A MATHEMATICAL PROGRAMMING MODEL OF TRADE AND PROTECTION APPLIED TO THE CANADIAN TEXTILE SECTOR

A MATHEMATICAL PROGRAMMING MODEL OF TRADE AND PROTECTION APPLIED TO THE CANADIAN TEXTILE SECTOR

by

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A thesis
submitted to the School of Graduate Studies
in partial fulfilment of the requirements
for the Degree
Doctor of Philosophy

McMaster University

March, 1985

TO MY PARENTS

DOCTOR OF PHILOSOPHY (1985) McMaster University
(Economics) Hamilton, Ontario

TITLE: A MATHEMATICAL PROGRAMMING MODEL OF TRADE AND PROTECTION APPLIED TO THE CANADIAN TEXTILE SECTOR

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NUMBER OF PAGES: ix, 163

ABSTRACT

This thesis develops a computable, non-linear programming, general equilibrium model of the Canadian textile sector for the purpose of addressing certain trade policy issues.

One of the unique features of the model is the specification of the objective function -- a CES nested in a Cobb-Douglas function. This objective function incorporates the assumption of diminishing marginal utility, an assumption which is almost universally accepted in microeconomic theory but which is conspicuously missing in linear programming models. This objective function also allows for imperfect substitutability between domestically produced textiles and imported textiles.

The textile sector is significantly disaggregated to allow for the interconnections among the various textile industries in the sector. In addition, unlike partial equilibrium models which do not consider what happens to other industries outside the sector under study, this model is able to shed some light on the behaviour of these industries.

The model is solved by an optimization package called MINOS (a modular in-core nonlinear optimization system) and then used to predict the 1979 variables to set a benchmark for the model. The model predicts most variables reasonably well.

The results of the experiments confirm Bhagwati's concept of equivalence as applied to general equilibrium models. The results also show that if protection in textiles is removed, imports will pour in, leading to declines in output and employment in the textile industries. The finding that there is considerable anti-protection in the textile sector agrees with the view expressed by other writers. The results also show that, in general, a textile industry at a later stage of processing tends to expand if it is the only one protected and an industry at an early stage of processing tends to contract if it is the only one protected.

Given any quota, its tariff equivalent can be computed using the model. With reference to tariffs and subsidies, the results show that one cannot say categorically that one means of protection is generally preferable to the other, a finding which is consistent with the trade distortions literature.

ACKNOWLEDGEMENTS

My deepest appreciation and gratitude goes to Professor J.R. Williams, the Chairman of my Supervisory Committee. His keen interest in the subject matter of the dissertation, his encouragement and guidance at every stage of the dissertation has helped to enrich it immensely. He was readily accessible and I am grateful to him for his time and effort.

Professor R.A. Muller's help in this thesis cannot be overemphasized. He was very helpful and patient with me especially with the package used to solve the model. His comments at various stages of the thesis were very constructive and I am grateful to him. I thank Professor D.W. Butterfield for helpful and constructive comments at various stages of the thesis, especially with the model and data chapters.

I would also like to thank John Ellis and Marianne Van Der Wel for their help in the computer work. The thesis was expertly typed by Aloma Munian to whom I am grateful.

Finally, I alone assume responsibility for any errors and/or omissions in this study. As Edward John Phelps (1822-1900) once said: "The man who makes no mistakes does not usually make anything."

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CHAPTER 1

INTRODUCTION

The Canadian textile sector has undergone rapid evolution and a number of significant changes in its international and domestic environments have occurred over the past two decades. Among these are: the "implementation of new technology resulting in a rapid increase in the world production of manmade fibres, especially those derived from petrochemicals, at the expense of cotton; ....excessive expansion of production facilities in the early 1970s leading to worldwide overcapacity, especially in the capital intensive areas of manmade fibres and yarns"[1], emergence of low-cost producing countries as major world exporters of textile products; and increased efforts by the high-cost producing countries to intensify their protective efforts as witnessed by the signing of the multifibre arrangement (MFA) in January 1974 and its subsequent extension until July 1986[2].

The history of the textile sector in Canada has been characterized by protection from imports, and without this protection the sector might have been

forced to undergo a major restructuring. The serious impact of imported textile products from low-cost countries began in the 1950s. The government responded to this influx of imports by negotiating a number of voluntary export restraint agreements beginning with Japan in 1960[3]. This was followed in 1970 by the government's formation of the Canadian Textile Policy leading to the establishment of the Textile and Clothing Board, which, among other things, was to accord special measures of protection against low-cost imports to goods which were particularly vulnerable to competition. In 1976, following appeals from provincial governments and the textile industries, the government introduced a system of global quotas on most clothing items under GATT Article XIX[4].

In June 1977, when Canada renewed its commitment to the MFA, it indicated that it wanted to "...adopt a hard line with regard to textile and clothing imports and to make use of the new allowance for 'reasonable departures' from the Agreement's provisions"[5]. Then the government announced that it intended to replace global quota on clothing with some restraint agreements under Article IV of the MFA[6]. By early 1980, a number of

bilateral agreements had been signed[7]. In general then, Canadian trade policy for the textile sector has been to maintain output and employment by means of tariff and non-tariff barriers on imports.

It would be interesting to be able to analyze this policy quantitatively, that is, to investigate the effects of some of these trade barriers on output, and imports in textile and non-textile sectors and on overall consumption and welfare. For this analysis, we need a model of the Canadian textile sector. There is considerable interdependence among the industries in the textile sector. The output of each phase of production, from the initial fibre stage to household products, is a major raw material for the next stage of production. (Textile and Clothing Inquiry, 1980.) The clothing industry is a major consumer of yarns and fabrics produced by the primary textile industry. Because of the complex interrelationships between the different industries of the textile sector, a suitable model must have a significant disaggregation of the textile sector and must be capable of incorporating these interconnections. A policy change in the textile sector has effects on

other sectors of the economy as well. To be able to investigate how industries outside of the textile sector react to policy changes in the textile industries, we need a general equilibrium model. A programming model allows the explicit treatment of interconnections between sectors in a general equilibrium framework.

If we believe that the consumer does not regard domestically produced textiles and imported textiles as identical commodities, a suitable model must be able to incorporate imperfect substitutability between these. Diminishing marginal utility in consumption is almost universally assumed in microeconomic theory. If we require the model to have such a characteristic, it will avoid the problem of corner solutions which is characteristic of linear programming models, and, in addition, capture imperfect substitutability between imported and domestic textile products. Since non-tariff barriers have been predominantly applied in the textile sector, the model must be able to capture some non-tariff barriers[2].

The approach of this study is to build a computable general equilibrium, non-linear programming model of the Canadian textile sector having the above

characteristics, namely: (a) having a significant disaggregation of the textile sector and incorporating the interconnections between the industries; (b) incorporating imperfect substitutability between domestic and imported textile products; (c) incorporating diminishing marginal utility and, thus, avoiding corner solutions, and (d) correctly expressing the non-tariff barriers to trade.

Such a model, properly constructed, can address a whole range of trade policy issues which other models cannot address. The model can be used to test the issue of comparative strength of industries within the textile sector. While the view is widely held that Canada has a comparative disadvantage in the textile sector as a whole, no published work has investigated comparative strength within the sector. Tariff equivalents of quotas can be computed with the model. Some writers, notably Bhagwati, have addressed the issue of equivalence between tariffs and quotas. Bhagwati (1965) noted that under competitive market-structure assumptions, in a partial equilibrium framework, the replacement of a tariff by a quota at the level of imports generated by the tariff can be viewed as creating an implicit tariff equal to the explicit

tariff that had been replaced by the quota. It will be interesting to investigate whether Bhagwati's definition of equivalence can be extended to a general equilibrium model. If tariffs and quotas are equivalent in the sense defined by Bhagwati, then it is true that for any tariff rate, there corresponds an equivalent quota (and vice versa) which will lead to an identical competitive equilibrium with the same level of output, consumption, imports and utility. The model developed in this dissertation allows such tariff equivalents to be computed. Another phenomenon which is worth investigating is how protection in the textile industries spills over to other industries. The question of whether tariffs are preferable to subsidies has been addressed by such writers as Haberler. In the framework of this model, this question can be investigated, by finding out whether one policy dominates the other with respect to output (and employment), utility, imports and consumption.

The study is organized into six chapters. Chapter 2 examines the organizational structure and institutional background of the sector to gain insight into some of the past, present and future conditions in the sector. Chapter 3 surveys some of the studies

that have examined textiles not only in Canada but elsewhere, and also discusses models that could be used for such studies. In chapter 4 the model employed in this study is presented and discussed. Because of some serious problems inherent in linear objective functions, we employ a non-linear objective function -- a nested constant elasticity of substitution (CES) objective function. Chapter 5 describes how the data obtained from Statistics Canada were organized to obtain the parameters for both the objective function and the constraints. The study ends with chapter 6 with a presentation and discussion of the empirical results and the conclusions.

FOOTNOTES

Chapter 1

1. Sector profile discussion paper (1978), page 15.

2. Canadian Textile Journal (February 1982), page 9.

3. Jenkins (1980), page 3.

4. See Table 2.6.

5. Biggs (1980), page 83.

6. Ibid.

7. See Table 2.6.

CHAPTER 2

THE CANADIAN TEXTILE SECTOR

2.1 Introduction

The Standard Industrial Classification of Canada (1980) classifies all economic activities into Divisions. Each Division is, in turn, subdidivided into Major Groups which are further subdivided into Industries. What we refer to in this dissertation as the textile sector consists of three Major Groups of Division E, Manufacturing. These are, respectively: The Primary Textile Industries (Major Group 18), The Textile Products Industries (Major Group 19), and The Clothing Industries (Major Group 24). The chapter begins by noting that the industries are interrelated and discussing some important statistics in Section 2.2. In Section 2.3, trade policies in the sector are discussed. The last section takes a look at the sector after the adoption of the textile policy of 1970.

2.2 The Textile Sector

There are a large number of industries in the Major Groups cited in the previous section (see Standard Industrial Classification of Canada, 1980) and the textile sector itself is made up of sixteen industries. As noted in chapter 1, the industries comprising the sector are closely interrelated. The production stages that are carried on in the sector "....(extend) from the production of manmade fibres and yarns, to the transformation of natural or manmade fibres into apparel fabrics, and to the production of a wide variety of household and industrial products" (Sector profile Discussion Paper (1978), p. 1). The first step to producing the finished good is the raw material -- natural or manmade fibre. Next, the raw fibre is sent to a spinning mill (such as the synthetic textile mill) which transforms it into yarn. The yarns then go to the mills which produce woven fabrics, knitted fabrics (e.g. the knitting mills). Lastly, the fabrics are converted by bleaching, dyeing and finishing in industries such as textile dyeing and finishing. (See Jackman and Dixon (1983), p. 13 for more discussion.) Thus the natural

fibres go through a variety of processes before they are transformed into end products.

The relative size of the industries in the sector in 1981 is shown in Table 2.1. The miscellaneous textile industries as a whole were the largest employer among the industries, accounting for 30.1% of the total employment of 67,600 people in 1981. These industries also ranked first in terms of the number of establishments and second in terms of shipments accounting for 54.9% and 22.9%, respectively. The manmade fibre, yarn and cloth mills had the highest value of shipments, 29.4%, out of a total value of $5439 million but ranked second and third, respectively, in employment and number of establishments. The smallest employer was the cordage and twine industry which accounted for less than 1% of total employment. This industry also ranked last in terms of the value of shipments, shipping only $33 million in 1981. The shipments of the textile sector represented about 2.3% of the output in all Canadian manufacturing and employment was about 3.7% of the total employment in Canadian manufacturing.

Table 2.2 distributes establishments in the sector in 1981 in seven size categories. The table indicates that 83% of the establishments accounted for

only 23.2% of employment implying that these establishments have small sizes. In fact, each of these establishments had fewer than 100 employees in 1981. Only 19 (2%) out of the 952 establishments had employment sizes of over 500 employees. The average number of employees per establishment and the value of shipments per establishment were 68 and $5.7 million, respectively, in 1981. Table 2.3 shows concentration data over the period 1970 to 1980. The table shows that in general, the textile industries as a whole are more concentrated than the clothing industries with the knitting mill industries in between. Since most of the textile industries do not produce end products whereas the clothing industries do, it follows that, in general, industries at early stages of processing tend to be more concentrated than those at later stages of processing. For example, cotton yarn and cloth mills (early stage processor) is more concentrated than textile dyeing and finishing (late stage processor), as shown in Table 2.3. Presumably, to exploit specialization and economies of scale, some of the smaller firms have merged. Thus there are few firms producing certain products. The textile and clothing inquiry (1980, p. 24), notes that "....each of the various types of manmade fibres is

produced by only one or two firms. Similarly, there are only two Canadian weavers of cotton apparel fabrics, including denim, two of nylon apparel fabrics, three of polyester apparel fabrics, two of sheets and pillowcases and three of towels. In addition, 85% of domestic production of worsted fabrics is supplied by two firms".

As Table 2.4 shows, the textile sector is concentrated in Ontario and Quebec with the two provinces accounting for 91% of the total employment and 71% of the establishments in 1981. However, there is some concentration of certain products in the provinces. Table 2.5 shows that while Quebec is the sole employer in the carpet, mat and rug industry, the automobile fabric accessories industry and the miscellaneous textile industries are concentrated in Ontario. While the Western Provinces accounted for only 6.7% of the total employment in textiles in 1981 (see Table 2.5), there is a high concentration of canvas products and in fact, employment in this industry ranked second to Ontario in 1981.

TABLE 2.1 RELATIVE SIZE OF INDUSTRIES, TEXTILE SECTOR, 1981

1980 SIC Code	Industries	ESTABLISHMENTS No.	%	VALUE OF SHIPMENTS $000,000	%	EMPLOYMENT No.	%
181	Cotton yarn and cloth mills	20	2.1	817.9	15.0	10,003	14.8
182	Wool yarn and cloth mills	44	4.6	280.9	5.2	4,682	6.9
183	Man-made fibre, yarn and cloth mills	89	9.3	1598.0	29.4	15,847	23.4
1831	Fibre and filament yarn	14	1.5	783.4	14.4	6,140	9.1
1832	Throwsters, spun yarn and cloth mills	75	7.9	814.6	15.0	9,707	14.3
184	Cordage and twine industry	24	2.5	32.9	0.6	535	0.8
185	Felt and fibre processing mills	26	2.7	66.6	1.2	1,020	1.5
1851	Fibre processing mills	12	1.3	14.9	0.3	246	0.4
1852	Pressed and punched felt mills	14	1.5	51.7	1.0	774	1.1
186	Carpet, mat and rug industry	31	3.3	696.0	12.8	5,941	8.8
187	Canvas products, cotton and jute bags	176	18.5	180.4	3.3	2,893	4.3
1871	Cotton and jute bags manufacturers	22	2.3	67.9	1.2	683	1.0
1872	Canvas products manufacturers	154	16.2	112.5	2.1	2,210	3.3
188	Automobile fabric accessories industries	19	2.0	521.1	9.6	6,383	9.4
189	Miscellaneous textile industries	523	54.9	1245.3	22.9	20,369	30.1
1891	Thread mills	12	1.3	80.5	1.5	845	1.2
1892	Narrow fabric mills	39	4.1	86.6	1.6	1,958	3.0
1893	Embroidery, pleating, hemstitching	70	7.4	40.9	0.8	1,573	2.3
1894	Textile dyeing and finishing plants	92	9.7	151.3	2.8	3,387	5.0
1899	Miscellaneous textile industries (n.e.s.)	310	32.6	886.0	16.3	12,606	18.6
	TOTAL	952	99.9	5439.0	100.0	67,673	100.0

SOURCE: Statistics Canada: Annual Census of Manufacturers, Catalogue Number 31-203.

TABLE 2.2 SIZE AND DISTRIBUTION OF ESTABLISHMENTS, TEXTILE SECTOR, 1981

	ESTABLISHMENTS		EMPLOYEES	
Group Size	No.	%	No.	%
Less than 20	534	56.1	3,750	5.8
20-49	176	18.5	5,608	8.7
50-99	80	8.4	5,636	8.7
100-199	73	7.7	10,291	15.9
200-499	70	7.4	21,849	33.7
500-999	12	1.3	7,843	12.1
1000 and over	7	0.7	9,769	15.1
TOTAL	952	100.1	64,746	100.0

SOURCE: Statistics Canada: Annual Census of Manufactures, Catalogue Number 31-203

TABLE 2.3

Measures of Concentration* (%): Textile Sector, 1970-1980

	1970	1972	1974	1976	1978	1980
Textile industries**	59.5	61.4	60.1	58.9	58.0	59.3
Knitting mills**	25.3	23.5	23.1	n.a.	22.9	23.1
Clothing industries**	14.5	14.4	n.a.	n.a.	16.0	n.a.
Cotton yarn and cloth mills	93.3	97.5	n.a.	n.a.	n.a.	n.a.
Wool yarn and cloth mills	38.1	35.2	40.2	52.2	47.7	48.0
Fibre and filament yarn manufacturers	82.8	93.9	93.8	n.a.	90.5	n.a.
Cordage and twine industry	77.4	73.1	76.9	n.a.	63.1	70.6
Fibre processing mills	49.3	n.a.	59.7	61.6	63.0	63.9
Pressed and punched felt mills	78.3	72.4	71.6	65.0	68.2	67.9
Carpet, mat and rug industry	42.6	43.3	39.3	44.0	47.0	48.4
Cotton and jute bag manufacturers	57.8	68.2	n.a.	68.2	61.8	56.8
Canvas products manufacturers	34.3	n.a.	n.a.	31.3	25.8	29.1
Thread mills	82.1	n.a.	n.a.	n.a.	83.7	84.8
Narrow fabric mills	55.2	52.5	48.8	50.2	45.2	47.4
Textile dyeing and finishing	41.7	59.7	n.a.	42.9	39.2	45.1
Miscellaneous textile industries	36.7	33.3	33.2	33.6	32.6	29.0
Hosiery mills	24.9	24.1	24.8	27.3	28.3	29.2
Other knitting mills	20.9	18.6	19.6	n.a.	18.5	18.3

* Concentration is measured by the leading four enterprices' share of industry shipments.

