changes have taken place in state firms’ behaviour since economic reform. The author’s survey, when supplemented by earlier studies on this subject,
clearly indicated that post-reform state enterprises have become more profit-oriented or cost-minded. It was shown that under current institutional arrangements, the incentive exists for state firms to economise on production inputs, or at least on the use of raw materials.

The first stage of market development in China involved the establishment of a dual price system. It was argued that under this system physical shortage should in theory be non-existent because any excess demand would be cleared at the price prevailing on the secondary market. This argument received strong support from the author's survey, which showed that fibre markets have recently developed to the extent that a majority of firms' purchases are now based on secondary markets. Firms are no longer forced to substitute, and market prices have become a dominant factor governing firms' choice of fibres.

The budget constraint of state firms has also hardened as a result of economic reform. Although the extent to which the budget constraint has hardened is arguable, there are many indications that the post-reform budget constraint is at least not as soft as it was previously. It would seem that state firms are indeed under pressure to respond to price signals.

The own- and cross- price elasticity of derived demand for wool is low in the short run but higher in the long run

The Chinese wool textile industry was used as a case study for examining price responsiveness and price competition between fibres. Using a dynamic translog cost model, the study found that short-run demand for wool was price inelastic (-0.2). This finding was in agreement with the consensus reached in empirical studies of price responsiveness of derived demand for wool in other countries. However, it was inconsistent with the high price responsiveness of final demand for wool products revealed in chapter 3. It was argued that this inconsistency may have resulted in part from the continuing softness of post-reform budget constraint. If this argument holds, it can be expected that further economic reform would make future demand for wool more price-elastic.
While wool demand was inelastic in the short run, the responsiveness of demand to a change in price increases in the long run. The adjustment rate was estimated to be 0.37 \((1-\lambda)\), an even higher rate than in developed countries.\(^1\) The four-year (approximate long-run) price elasticity of derived demand for wool was found to be -0.52.

The study also found that there has been heavy price competition between wool and chemical fibres in the Chinese wool textile industry. Although a relatively low own-price elasticity provided wool with some market power, the relatively higher price responsiveness of demand for chemical fibres meant that a fall in the chemical fibre price, given a constant wool price, would cause a relatively larger substitution effect, especially in the long run; this was because in the long run demand for chemical fibres was price-elastic.

**Policies affect mills’ demand pattern for fibres**

Fibre demand and substitution were also found to be heavily influenced by policies. The Chinese government has had a longstanding policy of fibre self-sufficiency. This policy places overwhelming emphasis on the development of chemical fibres as a long-term solution to domestic fibre supply constraints. With the adoption of such a policy, it could be expected that China’s trade and foreign exchange policies with respect to natural fibre imports would be restrictive.

The trend for fibre self-sufficiency to fall as the economy grows is inevitable, especially in the case of a resource-poor and/or densely populated economy. Over the past decade or so, because of a faster increase in wool than in cotton consumption combined with a slower increase in wool than in cotton production, self-sufficiency in wool has declined at a faster rate than self-sufficiency in cotton. This strengthened the government’s determination to endorse its fibre substitution policy in the Chinese wool textile industry, thereby resulting in a heavier substitution with chemical fibres of wool than cotton.

\(^1\) In their study of fibre substitution in the raw fibre market in the United States, Japan and Europe, Ball et al. (1989) found that the adjustment rate was 0.14.
Under the economic system as it was before reform, planning provided the government with a powerful tool to endorse its fibre substitution policy. The declining role of economic planning as a result of economic reform created a need for alternative policy instruments for influencing fibre demand and substitution. This need has been met by trade and foreign exchange policies.

The study showed that the relative importance of trade and foreign exchange restrictions has changed significantly. In the pre-reform economy, import tariffs tended not to have a real economic effect on mills’ demand for fibres, although they had an indirect effect through their impact on final demand for fibre products; import planning and foreign exchange controls acted effectively as a quota on imports. With the rise of more profit- and market-oriented firms in the post-reform era, tariffs began to have a significant impact on mills’ demand. Import quotas, although until recently not a major factor in depressing mills’ demand, will become more important as recent changes in the foreign exchange system take effect. Foreign exchange controls were a significant factor in constraining import demand under the previous dual foreign exchange system. The recent abolition of the dual foreign exchange system is expected to ease this constraint.

Wool demand has been particularly hard hit by trade and foreign exchange restrictions: because wool imports are subject to both tariff and quota restrictions; and because mills’ consumption of wool has always been more dependent on imports of wool than of cotton or chemical fibres.

