AN INTERNATIONAL TRADE ANALYSIS FOR SELECTED PAPER PRODUCTS

by

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CHAPTER I

INTRODUCTION

1.1 History of Paper

Discovered in 105 A.D. in China, the art of papermaking spread throughout the Middle East and Europe. The art was not established in the United States until late in the thirteenth century although the art had already flourished in Europe by then. By the time of the American Revolution, however, the paper industry was firmly established in the northeastern states of Pennsylvania, New York, Massachusetts, Connecticut, and Maine.

The concentration of paper production in the various producing regions of the world may be attributed to two groups of factors: (a) factors affecting the demand for paper, and (b) factors affecting the supply of paper. The Industrial Revolution brought forth high economic growth and standard of living for many western economies. The establishment of universities not only made the populace literate, hence the increased demand for literature, but in the process of learning, reading material also had to be provided. The surging demand for paper, accompanied by production innovations such as the Fourdrinier and multiple-impression printing, which facilitated the production of paper and of printing, stimulated the search for a new raw material to substitute for the increasingly scarce cotton and linen rags. Due to their early industrialization, and consequently high income levels, Europe and North America have been, and still are, the traditional consuming regions.

Before wood pulp became a major source of raw material in the production of paper, paper mills were centered around metropolitan areas where cotton and linen rags were abundant. But as wood pulp became more popular and cheaper as a source of raw material, paper mills soon followed in the wake of lumber mills. Regions which were leaders, at one time or another, in lumber manufacturing became the principal pulp-producing areas a decade or so later. The popularity of wood pulp as a raw material consequently led to regions naturally endowed with softwood and plentiful water to be the traditional suppliers of paper products. Europe, North American, and the U.S.S.R. have been, and still are, the traditional suppliers.

The fact that Europe and North America are both the biggest producers and largest consumers of paper and paperboard products conceals the fact that substantial intraregional trade takes place within these two continents. Within Europe, the Nordic countries tends to be an excess supply area while the rest of Europe tends to be the excess demand area. Canada tends to be an excess supply area on the North American continent, with the United States an excess demand area. The supply attributes of each region and early industrialization partly explain these tendencies.

1.2 Problematic Situation

Over the last four decades approximately 80 percent or more of the total world production, consumption, and trade of newsprint, other printing and writing paper, and other paper and paperboard has been accounted for by only a few regions, all of which are developed economies. The regions include North America, the European Economic Community (EEC), the Nordic countries, and Japan. In this study, North America consists of Canada and the United States (U.S.); the EEC comprises Belgium-Luxembourg, Denmark, France, the Federal Republic of Germany (West Germany), Ireland, Italy, the Netherlands, and the United Kingdom. The Nordic countries consist of Finland, Norway, and Sweden.

Although these regions still account for a large share of world production, consumption, and trade of paper and paperboard products, there has been a declining trend in their share, albeit the absolute magnitudes have been increasing (see Tables 1.1, 1.2, and 1.3). The decline in the developed countries' share of the world total is due to the growing importance of the less developed countries. Both the share of the world total as well as the absolute volume of production, consumption, and trade of the less developed countries have been trending upward.

In spite of the dominance by a few regions in the world market for paper and paperboard products, no one region is able to exert a significant influence on the prices of these products. Rather, the prices are set by world market conditions. As such, firms engaged in

Table 1.1

Production, Consumption, Imports, and Exports of
Newsprint for Selected Years, By Regions

Regions	1948				1958			
	Production	Consumption	Imports	Exports	Production	Consumption	Imports	Exports
	thousand metric tons							
1. North and Central America	5350	5380	3990	3960	7040	6325	4555	5270
Canada	4210	284	0	3926	5471	315	0	5156
United States	794	4751	3987	30	1556	5880	4430	116
2. Europe	1400	990	260	670	3495	3325	1175	1345
Nordic	764	176	0	588	1258	248	1	1011
EEC	571	732	206	45	1706	2525	1101	192
3. Japan	101	104	3	0	571	561	2	12
Percent of world total	99.0	92.4	89.9	99.8	91.8	84.8	84.8	97.9
World total	6920	7010	4730	4640	12095	12045	6720	6770

Source: Yearbook of Forest Products, FAO, United Nations, various years.