** Weighted averages calculated on the basis of value added.

n.a. - not available

SOURCE: Industrial Organization in the manufacturing, mining and logging industries (1980). Statistics Canada catalogue number 31-402.

TABLE 2.4

Regional Distribution of Establishments, Textile Sector

1981

	Establishments		Employment	
Province	No.	%	No.	%
Quebec	368	34.3	32122	46.4
Ontario	393	36.7	30764	44.4
Western Provinces	251	23.4	4683	6.7
Atlantic Provinces	60	5.6	1734	2.5
Total	1072*	100.0	69303*	100.0

SOURCE: Statistics Canada: Annual Census of Manufactures Catalogue Number 31-203.

* There is some inconsistency in the Statistics Canada data.

TABLE 2.5 REGIONAL DISTRIBUTION OF EMPLOYMENT AND ESTABLISHMENTS BY INDUSTRIES, TEXTILE SECTOR, 1981

Sic Code		QUEBEC		ONTARIO		ATLANTIC		WESTERN	
		Est.	Empl.	Est.	Empl.	Est.	Empl.	Est.	Empl.
181	Cotton yarn and cloth mills	14	--	5	--	2	--	--	--
182	Wool yarn and cloth mills	21	2866	9	1368	14	--	10	179
183	Man-made fibre, yarn and cloth mills	44	6144	41	9020	6	--	2	--
1831	Fibre and filament yarn manufacturers	5	--	8	--	--	--	2	--
1832	Throwsters, spun yarn and cloth mills	39	--	33	--	6	--	--	64
184	Cordage and twine industry	1	--	13	419	6	--	8	--
185	Felt and fibre preparing mills	5	--	20	873	--	--	1	--
1851	Fibre preparing mills	2	--	9	--	--	--	1	--
1852	Pressed and punched felt mills	3	--	11	--	--	--	--	--
186	Carpet, mat and rug industry	19	2999	10	--	2	--	2	--
187	Canvas products, cotton and jute bags	42	701	78	1343	12	--	77	--
1871	Cotton and jute bag manufacturers	10	337	5	108	2	--	11	--
1872	Canvas products manufacturers	32	364	73	1235	10	36	66	927
188	Automobile fabric accessories industry	4	--	12	6266	--	--	2	73
189	Miscellaneous textile industries	218	--	205	7977	16	30	91	582
1891	Thread mills	10	--	2	--	2	--	55	--
1892	Narrow fabric mills	28	1389	11	--	--	--	--	112
1893	Embroidery, planting, hemstitching	30	625	26	694	2	--	21	--
1894	Textile dyeing and finishing	53	2693	28	--	6	--	15	
1899	Miscellaneous textile industries (n.e.s.)	97	5658	138	5931	10	--	110	
TOTAL		368	32122	393	30764	60	1734	251	4683
% OF TOTAL		34.3	46.4	36.7	44.4	5.6	2.5	23.4	6.7

-- = not available.

SOURCE: Statistics Canada: Annual Census of Manufacturers Catalogue Number 31-203.

2.3 The Trade Policy

Since 1960, international trade in textiles has been regulated by three international arrangements: Short-Term Arrangement Regarding International Trade in Cotton Textiles (STA) (1961-1962), Long-Term Arrangement Regarding International Trade in Cotton Textiles (LTA) (1962-1978) and the Multifibre Arrangement (MFA) (since 1971). (Canadian Textile Journal, June 1983, p. 53.) Whereas the STA and the LTA covered only cotton products, the MFA includes textiles and clothing made of wool and manmade fibres in addition to cotton products. These bodies were set primarily to deal with problems associated with textile imports and exports.

A sector profile of the textile and clothing industries in Canada (GATT-Fly, 1980, p. 29) claims that on a per capita basis, "imported textiles and clothing have penetrated the Canadian market far more severely than in any other industrialized country except Sweden". In the 1960s the share of the apparent Canadian market supplied by imports was about 38%. This increased to about 50% in 1976[1]. Thus, imports continued to pose a problem for the Canadian textile sector.

The Canadian Government's involvement in the textile sector with respect to trade policy issues began in 1960 when Canada formalized a voluntary export restraint agreement with Japan[2]. In 1961, another bilateral arrangement was negotiated with Hong Kong with respect to its exports of certain textile and clothing products and in 1963, some more arrangements with Israel, Portugal and Taiwan were finalized[3]. In spite of these bilateral restraint agreements, imports continued to increase their share of the Canadian market. This occurred first because countries not subject to restraints began exporting textile products to Canada and secondly, textiles not subject to restraints began penetrating the domestic market even from countries with whom negotiations had been completed[4].

In 1970, the Canadian government introduced a new textile policy. The policy was described as "...a comprehensive and forward-looking policy, dealing not only with protection against disruptive imports, but just as importantly, providing positive inducements for adjustment, for restructuring and for the optimum use of new technology, creative research and design"[5]. Among other things, the policy includes special measures

of protection for industries with good prospects of becoming competitive and phasing out those with least prospects, assistance programmes for industrial adjustment and export promotion programmes[6].

The Textile and Clothing Board (TCB) was formed to monitor imports and determine whether they were disruptive enough to call for restraint measures on the part of any producer. The TCB has to conduct inquiries, and if it is satisfied that imports are being disruptive, it makes recommendations to the government so that there is a long lag between the detection of injury and the implementation of policy[7].

There have been a number of actions taken since the adoption of the textile policy. Table 2.6 itemizes some of these measures. Global import quotas were imposed under GATT, Article XIX on a number of textile and clothing products. Again in 1978, global quotas were imposed on some clothing items. As Table 2.6 shows, a number of voluntary export restraint agreements have been negotiated under the MFA since 1976.

In terms of assistance programmes, the provincial governments have made significant contributions. Quebec committed itself to an $80 million four-year (1980-84) modernization programme for the textile and

clothing industries while Ontario committed itself to a one-year (1980-81), $15 million modernization programme for the province's textile and clothing industries[8]. The other provinces followed suit with some assistance programmes[9].

With regard to the success of the 1970 policy, the industries believe that it has been a failure. As Peter Clark, a consultant for the Canadian apparel manufacturers was quoted as saying (when commenting on the global quotas imposed on clothing items), they "....have had absolutely no effect. They're a bad joke.... They've moved the (foreign) competition into the areas of the market where Canadian producers are most competitive"[10]. As we shall see in the next chapter, this is one of the findings of Jenkins' study. To improve upon the policy of 1970, a new policy for the textile and clothing industries was introduced in 1981. Thur[11] claims the main features of the 1981 policy includes the allocation of $250 million for employment and modernization programmes. The coordinating body for this policy is the Canadian Industrial Renewal Board (CIRB).

TABLE 2.6

Actions Taken by Canada Under the Safeguard Provisions of GATT (Article XIX), MFA (Articles 3 and 4), and the General Preferential Tariff Since 1976

Product	MEASURES			Year Introduced
	GATT	MFA	Surveillance	
Worsted Spun	QR			1976
acrylic yarns	QR			1979
		VER(5)		1979
		QR(1)		1979
		VER(1)		1980
Certain texturized polyester yarns	S			1976
		VER(3)		1979
		VER(3)		1979
Rayon, nylon, polyester/ cotton yarns		VER(3)		1979
Double-knit fabrics	QR			1976
			MS	1979
Worsted fabrics, wool		VER(5)		1979
		VER(1)		1980
Broadwoven nylon filament fabrics		VER(4)		1979
Broadwoven polyester fabrics		VER(4)		1979
Cotton fabrics		VER(5)		1979
Man-made fabrics, various		VER(4)		1979
Coated fabrics		VER(2)		1979
Clothing items	QR			1976
	QR			1978
			MS	1979
		VER(7)		1979
		VER(7)		1979
		QR(1)		1979
		VER(2)		1980
Bedsheets		VER(5)		1979
Pillowcases		VER(5)		1979
Handbags			MS	1978
		VER(5)		1979
Cotton terry towels		VER(6)		1979
		VER(1)		1980
Work gloves	QR			1976
		VER(4)		1979
		VER(1)		1980
Miscellaneous household textiles		VER(4)		1979
Cordage, rope and twine		VER(2)		1979

VER = voluntary export restraint

MS = import surveillance

QR = quantitative restrictions

S = surtax

() = number of exporting countries affected.

SOURCE: Biggs (1980) Table 3.1.

2.4 The Textile Sector Since the Adoption of The Textile Policy

There have been upward and downward movements in the textile sector since the adoption of the textile policy. Table 2.7 shows output and employment in the sector and their changes from 1972 to 1983. Output and employment increased in 1972 and 1973, then they both decreased from 1974 to 1976. They both increased again in 1978 and 1979 and thereafter, employment is declining while output is fluctuating. Output and employment increased by 6.7% and 3.5%, respectively, in 1973 and this employment level was the highest ever attained since 1972. The bad performance of the sector from 1974 to 1976 could be due to the effects of the oil crisis which resulted in worldwide recession in 1974. Recovery seemed to have started in 1978 with output increasing by 4.6% and employment by 3.5% compared to 1977 figures. However, the sector started to contract in 1980 with output declining by 4.3% and employment by 1.4%. This occurred despite the large number of export restraint agreements negotiated in 1979 (see Table 2.6). Nevertheless, the growth rate

of 1.9% between 1977 and 1980 is somewhat higher than that for all manufacturing which stood at 1.6% over the same period[12]. 1982 was the worst year for the sector since 1972. Output declined by 18% and employment by 12.2%.

The profit performance of the sector since 1978 has not been bad compared to all manufacturing and compared to all industries. Tables 2.8 and 2.9 show the after-tax profit on capital employed and the after-tax profit on equity for the textile sector, all manufacturing industries and all industries from 1970 to 1981. Whereas prior to 1978, these after-tax profits for the textile sector were consistently lower than the corresponding figures for all manufacturing, from 1979 to 1981, these profits were higher for textiles. The averages over the period 1978 to 1981 for textiles are higher than for all manufacturing and all industries. It is likely that the sector can generate enough funds internally for investment and expansion in the 1980s. This comparison suggests that the Textile Policy has achieved some success in maintaining the viability of the sector.

This chapter has discussed the institutional

background of the textile sector including its past, present and future prospects. It was noted that while the sector is mostly concentrated in Ontario and Quebec, there is a high concentration of canvas products in the Western Provinces. It was also noted that the concentration ratios are in general higher for early stage processors. The trade policies did not appear to have had much effect on the performance of the industry. However, since 1978, the sector has not performed badly relative to all manufacturing and all industries. The next chapter reviews the literature on studies in textiles.

TABLE 2.7 OUTPUT AND EMPLOYMENT AND THEIR CHANGES, TEXTILE SECTOR, 1972-1983

	EMPLOYMENT		OUTPUT	
Year	No.	% change from previous year	Millions of 1971 $	% change from previous year
1972	74,242	7.1	2061.9	13.9
1973	76,863	3.5	2200.9	6.7
1974	75,647	-1.6	2135.0	-3.0
1975	71,050	-6.1	2012.7	-5.7
1976	68,209	-4.0	2093.0	-4.0
1977	65,508	-4.0	2185.3	4.4
1978	67,808	3.5	2285.5	4.6
1979	69,217	2.1	2464.8	7.8
1980	68,241	-1.4	2358.3	-4.3
1981	67,673	-0.8	2437.5	3.4
1982	59,416	-12.2	1998.4	-18.0
1983	n.a.		2164.1	8.3

SOURCE: Statistics Canada: Annual Census of Manufacturers, Catalogue Number 31-203 and System of National Accounts - Gross Domestic Product by Industry, Catalogue Number 61-213.

n.a. - not available

TABLE 2.8 AFTER-TAX PROFIT ON CAPITAL EMPLOYED, TEXTILE SECTOR, ALL MANUFACTURING AND ALL INDUSTRIES, 1970-1981

Year	Textile (%)	All Manufacturing (%)	All Industries (%)
1970	1.3	4.8	4.0
1971	4.7	5.9	4.6
1972	5.1	6.6	n.a.
1973	8.3	9.8	n.a.
1974	10.2	10.8	6.3
1975	5.7	8.2	5.2
1976	4.7	7.5	5.1
1977	5.9	6.8	4.9
1978	8.0	8.7	5.8
1979	12.9	10.7	6.9
1980	11.5	9.7	6.6
1981	8.4	8.1	5.4
Average 1970-81	7.2	8.1	
Average 1978-81	10.2	9.3	6.2

SOURCE: Statistics Canada: Corporation Financial Statistics, Catalogue Number 61-207.

TABLE 2.9 AFTER-TAX PROFIT ON EQUITY, TEXTILE SECTOR, ALL MANUFACTURING AND ALL INDUSTRIES 1970-1981

Year	Textile (%)	All Manufacturing (%)	All Industries (%)
1970	1.6	6.2	6.3
1971	5.9	7.7	7.4
1972	6.7	8.7	n.a.
1973	10.9	12.7	n.a.
1974	13.6	14.2	10.5
1975	7.4	10.9	9.0
1976	6.2	10.1	9.0
1977	7.8	9.3	8.7
1978	10.4	11.9	10.3
1979	16.8	14.4	12.3
1980	14.7	13.3	11.7
1981	11.0	11.8	9.7
Average 1970-1981	9.4	10.9	
Average 1978-1981	13.2	12.9	11.0

SOURCE: Statistics Canada: Corporation Financial Statistics, Catalogue Number 61-207.

FOOTNOTES

Chapter 2

1. Industry, Trade and Commerce (1978), "The Canadian Primary Textiles Industry: Sector Profile Discussion Paper, Government of Canada, p. 10.
2. Ibid., p. 16.
3. Textile and Clothing Inquiry (1980), p. 12.
4. Ibid., p. 13.
5. Ibid., p. 14.
6. See Canadian Textile Journal, June 1983, p. 54.
7. See Pestieau (1976), for more discussion.
8. Biggs (1980), p. 93 and Table A2.
9. Ibid., Table A2.
10. The Toronto Star, February 2, 1985, p. D3.
11. Thur, O. (June 1983), p. 55.
12. Annual Report on Textile and Clothing (1981), Table 2.

CHAPTER 3

RECENT STUDIES OF THE TEXTILE SECTOR

3.1 Introduction

In Chapter 2, the organizational structure of the sector as well as its past, present and future prospects were discussed. It was noted that the Canadian Textile Policy has achieved some success in maintaining the viability of the sector.

Considering the large number of problems facing the textile sector in Canada, among which is the problem caused by the influx of imports (especially in the past), it is very surprising to find that there are so few empirical studies even though the sector provides rich grounds for empirical analysis be it at the micro or macro level. A good body of data relevant to the sector is available and the degree of disaggregation of data is large compared to other sectors.

In Chapter 1, we established that an adequate model for analysing trade policy questions in the Canadian textile sector would at least reflect the

interrelationships between the different industries of the sector, the ability to substitute between imported and domestically produced goods (the 'Armington' assumption), the quantitative nature of non-tariff barriers and would provide some method of computing tariff equivalents of quotas.

Most of the industrial models reported in the literature are deficient in at least one of these areas. The published work tends to fall into four categories: descriptive studies, partial equilibrium econometric industry models, input-output models and general equilibrium models. In this chapter we will review a sample of studies in each category in the light of our requirements.

3.2 Descriptive Studies

Among the descriptive studies are the following: Pestieau (1976), Mahon (1984), and Jenkins (1980).

Pestieau evaluates the Canadian textile policy of 1970 and draws conclusions relevant to sectoral programs in any manufacturing industry. The study relies solely on questionnaires and interviews

with people. Most of her respondents mentioned delays in conducting injury investigations, in accepting the Textile and Clothing Board's recommendations and in negotiating agreements as one of the drawbacks of the policy. Pestieau argues that the policy has been a failure partly because of lags in implementing policy recommendations and partly because the policy-makers seemed to be at odds with the sector -- with the government claiming that the sector can become competitive without government interference and the sector claiming otherwise.

She calls for a review of the textile policy. She concludes that for a successful implementation of a sectoral program in any manufacturing industry, not only should there be an agreement between the industry and the government but an a priori appraisal of the industry's future needs to be undertaken.

Mahon (1984, p.3) argues that 'deindustrialization' of the Canadian economy, "that is, the progressive erosion of the domestic manufacturing base as a result of the inability of domestic forces to respond effectively to challenges emanating from the international environment", has politicized the debate

on an appropriate industrial strategy for Canada. She notes that even though deindustrialization is usually associated with sectors in which foreign capital dominates, it occurred in textiles where the opposite is true. She bases her analysis on the Marxist political economy approach. The concept of 'hegemonic class' or dominant capital plays a key role in her analysis. Mahon states that the resource sector has been the leading sector of the Canadian economy. She argues that for the leading sector or dominant capital to maintain its hegemonic position, it must make sacrifices to the other sectors for them to accept its leading position, that is, to maintain a "positive-sum" relationship, as Mahon puts it. She goes on to argue that the Canadian government's commitment to maintaining the resource sector as the leading sector has created a series of conflicts because of the "positive-sum" relationship that has to be maintained. The choice of an industrial strategy -- "continental rationalization", "technological sovereignity", and "full-employment" will be determined by the outcome of these conflicts.

With respect to textiles, Mahon argues that a full-employment strategy (a strategy favourable to

textiles) will only be undertaken if the labour movement is able to strengthen its bargaining position.

Jenkins analyzes the impact of the bilateral quota system imposed by the Canadian government on clothing imports in 1979. He finds that the quotas make both the Canadian consumer and producer worse off. The consumer is worse off because the quotas result in higher prices and the producer is worse off because the quotas create the incentive for the foreign producer to improve the quality of his product, thus making it more competitive with the Canadian product. At the same time, Jenkins asserts the quotas create the incentive for the Canadian producer to lower the quality of his product putting him at a disadvantage vis-a-vis the foreign producer who has a comparative advantage in low quality products. He recommends that the quotas should be abolished because they result in economic waste.