Tariffs have a direct price-raising effect, which reduces demand for imports. According to the author’s estimate, a 15 per cent tariff on greasy and scoured wool could result in a 3 per cent reduction in wool demand in the short run. In the longer run, because of the higher price elasticity, the reduction of wool demand caused by a tariff would be even larger — 7.8 per cent in four years’ time. This would be the equivalent of a 6,000 ton reduction in wool import volume in the short run and a 15,600 ton reduction in the long run. Import quotas, when binding, further raise the domestic price of fibres. Given the limited potential for growth in domestic wool production, heavier restrictions

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2 In 1992, China imported a total of 209,000 tons of wool (a mixture of clean and greasy wool).
on wool imports are likely to lead to the replacement of wool with other fibres such as chemical fibres and cotton.

Analysis of distortions in the foreign exchange regime based on the 'short-side rationing model' indicated that under the former two-tier foreign exchange system the official exchange rate was overvalued and the non-official rate undervalued. Because the Chinese wool textile industry is both an exporter of fibre products and an importer of fibre materials, it was doubly disadvantaged. Although the recent abolition of the two-tier foreign exchange system can be expected to have a positive impact on the industry, the continued existence of import quotas means that wool imports may be unable to benefit greatly from this reform.

**Mills’ choice of fibres: a micro view**

In an attempt to identify, and to rank the relative importance of, various factors affecting fibre demand and substitution, the author’s 1992 survey included a section asking Chinese wool textile manufacturers to indicate the factors governing their choice of fibres and the circumstances under which they would be prepared to use more wool in their textile production. The main results can be summarised as follows.

The results indicated first that most firms considered consumer demand to be an important factor influencing their choice of fibres. It appeared that, at the time of the survey, weak consumer demand for wool products was a significant factor in mills’ reduced demand for wool. Second, there was a clear tendency for wool textile mills to choose a combination of fibre inputs that would minimise their production costs given the set of fibre prices. Third, the increased instability of wool prices was a factor influencing mills’ choice of fibres. Fourth, restrictions on access to the foreign exchange market appeared to be affecting wool demand to a greater extent than import quotas had under the previous dual foreign exchange regime. Finally, progress in textile production technology favoured the use of chemical fibres.

The survey also yielded some information about cost/output relationships and their implications for fibre substitution. The results indicated that relatively more wool than chemical fibre users experienced rising direct per-unit cost as full capacity was
approached. This implied that when mills' operating rates rose, the cost of wool products would also increase, thereby making wool products less competitive on end-use markets.

STRATEGIC IMPLICATIONS

China has reached a critical point in its strategic choices on fibre specifications (Findlay and Watson 1990). Even though the industry has achieved spectacular growth in the past decade or so due to economic reform and the country's open door policy, the potential for further growth is huge. On the demand side, because the current level of fibre consumption per person in China is still low, further economic growth can be expected to continue to stimulate demand for fibre products. On the supply side, China has a comparative advantage in labour-intensive manufactures such as textiles and clothing and will not lose its competitiveness in the near future (WIRC 1993).

One important message of the study is that income growth has been and will remain one of the key determinants of mills' demand for fibres. While the propensity to consume textile fibres has tended to decline as income grows, the income elasticity of demand for certain types of fibres, such as wool, has remained relatively high. Recent experience shows that growth of per capita wool consumption has kept pace with that of per capita income. If this holds true in the future and assuming an average annual per capita income growth rate of 7.3 per cent (1980-90), per capita consumption of wool will rise from 0.19 kilograms (clean equivalent) in 1990 to 0.38 kilograms (clean equivalent) in 2000. In view of China's large and rising population, by the year 2000 total wool demand in China could show a net increase of 285,000 tons (clean equivalent) over the 1990 level.³

But whether this increase in demand will be fully translated into demand from mills, and eventually into demand for wool imports, will depend to a great extent on other factors. The first of these is technical change. Although the progress of penetration

³ The average annual growth rate of the Chinese population was 1.48 per cent in 1980-90. Assuming the same growth rate in future, the total population in China will increase from 1.14 billion in 1990 to 1.32 billion in 2000. Total wool consumption would then increase from 217,000 tons (clean equivalent) in 1990 to 502,000 tons, a net increase of 285,000 tons (clean equivalent).
of chemical fibres into the wool market will tend to ease as a result of gradual loss of diffusional momentum, further improvements in the quality and characteristics of chemical fibres are possible, and this would help chemical fibres to consolidate or even further expand their market share at the expense of wool.