Table 1.1 Continued

1968				1979			
Production	Consumption	Imports	Exports	Production	Consumption	Imports	Exports
- - - - - - - -	- - - - - - - -	- - - - thousand	metric tons - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -
10151	9297	6048	6902	12536	11370	6767	7933
7432	647	0	6785	8756	888	0	7868
2682	8427	5862	117	3685	10175	6552	65
5339	4951	1999	2387	6063	6008	3385	3440
2442	334	0	2108	3382	288	0	3094
2083	3709	1769	143	1745	4550	3020	215
1471	1569	104	6	2566	2528	52	90
87.9	82.5	84.7	95.7	83.5	79.0	84.1	93.2
19300	19213	9626	9713	25345	25187	12137	12295

Table 1.2

Production, Consumption, Imports, and Exports of Printing Paper for Selected Years, By Regions

Regions	1958 Production	1958 Consumption	1958 Imports	1958 Exports	1968 Production	1968 Consumption	1968 Imports	1968 Exports
	thousand metric tons							
1. North and Central America	5460	5415	65	110	10413	10405	268	276
Canada	313	278	8	43	611	487	22	146
United States	5079	5047	34	66	9659	9692	160	127
2. Europe	4080	3685	170	565	8828	8202	1517	2143
Nordic	586	299	0	291	1542	617	19	944
EEC	2606	2637	149	118	5508	6020	1333	821
3. Japan	705	647	0	58	1652	1509	2	145
Percent of world total	89.9	86.9	42.0	99.1	86.7	84.0	71.2	96.4
World total	11395	11215	560	740	24111	23959	2509	2661

Source: Yearbook of Forest Products, FAO, United Nations, various years.

Table 1.2 Continued

1979			
Production	Consumption	Imports	Exports
- - - - -	- - - - -	- - - - -	- - - - -
15617	16064	1264	817
1478	1072	118	524
13684	14451	1051	284
14989	13577	4087	5499
3392	1094	76	2374
8749	10007	3500	2242
3771	3701	38	108
84.3	81.7	81.6	97.5
40796	40812	6608	6592

Table 1.3

Production, Consumption, Imports, and Exports of
Paperboard for Selected Years, By Regions

Regions	1948				1958			
	Production	Consumption	Imports	Exports	Production	Consumption	Imports	Exports
	thousand metric tons							
1. North and Central America	20220	19940	230	510	21509	21319	400	590
Canada	1122	1008	88	202	1349	1358	119	110
United States	19093	18827	141	307	19825	19503	158	480
2. Europe	4840	4356	630	1120	11075	10745	1755	2085
Nordic	1383	591	12	804	2056	772	28	1314
EEC	3027	3356	569	240	6746	7730	1549	565
3. Japan	327	326	3	4	1714	1682	3	35
Percent of world total	98.0	96.4	72.5	97.3	87.4	85.6	73.3	97.8
World total	25910	25420	1190	1680	39260	39435	2945	2770

Source: Yearbook of Forest Products, FAO, United Nations, various years.

Table 1.3 Continued

1968				1979			
Production	Consumption	Imports	Exports	Production	Consumption	Imports	Exports
- - - - - - -	- - - - - - -	- - - - - - -	thousand	metric tons	- - - - - - -	- - - - - - -	- - - - - - -
34799	35109	673	2363	44913	42543	1152	3522
2354	2119	149	384	3555	2723	201	1033
31777	29896	95	1976	40196	38162	429	2463
20056	20668	5135	4523	29035	28797	8822	9060
4526	1404	127	3249	6635	1825	276	5086
11002	14297	4237	942	14456	18765	7103	2794
6835	6657	29	207	11524	11494	338	368
86.1	84.2	76.8	94.4	81.7	80.0	79.5	91.9
71661	71748	7599	7512	104645	103524	12968	14089

the manufacture of these products, especially those in the main producing and consuming regions, not only have to be aware of local market conditions but also global conditions. Policy makers too must be aware of global conditions. This is especially true for policy makers in Canada and the Nordic countries, since the forest industry is one of the biggest, if not the biggest, earners of foreign exchange in these countries. For example, pulp, paper and paperboard products were Canada's major export, valued at approximately $7 billion in 1979 - more than motor vehicle parts and accessories. For the same period, the value of gross production of pulp and paper mills represented 3.6 percent of Canada's GNP.