These three studies provide descriptive detail to analyze some aspects of the Canadian textile sector. However, they are not formal quantitative models in which the effects of changes in policy parameters can be traced. Jenkins uses a diagrammatic

exposition based on partial equilibrium analysis. To adequately analyze the effects of changes in policy parameters, one needs a general equilibrium model.

3.3 Econometric Studies

The econometric studies include the following: McFetridge (1973), Miller (1971), Lewis (1972), Wallace, Naylor and Sasser (1968), and Isard (1973).

McFetridge employs a price adjustment equation to study the price formation in the Canadian cotton textile industry. Of particular interest was to test the Hall and Hitch hypothesis that "prices will be changed if there is a significant change in wage or raw material costs but not in response to moderate or temporary shifts in demand"[1]. Dichotomizing demand disequilibrium into excess and deficient demand, McFetridge estimated a meticulously derived price equation which he used to investigate whether mark-up pricing is modified by excess demand or supply, and if

it is, whether the relationship between the price change and market disequilibrium is nonlinear, that is, whether relatively small discrepancies between demand and output will ultimately result in more than proportionate change in the absolute value of the rate of price change.

His results show that in the Canadian cotton textile industry, the market disequilibrium is reflected in the output price in addition to unit labour costs, and that the relationship between the demand disequilibrium and the rate of price change is linear whether the disequilibrium is caused by excess demand or excess supply. Thus his results reject the Hall and Hitch hypothesis.

Miller's study focuses on the short-run aspects of the output-factor relationship of the U.S. textile industries. He constructed a model that attempts to capture some cyclical swings in the production cycle, especially with respect to peak and off-peak periods. On the assumption that the demand for labour during off-peak periods is different from that during peak periods because of capacity constraints during peak periods, Miller constructed a

dichotomized (peak, off-peak) system of equations consisting of the following functions: production, peak period demand for production worker hours, and peak and off-peak demand for finished-goods inventories. He postulated that the reserve labour force is a substitute for inventories of finished goods because they both reduce the cost to the firm of backlogs. When applied to the U.S. woolen and cotton weaving industries, the hypothesis was empirically supported. He also found that the dichotomized model gives better prediction than a model based on standard (peak-off peak) specification.

Lewis estimated dynamic demand equations for seven U.S. textile fibres: cotton, apparel wool, cotton wool, rayon-acetate staple, rayon-acetate filament yarn, synthetic staples and synthetic filament yarn, mainly for the purpose of estimating their elasticities. He concluded that fibre demands are price-inelastic which he used as an explanation for the fluctuations in fibre prices. He also found that cotton and wool were income-elastic.

None of the above models is applicable to the problem at hand because they are not complete industrial models. Rather, they focus on specific

aspects of the industries, such as output, prices or elasticities.

Wallace, Naylor and Sasser constructed a recursive model of the U.S. textile industry to investigate the determinants of the following seven endogenous variables: demand for textile mill products, output of textile mill products, employment of production workers, earnings, prices, profit, and investment. The model consists of nine linear equations which recursively determine these seven variables and two apparel varibles. All of the equations had very good fits. Some of their results are that there is a significant positive relationship between imports and textile demand and that output is subject to very high seasonality.

Despite the fact that their model represents one of the first attempts at constructing a structural model of the industry, the model suffers from some serious drawbacks. First, the model lacks a market clearing mechanism. Price has no role in determining demand, and demand and supply conditions have no influence on price. Second, imports are exogenous; hence the model is incapable of determining the effects of protective policies (such as tariffs and quotas)

on the industry. This is one of the critical issues facing the textile industries in North America. Third, some of the equations lack theoretical justification. For example, the wage rate is explained solely by the number of people employed.

Isard's study focuses on the policy of increasing development assistance to developing countries through the phasing out of the U.S. textile industry and thereby importing from these countries. He built a five equation model in which the concept of vintage capital plays an important role in explaining the interrelationship between labour demand, investment, technological change and production. He found out that if technical change is at least two-thirds embodied then a substantial fraction of the employment impact of imports can be neutralized if investment in modern mills is reduced rather than allowing marginally profitable mills to close thus allowing imports to substitute for the output of modern mills. He estimated that a cutback in modernizing can allow any target employment level to be achieved by increasing imports by a factor of two. He concluded that development assistance can be provided to the developing countries through a policy

of phasing out the U.S. domestic textile sector. His study may provide a useful reference when discussing such questions as the effects of technological change on the sector.

Although the models in the last two studies discussed are somewhat more applicable to our problem than the previous ones, they still are inadequate. They are more applicable because they are complete industry models. That is, they are structural models of the sector in the sense that they attempt to incorporate all aspects of the sector rather than focusing on a particular aspect of it. They are inadequate because they are not disaggregated well enough to be able to incorporate the interrelationships among the textile industries. Also, neither Wallace, Naylor and Sasser nor Isard incorporates other sectors of the economy. Thus their models are partial equilibrium models. They do not handle inequalities well and thus cannot handle quantitative restrictions. As noted earlier, in Wallace, Naylor and Sasser's model imports are exogenous and therefore rule out the possibility of incorporating tariffs and hence the question of tariff equivalents is ruled out. A type of model that adequately incorporates intersector relationships is the input-output model.

3.4 Input-Output Studies

Among the contributions along these lines is the study by Bramson and Miles (1974). They constructed an input-output model of the U.K. textile sector to study the medium term prospects of the clothing, textile and manmade fibre industries. They produced a flow chart to demonstrate the inter-dependence between the industries. All final demands are exogenous in the model. Given these exogenously determined end-products, the model calculates the endogenous variables such as the weight of textile products purchased by each industry. Their model includes such features as imports of intermediate and final products, stock changes, re-use of waste and by-products within the industries and process losses.

Bramson and Miles used their model to construct a set of technical coefficients for 1980 from which those for 1977 were obtained. With the aid of other economic variables, they were able to prepare sets of projections of 1977 relative prices and consumers' expenditure. It was also possible with the aid of the model to project trend and cyclical changes in the textile industries.

Their model and an input-output model in general affords one of the best chances of developing a textile model suitable for the present study. It provides insights into the complex intersectoral relationships in the sector. However, their model is still not adequate for the problem at hand, for the following reasons. First, Bramson and Miles' model does not contain a 'rest of the economy sector' and hence represents a partial equilibrium approach. Thus, the model treats the textile sector in isolation and hence it is incapable of predicting changes in the industries outside the textile sector on the textile industries and vice versa. Second, input-output models take final demands as exogenous. Imports are one of the most important trade policy variables and it will be interesting to see how imports react to some policy changes. But because of the exogeneity of imports in input-output models, this cannot be investigated. Third, tariffs cannot be incorporated if imports are exogenous. Lastly, the levels of final demand might depend on the objective function. But because they are taken as exogenous, their levels might not correctly reflect changes in demand induced by policy change.

3.5 General Equilibrium Studies

Among the contributions in the general equilibrium mold are the studies by Evans (1970), Williams (1978), Shoven and Whalley (1973, 1974), Boadway and Treddenick (1978), and Harris (1984).

Evans' (1970) main contribution is the implementation of a linear programming approach to general equilibrium modelling. The basis for this approach had been laid earlier by Koopmans (1951) and others (see Williams (1978), p. 4). He discussed the structure and properties of a dynamic general equilibrium, linear programming model of trade and protection. Some of the main characteristics of his model are the inclusion of non-traded goods, the addition of capacity constraints on production, the inclusion of an endogenous investment function and a tariff revenue constraint. There are more factors of production than commodities in his model.

Evans' model is a very useful international trade model which can be used, among other things, to measure "effective protection" and to test the idea of comparative advantage. It is useful for investigating the effects of tariffs and non-tariff barriers

such as quotas on a whole host of endogenous variables. Compared with input-output models, linear programming models offer the big advantage of actually simulating a competitive equilibrium by maximizing (or minimizing) an objective function such that the first order conditions for optimization are also the conditions for a competitive equilibrium.

In spite of the above strengths of the model, it has certain deficiencies that make it inapplicable to our problem. Evans' model has more factors of production than commodities. The reason for doing this is that in linear models "....the number of commodities produced will equal the number of scarce factors of production. By defining a large number of factors of production, the possibility that the model will predict a higher degree of specialization than is observed in the 'real' world is lessened"[2]. Also in linear models, some constraints are included in an ad hoc basis to prevent overspecialization and other forms of extreme behaviour to which linear models are prone. Evans' objective function is to maximize a bundle of private consumption goods with the consumption coefficients chosen such that they sum to unity. As we shall see in the next chapter, this type of objective function

specification allows no substitution in consumption at all.

Williams (1978) implements a linear programming model of the Canadian economy similar to the spirit of Evans for the purpose of examining the effect of the Canadian-U.S. tariff structure on Canadian manufacturing industries. He uses input-output data to obtain his production coefficients. This enabled him to represent in great detail the interrelationships among industries. Williams maximizes total consumption less indirect taxes. The impact of the tariff on intermediate inputs is stressed in the study.

His results showed that with the exception of textiles, chemicals and food and agriculture, the tariff structure tends to shift Canada away from end products and towards earlier stages of processing. He also found the welfare gain from bilateral free trade with the U.S. to be 4% of real consumption or 2.6% of GNP, whereas the unilateral reduction of the Canadian tariff would produce a gain of 1.36% of real consumption.

The structure of Williams' model makes it more applicable to the present study than the previous ones discussed. The present study extends Williams'

model by disaggregating the textile sector and introducing a non-linear objective function.

Shoven and Whalley (1974) used a computational procedure due to Scarf (1973) to analyze a static general equilibrium international trade model with tariffs. They solved demand functions which were assumed to be derived from the maximization of a utility function even though no explicit utility function was specified. These demand functions of the consumers of each country (they considered a number of countries) were assumed to be homogeneous of degree zero in prices and government revenue. Given these assumptions, they defined a competitive equilibrium to be characterized by a set of prices such that (i) demand equals supply for each commodity; (ii) profit is maximized at these prices, and (iii) the tax revenue received by each country equals that distributed by the government. Not only was the model used to prove the existence of an equilibrium but it represents a method for the calculation of a competitive equilibrium on international markets with tariffs.

Shoven and Whalley (1973) described a method for computing a competitive equilibrium for an economy with producer and consumer commodity taxes. The theorem they used is an extension of the existence

proof of a competitive equilibrium without taxes[3]. This existence theorem is essential if one is to analyze the impact of policy parameters on a general equilibrium model incorporating taxes and tariffs. They considered an economy characterized by a set of demand functions, production technologies and an initial endowment of commodities. In conjunction with other assumptions, they were able to prove the existence of an equilibrium for such an economy. The procedure is useful for the analysis of the impact of tax reform proposals.

Even though Shoven and Whalley's models are very useful, they were not used in this study for the following reasons. Because they solve demand functions, one cannot incorporate quotas and hence tariff equivalents cannot be computed. Also, they do not specify any utility function but the demand functions obtained through the maximization of a utility function will depend on the particular form of the utility function.

Boadway and Treddenick (1978) investigated the effects of the Canadian tariff structure on the economy. They computed a static general equilibrium model with and without tariff and tax distortions and under differing assumptions about production technology and trade elasticities.

Their model consists of a neoclassical one made up of two primary inputs, capital and labour and intermediate flows. Both Cobb-Douglas and CES production functions are used for the primary inputs but fixed proportions and Cobb-Douglas for the intermediate inputs. They use the 'Armington' assumption that imports and domestically produced goods are imperfect substitutes. Like Shoven and Whalley, they solve demand functions. Using the actual tariff and taxes, they selected the remaining parameters (using Canadian input-output data) in order to reproduce the 1966 economy and thereby set a benchmark for the model.

Their results show that, contrary to expectations, the removal of the tariff increases the outputs of traded goods and decreases the outputs of non-traded ones. Not only was the tariff found to discourage Canadian manufacturing, the tax structure reinforces it in their model. The change in the welfare index was found to be small with the removal of the tariff. With respect to textiles, the removal of the tariff increased output using their 16-industry aggregation but decreased it when their 56-industry aggregation was used.

As noted earlier, they solve demand functions

in their model so quotas cannot be incorporated. The textile sector is not disaggregated to be able to incorporate the interconnections between them. They assert that their demand functions are consistent with a Cobb-Douglas utility function and thus use a Cobb-Douglas to calculate their welfare index. One drawback of this utility function is that the elasticity of substitution is unity. These reasons make their model inapplicable to our study.

Richard Harris (1984) uses an applied general equilibrium model incorporating economies of scale and imperfect competition to analyze Canadian trade policies. His model, consisting of fixed labour, internationally mobile capital, uses the 'Armington' assumption. Labour and capital are mobile within industries. The utility function is specified as a nested CES function.

There were considerable differences in his results between the perfectly competitive and imperfectly competitive models. Unilateral free trade yields no change in his perfectly competitive model whereas it yields a welfare gain of 4.1% of 1976 national income in the industrial organization model without product differentiation. The product differen-

tiation model yields a smaller welfare gain (2.7%). With respect to textiles, unilateral free trade yields an increase in output in the imperfectly competitive model, whereas output decreases in the perfectly competitive model. He concludes that applied general equilibrium models which ignore industrial organization features might be misspecified.

Harris' model is so complex that it is not clear whether his results are due to features of the model other than the economies of scale aspect which is stressed in the model. As Whalley notes, "I also have reservations concerning the way non-competitive behaviour is incorporated in the model. While the main focus of Harris' work has been the scale economy aspects of the model, my sense is that other features, such as international capital mobility, may also be important in determining his results, thus raising further issues of empirical specification"[4]. Also the textile sector is not disaggregated to the extent desired in the current thesis.

In the light of the discussion in this chapter, we are of the opinion that an adequate international trade model of the Canadian textile sector is a

general equilibrium model of the type pioneered by Williams and supplemented by nonlinearities. In this application, we construct a non-linear programming model based on input-output data. The input-output data allow for the interdependencies among different industries of the sector. A general equilibrium model will incorporate industries which are outside of the textile sector. A programming model is useful because it can handle both equality and inequality constraints and computer algorithms for finding solutions are available generally. Non-linearity is essential because it can incorporate the 'Armington' assumption of imperfect substitutability, incorporate diminishing marginal utility and avoid some of the extreme behaviour associated with linear models. Such a model is discussed in chapter 4.

FOOTNOTES

Chapter 3

1. Hall and Hitch (1939), page 33.

2. Evans (1970), page 21.

3. Debreu (1959), Scarf (1967), or Arrow and Hahn (1971).

4. Whalley (1984), page 388.

CHAPTER 4

THE MODEL

4.1 Introduction

The purpose of the model described in this chapter is to provide a computable general equilibrium model of the Canadian textile sector capable of answering certain trade policy questions. Such a model should have significant disaggregation of the textile sector, avoid corner solutions, incorporate imperfect substitutability between domestic and imported goods, incorporate the assumption of diminishing marginal utility and be able to capture some non-tariff barriers. In Chapter 3 we concluded that none of the models employed in the review literature is adequate for such a study because of certain deficiencies. We present and discuss the model employed in this thesis in this chapter.

The chapter begins with a discussion of the objective function and why a linear objective function is inappropriate. The chapter then goes on to discuss the primal constraints. Finally, after forming the Lagrangean function, the dual constraints and their

interpretations are derived from the Kuhn-Tucker conditions. Table 4.1 gives the symbols used in the model.

The model simulates the behaviour of a market economy in which all economic agents are engaged in optimizing behaviour. Such a behaviour on the part of individuals will not necessarily lead to a maximum of aggregate utility, however, because of the distorting effects of tariffs, taxes and other types of constraints imposed by government. In order for the objective function to be consistent with the assumption of competitive equilibrium, the objective function at the aggregate level is given by the general form

$$u = u^*(c_i, c_i^*) - G \qquad (4.1)$$

where c_i is the consumption of commodity i out of domestic production, c_i^* is the consumption of commodity i out of imports, and G is the government revenue from indirect taxes. The last term, G, is included in order to incorporate the distorting effects of indirect taxes and tariffs. As will be shown in section 4.4, the inclusion of G in this

manner leads to dual constraints which correctly incorporate the distorting effects of indirect taxes and tariffs. Note that u^* must have value units so that it is measured in the same units as G.

Thus, the objective is to maximize equation (4.1) subject to material balance constraints, the balance of payments constraint, import constraints, capital constraints, the labour constraint, and the tariff-tax constraint. Altogether the model is made up of twenty-one industries, sixty-five constraints, and one hundred and twenty-two activities or endogenous variables. The dual constraints obtained from the maximization problem are the price-cost long-run equilibrium conditions expected in a market economy.

The function u^* may be interpreted as an aggregate utility function if all individuals have identical homothetic utility functions. Under this condition the total demand for each commodity is independent of the distribution of income.

4.2 The Objective Function

The choice of a functional form for the objective function is not an easy task. One possible form is the linear function

$$u^* = \sum_i w_i c_i \qquad (4.2)$$

where c_i is the consumption of commodity i and w_i is a fixed weight. If the measurement units of the commodities are appropriately chosen, the w_i may be specified to be unity, so that

$$u^* = \sum_i c_i \qquad (4.3)$$

is the maximand. Such a utility or welfare function has linear indifference surfaces and thus an infinite elasticity of substitution -- the commodities are treated as perfect substitutes. If such an objective function is maximized subject to linear constraints, substitution, limited only by supply constraints, will take place with the cheaper goods (in terms of shadow prices) driving out the more expensive; that is one is likely to have a corner

solution. In order to circumvent this, constraints such as

$$c_i = \ell_i C, \qquad \ell_i = \text{constant} \qquad (4.4)$$

(where C or $\sum_i c_i$ is the maximand) are sometimes used. This fixed proportions objective function allows no substitution at all. Thus, one of the major problems of the linear objective function is that it cannot incorporate imperfect substitutability and hence cannot adequately deal with price effects.