A second factor is relative prices. As post-reform state enterprises become more profit- and market-oriented, relative prices can be expected to play an increasingly important role in future fibre substitution trends. If domestic and overseas wool suppliers fail to deliver a competitive price for wool in the future, textile processors will be under pressure to switch to other competing fibres, especially chemical fibres.

The direction of future changes in policy is a third factor. Although China is likely to continue to pursue a fibre self-sufficiency policy, there will probably be less emphasis on this policy as export capability grows and foreign exchange constraints are relaxed. The immediate threat to wool demand appears to come from trade restrictions. China has not so far announced a plan to remove the quota on wool imports, although it has made a commitment to GATT that it will remove import licences on a wide range of commodities. Moreover, as reported, China has scheduled a 50 per cent reduction in tariff rates on chemical fibres from present levels in two or three years (Xiao 1992). This will change the relative prices of wool and chemical fibres and hence dampen the demand for wool.

A fourth factor is the ability to manage risks associated with price instability. The fact that China has emerged as a major player in the international wool market could itself become a new source of price instability. Failure to keep wool price fluctuations within a reasonable range or to provide a mechanism for reducing risks could cause the Chinese government to doubt the reliability of the world market; it could also create a shift in mills' demand away from wool towards more stably priced synthetics.

The last factor concerns the cost structure of the Chinese wool textile industry. Wool may be inherently disadvantaged by its processing cost in comparison with chemical fibres. Adjustments made so far in the Chinese textile industry following the

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4 In 1992, China made a commitment to reduce the number of goods restricted by import licensing to one-third of current levels in three to five years (Fang and Meng 1993).
recent recession appear to have been concentrated more on capacity reduction than on
the upgrading of technology and equipment. However, once demand picks up again, as is
now happening, the industry needs to make some important decisions about fibre
specialisation. Where it invests will of course be influenced in part by consumer demand,
as well as by mills’ perceptions about raw material supply.

The discussion suggests that there are a number of strategic options that foreign
wool suppliers — including Australia, a major wool supplier — can take at this critical
stage to influence China to reach an outcome that will best suit wool consumers’ and
producers’ interests.

Seek opportunities to blend wool with chemical fibres

Given that chemical fibres are well established as a textile fibre in the Chinese wool
textile industry and that further improvements in the quality and characteristics of
chemical fibres are likely, wool needs to rethink its position in the textile fibre market. In
the past, wool has been promoted by the International Wool Secretariat (IWS) mainly on
a generic basis; despite its wide-ranging natural characteristics, wool has been treated as
a single-dimension commodity. This focus has neglected the role of wool as a blending
companion to other fibres (Stoeckel et al. 1990).

Prompted by the fibre substitution policy, recent R&D in China has concentrated
on developing the characteristics of chemical fibres that most nearly emulate those of
wool, particularly of fine wool. This represents a potential threat to the wool demand in
the future. If Chinese consumers are made, however, more aware of the unique
characteristics of Australian wool, it will then be less easy for chemical fibres to replace
wool and more likely that chemical fibres and wool are seen as good companions. The
recent refocussing of Australia’s wool marketing strategy on blends is certainly a
significant move which may prevent wool from being further passively substituted.

Price wool competitively

A competitive price is essential if wool is to expand its market share, given that technical
change has already made a wide range of competing fibres available on the textile fibre
market and that firms in China have already become more responsive to changes in prices as a result of economic reform.

A competitive wool price is a product of an efficient production and marketing system. Although Australia has a comparative advantage in producing low-cost and high-quality wool, the previous reserve price system proved disastrous for the industry. This system not only bred inefficiency in production but also discouraged wool consumption. In order to enhance the prospects of wool usage as a whole, China’s domestic production and marketing system is also in need of reform. Although wool production has become more efficient over the past decade or so due to the adoption of the household responsibility system, China’s wool pricing and marketing system remains very inefficient. The major impediment to the efficient marketing of raw wool has been the practice of pricing wool on a greasy weight basis. This means that growers of higher yielding wool are not properly rewarded and users have to face a declining yield of greasy wool they purchase (and hence higher prices). A second impediment is the monopoly power accrued to the supply and marketing cooperatives. Cooperatives that buy and sell wool benefit from a 27 per cent institutionalised profit margin (Lin 1993). This clearly discourages both the production and consumption of wool.