In contrast to Canada, paper and allied products production represented only 0.8 percent of the United States' GNP for 1979. The meager proportion at the national level, however, does not dwarf the United States' dominance at the global level. Since World War II the United States has been, and still is, the biggest producer and consumer of paper and paperboard products. The United States consumed 10.2 million metric tons of newsprint in 1979, equivalent to 40 percent of the world total. It is also the biggest importer of newsprint in the world. The United States' imports represented 94 percent of the world total in 1979. The United States is also the biggest producer of printing and writing paper; however, most of its production is domestically consumed. More than 40 million metric tons of other paper and paperboard, equivalent to 38 percent of world production, was produced in the United States in 1979. Of this total, 38 million metric tons were used domestically. The United States is also one of the biggest exporting countries of this product category.

There has been a substantial growth in the production of these three products in the United States, as well as in the other major producing countries, since World War II. Obviously, the growth in production at the national level implies a similar growth at the regional levels; however, the growth rates vary across regions and across products (see Table 1.4).

For the purpose of this study, the United States is divided into three regions for each of the products considered here, but the regions are not the same for each product.[1] The South is the biggest producing region in the United States for all three product categories (see Tables 1.5 - 1.7).[2] The South produces about 55 percent of the total United States newsprint production, with the other two regions producing almost an equal share of the residual. The South also produces approximately 57 percent of the United States total production of other paper and paperboard. The share of the United States production of other writing and printing paper by the South has been steadily increasing. In 1972 this region produced about 20 percent of the total U.S. production of

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1. The regional classification for all products is given in Appendix A.

2. For other printing and writing paper the rest of the United States can be renamed the South since the South produces about 90 percent of the total for this region. Henceforth, the rest of the United States will be referred to as the South for other printing and writing paper.

Table 1.4

Production Growth Rates for Newsprint, Printing Paper, and Paperboard for United States, Selected Periods

Product	1948-1979[1]	1968-1979
	----- per cent -----	
Newsprint	68.63	37.40
Printing paper[2]	65.92	41.67
Paperboard	30.21	26.49

1. The mean of the average rates for three periods: 1948-1958, 1958-1968, and 1968-1979 was computed.
2. For this product group, the growth rate was computed as the mean of the average rates for 1958-1968 and 1968-1979.

Table 1.5

Production of Newsprint for the United States for Selected Years, by Regions[1]

Regions	1962	1967	1972	1978
	- - - - - - - - - - short tons - - - - - - - - - -			
North	482272 (22.99)	620543 (24.67)	773588 (22.42)	767041 (21.99)
South	1140953 (54.39)	1304163 (52.70)	1887191 (54.63)	1932305 (55.38)
West	474617 (22.62)	560034 (22.63)	789942 (22.89)	789533 (22.63)

1. Percentage of the United States total is given in parentheses.

Table 1.6

Production of Printing Paper for the United States for Selected Years, by Regions[1]

Regions	1962	1967	1972	1978
	short tons			
Northeast	2994341 (43.09)	3878271 (39.20)	4144355 (33.82)	4990641 (33.29)
North Central	2579319 (37.12)	3030851 (30.64)	3746697 (30.57)	4434489 (29.58)
South	1374704 (19.78)	2983470 (30.16)	4363467 (35.61)	5568309 (37.14)

1. Percentage of the United States total is given in parentheses.

Table 1.7

Production of Paperboard for the United States
for Selected Years, by Regions[1]

Regions	1962	1967	1972	1978
	- - - - - - - - - -	short tons	- - - - - - - - - -	
North	10588104 (37.23)	11421928 (33.22)	10521993 (26.43)	12865888 (28.16)
South	13814680 (48.57)	17583227 (51.15)	23337738 (58.63)	26125910 (57.19)
West	4037192 (14.20)	5373696 (15.63)	5948019 (14.94)	6689942 (14.64)

1. Percentage of the United States total is given in parentheses.

other printing and writing paper but by 1978 it was producing about 37 percent of the total, roughly 6 million short tons. The rise of the South as the major producing region for all three paper product groups is attributed to the expansion of capacity in the South, the use of modern production plants, and the use of pine as a source of raw material. In contrast, the decline of the North as the leading producing region is attributable to the use of old equipment and the lack of investment in new capacity.