In order to circumvent the problem associated with linearity, Sandee (in Carter, 1967) puts lower and upper bounds on each consumption activity. But, as Carter (1967) argues, this "is referred to as a 'compromise' between the strictly proportional consumption formulation and the unstable completely substitutable form, but it does little to remedy the basic problem -- the lack of ability to adjust to price relationships. Only occasionally will a consumption activity not be at one or the other of the bounds, typically exhibiting a flip-flop reaction to price changes."

The economic theory of the consumer requires that, given the general function,

$$u^* = u^*(c_1,\ldots,c_n) \qquad (4.5)$$

marginal utilities must be positive, and the implied indifference curves are usually assumed to be strictly convex to the origin

$$\frac{\partial u^*}{\partial c_i} > 0$$

and

$$\left(\frac{\partial u^*}{\partial c_1}\right)^2 \frac{\partial^2 u^*}{\partial c_2^2} + \left(\frac{\partial u^*}{\partial c_2}\right)^2 \frac{\partial^2 u^*}{\partial c_1^2}$$

$$- 2\frac{\partial u^*}{\partial c_1}\frac{\partial u^*}{\partial c_2}\frac{\partial^2 u^*}{\partial c_1 \partial c_2} < 0 \qquad (4.6)$$

etc.

In the linear programming context, we find, from equation (4.2), that

$$\frac{\partial u^*}{\partial c_i} = w_i > 0$$

and

$$\frac{\partial^2 u^*}{\partial c_i^2} = 0 \qquad (4.7)$$

that is, constant marginal utility, which implies linear, rather than strictly convex, indifference curves. Furthermore, the conventional requirement for an interior solution is

$$\frac{\partial u^*/\partial c_i}{\partial u^*/\partial c_j} = \frac{p_i}{p_j} \qquad (4.8)$$

but in the linear programming model

$$\frac{\partial u^*/\partial c_i}{\partial u^*/\partial c_j} = \frac{w_i}{w_j} = \text{constant} \qquad (4.9)$$

which can only be equal to p_i/p_j by accident. Thus the problem seems to lie with the constant marginal utility requirement of the linear model. In order to satisfy conditions (4.6) and thus have an interior solution, we must have a non-linear maximand.

In this dissertation, the objective function takes the specific form of a constant elasticity of substitution (CES) utility function nested in a Cobb-Douglas function along the lines disucssed in other studies[1]:

$$u = D \prod_i E_i^{s_i} - G \tag{4.10}$$

$$E_i = (A_i c_i^{-\alpha_i} + B_i c_i^{*-\alpha_i})^{-1/\alpha_i}$$

$$-1 < \alpha_i < \infty, \quad \alpha_i \neq 0$$

$$\text{and} \quad \sum_i s_i = 1 \tag{4.11}$$

In these expressions, c_i is the consumption of commodity i out of domestic production, c_i^* is the amount of imports of commodity i consumed and D, s_i, A_i, B_i and α_i are parameters to be estimated. Imported commodity i is physically similar to domestically produced commodity i but is not a perfect substitute for it. The elasticity of substitution between the two is

$$\sigma_i = \frac{1}{1 + \alpha_i} \tag{4.12}$$

Thus, the function u^* implies an elasticity of substitution equal to one (from 4.10) between different commodities, but elasticities of substitution

differ from one between domestically produced and imported variants of the same commodity.

4.3 The Primal Constraints

G, the amount of indirect taxes collected is defined by

$$G = \sum_{i=1}^{21} t_i x_i + \sum_{i=1}^{16} r_i m_i + \sum_{i=1}^{21} d_i c_i + \sum_{i=1}^{16} d_i c_i^*$$

$$+ \sum_{i=17}^{21} r_i \lambda_{c_i} x_i + \sum_{i=1}^{16} r_{Ni} \lambda_{Ni} x_i + r_N M$$

$$+ d_M M \qquad (4.13)$$

where x_i is the output of commodity i, t_i is the specific tax (negative for subsidy) per unit of output in industry i, r_i is the specific tariff on imported good i, r_{Ni} is the specific tariff rate on textile imports (for intermediate use) of commodity i, r_N is the tariff rate on non-competing imports for final use[2],

m_i is the amount imported of commodity i, d_i is the sales tax on commodity i, d_M is the sales tax on non-competing imports for final use.

The model does not attempt to measure the distorting effects of direct taxes on income nor is there any constraint which requires that the government's budget be balanced. Indirect taxes do create distortions, however, and therefore equation (4.13) must constitute one of the constraints of the model and G must appear in the objective function to take account of this distortion. As will be noted below, with this constraint present, the shadow prices calculated from the dual will be identical to those which would emerge in a market economy.

To simulate a market economy we also require that supply of each commodity be at least as great as demand. This constraint takes the form[3]:

$$\sum_{j=1}^{21} a_{ij}x_j + c_i + e_iX + y_i + \bar{g}_i \leq x_i + \lambda_{ci}x_i$$

$$i = 1,\ldots,21 \qquad (4.14)$$

where a_{ij} is the amount of commodity i used up in the production of a unit of x_j output, X is total exports, e_i is the export share of industry i in total exports (assumed constant), $\bar{g}_i$ is the amount of commodity i sold to the government, and y_i is the output of capital goods industry i (i = 17, 18) delivered to all industries for the purpose of capital formation. It is assumed that only the construction and machinery industries produce outputs which are used as intermediate products by the other industries to form capital. Thus $y_i = 0$ for industries 1 to 16 and 19 to 21.

The parameter λ_{ci} is the proportion of commodity i imported per unit of industry i output. In industries 1 to 16, $\lambda_{ci} = 0$. Industries 17 to 21 are large aggregated industries and output consists of a large number of heterogeneous products representing all of the economy outside of textiles. No attempt is made to measure substitution between domestic consumption, c_i, and imports, c_i^*, in these industries. It is assumed, rather, that there is a fixed ratio between imports and domestic production. Imports in the amount of $\lambda_{ci}x_i$ become part of total supply. In

the textile industries, it is assumed that domestic and imported goods are imperfect substitutes, and therefore, imports cannot be added to domestic supply, that is $\lambda_{ci} = 0$.

The balance of payments constraint is

$$\sum_{i=17}^{21} (1-r_i)\lambda_{ci}x_i + \sum_{i=1}^{16} (1-r_{Ni})\lambda_{Ni}x_i$$

$$+ \sum_{i=1}^{16} p_i^m m_i + (-p^e + s^e)X + (1-r_N)M \leq F \qquad (4.15)$$

In constraint (4.15), p_i^m is the price in foreign currency of imported textiles. Units of quantity are defined so that the tariff included price $(p_i^n + r_i)$ is unity in the base year (1979). p^e is the price in foreign currency of exports inclusive of the foreign tariff, s^e. Here again, units of quantity are chosen so that the tariff excluded price $(p^e - s^e)$ is unity in 1979, in terms of domestic currency. M denotes non-competing imports for final consumption[4]. Non-competing

imports are imported goods for which there is no domestic supply (for example, raw cotton, natural rubber, and cocoa beans). λ_{Ni} is the amount of imports both competing and non-competing, required for intermediate use per unit of output[5]; F is the net capital inflow (outflow if negative) and m_i is the amount of imports (for consumption) of goods physically similar to those in domestic industry i.

The m_i are suppliers to consumers. Let c_i^* be the amount of m_i purchased by consumers. We require that demand for consumption cannot exceed the actual amount imported, that is

$$c_i^* - m_i \leq 0 \qquad (4.16)$$

Production in each industry is limited by the amount of capital. Let f_i be the capital-output ratio in industry i and v_i the supply of capital. Then

$$f_i x_i - v_i \leq 0 \qquad (4.17)$$

There is a limited initial total supply of capital, $\bar{V}_0$, but capital may be produced during the

period. Let k_i be the amount of capital formation during the period in industry i.

The capital stock constraint is then[6]

$$-\sum_{i=1}^{21} k_i + \sum_{i=1}^{21} v_i \leq \bar{v}_0 \qquad (4.18)$$

Capital is produced by transferring commodity output to the industries producing capital goods. Let h_{ij} be the amount of industry i goods needed to produce one unit of capital in industry j. Industry 17 is the machinery industry and industry 18 the construction industry, the two industries whose outputs are used by the other industries to produce capital. Since y_i is the amount of industry i production purchased for the production of capital goods we have two constraints on capital:

$$\sum_{j=1}^{21} h_{ij}k_j \leq y_i \qquad i = 17,18 \qquad (4.19)$$

The left hand side (L.H.S.) of (4.19) could be interpreted as the demand for industry i's output for capital formation (or investment) and the right hand

side (R.H.S.) the supply of the output of industry i for capital formation.

Finally, there are two resource constraints. First, there is an end of period target for total capital stock, V_T. This constraint is[7]

$$-\sum_{i=1}^{21} v_i \leq -V_T \qquad (4.20)$$

Second, there is a labour constraint:

$$W + \sum_{i=1}^{21} b_i x_i \leq \bar{L}_0 \qquad (4.21)$$

where W is the total amount of labour used by households as final demand (including wages and supplementary labour income)[8], b_i is the labour-output ratio in industry i, and $\bar{L}_0$ is the total labour supply available in the economy.

4.4 The Dual Constraints

The dual constraints represent cost-price conditions for a market economy in long-run competitive equilibrium. These are derived from the Kuhn-Tucker conditions for maximizing the objective function subject to the constraints described in the previous section. Since the constraints set is convex (all the constraints are linear) and the objective function is concave, the Kuhn-Tucker conditions are both necessary and sufficient for a maximum maximorum. Greek letters (other than λ which has been used above) are used to denote Lagrange multipliers (dual variables). We wish to maximize the Lagrangean function with respect to the primal variables.

$$Z = u(c_i, c_i^*, G, M, W) + \sum_{i=1}^{21} \psi_i (x_i + \lambda_{ci} x_i$$

$$- \sum_{j=1}^{21} a_{ij} x_j - c_i - e_i X - y_i - \bar{g}_i)$$

$$+ \varepsilon (F - (1 - r_N) M - \sum_{i=17}^{21} (1 - r_i) \lambda_{ci} x_i$$

$$- \sum_{i=1}^{16} (1 - r_{Ni}) \lambda_{Ni} x_i - \sum_{i=1}^{16} p_i^m m_i$$

...continued

$$- (-p^e + s^e)X) + \sum_{i=1}^{16} \gamma_i (m_i - c_i^*)$$

$$+ \sum_{i=17}^{18} \theta_i (y_i - \sum_{j=1}^{21} h_{ij} k_j) + \sum_{i=1}^{21} \delta_i (v_i - f_i x_i)$$

$$+ \mu_0 (\bar{V}_0 + \sum_{i=1}^{21} k_i - \sum_{i=1}^{21} v_i) + \mu_T (-V_T + \sum_{i=1}^{21} v_i)$$

$$+ \omega (\bar{L}_0 - W - \sum_{i=1}^{21} b_i x_i)$$

$$+ \beta (G - \sum_{i=1}^{21} t_i x_i - \sum_{i=1}^{16} r_i m_i - \sum_{i=1}^{21} d_i c_i$$

$$- \sum_{i=1}^{16} d_i c_i^* - d_M M - \sum_{i=17}^{21} r_i \lambda_{ci} x_i$$

$$- \sum_{i=1}^{16} r_{Ni} \lambda_{Ni} x_i - r_N M) \qquad (4.22)$$

Taking the partial derivative of Z with respect to each of the primal variables x_j, m_j, X, c_j, c_j^*, Y_j, k_j, v_j, M, W and G and using the Kuhn-Tucker conditions, we obtain the dual constraints (4.24) through

(4.35) as noted below.

The value of each dual variable at the optimum represents (or is very close to) the contribution to the objective function of changing the right hand side of the constraint by a unit. As Balinski and Baumol (1968) point out, "While the optimal value of the dual variable v_k^0 cannot always be interpreted as the marginal profit yield of the k^{th} input, since the latter is not always defined, v_k^0 will invariably lie between the corresponding right and left hand partial derivatives which exist and are finite... It follows at once that at a value of c_k where the partial derivative is well defined so that the left and right hand derivatives are equal, then the optimal value of the corresponding dual variable v_k^0 must be precisely equal to that derivative, $\frac{\partial \Pi(c)}{\partial c_k}$." For example, the dual variable of the labour constraint, ω, is given by $\omega = \frac{\partial \tilde{u}}{\partial \bar{L}_0}$ where $\tilde{u}$ is the maximized value of the objective function. Since $\tilde{u}$ is measured in value terms and $\bar{L}_0$ is in units of labour input, ω must be value per unit of labour, that is, the wage rate. Thus each dual variable has the dimension of a price or cost or value to be associated with the constraint.

The partial derivative of Z with respect to x_j is

$$\frac{\partial Z}{\partial x_j} = \psi_j + \lambda_{cj}\psi_j - \sum_{i=1}^{21} a_{ij}\psi_i - \varepsilon(1-r_j)\lambda_{cj}$$

$$- (1-r_{Nj})\varepsilon\lambda_{Nj} - \delta_j f_j - \omega b_j - \beta t_j$$

$$- \beta r_{Nj}\lambda_{Nj} - \beta r_j \lambda_{cj} \qquad (4.23)$$

where ψ_j is the domestic price of commodity j, ε is the exchange rate defined as the number of Canadian dollars equivalent to one unit of foreign currency[9], δ_j is the rental value of a unit of capital in industry j, ω is the wage rate and β is the marginal disutility of paying one dollar's worth of indirect taxes. As will be shown later when measuring in 1979 purchasing power the value of β is unity. Application of the Kuhn-Tucker conditions gives

$$\frac{\partial z}{\partial x_j} \leq 0, \quad x_j \geq 0 \qquad (4.24a)$$

and

$$x_j \frac{\partial Z}{\partial x_j} = 0 \qquad (4.24b)$$

where (24a) is the marginal condition and (4.24b) is the complementary slackness condition. That is,

$$\psi_j + \lambda_{cj}(\psi_j - \varepsilon(1 - r_j) - \beta r_j) \leq \sum_{i=1}^{21} a_{ij}\psi_i$$

$$+ \varepsilon(1 - r_{Nj})\lambda_{Nj} + \delta_j f_j + \omega b_j + \beta t_j$$

$$+ \beta r_{Nj}\lambda_{Nj}, \qquad x_j \geq 0 \qquad (4.25a)$$

and

$$x_j(\psi_j + \lambda_{cj}(\psi_j - \varepsilon(1 - r_j) - \beta r_j)$$

$$- \sum_{i=1}^{21} a_{ij}\psi_i - \varepsilon(1 - r_{Nj})\lambda_{Nj} - \delta_j f_j - \omega b_j$$

$$- \beta t_j - \beta r_{Nj}\lambda_{Nj}) = 0 \qquad (4.25b)$$

The marginal condition (4.25a) requires that the total cost of producing a unit of output (cost of intermediate inputs, cost of imports, capital cost, labour cost and taxes plus tariffs) must be at least as great as the price of the commodity plus profits earned on associated imports[10]. The complementary slackness condition means that if the optimal solution calls for the active production of the j^{th} product ($x_j > 0$) then the equality must hold in (4.24a) and 4.25a). If, on the other hand, the cost of production exceeds price ($\partial Z/\partial x_j < 0$), then industry j must be making losses so that activity j must not be used ($x_j = 0$).

The m_j activities transfer textile imports to domestic use and record the effects on the balance of payments. Partially differentiating (4.22) with respect to m_j and applying the Kuhn-Tucker conditions, we obtain

$$\gamma_j - \varepsilon p_j^m - \beta r_j \leq 0, \qquad m_j \geq 0 \qquad (4.26a)$$

and

$$m_j(\gamma_j - \varepsilon p_j^m - \beta r_j) = 0 \qquad (4.26b)$$

where γ_j is the domestic price of imports of textile commodity j. Constraint (4.26a) states that the foreign price of commodity j adjusted for the exchange rate, plus the tariff, should be no less than the domestic price of the same commodity. The complementary slackness condition (4.26b) means that if the inequality in (4.26a) holds then none will be imported ($m_j = 0$) because it will be cheaper to buy at home. If some goods are imported ($m_j > 0$) then the equality must hold.

The export activity transfers domestic production abroad and records the effects on the balance of payments. The partial derivative of Z with respect to X and the application of the Kuhn-Tucker conditions yield

$$-\sum_j \psi_j e_j - \varepsilon(-p^e + s^e) \leq 0, \quad X \geq 0, \qquad (4.27a)$$

and

$$X(-\sum_j \psi_j e_j - \varepsilon(-p^e + s^e)) = 0 \qquad (4.27b)$$

The marginal condition (4.27a) states that the domestic price of the composite commodity exports plus the export tax must be at least as great as the foreign price adjusted

for the exchange rate. Equation (4.27b) shows that if (4.27a) holds as a strict inequality, then $X = 0$, that is foreigners will not import from Canada (that is, Canada will not export) because it will be cheaper for them to buy from their home markets. If some goods are exported ($X > 0$) then the equality must hold.

The c_j and c_j^* are retailing activities in which goods are transferred to final use. The c_j activities transfer goods from domestic production to final use while the c_j^* activities transfer goods from imports to final use. The partial derivative of Z with respect to c_j plus the Kuhn-Tucker conditions give

$$\frac{\partial u}{\partial c_j} \leq \psi_j + \beta d_j, \quad c_j \geq 0, \tag{4.28a}$$

and

$$c_j\left(\frac{\partial u}{\partial c_j} - \psi_j - \beta d_j\right) = 0 \tag{4.28b}$$

Constraint (4.28a) states that the price of commodity j plus the sales tax must be no less than the marginal utility of the commodity. Equation (4.28b) implies that if the inequality in (4.28a) holds then c_j is zero. That is, if the cost of acquiring a unit of the good is greater than the marginal utility (or price of the good)

then none will be consumed. If some good is consumed ($c_j > 0$) then the equality must hold.

For the c_j^* activities, we have

$$\frac{\partial u}{\partial c_j^*} \leq \gamma_j + \beta d_j, \qquad c_j^* \geq 0 \tag{4.29a}$$

and

$$c_j^*\left(\frac{\partial u}{\partial c_j^*} - \gamma_j - \beta d_j\right) = 0 \tag{4.29b}$$

These conditions have similar interpretations as (4.28a) and (4.28b).