In recent years, the government has attempted to remove some of these impediments. The introduction of an auction system has begun to shift the wool market towards pricing based on quality and clean yield and towards direct interaction between wool processors and growers (Watson and Findlay 1992).

Australia could play a significant role in accelerating this reform process given its substantial expertise in wool classing, handling, objective measurement and selling (Connolly and Roper 1991). Australian aid bodies and the Australian Wool Corporation have already provided valuable assistance to China in the area of raw wool marketing. If they continue to do so, this will certainly influence future fibre specialisation in the Chinese textile industry.

Improvement in China’s production and marketing efficiency will of course lead to an increase in the competitiveness of domestically produced versus imported wool. This may put Australian wool at an disadvantage. But the immediate and longer term
Problem facing Australia and the international wool industry in general is how to prevent the Chinese wool textile industry from becoming more synthetic-oriented. If domestic price and quality issues are not solved quickly, the industry will be under pressure to switch new investment away from wool and toward synthetics. This danger was made clear by Findlay and Watson (1990):

> Once production capacity with a specialisation in processing synthetics, along with the appropriate skills in the workforce, are in place, the relative cost of switching back to wool will be high (Findlay and Watson 1990, p. 19).

Influence China's policies

Policy issues constitute perhaps the most important area in which Australia can act at this critical time. China's fibre self-sufficiency policy has its roots in foreign exchange constraint and uncertainty about the world market. Foreign exchange difficulties could be partially resolved by easing access to international markets and instituting a more efficient foreign exchange management system. Currently, China's exports of textiles and clothing are restricted by the Multi-fibre Arrangement (MFA). Being out of the GATT system, China has also been discriminated against in terms of access to the markets of major industrialised countries. Removal of these barriers to Chinese exports would certainly ease China's foreign exchange constraints. It is therefore in Australia's interest to support China in its efforts to reduce the restrictive effect of MFA and to rejoin GATT (Findlay and Watson 1990).

China's application to rejoin GATT is currently being considered by a working party. Acceptance into GATT requires that China bring its trade and foreign exchange regimes more into line with GATT principles (WIRC 1993), and thus further reform can be expected in the country's economic, trade and foreign exchange systems. This reform is important if China is to achieve further income growth and resource reallocation toward an internationally competitive textile industry (Findlay and Watson 1992).

The focus of China's economic reform has recently shifted toward stressing the link between the micro-economic reform agenda and management of the macro-economic system. During the present transitional period, macro-economic instability —
associated with sharp variation of direct controls over credit, trade and foreign exchange allocation — could remain an important factor in the volatility of China’s fibre demand. Success in macro-economic reform is, therefore, crucial to the assurance of a stable market for fibres, including wool. If the basic macro-economic issues are not resolved quickly, and if China fails to break the boom-bust cycle, China’s fibre market is likely to remain unstable and volatile, as evidenced by the experience of recent years.

Given current trends in the consumption and production of wool, China can be expected to become increasingly dependent on imports (Figure 9.1). By the turn of the century, China’s import share could reach about 20 per cent of the current total world wool trade. Unless the world wool industry, and the Australian industry in particular, can send a clear message to China that it is ready and willing to accommodate this growth, China is likely to continue to develop reliance on chemical fibres in order to reduce its import dependency.

Figure 9.1 Prediction of Wool Demand and Domestic Production in China

![Figure 9.1 Prediction of Wool Demand and Domestic Production in China](image)

Note: The predicted demand trend is based on the assumption that income elasticity of demand for wool, per capita income and population growth rates will remain the same as in the past. Production forecast is an extrapolation of the trend for 1980-90.

The most urgent issue on the trade policy agenda is to have quantitative restrictions on wool imports removed. This is because import quotas can cause great uncertainty for Australian wool exports. Removal of tariffs is important, especially in the context of pressure from the United States to remove import tariffs on chemical fibres.
There has already been some discussion between Australia and China on these issues, and China has indicated its willingness to consider removal of import quotas and tariffs on wool. Such discussions are important, even if implementation will have to occur in the context of China’s meeting GATT membership criteria (WIRC 1993).

**Bring wool futures market into full play**

With China’s emergence as a major player in the international wool market in the 1980s, fluctuations in the wool price have increased significantly. This has caused great uncertainty both for consuming and producing countries. Action needs to be taken if wool wants to compete with more stably priced synthetics.