1.3 Problem

In spite of the increases in production by all regions, especially the South, the United States continues to rely on foreign sources to supplement its demand for newsprint as well as to absorb its supply of other paper and paperboard. Canada has been and still is the major exporter of newsprint to the United States. Slightly more than 54 percent of total United States' exports of other paper and paperboard go to the EEC and Latin America. This reliance of foreign sources is a manifestation of the international characteristics of the markets for these products.

What lies in the future for the United States paper and paperboard industry remains uncertain. The growing importance of the southern region and the nation's continued reliance on trade for a significant proportion of its domestic needs is of concern to the industry and the nation. The probable consequences of past and potential changes in the sources of supply of and the markets for newsprint, other printing and writing paper, and other paper and paperboard are valuable information to both the private and public sectors of the industry. An economic analysis of the United States markets for these products in this period of uncertainty should provide decision makers with relevant and important information. However, an economic analysis of the United States markets requires not only the analysis of the domestic market but also the international market, the significance of which has been alluded to before. As Sedjo and Radcliffe (42) commented

> "...an assessment of questions of international trade and forest resources, particularly for a country as large and diverse as the United States, requires not only a look at national and international trade, but also a regional assessment in which regions roughly correspond geographically forested areas." p.3, Chapter I.

In the paper and paperboard industry, annual, five-year, and sometimes even ten-year projections of local as well as global market conditions are important information for decision making in current production, shipment, and investment plans. Such information is valuable not only to the private sector but also to the public sector. For example, the U.S. Forest Service which has been delegated by the Congress to manage National Forests,[3] has the responsibility to:[4]

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3. National Forests account for about 23 percent of the total commercial forests lands with the remainder accounted for by private landowners.

4. U.S.D.A., Forest Service, <u>An Assessment of the Forest and Range Land Situation in the United States</u>, review draft, p. XV.

> "...prepare a Renewable Resource Assessment ... the Assessment shall be prepared not later than December 31, 1975, and shall be updated during 1979 and each tenth year thereafter, and shall include but not limited to:
>
> (1) An analysis of present and anticipated uses, demand for, and supply of the renewable resources of forests, range, and other associated lands with the consideration of the international resources situation, and an emphasis of pertinent supply and demand and price relationship trends;..."

In part, this directive was designed to overcome the general lack of interest in the international aspects of the forest economy in contraposition to the growing importance of international trade in forest products. Even the recent 1980 timber assessment model developed by Adams and Haynes (2) for the U.S. Forest Service has largely ignored the international trade aspects, other than to include Canada as a region of the forest economy. While the public sector of the industry is primarily concerned with the management of forest resources at the earlier stages of the marketing channel, namely the supply of the raw material (wood)[5], the private sector is not only interested in the beginning stages but also the later stages of the marketing chain.[6]

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5. Many of the U.S. Forest Service studies have been geared towards ensuring sufficient supply of stumpage to meet projected demand situations.

6. The transformation of the raw material into the final product can be envisaged as one continuous process. The raw material and the transformed products at the different stages of this process are hauled by a series of conveyor belts. Consider the production of newsprint. Initially groundwood is conveyed to a pulping machine; the resulting pulp in turn is conveyed to another machine which transforms it into newsprint. The preservation of this continuity in production is of such importance that many of the larger firms are vertically integrated.

Forecasts of future demand for their products are, therefore, important information in assisting private firms to decide on plant location and also market penetration.

In the past, forecast of future demand for paper and paperboard products was based not on price but on other variables of which the two most commonly used were per capita income and population. In the present section only the main findings of past studies will be presented; a detailed literature review will be presented in a later chapter. The common conclusion of studies in the early sixties was that the demand for paper and paperboard was insensitive to price. Not until the mid-seventies was there evidence to support that demand for these products responded to price. Even when the estimated price coefficient was significant the price elasticity of demand for these products still proved to be inelastic. The degree of sensitivity of demand to price changes still remains in doubt. A determination of the degree of sensitivity should help clear up some of the doubts, as well as provide a basis for projecting future demand.

Similarly, the sensitivity of supply to price changes has also been in doubt. In fact, only a few studies have dealt with this issue. None of the studies on the demand for paper and paperboard products considered the interdependence of supply and demand. As a result, the determination of the sensitivity of supply to price would also be important information. This information would be useful for the projection of future supplies. The literature review on the supply function will be presented in a later chapter.