The M activity transfers non-competing imports to consumption and records the effect on the balance of payments. Partially differentiating Z with respect to M and using the Kuhn-Tucker conditions, we have

$$\frac{\partial u}{\partial M} \leq \varepsilon(1 - r_N) + \beta(r_N + d_M)$$

$$M \geq 0 \tag{4.30a}$$

and

$$M\left(\frac{\partial u}{\partial M} - \varepsilon(1 - r_N) - \beta(r_N + d_M)\right) = 0 \tag{4.30b}$$

These constraints state that the

foreign price of non-competing imports converted to Canadian dollars plus the tariff cost must be at least as great as its marginal utility in consumption. If the inequality holds then the complementary slackness condition implies that there will be no imports. If some commodities are imported then the equality must hold.

The W activity transfers labour into final use. The Kuhn-Tucker conditions give us

$$\frac{\partial u}{\partial W} \leq \omega \qquad (4.31a)$$

and

$$W\left(\frac{\partial u}{\partial W} - \omega\right) = 0 \qquad (4.31b)$$

If consumers choose to buy labour directly ($W > 0$) then the marginal utility of labour equals the cost of labour (the wage rate). However, if the inequality holds then the cost of labour exceeds its marginal utility and there will be no purchase of labour.

Since the tax constraint (equation (4.13)) holds as an equality, the Kuhn-Tucker conditions applicable to the G activity must be an equality; that is

$$\frac{\partial u}{\partial G} + \beta = 0 \qquad (4.32a)$$

Since

$$\partial u/\partial G = -1, \text{ we have } \beta = 1 \qquad (4.32b)$$

This states that the marginal disutility of government revenue equals the marginal utility cost of taxes.

The y_j activities transfer goods from producers to purchasers of capital. The Kuhn-Tucker conditions applicable in this case are

$$\theta_j - \Psi_j \leq 0, \qquad y_j \geq 0 \qquad (4.33a)$$

and

$$y_j(\theta_j - \Psi_j) = 0 \qquad (4.33b)$$

where θ_j is the cost of commodity j sold to capital use or the value of a unit of commodity j used as capital. These state that the value of commodity j in consumption is at least as great as its value for capital use. If the inequality holds then all of commodity j will be used for consumption and none will be used to form capital ($y_j = 0$). If some is used to form capital ($y_j > 0$) then the equality must hold.

The k_j activities transform newly produced capital goods from the producing industries (j = 17, 18) into capital for the using industries. Partially differentiating Z with respect to k_j and applying the Kuhn-Tucker conditions, we obtain

$$\mu_0 - \sum_{i=17}^{18} h_{ij}\theta_i \leq 0, \qquad k_j \geq 0 \qquad (4.34a)$$

and

$$k_j(\mu_0 - \sum_{i=17}^{18} h_{ij}\theta_i) = 0 \qquad (4.34b)$$

where μ_0 is the price of old capital[11]. Constraint (4.34a) states that the commodity cost of a unit of capital in industry j should be at least as great as the price of old capital. Condition (4.34b) states that if the inequality in (4.34a) holds then industry j will not acquire new capital ($k_j = 0$). If new capital is acquired by industry j then the equality must hold.

Activities v_j refer to the allocation of the total capital stock (new plus old) to using industries. The Kuhn-Tucker conditions yield

$$-\mu_0 + \delta_j + \mu_T \leq 0, \qquad v_j \geq 0 \qquad (4.35a)$$

and

$$v_j(-\mu_0 + \delta_j + \mu_T) = 0 \qquad (4.35b)$$

where μ_T is the end of period price of capital. The marginal condition states that the cost of providing a unit of capital $(\mu_0 - \mu_T)$ to industry j must be greater than or equal to the rental price, δ_j. (4.35b) states that if the inequality holds then there will be no capital allocation to industry j $(v_j = 0)$. However, if $v_j > 0$) then the equality must hold. This in turn implies that the rental value of capital must be the same in each capital using industry.

In this chapter, we have discussed the model used in the dissertation. Before the model can be used, however, data are needed. Chapter 5 discusses the sources of data.

TABLE 4.1

TABLE OF SYMBOLS

u = value of the objective function

u^* = nonlinear part of the objective function

$\tilde{u}$ = maximized value of the objective function

c_i = consumption of commodity i out of domestic production

c_i^* = consumption of commodity i out of imports

G = government revenue from indirect taxes

D = efficiency parameter of the CES function

s_i = expenditure share in the Cobb-Douglas function

E_i = aggregate consumption expenditure on domestically produced and imported commodity i

A_i, B_i = consumption-intensity parameters

α_i = substitution parameter of the CES function

σ_i = elasticity of substitution in consumption between domestically produced and imported commodity i

a_{ij} = proportion of domestically produced commodity i used up in the production of a unit of x_j output

t_i = specific tax per unit of output in industry i

r_i = specific tariff on imported good i

d_N = sales tax on non-competing imports for comsumption

d_i = sales tax on commodity i

r_{Ni} = specific tariff rate on imports of commodity i for intermediate use

r_N = specific tariff rate on non-competing imports for consumption

λ_{Ci} = proportion of commodity i imported per unit of industry i output

λ_{Ni} = proportion of imports required for intermediate use per unit of output of commodity j

f_i = capital-output ratio in industry i

b_i = labour-output ratio in industry i

p_i^m = price in foreign currency of imported textiles

p^e = price in foreign currency of exports

X = total exports

s^e = foreign tariff on exports

h_{ij} = proportion of commodity i needed to produce one unit of capital in industry j

ψ_i = domestic price of commodity i

ε = exchange rate defined as the number of Canadian dollars equivalent to one unit of foreign currency

γ_i = domestic price of imports of textile commodity i

θ_i = cost of commodity i sold to capital use

δ_i = rental value of a unit of capital in industry i

μ_0 = price of old capital

μ_T = end of period price of capital

ω = wage rate

β = marginal disutility of paying a dollar's worth of indirect taxes

r_{Ni} = specific tariff on imports for intermediate use for textiles

r_N = specific tariff on non-competing imports for consumption

$\bar{F}$ = net capital inflow

$\bar{V}_0$ = total supply of old capital in the economy

$\bar{L}_0$ = total labour supply in the economy

V_T = target end of period capital stock

M = non-competing imports for final use

W = total amount of labour used by households

x_i = gross output of commodity i

m_i = amount imported of commodity i for final use

e_i = export share of industry i in total exports

$\bar{g}_i$ = amount of commodity i sold to the government

y_i = amount of commodity i sold to producers of capital goods

v_i = supply of capital in industry i

k_i = amount of capital produced in the period in industry i

FOOTNOTES

Chapter 4

1. This is discussed in Shoven and Whalley (1984).

2. For the purpose of this thesis, $r_i = 0$, $i = 17,\ldots,21$ and $r_{Ni} = r_N = 0$.

3. Exogenous variables are denoted by a bar, e.g., $\bar{g}$.

4. M is an argument in the utility function u^*.

5. Note that for industries 17 through 21, the very small quantities of non-competing imports have been included in the λ_{ci} coefficients.

6. Note that this constraint allows initial capital to be reallocated across industries. This assumption is appropriate in a static model which allows contraction of industries without specifying the dynamic adjustment in detail.

7. This constraint forces the model to follow the observed growth path of total capital (see page 87), and thus prevents it from expanding consumption at the expense of future growth.

8. W is also an argument in the objective function, u^*.

9. Note that the unit of foreign currency has been chosen to have a 1979 price of one Canadian dollar.

10. The production of one unit of a non-textile commodity ($i = 17,\ldots,21$) implies the importation of λ_{cj} units of the same commodity.

11. Note that the price of old capital is the same in all industries since (4.18) allows capital to be freely transferred from one industry to another.

CHAPTER 5

THE DATA

5.1 Introduction

This chapter describes how the many input-output type parameters were organized from the data supplied by Statistics Canada. All industries in the economy had to be classified into one of twenty-one aggregated industries. This aggregation allows significant disaggregation of the textile sector into sixteen industries and the remaining sectors of the economy into five aggregated industries. Exporting and importing industries behave differently to trade policy changes. If there is a deterioriation in the terms of trade, for example, the industries engaged in exporting activities are expected to expand while those engaged in competition with imports are expected to contract. It was therefore desirable to aggregate the non-textile industries into exporting industries, importing industries and those which are domestic (neither exporting nor importing). It was also decided to distinguish producers of capital goods, the machinery and construction

industries, from other industries in the economy. As a result, the costs of machines and construction are distinguished in the dual from other cost categories.

The first sixteen industries are aggregations of the 1971 input-output code consisting of codes 04300 (cotton, yarn and cloth mills) through 05800 (clothing industries). The correspondences between this code and the Standard Industrial Classification can be found in Standard Industrial Classification (1980), Statistics Canada, Ottawa . Machinery, designated as industry seventeen in the dissertation, is made up of codes 09200 through 09500 inclusive. The construction industry, industry eighteen, consists of codes 13800 to 14600, inclusive.

The other industries in the dissertation were obtained by aggregation as part of three classes -- exporting activities, importing activities or domestic activities, according to the ratio of exports to output and imports to output. If the ratio of imports to output is greater than or equal to five percent and the ratio of exports to output is less than five percent, the industry is classified as an importing industry. If the ratio of exports to output

is greater than or equal to five percent while the ratio of imports to output is less than five percent, the industry is classified as an exporting industry. If both ratios are greater than five percent, the industry is classified as exporting or importing, depending on which ratio is the greater. If both ratios are less than five percent, the industry is classified as a domestic industry. All the domestic industries were aggregated into one industry called domestic industry and likewise for the exporting and importing industries. The classification of industries is shown in Tables 1-6 of the Appendix.

5.2 Parameters Needed for the Constraints

The model described in the previous section requires some parameters for the constraints before it can be run. As with most input-output models, values for the intermediate input coefficients, a_{ij}'s, are needed along with the capital-output ratios, f_i's, and

labour-output ratios, b_i's. The tax constraint requires values for the sales tax rates, d_i, the import tariff rates, r_i's, and the industrial tax rates, t_i's. The material balance and balance of payments constraints require knowledge of the import-output ratios, λ_{Ci}'s, and λ_{Ni}'s. Lastly, the constraints on capital conditions (4.19) require a value for each h_{ij}, the proportion of commodity i needed to produce a unit of output in industry j.

The matrix of intermediate input coefficients consists of elements a_{ij}, where $a_{ij} = x_{ij}/x_j$, x_{ij} is the output of the i^{th} industry absorbed in the production of the j^{th} industry and x_j is the output of the j^{th} industry. The x_{ij}'s were obtained from the "DU matrix" of the input-output data for 1979 obtained from Statistics Canada. The outputs x_j's, were obtained from the "outputs" section of the same data.

Import-Output ratios for the non-textile industries, λ_{Ci}'s, were obtained by taking the ratio of imports (obtained from the "trade in industry space" section of the input-output data) to output. Imports for intermediate use to output ratios for the textile industries, λ_{Ni}'s, were obtained using trade of Canada data. Under the standard commodity

classification code (SCC), imports are classified in such a way that imports for intermediate use have certain codes and imports for consumption have different codes. For a given SCC classification corresponding to a given input-output classification, the ratio, θ, of imports for intermediate use to total imports was calculated for 1979. This ratio was then applied to the total imports figures obtained from the Statistics Canada input-output data to get total imports for intermediate use. If M_{int} denotes imports for intermediate use and M_{Total} denotes total imports, then $M_{int} = \theta M_{Total}$.

Each of the twenty-one industries also imported raw and semi-processed cotton, natural rubber, raw sugar, cocoa beans, green coffee, tropical fruit, and some unallocated imports for intermediate use. The values of these were obtained from the "intermediate primaries" section of the input-output data and were added to M_{int} to get the final total imports for intermediate use, M^{*}_{Total}. Therefore, λ_{Ni} could be calculated from

$$\lambda_{Ni} = \frac{M^{*}_{Total}}{Output}$$

The amount of commodity i needed to produce

a unit of capital in industry j, the h_{ij}'s, could in principle, be obtained as follows:

$$h_{17,j} = \frac{T_{17,j}}{T_{17,j} + T_{18,j}}$$

and

$$h_{18,j} = \frac{T_{18,j}}{T_{17,j} + T_{18,j}}$$

where $T_{17,j}$ = total value of machinery in industry j

$T_{18,j}$ = total value of construction in industry j

Because of data problems in obtaining the values of machinery and construction at the level of aggregation used, it was assumed that the h_{ij}'s were constant across industries and hence equal.

The capital-output ratio, f_i, was obtained by taking the ratio of operating surplus[1] to output in industry i.

Labour is measured by the value of wages and salaries plus supplementary labour income (obtained from the intermediate primaries section of the input-output data). The labour-output ratio, b_i, was obtained

by taking the ratio of labour to output. The specific tax, t_i, on industry i was obtained by dividing commodity indirect taxes less subsidies plus other indirect taxes (from the intermediate primaries section of the input-output data) by the output of industry i. The sales tax, d_i, on the consumption of commodity i was obtained by dividing commodity indirect taxes plus other indirect taxes (from the final primaries section of the input-output data) by total final consumption. Import tariffs, r_i's, were obtained from the valuation conversion coefficients section of the input-output data. The foreign tariff rate, s^e, was set to zero.

5.3 Right Hand Side Constants

Government purchases (including other exogenous demand) g_i's, from industry i were obtained from the "DF matrix" of the input-output data as the sum of current gross government expenditure, inventory change, and government sales of goods and services (negative). Net capital inflow was obtained from the difference between imports and exports in the input-output table. Thus it includes current account terms

such as dividends paid to non-residents. A representative figure for capital stock at the beginning of 1979 was obtained from the sum of payments for the rent of capital. The payments were assumed to be the sum of operating surplus and net income of unincorporated business. Since units of capital are arbitrary, they may be chosen so that the ratio of rental payments to capital stock is unity in the base period 1979. Therefore, we may take the total rental payments on capital in 1979 as our measure of capital supply. The target capital stock at the end of the period V_T, was assumed to be the actual end of period capital stock implied by the initial capital stock, $\bar{V}_0$, and actual capital formation in 1979. Wages and salaries plus supplementary labour income (from the intermediate primaries section of the input-output data) plus wages and salaries plus supplementary labour income (from the final primaries section) were added to obtain the total labour supply available in the economy.

5.4 Initial (1979) Values of the Endogenous Variables

In an input-output model such as this it is important to check whether the rows and columns of the constraint matrix add up. This is to ensure that there have been no errors in the parameter calculations. The matrix product of the constraint matrix and the vector of endogenous variables must give the right hand side constants while the columns of the constraint matrix must add up to the marginal utilities or zeros according to whether or not the particular column involves an objective function variable. The columns involving the variables in the objective function must add up to the marginal utilities while the other columns must add up to zeros. For this, observed 1979 values of the endogenous variables are needed. That is, the model must satisfy the actual 1979 conditions. This check was done and the adding up condition did hold for the model

Textile imports for final use, m_i, were obtained by subtracting imports for intermediate use, M^*_{Total} (calculated earlier), from total imports (obtained from the "Trade in industry space" section of the input-output data). Consumption of commodity i

out of imports, c_i^*, was taken to be equal to imports for final use, m_i. Total consumption is the sum of domestic consumption, c_i, and imported consumption, m_i. Therefore, domestic consumption is the difference between total consumption (obtained from the input-output data) and imported consumption, m_i. Output, x_i, was obtained directly from the "outputs" section of the input-output data. Total exports, X, was obtained from the "trade in industry space" section of the input-output data. The operating surplus plus net income of unincorporated business in industry i was taken to represent the supply of capital, v_i, in industry i. The reader will recall that units of capital stock are chosen such that the value of capital stock in 1979 is equal to the rental paid on the stock. Imports for final consumption of goods not made in Canada, M, wage and salaries and supplementary labour income, W, and government revenue from indirect taxes, G, were obtained from the final primaries section of the input-output data. Imports, M, are made up of imports of raw cotton, natural rubber, raw sugar, cocoa beans, green coffee, tropical fruit, and unallocated imports.

5.5 Parameter Setting for the Objective Function

Before simulations of the effects of trade policy can be performed, values for all parameters in the objective function, D, s_i, A_i, Bi and α_i must be assigned.