History shows that the buffer stock system, although it may have helped to stabilise prices in the short run, has not achieved this goal in the long run. The recent downfall of the Australian reserve price scheme clearly indicates that the buffer stock system is not a good long-term solution.

Another possibility would be to establish long-term agreements between consumers and suppliers. In the case of wool, however, where price instability is caused mainly by fluctuations in demand, consuming countries are unlikely to show much interest in this sort of agreement, preferring rather to shift the stock burden to supplying countries (Smith 1978). Moreover, in a situation in which there are large wool stocks and the wool price is depressed, consuming countries can be expected to be wary of overcommitting themselves. Given this situation, and the experience of the Australia-Japan wool trade, the pursuit of a long-term wool trade agreement with China is likely to be difficult and unproductive.

A third option, suggested in WIRC (1993), is to bring a futures market for wool into full play. The functioning of Australia’s futures market for wool was hampered by the discretionary actions of government. With the abolition of the reserve price scheme, it is expected that the Sydney wool futures market will once again become active. Institutional reform could deepen the futures market and enhance its reliability and effectiveness, notably through the promotion of a deliverable wool market. This would
allow risk to be distributed efficiently, and market participants could avoid or reduce risk if they wished to do so (WIRC 1993).

Futures markets are no longer new to China: in fact, China already actively uses these markets when importing grain and cotton. Domestic futures markets are also emerging. If the wool futures market could be brought to China’s attention, this would certainly help China to minimise the risks generated by price instability. And this in turn could lead to a greater use of wool. “The issue of futures market is peripheral to the main themes of the current research, but it is an important topic for future studies given its controversy.”

Continue to provide China with technical assistance in wool processing

The importance of providing China with technical assistance in the later stages of wool processing has been widely recognised by the Australian wool industry and researchers (WIRC 1993; Connolly and Roper 1991; Findlay and Watson 1990). The essential reasoning is that technical assistance will help the Chinese wool textile industry to increase the quality of its products and lower production costs. This in turn will enhance the competitiveness of wool on end-use markets both in China and abroad, and hence lead to greater demand for raw wool.

A number of projects have been put in place in recent years by the Australian Wool Corporation, the International Wool Secretariat and the Australian International Development Assistance Bureau. These include Woolmark certification, provision of market information and assistance with fashion styling and design. But these activities are still overly small in scale, mainly due to limited funding. Further technical assistance is needed, especially in the area of cost-saving technology. This may help wool to compete more efficiently with chemical fibres.

DIRECTIONS FOR FUTURE RESEARCH

While the thesis has extended considerably our understanding of factors affecting demand for fibres, and in particular substitution between fibres, other questions remain which would be productive areas for further research.
First, analysis in the thesis of domestic final demand for fibre products has necessarily been based on aggregate household expenditure survey data and textile retail sales data. In the nature of things, these data cannot shed light on changes in consumer demand behaviour at the end-use level. In view of the potential size of China’s end-use markets for wool and the extent to which Chinese wool textile mills have in the past responded to changes in consumer demand, future research needs to target end-use fibre demand and substitution. A household-level survey on the Chinese textile and clothing markets would be necessary to support the extension of the analysis into these areas. It would be productive for the International Wool Secretariat (IWS) to come to some arrangement with China to initiate such a survey — as it did with Japan.

Second, it was not possible to obtain the kind of data for non-state enterprises that the survey generated for state enterprises. This is partly the results of state enterprises still being bound to co-operate with central agencies seeking data. It is more difficult and expensive to obtain data from non-state enterprises. In the past decade or so, the importance of non-state enterprises (such as rural enterprises and joint ventures) in the Chinese textile industry has increased substantially as a result of economic reform and the open door policy. Moreover, as non-state enterprises have been subject to different policy constraints, their demand behaviour with respect to choice of fibres may differ from that of state-owned enterprises. The filling of these gaps must await surveys with access to much larger resources than those have available for this thesis.

Third, another major step in reform of the foreign exchange system was taken at the time when the thesis was being completed. While some preliminary assessment of its impact on the Chinese wool market has been presented in the thesis, the full effect of this change is yet to be seen. There is clearly a need to explore this important topic further in future studies.

The thesis has brought together more information and allowed more profound analysis of fibre substitution in the Chinese textile industry. I hope the thesis will persuade others to continue the work into these areas. It is important for development in China and in fibre supplying countries that it should do so.


AGPS, Canberra.


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