1.4 Hypothesis and Objectives

This dissertation will address the problems alluded to in the preceding section. Specifically, the dissertation is an attempt to test the following hypothesis for newsprint, other printing and writing paper, and other paper and paperboard in each of these regions - the United States, Canada, Japan, the European Economic Community, and the Nordic countries:

1. If producers in a particular region respond to the influence of economic factors, the variations in the quantity supplied of each product in that region will be explained by variations in the price of that product and the cost of inputs;
2. If consumers in a particular region respond to the influence of economic factors, the variations in the quantity consumed of each product in that region will be explained by variations in the price of the product, the prices of its substitutes, and income;
3. If producers in each region attempt to maximize their average net return from the sale of their product to all consuming regions and consumers in each region attempt to minimize the average net cost of their purchases from all producing regions, then the difference between the simulated regional trade flow and the actual flow will be relatively small; and
4. Changes in transportation costs and in the level of any of the factors explaining regional supply and regional demand will result in a different set of regional prices, production, consumption, and trade flow, if the preceding hypotheses are valid.

Corresponding to the hypotheses presented in the preceding section the objectives of the dissertation may be listed as follows:

1. To estimate the supply function of each product in each of the producing regions;
2. To estimate the demand function of each product in each of the consuming regions;
3. To construct a model, using the above supply and demand functions, capable of simulating the historical market behavior;
4. To compare the simulated and actual market behavior; and
5. To project the regional prices, production, consumption, and trade flow under alternative assumptions of future economic conditions.

1.5 General Procedure

The selection of the variables to be included in the supply and demand functions will be based on economic theory and the inherent characteristics of the products themselves as well as the characteristics of the market for these products. Once these functions have been fully specified, they will be estimated on the basis of statistical theory and econometric techniques. The resulting estimated equations will be incorporated into a market allocation algorithm. In particular, the reactive programming algorithm will be used to determine the regional prices, production, consumption, and trade flows. The same program will be used to trace the effects of various alternative paths of future economic growth on the regional magnitudes.

1.6 Thesis Organization

The literature review will be interspersed in the chapters in which they are most appropriate and relevant. The following chapter presents the theoretical framework of the spatial equilibrium problem. Chapter III describes the specification of the supply and demand relationships. The scope of the study and the final estimates of the supply and demand relationships of each product for all of the producing and consuming regions are presented in Chapter IV. Chapter V presents a literature review on the demand for and supply of paper products. A graphical representation and the mathematical formulation of the reactive program is presented in that chapter. The method of incorporating the estimated demand and supply function in the reactive programming algorithm is presented in the next chapter. Chapter VI also includes a description of the transportation data, a way of incorporating ad valorem tariffs into the analysis, and a comparison between the actual and simulated market behavior. The projections of regional prices, production, consumption, and trade flow is presented in Chapter VII. Finally the last chapter, Chapter VIII, presents the summary and conclusions of the dissertation.

CHAPTER II

ANALYTICAL FRAMEWORK

2.1 The Generalized Spatial Problem

The determination of the equilibrium price, as well as the production, consumption, and trade flow, among spatially separated markets, which is the problem at hand, has an ancient history.

> "...The first explicit statement that competitive market price is determined by the intersection of supply and demand functions seems to have been given by A. A. Cournot in 1838 in connection, curiously enough, with the more complicated problem of price relations between two spatially separate markets - such as Liverpool and New York."[1]

The formulation of a general theory of location and space, however, had a much more antiquated antecedence.

Following Ricardo's exposition of the theory of comparative advantage, the construction of a general theory of location and space had been the major undertaking of many economic theorists. These endeavors resulted in the general equilibrium theory as expounded by Walras, Pareto, Cassel, and Wicksell and their modern counterparts

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1. Samuelson, Paul A., "Spatial Price Equilibrium and Linear Programming," American Economic Review, 42 (3), 1952, p. 283.

Hicks, Mosak, Lange, Samuelson, Arrow, and Debreu.[2] However, the theory elaborated by these economists did not incorporate space within its framework. The incorporation of space within a generalized theory emerged in the works of the location theorists such as Thunen, Weber, Palander, Hoover, Loesch, Dunn, and Isard, and the international trade theorists such as Yntema, Ohlin, Mosak, Graham, Samuelson, and Kemp.[3] Even though these economists were successful in developing a fully specified conceptual framework, an operational model was not available.