Units for each of the commodities are defined so that each 1979 price, exclusive of sales taxes but inclusive of tariffs (where applicable), equals one. Thus in the base period the sum of the consumption of domestic textile good i, c_{i0}, and the consumption of the competing imported textile good, c^*_{i0}, adjusted for sales taxes, equals total consumption (expenditure) of good i, E_{i0}.

$$E_{i0} = (c_{i0} + c^*_{i0}) \ (1 + d_i) \qquad (5.1)$$

$$i = 1,\ldots,16$$

Thus it is desirable to choose the parameters of each CES function defining a composite textile commodity so that its value in the base period equals total consumption (expenditure) in the base period.

$$E_{i0} = (A_i c_{i0}^{-\alpha_i} + B_i c_{i0}^{*-\alpha_i})^{-1/\alpha_i}$$

$$i = 1,\ldots,16 \qquad (5.2)$$

Equation (5.2) is not sufficient to specify the three parameters, A_i, B_i and α_i. Additional restrictions can be obtained by recalling that consumer choice theory requires that the ratio of the marginal utilities of the two commodities is equal to the ratio of their prices. Since each commodity price equals one in the base period, and both face the same sales tax, the marginal utilities of each commodity must be equal in the base period. In particular, the marginal utility of the domestically produced textile commodity i, c_i, must equal the marginal utility of the competing imported commodity, c_i^*, in the base period.

$$\left.\frac{\partial u^*}{\partial c_i}\right|_{\text{base period}} = \left.\frac{\partial u^*}{\partial c_i^*}\right|_{\text{base period}} \qquad (5.3)$$

Since the objective function, u^*, is a composite function, each of the above marginal utilities is the product of two derivatives:

$$\frac{\partial u^*}{\partial c_i} = \frac{\partial u^*}{\partial E_i} \cdot \frac{\partial E_i}{\partial c_i}$$

and $$\frac{\partial u^*}{\partial c_i^*} = \frac{\partial u^*}{\partial E_i} \cdot \frac{\partial E_i}{\partial c_i^*}$$

Thus the equality of the two marginal utilities (equation (5.3)) implies that the corresponding partial derivatives of the CES function defining E_i are also equal in the base period.

$$\frac{\partial E_i}{\partial c_i}(c_{i0}, c_{i0}^*) = \frac{\partial E_i}{\partial c_i^*}(c_{i0}, c_{i0}^*) \quad i = 1,\ldots,16 \tag{5.4}$$

Finally, we observe that the CES functions are homogeneous of degree one in c_i and c_i^*, so that Euler's Theorem implies the functional relationship

$$E_i(c_i,c_i^*) = c_i \frac{\partial E_i}{\partial c_i}(c_i, c_i^*) + c_i^* \frac{\partial E_i}{\partial c_i^*}(c_i,c_i^*)$$

$$i = 1,\ldots,16 \tag{5.5}$$

In particular, this relationship must hold at base period values.

$$E_{i0} = c_{i0} \frac{\partial E_i}{\partial c_i}(c_{i0}, c_{i0}^*) + c_{i0}^* \frac{\partial E_i}{\partial c_i^*}(c_{i0},c_{i0}^*)$$

$$i = 1,\ldots,16 \tag{5.6}$$

Together, equations (5.1), (5.4) and (5.6) imply that the partial derivatives of each CES function, $E_i(c_i, c_i^*)$, must equal $(1 + d_i)$ in the base period.

$$\frac{\partial E_i}{\partial c_i}(c_{i0}, c_{i0}^*) = \frac{\partial E_i}{\partial c_i^*}(c_{i0}, c_{i0}^*) = 1 + d_i$$

$$i = 1,\ldots,16 \qquad (5.7)$$

Differentiating the CES functions and using equation (5.2) allows the conditions (5.7) to be restated as follows:

$$\frac{\partial E_i}{\partial c_i}(c_{i0}, c_{i0}^*) = A_i \left(\frac{E_{i0}}{c_{i0}}\right)^{1+\alpha_i} = 1 + d_i \qquad (5.8)$$

$$\frac{\partial E_i}{\partial c_i^*}(c_{i0}, c_{i0}^*) = B_i \left(\frac{E_{i0}}{c_{i0}^*}\right)^{1+\alpha_i} = 1 + d_i \qquad (5.9)$$

Unfortunately, the three equations (5.2), (5.8), and (5.9) are not independent, since if any

two are satisfied the third must be satisfied by Euler's Theorem. Thus one additional restriction is required in order to specify the three parameters A_i, B_i and α_i. The additional restriction is provided by (4.12) which implies that

$$\alpha_i = \frac{1}{\sigma_i} - 1$$

In turn, σ_i, can be calculated from an independent estimate of the elasticity of demand for textiles for either imported textile products or domestically produced textiles using a formula developed by Melvin and Warne (1973).

They show that

$$\varepsilon_{c_i} = \frac{\left[1 + \sigma_i \left(\frac{B_i}{A_i}\right)^{\sigma_i} \left(\frac{p_{c_i}}{p^*_{c_i}}\right)^{-\sigma_i \alpha_i}\right]}{\left[1 + \left(\frac{B_i}{A_i}\right)^{\sigma_i} \left(\frac{p_{c_i}}{p^*_{c_i}}\right)^{-\sigma_i \alpha_i}\right]} \qquad (5.10)$$

for domestically produced textiles and

$$\varepsilon_{c_i^*} = \frac{\left[1 + \sigma_i \left(\frac{A_i}{B_i}\right)^{\sigma_i} \left(\frac{p_{c_i^*}}{p_{c_i}}\right)^{-\sigma_i \alpha_i}\right]}{\left[1 + \left(\frac{A_i}{B_i}\right)^{\sigma_i} \left(\frac{p_{c_i^*}}{p_{c_i}}\right)^{-\sigma_i \alpha_i}\right]} \qquad (5.11)$$

for imported textile products, where ε_{c_i} is the elasticity of demand for c_i and $\varepsilon_{c_i^*}$ is the elasticity of demand for c_i^*. From (5.10) and (5.11), and using (5.8), (5.9) and (4.12) and setting $p_{c_i^*} = p_{c_i} = 1 + d_i$, $E_{i0} = (c_{i0} + c_{i0}^*)(1 + d_i)$, we have

$$\sigma_i = \frac{1 - \varepsilon_{c_i}\left(\frac{E_{i0}}{c_{i0}} - d_i\right)}{(1 + d_i) - \frac{E_{i0}}{c_{i0}}} \qquad (5.12)$$

and

$$\sigma_i = \frac{1 - \varepsilon_{c_i^*}^{*}\left(\frac{E_{i0}}{c_{i0}^{*}} - d_i\right)}{(1 + d_i) - \frac{E_{i0}}{c_{i0}^{*}}} \qquad (5.13)$$

Thus knowing ε_{c_i} or $\varepsilon_{c_i^*}^{*}$, σ_i can be calculated from (5.12) or (5.13) using 1979 data. Knowing σ_i, α_i can be calculated from (4.12); and knowing α_i, A_i and B_i can be calculated from (5.8) and (5.9). The elasticity of demand for imported textiles, $\varepsilon_{c_i^*}^{*}$, was used to calculate σ_i from (5.13). For each textile commodity, the common value, -1.14, was used. This value was the estimate for textiles for the U.S. during the period 1960-1975 reported in Stern, Francis and Schumacher (1976).

The values of D and s_i were calculated by a procedure similar to that outlined above. First, the requirement that the value of u^* in the base period equals total base period expenditure, E_0, is imposed.

$$u^* \Big|_{\text{base period}} = E_0 \tag{5.14}$$

Second, consumer choice theory and the fact that all prices equal $(1 + d_i)$ in the base period imply equal marginal utilities for each composite commodity in the base period.

$$\frac{\partial u^*}{\partial E_i}\Big|_{\text{base period}} = \frac{\partial u^*}{\partial E_j}\Big|_{\text{base period}}$$

$$i \neq j \tag{5.15}$$

Applying this condition, and assuming that the Cobb-Douglas function, u^*, exhibits constant returns to scale (implying $\sum_i s_i = 1$) yields

$$s_i = \frac{E_{i0}}{E_0} \tag{5.16}$$

Once the s_i is determined, the final parameter D can be calculated from condition (5.14).

$$D = \frac{E_0}{\prod_i E_{i0}^{s_i}} \tag{5.17}$$

FOOTNOTE

Chapter 5

1. In the input-output structure of the Canadian economy, operating surplus is defined to include (among other things), corporation profits (before corporation income taxes and before payments of interest and dividends). Therefore, this includes undistributed corporation profits and dividends.

CHAPTER 6

EMPIRICAL RESULTS AND CONCLUSIONS

6.1 Introduction

The previous chapter discussed the data sources and how the parameter values required to implement the model in chapter 4 were obtained. The present chapter presents and discusses the empirical results and the conclusions of the thesis.

The model described in chapter 4 was solved using Minos (a modular in-core nonlinear optimization system). Minos is a general purpose nonlinear programming system, designed to solve large scale optimization problems involving nonlinearities, in either the objective function or in the constraints. It was developed at the Systems Optimization Laboratory at the Department of Operations Research, Stanford University, by Bruce A. Murtagh and Michael A. Saunders (1980).

For numerical reliability, units were chosen so that most of the endogenous variables satisfied the

condition $10^{-2} \leq |x_j| \leq 10^2$ (as required by Minos). For numerical stability, to enhance convergence and to prevent singularities in the objective function, lower bounds were put on the variables appearing in the nonlinear part of the objective function. The maximum lower bound was 0.01 billion dollars. All variables were measured in billions of 1979 dollars.

The next five sections are devoted to empirically applying the model to answer certain trade policy questions. Section 6.3 attempts to establish a benchmark equilibrium for the economy from which comparisons can be made. Section 6.3 examines how the industries will react to sectoral free trade in textiles. The objective here is to determine which of the textile industries would be strongest in a situation of sectoral free trade. While the view is widely held that Canada has a comparative disadvantage in textiles as a whole, no published work has investigated the comparative strangths of the individual textile industries. In Section 6.4 we investigate the question of equivalence of tariffs and quotas in this model. While Bhagwati's analysis of the problem in a partial equilibrium framework considered 'equiva-

lence' industry by industry, it would be interesting to investigate whether equivalence in Bhagwati's sense holds when a set of industries is considered simultaneously. Very little has been done in exploring equivalence in a general equilibrium framework. Section 6.5 addresses the question of spillover protection in the textile sector. Most of the textile industries purchase intermediate goods from the others. The protection in one tends to spill over to the others leading to increases in output and employment outside the protected industry. The output effects are offset by cost effects. Tariffs raise the costs of intermediate goods so that other industries purchasing intermediate goods from the protected one may reduce output. To the extent that these cost effects dominate, it is expected that a lower level of protection is needed in any particular industry if it is the only one in the textile sector receiving protection. Section 6.6 compares tariffs with subsidies. This question has been addressed by writers such as Haberler (1936) who asserted that "...duties are the most important and most rational weapons of trade policy". We compare the two policies with respect to output,

utility, imports and consumption. The last section, 6.7, is devoted to the conclusions of the thesis.

6.2 The Reference Case

The model was first run with the observed 1979 tariffs in effect to ascertain whether the results obtained would be close enough to the observed 1979 values for the model to be regarded as a good representation of the Canadian textile sector. In this and subsequent experiments, attention was focussed on four endogenous variables -- output (and employment), consumption, imports and utility.

The results of this first experiment are shown in Tables 6.1 to 6.3. These tables show how output, consumption and import levels predicted by the model differ from the actual 1979 observed values. Table 6.1 shows that of the twenty-one industrial output levels yielded by the model, fourteen differ from their actual values by less than 5%, six are between 5% and 10%, and only one differs from its actual value by 11.5%. Table 6.2 shows that apart from two industries (fibre preparing mills and cotton

and jute bag industry) in which domestic consumption fell to its lower bound, all the consumption levels predicted by the model differ from their actual values by less than 4%. Table 6.3 shows that all the import levels predicted by the model differ from their actual values by less than 3%. It was our judgement that the model thus predicts the 1979 values well enough for the purposes of this study.

In six textile industries, all imports were for intermediate use. Since imports in these industries are not used for final consumption, they are not arguments in the objective function. Thus there are ten instead of sixteen import figures in Table 6.3.

6.3 Sectoral Free Trade in Textiles

The model was solved with tariffs and quotas in all of the textile industries removed to get the sectoral free trade version of the model. To obtain this, r_i was put to zero in equation (4.13), that is, equation(4.13) was replaced by

$$G = \sum_{i=1}^{21} t_i x_i + \sum_{i=1}^{21} d_i c_i + \sum_{i=1}^{16} d_i c_i^* + d_M M \quad (6.1)$$

As noted earlier, the objective here is to determine how the industries, especially the textile industries, will react to a situation of sectoral free trade. The results of this exercise are shown in Tables 6.4 to 6.7.

Table 6.4 shows changes in output levels under sectoral free trade. With the exception of the cordage and twine industry (in which output remained the same as the tariff regime level) and three other industries -- pressed and punched felt mills, miscellaneous textile industry (in which output barely decreased), and cotton and jute bag industry (in which output barely increased), the output and employment levels of the textile sector declined. The decline in output was higher in the knitting mill and clothing industries while the primary textile industries (industries 1 to 13) showed little decline. While output and employment declined in the domestic and construction industries, those in the machinery, exporting and import competing industries increased. This implies that the economic system adjusts to sectoral free trade through both import

substitution and export expansion. In fact, total exports increased under sectoral free trade.

Table 6.5 shows the changes in consumption levels. Apart from the fibre preparing mills and cotton and jute bag industry in which consumption remained at its lower bound, consumption (out of domestic production) of all other goods, and in particular, consumption in the remaining textile industries declined under sectoral free trade. It might seem inconsistent that consumption in the import competing and exporting industries should decline while output increased but this is possible if (as was the case) exports and intermediate input demand $\sum_j a_{ij}x_j$ increase.

Table 6.6 shows changes in import levels under sectoral free trade in textiles and Table 6.7 shows utility levels under different trade policy regimes. Imports of all ten textile industries increased under sectoral free trade. Thus the textile sector adjusts to sectoral free by contracting output, employment, consumption and importing more textile products. This result also ties in with the opinion expressed by the Canadian textile and clothing board when it asserts: "There is sufficient reason

to believe that should the special measures of protection be terminated on December 31, 1981, imports from 'low-cost' and state-trading sources would increase in a rapid and disorderly fashion, causing damage to Canadian production and employment which would be difficult to repair." (Textile and Clothing Inquiry, June 1980.) This result is not surprising because the 1979 levels of output and employment were maintained by protectionist policies.

Even though consumption of all goods, and in particular textile products declined, utility increased under sectoral free trade. This means that the increase in utility due to increased textile imports more than compensated for the decline in utility due to decreased consumption of domestic products. The difference in the utilities between the sectoral free trade regime and the tariff regime is a measure of the social cost associated with choosing the tariff regime rather than the sectoral free trade regime.

Although the reaction of the textile industries to sectoral free trade is what one would expect in a partial equilibrium model, these results are not guaranteed in a general equilibrium model such as ours which can take the reaction of the import competing and exporting

TABLE 6.1

OUTPUT LEVELS WITH DIRECT TARIFFS IN EFFECT (MILLIONS OF 1979 DOLLARS)

Industry	Name	Observed (1979)	Predicted by model	% deviation from observed
1	Cotton yarn and cloth mills	599.35	595.86	-0.6
2	Wool yarn and cotton mills	230.01	225.40	-2.0
3	Synthetic textile mills	1,235.52	1.234.95	-0.1
4	Fibre preparing mills	28.72	27.28	-5.0
5	Thread mills	50.97	46.40	-9.0
6	Cordage and twine industry	30.77	27.22	-11.5
7	Narrow Fabric mills	70.55	66.69	-5.5
8	Pressed and punched felt mills	33.21	30.62	-7.8
9	Carpet, mat and rug industry	548.62	549.61	0.2
10	Textile dyeing and finishing	131.07	124.49	-5.0
11	Canvas products industry	85.32	81.26	-4.8
12	Cotton and jute bag industry	49.79	54.32	9.1
13	Miscellaneous textile industry	1,063.87	1,081.82	1.7
14	Hosiery mills	161.81	156.34	-3.4
15	Other knitting mills	682.12	668.37	-2.0
16	Clothing industries	3,787.73	3,715.41	-1.9
17	Machinery industry	7,133.69	7,471.29	4.7
18	Construction industry	43,828.45	45,410.96	3.6
19	Exporting industry	120,021.57	122,670.29	2.2
20	Importing industry	101,531.64	103,307.99	1.7
21	Domestic industry	162,118.42	165,521.87	2.1

TABLE 6.2

DOMESTIC CONSUMPTION LEVELS WITH DIRECT TARIFFS IN EFFECT (MILLIONS OF 1979 DOLLARS)

Industry	Name	Observed (1979)	Predicted by model	% deviation from observed
1	Cotton yarn and cloth mills	147.37	147.98	0.4
2	Wool yarn and cotton mills	33.76	33.57	-0.6
3	Synthetic textile mills	145.34	146.23	0.6
4	Fibre preparing mills	5.93	10.00	(a)
5	Thread mills	12.87	12.94	0.5
6	Cordage and twine industry	2.33	2.33	0.0
7	Narrow fabric mills	37.38	36.89	-1.3
8	Pressed and punched felt mills	11.10	10.91	-1.7
9	Carpet, mat and rug industry	205.55	202.03	-1.7
10	Textile dyeing and finishing	16.87	16.80	-0.4
11	Canvas products industry	24.78	23.98	-3.1
12	Cotton and jute bag industry	6.31	10.00	(a)
13	Miscellaneous textile industry	50.70	49.35	-2.7
14	Hosiery mills	146.30	142.30	-2.7
15	Other knitting mills	365.09	359.05	-1.7
16	Clothing industries	3,122.23	3,047.03	-2.4
17	Machinery industry	663.57	669.41	0.9
18	Construction industry	109.15	108.15	-0.9
19	Exporting industry	22,936.46	23,634.64	3.0
20	Importing industry	24,794.69	24,944.34	0.6
21	Domestic industry	79,107.75	80,945.56	2.3

(a) at lower bound imposed to achieve convergence of the solution algorithm.