It was not until the development of mathematical programming in the late 1940's and early 1950's by Koopmans, Dantzig, and others that an operational model became possible. Building upon their work, Samuelson showed how the general non-normative problem of partial equilibrium among spatially separated markets, as formulated by Enke, could be converted into an extremum problem. In addition, he showed that the problem of interconnected competitive markets contained within it the Koopmans minimum transportation cost problem.

Since many of the empirical studies on the spatial equilibrium problem that followed were based on Samuelson's conceptualization of the problem, a summary of his work is presented in the next section. In the last section the various attempts of operationalizing Samuelson's concept is presented.

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2. Takayama, Takashi and George G. Judge, Spatial and Temporal Price and Allocation Models, Amsterdam: North-Holland Publishing Co., 1971, p. 2.

3. Ibid.

2.2 Samuelson's Welfare Maximization

Samuelson's insightful contribution to the spatial problem was in extending the applications of the original Koopmans/Dantzig model on activity analysis. Whereas the latter assumed fixed regional supplies and demands Samuelson, instead, assumed them to be variable functions which would adjust interregional shipments in such a way as to maximize economic welfare.[4]

Samuelson, the genius that he is, conceived of the solution to the determination of the equilibirum price for spatially separated markets in terms of a concept that can be likened to consumer surplus. In the vein of Adam Smith's 'invisible hands' -- with "...innumerable atomistic competitors operate in the background, pursuing their private interests and taking no account of any centralized magnitude that is to be maximized,"[5] -- a single spatial equilibrium price is determined. For continuous, smooth, and positively sloped supply and negatively sloped demand curves, this equilibrium should be stable. This should be so since, intuitively, arbitragers can be expected to enter the market should costly cross-haulages prevail.

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4. Boyd, Roy G., The Effects of U.S. Domestic Shipping Regulations on the North American Lumber Market, unpublished Ph.D dissertation, Duke University, 1981.

5. Samuelson (38), p.285.

To avoid the ambiguity that is attached to the notion of consumer surplus, Samuelson terms his measure of welfare as the "social pay-off" of the region which he defines as "the algebraic area under its excess demand curve."[6] Thus far, the price mechanics have been decentralized. However, the same price determination can be envisioned as being centrally determined if an objective function is being maximized. In particular, the spatial equilibrium magnitudes can be obtained by maximizing the net social pay-off, which Samuelson defined as the sum of the social pay-offs of all the regions minus the total cost of transportation.

The maximization problem is best elucidated for the simple one-product two-region case. The problem can be solved graphically using the back-to-back diagram as illustrated in Figure 2.1. The problem is simplified further by assuming linear supply and demand curves. It is also assumed that unit transportation costs are independent of volume and distance. The pretrade equilibrium for Region 1 and Region 2 are represented by A_1 and A_2 respectively. Assume that trade is possible between the two regions and T_{12} is the cost of transporting a unit volume of the homogeneous product from Region 1 to 2. Since the pretrade price in Region 2 is higher than that of Region 1 trade will never flow from Region 2 to 1.

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6. op. cit., p.288.