TABLE 6.3

IMPORTS (FOR FINAL CONSUMPTION) LEVELS WITH DIRECT TARIFFS IN EFFECT

(MILLIONS OF 1979 DOLLARS)

Industry	Name	Observed (1979)	Predicted by Model	% deviation from observed
1	Cotton yarn and cloth mills	8.10	8.28	2.2
2	Wool yarn and cloth mills	10.76	11.03	2.5
6	Cordage and twine industry	6.24	6.39	2.4
9	Carpet, mat and rug industry	124.95	128.27	2.7
10	Textile dyeing and finishing	2.12	2.17	2.4
11	Canvas products industry	19.47	20.02	2.8
13	Miscellaneous textile industry	494.38	506.66	2.5
14	Hosiery mills	33.72	34.65	2.8
15	Other knitting mills	205.48	210.73	2.6
16	Clothing industries	876.27	900.01	2.7

TABLE 6.4

OUTPUT LEVELS UNDER SECTORAL FREE TRADE IN TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Output Level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	593.41	-0.4
2	Wool yarn and cotton mills	224.53	-0.4
3	Synthetic textile mills	1,230.64	-0.3
4	Fibre preparing mills	27.20	-0.3
5	Thread mills	46.15	-0.5
6	Cordage and twine industry	27.22	0.0
7	Narrow fabric mills	66.50	-0.3
8	Pressed and punched felt mills	30.61	-0.03
9	Carpet, mat and rug industry	547.84	-0.3
10	Textile dyeing and finishing	123.65	-0.7
11	Canvas products industry	80.78	-0.6
12	Cotton and jute bag industry	54.35	0.06
13	Miscellaneous textile industry	1,081.43	-0.04
14	Hosiery mills	155.18	-0.7
15	Other knitting mills	659.06	-1.4
16	Clothing industries	3,685.89	-0.8
17	Machinery industry	7,477.15	0.08
18	Construction industry	45,408.76	-0.01
19	Exporting industry	122,838.50	0.1
20	Importing industry	103,358.29	0.1
21	Domestic industry	165,372.12	-0.1

TABLE 6.5

DOMESTIC CONSUMPTION LEVELS UNDER SECTORAL FREE TRADE IN TEXTILES
(MILLIONS OF 1979 DOLLARS)

Industry	Name	Consumption	% deviation from tariff regime level
1	Cotton yarn and cloth mills	147.51	-0.3
2	Wool yarn and cotton mills	33.30	-0.8
3	Synthetic textile mills	145.97	-0.2
4	Fibre preparing mills	10.00	(a)
5	Thread mills	12.92	-0.2
6	Cordage and twine industry	2.28	-2.1
7	Narrow fabric mills	36.84	-0.1
8	Pressed and punched felt mills	10.90	-0.1
9	Carpet, mat and rug industry	200.00	-1.0
10	Textile dyeing and finishing	16.71	-0.5
11	Canvas products industry	23.50	-2.0
12	Cotton and jute bag industry	10.00	(a)
13	Miscellaneous textile industry	46.68	-5.4
14	Hosiery mills	141.16	-0.8
15	Other knitting mills	351.33	-2.2
16	Clothing industries	3,018.48	-0.9
17	Machinery industry	668.20	-0.2
18	Construction industry	108.02	-0.1
19	Exporting industry	23,578.35	-0.2
20	Importing industry	24,900.48	-0.2
21	Domestic industry	80,777.32	-0.2

(a) at lower bound imposed to achieve convergence of the solution algorithm.

TABLE 6.6

IMPORT LEVELS UNDER SECTORAL FREE TRADE IN TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Import level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	10.26	23.9
2	Wool yarn and cloth mills	12.99	17.8
6	Cordage and twine industry	6.76	5.8
9	Carpet, mat and rug industry	144.21	12.4
10	Textile dyeing and finishing	2.82	30.0
11	Canvas products industry	24.30	21.4
13	Miscellaneous textile industry	528.87	4.4
14	Hosiery mills	44.35	28.0
15	Other knitting mills	281.19	33.4
16	Clothing industries	1,142.04	26.9

industries into consideration. In partial equilibrium models, we do not consider industries other than the one under study. In general equilibrium models, such as ours, examination of the effects on other industries is possible.

6.4 Tariffs Versus Quotas

Table 6.8 shows values for direct and implicit tariffs. The direct tariffs are the observed 1979 tariffs. As noted above, when these tariffs are used in the simulation we obtain the simulated import levels. When quotas, equal to these import levels are introduced (in place of the tariffs), they appear as constraints in the primal problem. Associated with each constraint is a dual variable. These dual variables are called "implicit tariffs" by Bhagwati (1965).

As noted earlier, this section is designed to explore Bhagwati's definition of equivalence in this model. To obtain the results in Table 6.8, equation (4.13) was replaced by equations (6.1) and (6.2):

$$G = \sum_{i=1}^{21} t_i x_i + \sum_{i=1}^{21} d_i c_i + \sum_{i=1}^{16} d_i c_i^* + d_M M \tag{6.1}$$

$$m_i \leq \bar{m}_i, \qquad i = 1,\ldots,16 \tag{6.2}$$

where $\bar{m}_i$'s are the simulated import levels when equation (4.13) is in effect. The direct tariffs in Table 6.8 are the r_i's in equation (4.13) and the implicit tariffs are the dual variables associated with constraints (6.2).

It can be shown from the Kuhn-Tucker conditions that in fact tariffs and quotas are equivalent in Bhagwati's sense, if, as we assume, the public spends the rents obtained from the quota in the same manner that it previously spent the tariff revenues which were distributed to it by the government. With the direct tariffs, the Kuhn-Tucker condition give

$$\frac{\partial Z}{\partial m_j} = \gamma_j - \varepsilon p_j^m - r_j \leq 0 \tag{6.3}$$

while with the quotas they give

$$\frac{\partial Z}{\partial m_j} = \gamma_j - \varepsilon p_j^m - \eta_j \leq 0 \tag{6.4}$$

where η_j is the implicit tariff and the other variables are as defined earlier. The other Kuhn-Tucker conditions in the two regimes remain the same, except that the government tax revenues are reduced by the amount of revenue it previously collected under the tariff and those who earn rent from importing under the quota earn less incomes under the tariff. Suppose the tariff regime has an optimal solution. Since all the other parameters of the model are the same in the two regimes, it can be seen from equations (6.3) and (6.4) that the quota regime will have the same optimal solution if $\eta_j = r_j$, that is, if the explicit and implicit tariffs are the same. Thus, Bhagwati's definition of equivalence holds in this model. This is supported by the results of Table 6.8. The table shows that apart from one case in which the direct and implicit tariffs differ by 1.17%, the percentage differences are all less than 0.3%. In fact, in two cases, the implicit and direct tariffs are identical. These differences are very small for all practical purposes and vindicate the equivalence proposition.

The results of this section are a useful extension of Bhagwati's concept of equivalence to a general equilibrium model. In particular, we have shown

TABLE 6.7

UTILITY LEVELS (BILLIONS OF 1979 DOLLARS

Trade Policy	Utility level	Change from tariff regime level	% deviation from tariff regime level
Tariffs	152.8009	0.0	0.0
Quotas	153.0853	0.2844	0.19
Sectoral Free Trade	153.1189	0.3180	0.21
Uniform Output Subsidy	153.1187	0.3178	0.21
Uniform Labour Subsidy	153.1187	0.3178	0.21

TABLE 6.8

IMPLICIT AND DIRECT TARIFFS

Industry	Name	Direct Tariff	Implicit Tariff	% Difference
1	Cotton yarn and cloth mills	0.18571	0.18617	0.248
2	Wool yarn and cloth mills	0.14544	0.14514	0.206
6	Cordage and twine industry	0.05298	0.05360	1.170
9	Carpet, mat and rug industry	0.10675	0.10677	0.019
10	Textile dyeing and finishing	0.22316	0.22265	0.220
11	Canvas products industry	0.17009	0.16990	0.112
13	Miscellaneous textile industry	0.04189	0.04189	0.000
14	Hosiery mills	0.21084	0.21078	0.028
15	Other knitting mills	0.24197	0.24198	0.003
16	Clothing industries	0.20423	0.20423	0.000

how tariff equivalents to any quota can be calculated while taking into account the general equilibrium nature of the economy. These tariff equivalents are endogenous to the model and their values will change with changes in any of the exogenous parameters such as labour supply or government final demand.

6.5 Spillover Protection in the Textile Sector

Table 6.9 shows the tariff equivalent necessary to maintain output in one textile industry when protection in all other textile industries is lowered to zero. This is compared with the tariff equivalent when the protection is in conjunction with protection in all textiles. As noted in section 6.1, the objective here is to determine whether or not, as a result of the complex interrelationships between the industries, tariffs or quotas on all textile industries supplement or reduce the protection in each alone. The figures in Table 6.9 were obtained by imposing the constraints in equations (6.1) and (6.2). In obtaining the tariff equivalents under "protection in all textiles", all the constraints in equation (6.2) were imposed simultaneously together with equation (6.1) and the tariff equivalent in the designated

industry was noted. In obtaining the values under "protection alone", the constraints in equation (6.2) were imposed one at a time alongside equation (6.1) and the tariff equivalent was noted.

In all cases, the tariff equivalent needed to protect each industry alone is less than when all the textile industries are protected even though some of the differences are very small. Thus, the textile industries incur indirect cost from protection in other textile industries, that is, there is antiprotection in the textile industries. This result is in agreement with Williams when he notes that "the high levels of anti-protection characteristic of all industrial groups in the textile sector are one of its most notable features". (Williams, 1978, p. 145.)

In all cases, consumption in the fibre preparing mills and cotton and jute bag industry fell to their lower bounds in both experiments (when an industry is protected alone and when all textile industries are protected). Consumption in the remaining textile industries was higher when all textile industries were protected than when only one was protected. Imports in each textile industry (except the protected one whose imports had been set with a quota) increased when only

that industry was protected. Except for the protected industry whose output increased in some cases and declined in others, when we moved to freer trade (that is, when we moved from protection in all textiles to protection in only one), the output level in each textile industry declined.

Of the aggregated industries, while consumption declined in each of them when we moved to freer trade, outputs in the construction and domestic industries declined and those in the machinery, exporting and import competing industries increased. Thus the system adjusts to freer trade through both import and export expansion. In all cases there is a substitution of imported textile consumption for domestic consumption. Utility increased in all cases when we moved to freer trade implying that the increase in utility due to increased consumption of imported textile products more than compensated for the decline in utility due to decreased domestic consumption.

The output levels in the protected industries in the two regimes is shown in Table 6.9a. The table shows that the output levels in three textile industries increased whereas they declined in the remaining seven when we moved to freer trade. The percentage differences

in Table 6.9 are measures of the cost burden associated with protection in all textiles compared to only one of them. The three industries in which output increased are the three industries in which the cost effects are highest. A move to freer trade relieves these industries of the high cost loads leading to increases in output. In these industries, the cost effect dominates the output effect. Two of the three industries -- the carpet,mat and rug industry, and the miscellaneous textile industry -- are industries at later stages of processing. Thus in general, a textile industry at a later stage of processing tends to expand if it is the only one protected. In the industries in which output contracted, the output effect dominates the cost effect even though Table 6.9 shows them to have some cost relief from movement to freer trade. Three of the four industries in which output declined most -- textile dyeing and finishing, cotton yarn and cloth mills, and wool yarn and cloth mills -- are industries at early stages of processing. These industries ship a large proportion of their outputs to intermediate users. If such an industry is the only one protected, the other industries (which are no longer receiving protection) cut down on their outputs, thus they buy less from this protected industry leading to a decline in its output. In these industries,

TABLE 6.9

TARIFF EQUIVALENTS FOR PROTECTION IN ALL TEXTILE INDUSTRIES VERSUS PROTECTION IN EACH TEXTILE INDUSTRY ALONE

Industry	Name	Protection Alone	Protection in all textiles	% Difference
1	Cotton yarn and cloth mills	0.18455	0.18617	0.878
2	Wool yarn and cloth mills	0.14338	0.14514	1.228
6	Cordage and twine industry	0.05163	0.05360	3.816
9	Carpet, mat and rug industry	0.10495	0.10677	1.734
10	Textile dyeing and finishing	0.22108	0.22265	0.710
11	Canvas products industry	0.16814	0.16990	1.047
13	Miscellaneous textile industry	0.04002	0.04189	4.673
14	Hosiery mills	0.20914	0.21078	0.784
15	Other knitting mills	0.24069	0.24198	0.536
16	Clothing industries	0.20364	0.20423	0.290

TABLE 6.9a

OUTPUT LEVELS WHEN PROTECTION IS IN ONE INDUSTRY VERSUS OUTPUT LEVELS WHEN PROTECTION IS IN ALL TEXTILE INDUSTRIES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Protection in all textiles	Protectio alone	% difference
1	Cotton yarn and cloth mills	595.86	593.56	-0.386
2	Wool yarn and cloth mills	225.40	224.67	-0.324
6	Cordage and twine industry	27.22	27.24	0.073
9	Carpet, mat and rug industry	549.62	549.66	0.007
10	Textile dyeing and finishing	124.49	123.71	-0.627
11	Canvas products industry	81.26	81.23	-0.037
13	Miscellaneous textile industry	1,081.82	1,082.99	0.108
14	Hosiery mills	156.34	156.19	-0.096
15	Other knitting mills	668.37	666.08	-0.343
16	Clothing industries	3,715.41	3,714.15	-0.034

therefore, the output effect dominates the cost effect (associated with buying cheaply from unprotected industries). Thus in general, a textile industry at an early stage of processing tends to contract output if it is the only one protected.

This section has shown that while there is antiprotection in the textile sector, a move to freer trade will not necessarily increase output if the output effect is very strong. The results also show that while, in general, a textile industry at a later stage of processing tends to expand if it is the only one protected and an industry at an early stage of processing tends to contract if it is the only one protected, this trend could be reversed depending on whether the output or cost effect dominates. These conclusions are very interesting and emphasize the importance of obtaining results from a computable general equilibrium model.

6.6 Subsidy on Textiles

As is well known, free trade is better than protection as far as utility or welfare of individuals is concerned. But as has been shown in section 6.3, a tariff policy generates more output and consumption of domestic textiles than does sectoral free trade. In the same vein the following question can be posed: How does a tariff

policy differ from other forms of protective measures? If a choice can be made from a variety of protective policies, which policy would create greatest output and employment for the Canadian textile industries. In this regard, a tariff policy will be compared with a uniform output subsidy and a uniform labour subsidy. The results under the output subsidy are shown in Tables 6.10 to 6.12 and those under the labour subsidy are shown in Tables 6.13 to 6.15.

To obtain the results in tables 6.10 to 6.12, equation (4.13) was replaced by equation (6.1) and equation (6.3) was added:

$$\sum_{i=1}^{16} x_i \geq \bar{X} \qquad (6.3)$$

where $\bar{X}$ is the total output in all textiles in the simulated base year 1979. Constraint (6.3) states that the total output in all textiles must be at least as great as the simulated base year value. To show that (6.3) can be interpreted as a uniform output subsidy, we add

$\S\left(\sum_{i=1}^{16} x_i - \bar{X}\right)$ to equation (4.22) and apply the Kuhn-Tucker conditions. We obtain (instead of equation (4.25a)):

$$\S + \psi_j + \lambda_{cj}(\psi_j - \varepsilon) \leq \sum_{i=1}^{21} a_{ij}\psi_i + \varepsilon\lambda_{Nj}$$

$$+ \delta_j f_j + \omega b_j + \beta t_j \qquad (6.4)$$

(recall that $\lambda_{cj} = 0$ for textiles), which states that the total cost of producing commodity j must be at least as great as the price plus the subsidy per unit of output in textiles. Thus § is the per unit output subsidy on textiles.

To obtain the results in Tables 6.13 to 6.15, equation (4.13) was replaced by equation (6.1) and equation (6.5) was added:

$$\sum_{i=1}^{16} b_i x_i \geq \bar{L} \qquad (6.5)$$

where $\bar{L}$ is the total amount of labour in all textiles in the simulated base year 1979. Constraint (6.5) states that the total amount of labour in all textiles be at least as great as the simulated base year value. To show that the dual variable associated with (6.5) can be interpreted as a uniform labour subsidy, we add $\rho(\sum_{i=1}^{16} b_i x_i - \bar{L})$ to equation (4.22) and apply the Kuhn-Tucker conditions. We obtain (instead of equation (4.25a)):

$$\psi_j + \lambda_{cj}(\psi_j - \varepsilon) \leq \sum_{i=1}^{16} a_{ij}\psi_i + \varepsilon\lambda_{Nj}$$

$$+ \delta_j f_j - (\omega - \rho)b_j + \beta t_j \qquad (6.6)$$

As in (6.4), ρ in (6.6) can be interpreted as the subsidy per unit of labour. The output subsidy § in (6.4) was found to be 0.00829 and the labour subsidy ρ was found to be 0.02846.

Table 6.10 shows the output (and employment) levels under the output subsidy regime. It can be seen that compared to the tariff regime, no generalization can be made with respect to the behaviour of the textile industries. Fourteen of the textile industries showed increases in output and employment whereas the remaining two showed decreases even though some of the changes are small. Output and employment declined in the canvas products industry and the other knitting mills industry. Of the aggregated industries, while output and employment declined in the construction and domestic industries, they increased in the machinery, exporting and importing industries.

Table 6.11 shows the consumption levels and their changes from the tariff regime levels. Apart from the fibre preparing mills and cotton and jute bag industry in which consumption fell to its lower bound,

consumption in some textile industries increased and some decreased. Consumption in all the aggregated industries declined. Table 6.12 shows that import levels were all higher under the uniform output subsidy than under tariffs. Utility increased by about 0.2% which is 200 million 1979 dollars.

Tables 6.13 to 6.15 show the results under a uniform labour subsidy as epitomized by equations (6.5) and (6.6). As in the case of output subsidy, no generalization can be made. Table 6.13 shows that whereas output and employment in three textile industries declined, those in the remaining thirteen increased. The behaviour of the aggregated industries with respect to output and employment are identical to the results under output subsidy. Just as under the output subsidy, consumption declined in some industries and increased in others. Utility and imports were all higher under labour subsidy as compared with the tariff regime. The difference between the results under output and labour subsidies is that apart from the fact that the magnitudes of the changes from the tariff regime levels are different, in the carpet, mat and rug industry, the output and consumption changes are reversed, that is whereas under the uniform output subsidy, output and consumption

increased in this industry, they declined under labour subsidy even though the percentage changes are small in both cases.

Thus if the 1979 tariffs on textiles were replaced by a uniform output subsidy of 0.00829, total output in all textiles would remain unchanged. However, there would be redistribution with some industries expanding output and employment and others contracting. Imports of all textile products and utility would increase under the new regime. Similarly, if the 1979 tariffs were replaced by a uniform labour subsidy of 0.02846, some industries would expand output and employment while others would contract. Again imports of textile products and utility would increase.

The modern literature on distortions (see Chacholiades (1978), ch. 17) suggests that tariffs distort both the consumption and production patterns whereas subsidies distort only the production pattern. Our empirical results confirm what is expected by the distortions literature. The Haberler (1936, p. 212) conjecture that "duties are the most important and most rational weaponsof trade policy", does not stand up under modern analysis.

TABLE 6.10

OUTPUT LEVELS UNDER UNIFORM OUTPUT SUBSIDY ON TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Output level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	596.09	0.04
2	Wool yarn and cotton mills	225.47	0.03
3	Synthetic textile mills	1,235.56	0.05
4	Fibre preparing mills	27.29	0.04
5	Thread mills	46.44	0.09
6	Cordage and twine industry	27.24	0.07
7	Narrow fabric mills	66.79	0.1
8	Pressed and punched felt mills	30.69	0.2
9	Carpet, mat and rug industry	550.05	0.08
10	Textile dyeing and finishing	124.52	0.02
11	Canvas products industry	81.02	-0.3
12	Cotton and jute bag industry	54.35	0.06
13	Miscellaneous textile industry	1,082.26	0.04
14	Hosiery mills	156.49	0.1
15	Other knitting mills	664.51	-0.6
16	Clothing industries	3,717.28	0.05
17	Machinery industry	7,476.99	0.08
18	Construction industry	45,408.25	-0.01
19	Exporting industry	122,838.85	0.1
20	Importing industry	103,353.68	0.04
21	Domestic industry	165,353.74	-0.1

TABLE 6.11

CONSUMPTION LEVELS UNDER UNIFORM OUTPUT SUBSIDY ON TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Consumption Level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	148.32	0.2
2	Wool yarn and cotton mills	33.49	-0.2
3	Synthetic textile mills	146.81	0.4
4	Fibre preparing mills	10.00	(a)
5	Thread mills	13.00	0.5
6	Cordage and twine industry	2.29	-1.7
7	Narrow Fabric mills	37.05	0.4
8	Pressed and punched felt mills	10.98	0.6
9	Carpet, mat and rug industry	202.14	0.1
10	Textile dyeing and finishing	16.83	0.2
11	Canvas products industry	23.72	-1.1
12	Cotton and jute bag industry	10.00	(a)
13	Miscellaneous textile industry	47.31	-4.1
14	Hosiery mills	142.45	0.1
15	Other knitting mills	354.79	-1.2
16	Clothing industries	3,048.08	0.03
17	Machinery industry	668.01	-0.2
18	Construction industry	107.97	-0.2
19	Exporting industry	23,575.45	-0.3
20	Importing Industry	24,892.36	-0.2
21	Domestic industry	80,759.25	-0.2

(a) at lower bound

TABLE 6.12

IMPORT LEVELS UNDER UNIFORM OUTPUT SUBSIDY ON TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Import level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	10.26	23.9
2	Wool yarn and cloth mills	12.98	17.7
6	Cordage and twine industry	6.75	5.6
9	Carpet, mat and rug industry	144.00	12.3
10	Textile dyeing and finishing	2.82	30.0
11	Canvas products industry	24.27	21.2
13	Miscellaneous textile industry	528.43	4.3
14	Hosiery mills	44.29	27.8
15	Other knitting mills	280.81	33.3
16	Clothing industries	1,140.43	26.7

TABLE 6.13

OUTPUT LEVELS UNDER UNIFORM LABOUR SUBISDY ON TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Output Level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	595.98	0.02
2	Wool yarn and cotton mills	225.48	0.04
3	Synthetic textile mills	1,235.26	0.03
4	Fibre preparing mills	27.29	0.04
5	Thread mills	46.43	0.06
6	Cordage and twine industry	27.24	0.07
7	Narrow Fabric mills	66.81	0.2
8	Pressed and punched felt mills	30.69	0.2
9	Carpet, mat and rug industry	549.36	-0.05
10	Textile dyeing and finishing	124.54	0.04
11	Canvas products industry	81.03	-0.3
12	Cotton and jute bad industry	54.35	0.06
13	Miscellaneous textile industry	1,082.22	0.04
14	Hosiery mills	156.58	0.2
15	Other knitting mills	664.30	-0.6
16	Clothing industries	3,718.14	0.07
17	Machinery industry	7,476.99	0.08
18	Construction industry	45,408.26	-0.01
19	Exporting industry	122,838.55	0.1
20	Importing industry	103,353.41	0.04
21	Domestic industry	165,354.13	-0.1

TABLE 6.14

CONSUMPTION LEVELS UNDER UNIFORM LABOUR SUBSIDY ON TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Consumption Level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	148.14	0.1
2	Wool yarn and cotton mills	33.50	-0.2
3	Synthetic textile mills	146.61	0.3
4	Fibre preparing mills	10.00	(a)
5	Thread mills	12.98	0.3
6	Cordage and twine industry	2.29	-1.7
7	Narrow fabric mills	37.08	0.5
8	Pressed and punched felt mills	10.98	0.6
9	Carpet, mat and rug industry	201.46	-0.3
10	Textile dyeing and finishing	16.84	0.2
11	Canvas products industry	23.73	-1.0
12	Cotton and jute bag industry	10.00	(a)
13	Miscellaneous textile industry	47.24	-4.3
14	Hosiery mills	142.45	0.2
15	Other knitting mills	354.52	-1.3
16	Clothing industry	3,048.92	0.06
17	Machinery industry	668.01	-0.2
18	Construction industry	107.96	-0.2
19	Exporting industry	23,575.45	-0.3
20	Importing industry	24,892.26	-0.2
21	Domestic industry	80,759.73	-0.2

(a) at lower bound

TABLE 6.15

IMPORT LEVELS UNDER UNIFORM LABOUR SUBSIDY ON TEXTILES (MILLIONS OF 1979 DOLLARS)

Industry	Name	Import level	% deviation from tariff regime level
1	Cotton yarn and cloth mills	10.26	23.9
2	Wool yarn and cloth mills	12.98	17.7
6	Cordage and twine industry	6.75	5.6
9	Carpet, mat and rug industry	144.06	12.3
10	Textile dyeing and finishing	2.82	30.0
11	Canvas products industry	24.27	21.2
13	Miscellaneous textile industry	528.46	4.3
14	Hosiery mills	44.29	27.8
15	Other knitting mills	280.84	33.3
16	Clothing industries	1,140.37	26.7

However, it should be noted that output and employment in certain textile industries fell under the subsidy regimes. Thus if employment in these specific industries is a policy objective tariffs might be preferable.

Thus, apart from the question of ease of application, one cannot state categorically that either tariffs or subsidies are preferable as a means of protection. Each case must be studied separately and judged on its own merit.

6.7 Summary and Conclusions

This dissertation has studied the Canadian textile sector focussing on the structure of the industry, its institutional background, its past, present and future states, but more importantly, building a computable model capable of analyzing the sensitivity of the industries to some trade policy barriers. It was established that an adequate model for such a study should have significant disaggregation of the sector to be able to incorporate the interrelationships between the industries. It should also incorporate

the imperfect substitutability in consumption between domestically produced textiles and imported textiles, incorporate the almost universally accepted micro-economic assumption of convex indifference curves and should be able to incorporate some non-tariff barriers.

In this regard, a nonlinear programming, general equilibrium international trade model of the sector has been constructed. The textile sector was disaggregated into sixteen industries and the remaining sectors of the economy classified into one of five industries -- machinery, construction, exporting, importing or domestic.

Of particular importance in the formulation of the objective function was according the dual role of incorporating the assumption of convex indifference curves (an assumption which has been conspicuously missing in the traditional linear programming approach) and allowing for imperfect substitutability between domestically produced textiles and imported textiles. The objective function therefore took the form of a constant elasticity of substitution (CES) form nested in a Cobb-Douglas form. All the primal constraints were specified to be linear. It has been shown that

the dual constraints, obtained by the application of the Kuhn-Tucker conditions, make economic sense and are in fact, the conditions that would emerge in a market economy in long-run competitive equilibrium. Altogether the model was made up of twenty-one industries, sixty-five constraints and one hundred and twenty-two activities.

The model was solved using a package called MINOS (a modular in-core nonlinear optimization system). Credibility can be given to the model in the sense that despite its complexity and numerous assumptions, the endogenous variables yielded by the model when all the observed tariff levels were in effect (the reference case) were quite close to the actual observed 1979 values. Of the twenty-one output (and employment) values, fourteen of them differ from their actual 1979 values by less than 5%, six are between 5% and 10% and only one differs from its actual value by 12%. All the consumption levels yielded by the model differ from their actual values by less than 4%. All the import figures differ from their actual values by less than 3%. It was our judgement that these figures are close enough for the purposes of this study.

On the equivalence of tariffs and quotas, the results confirmed Bhagwati's concept of equivalence, that is, under a quota regime, the dual variables generated can be taken as tariffs (for all practical purposes) levied instead of the quota and under a tariff regime, the import levels can be imposed as quotas instead of the tariffs. Thus, Bhagwati's definition of equivalence applies not only to partial equilibrium models but can apply to general equilibrium ones if the appropriate conditions are satisfied. The results confirm an important generalization to Bhagwati's concept, that is, a set of quotas can be imposed on a set of industries (rather than imposing them one at a time) and the dual variables as a set can be considered as equivalent (in Bhagwati's sense) to a set of quotas. The model also provides a practical means of computing tariff equivalents.

The adjustment of the textile industries to a situation of sectoral free trade agrees with the popularly held view that should the protection in the industries be removed, imports would pour in, leading to decline in output and employment in the textile sector. The results show that the hardest hit industries in the adjustment process are the clothing and knitting mill

industries. The adjustment process was also accompanied by an expansion of both the import-competing and exporting industries. Utility was higher under sectoral free trade.

With regard to the question of whether protection in all textiles reduces or augments protection in each alone, the results showed that each textile industry incurs indirect cost from protection in all textiles, that is, there is antiprotection in the industries. This result agrees with the view expressed by such writers as Williams (1978). The results also show that, in most cases, a textile industry at a later stage of processing tends to expand if it is the only one protected and an industry at an early stage of processing tends to contract if it is the only one protected.

With reference to tariffs and subsidies, the results showed that one cannot categorically say that one means of protection is generally preferable to the other. The replacement of the 1979 tariffs on textiles by a uniform output subsidy of 0.01894 would keep total output in textiles unchanged; however, some industries would expand output while others would contract.

Similarly, under a uniform labour subsidy, some textile industries would expand while others would contract. The result that utility increased under either output or labour subsidy conforms with the modern literature on distortions. We have shown that effects of trade distortions can be computed numerically and that the utility losses or gains from following alternative policies are likely to be quite small.

APPENDIX

TABLE 1. Textile and Clothing Industries

Aggregated Industry	Input-Output Code	Name
1	04300	Cotton Yarn and Cloth Mills
2	04400	Wool Yarn and Cloth Mills
3	04500	Synthetic Textile Mills
4	04600	Fibre Preparing Mills
5	04700	Thread Mills
6	04800	Cordage and Twine Industry
7	04900	Narrow Fabric Mills
8	05000	Pressed and Punched Felt Mills
9	05100	Carpet, Mat and Rug Industry
10	05200	Textile Dyeing and Finishing
11	05300	Canvas Products Industry
12	05400	Cotton and Jute Bag Industry
13	05500	Miscellaneous Textile Industry
14	05600	Hosiery Mills
15	05700	Other Knitting Mills
16	05800	Clothing Industries

TABLE 2. The Machinery Industry (17)

Input-Output Code	Name
09200	Agriculture Implement Industry
09300	Miscellaneous Machinery and Equipment Manufacturers
09400	Commercial Refrigeration and Air-Conditioning Manufacturers
09500	Office and Store Machinery Manufacturers

TABLE 3. The Construction Industry (18)

Input-Output Code	Name
13800	Repair Construction
13900	Residential Construction
14000	Non-Residential Construction
14100	Road Highway Airstrip Construction
14200	Gas and Oil Facility Construction
14300	Dams and Irrigation Projects
14400	Railway Telephone Telegraph Construction
14500	Other Engineering Construction
14600	Construction Other Activities

TABLE 4. The Exporting Industry (19)

Input-Output Code	Name
00100	Agriculture
00300	Fishing, Hunting and Trapping
00400	Gold Mines
00500	Uranium Mines
00600	Iron Mines
00700	Base Metal and Other Metal Mines
00900	Petroleum and Gas Wells
01000	Asbestos Mines
01100	Gypsum Mines
01300	Other Non-Metal Mines
01600	Slaughtering and Meat Processors
01800	Dairy Factories
01900	Fish Products Industry
02100	Feed Manufacturers
02200	Flour and Breakfast Cereals Industry
03000	Distilleries
03300	Leaf Tobacco Processing
05900	Sawmills
06000	Veneer and Plywood Mills
06100	Sash and Door and Planning Mills
06200	Wooden Box Factories
06400	Miscellaneous Wood Industries
06600	Office Furniture Industry
06800	Electric Lamp and Shade Industry
06900	Pulp and Paper Industry
07000	Asphalt and Related Products
07800	Aluminium Smelting and Refining
07900	Other Smelting and Refining
08100	Copper and Alloy Rolling
08200	Metal Casting and Extruding Nes

...continued

Input-Output Code	Name
09700	Motor Vehicle Manufacturers
10100	Shipbuilding and Repair
10200	Miscellaneous Transport Equipment Industry
10900	Manufacturers of Electric Wire and Cable
11100	Cement Manufacturers
11200	Lime Manufacturers
11300	Concrete Products Manufacturers
12000	Abrasives Manufacturers
12300	Manufacturers of Mixed Fertilizers
18700	Transportation Margins

TABLE 5. The Importing Industry (20)

Input-Output Code	Name
00800	Coal Mines
02100	Salt Mines
01400	Quarries and Sand Pits
02000	Fruit and Vegetable Processing
02300	Biscuits Manufacturers
02500	Confectionery Manufacturers
02700	Vegetable Oil Mills
02800	Miscellaneous Food Industries
03200	Wineries
03500	Rubber and Footwear Manufacturers
03600	Tire and Tube Manufacturers
03700	Other Rubber Industries
03800	Plastic Fabricators, Nes
03900	Leather Tanneries
04000	Shoe Factories
04100	Leather Glove Factories
04200	Small Leather Goods Manufacturers
06500	Household Furniture Industry
06700	Other Furniture Industries
07100	Paper Box and Bag Manufacturers
07200	Other Paper Converters
07300	Printing and Publishing
07400	Engraving, Stereotyping Industry
07500	Iron and Steel Industry
07600	Steel Pipe and Tube Mills
07700	Iron Foundries

...continued

Input-Output Code	Name
08000	Aluminium Rolling and Extruding
08300	Boiler and Plate Works
08400	Fabricated Structure Metal Industry
08500	Ornamental and Arch. Metal Industry
08600	Metal Stamp. Press. and Coat. Industry
08700	Wire and Wire Products Manufacturers
08800	Hardware Tool and Cutlery Manufacturers
08900	Heating Equipment Manufacturers
09000	Machine Shops
09100	Miscellaneous Metal Fabricating Industry
09600	Aircraft and Parts Manufacturers
09800	Truck Body and Trailer Manufacturers
09900	Motor Vehicle Parts and Accessories Manufacturers
10000	Railway Rolling Stock Industry
10300	Small Electrical Appliances
10400	Major Appliances Electrical and Non-Electrical
10500	Radio and Television Receivers
10600	Communications Equipment Manufacturers
10700	Manufacturers of Elect. and Ind. Equipment
10800	Battery Manufacturers
11000	Manufacturers of Miscellaneous Electrical Products
11500	Clay Products Manufacturers
11600	Refractories Manufacturers
11700	Stone Products Manufacturers
11800	Other Non-Metallic Products Industries
11900	Glass and Glass Products Manufacturers
12100	Petroleum Refineries
12200	Other Petroleum and Coal Products Industries

...continued

Input-Output Code	Name
12400	Manufacturers of Plastic and Synthetic Res.
12500	Manufacturers of Pharm. and Medicines
12600	Paint and Varnish Manufacturers
12700	Manufacturers of Soap and Cleaning Comp.
13800	Manufacturers of Toilet Preparations
12900	Manufacturers of Industrial Chemicals
13000	Other Chemical Industries
13100	Scientific and Prof. Equipment Manufacturers
13200	Jewelery and Silverware Manufacturers
13300	Broom Brush and Mop Industry
13400	Sporting Goods and Toy Industry
13500	Linoleum and Coated Fabrics Industry
13600	Signs and Displays Industry
13700	Miscellaneous Manufacturing Industries Nes.
14900	Water Transport
15000	Railway Transport
15500	Pipeline Transport
15700	Storage Transport
16400	Wholesale Trade
17600	Professional Services to Business
17700	Advertising Services
18300	Miscellaneous Services to Business and Persons

TABLE 6. The Domestic Industry (21)

Input-Output Code	Name
00200	Forestry
01500	Services Incidental to Mining
01700	Poultry Processors
02400	Bakeries
02600	Sugar Refineries
02900	Soft Drink Manufacturers
02100	Breweries
03400	Tobacco Products Manufacturers
06300	Coffin and Casket Industry
11400	Ready-Mix Concrete Manufacturers
14700	Air Transport
14800	Services Incidental to Transport
15100	Truck Transport
15200	Bus Transport Interurban and Rural
15300	Urban Transport Systems
15400	Taxicab Operations
15600	Highway and Bridge Manitenance
15800	Radio and Telecommunication Broadcasting
15900	Communication Industries, Nes.
16000	Post Office
16100	Electric Power
16200	Gas Distribution
16300	Water and Other Utilities

...continued

Input-Output Code	Name
16500	Retail Trade
16600	Owner Occupied Dwellings
16700	Government Royalties on Natural Resources
16800	Banks and Credit Unions
16900	Insurance
17000	Other Financial Institutions and Real Estate
17100	Education and Related Services
17200	Hospitals
17300	Health Services
17400	Motion Picture Theatres
17500	Other Recreational Services
17800	Laundries and Cleaners
17900	Accommodation and Food Services
18000	Other Personal Services
18100	Photography
18200	Miscellaneous Repair and Maintenance
18400	Operating Supplies
18500	Office Supplies
18600	Cafeteria Requ.
18800	Laboratory Supplies
18900	Travel and Entertainment
19000	Advertising and Promotion
19100	Machinery Repair Services

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