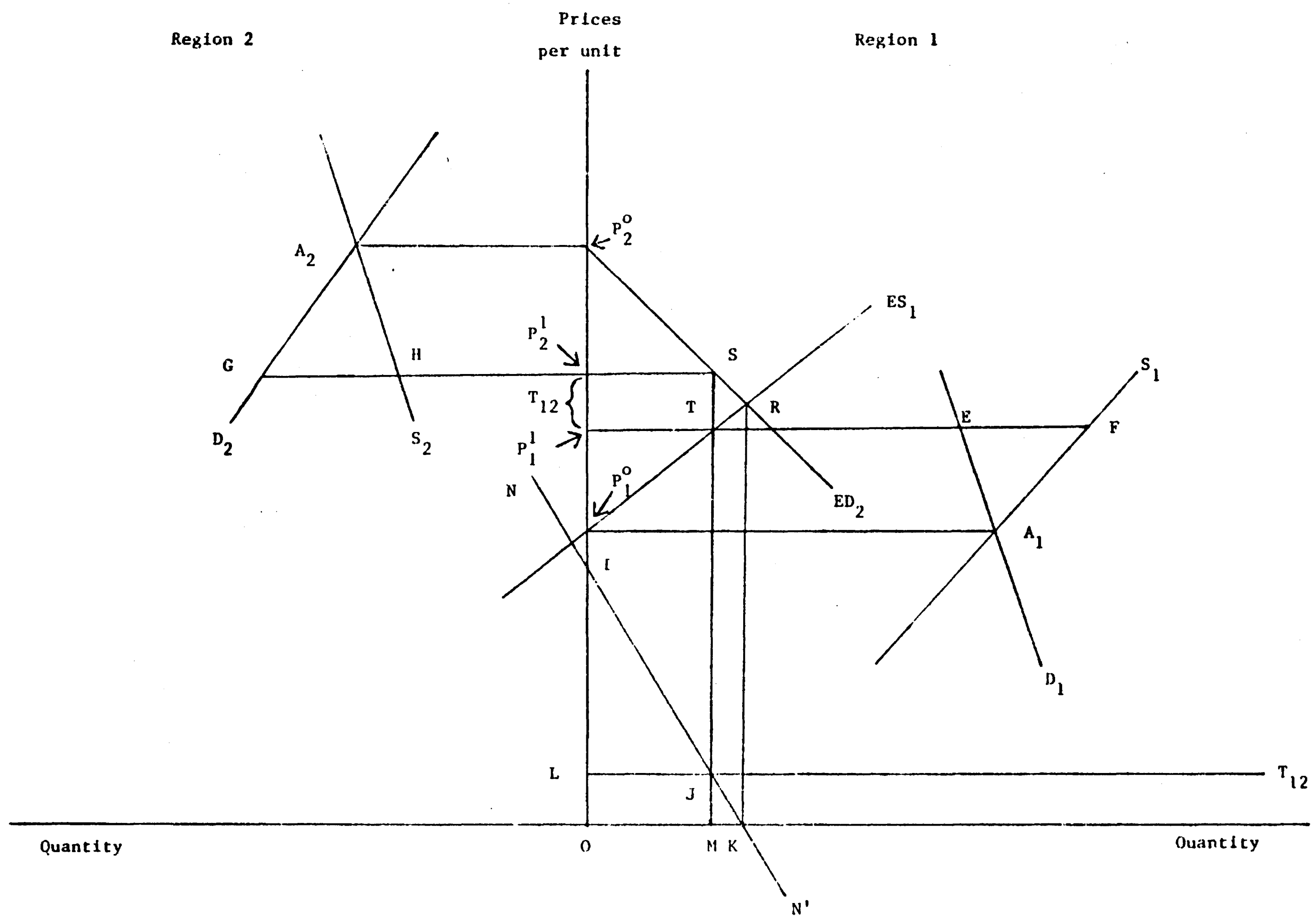

Figure 2.1

Spatial Equilibrium for a Two Region Case

Trade will flow from Region 1 to 2 because the pretrade price differential exceeds the transport costs. The solution to the equilibrium regional prices, production, consumption, and trade flow can be shown in two equivalent ways. One way of obtaining the solution is to look at the excess supply curves of the two regions. The excess supply curve is defined as the horizontal difference between supply and demand at each price. The excess supply curve for Region 1, ES_1, is positively sloped but negatively sloped for Region 2 (since the difference is negative with reference to the left quadrant). Region 2's excess supply curve is also an excess demand curve, ED_2 or the negative of an excess supply curve. The equilibrium is attained at R if transportation costs were zero. Since the transportation cost is positive, the final equilibrium will occur where the vertical difference between ED_2 and ES_1 is precisely T_{12}, or ST in Figure 2.1. Region 1 will produce P_1^1F, of which P_1^1E will be consumed locally, and EF will be exported to Region 2. On the other hand, Region 2 will consume P_2^1G, of which P_2^1H will be supplied locally, with GH imported from Region 1. By construction, GH = EF = $P_2^1S = P_1^1T$. Region 1 will continue to export to Region 2 until the price in Region 2 exceeds the price in Region 1 by exactly the unit transport cost, T_{12}.

Another way of obtaining the same solution is by using the vertical difference between the excess supply curves which is depicted as NN' in Figure 2.1. This curve is obtained by computing the vertical difference (in prices) at each quantity. In essence, the area under this curve measures the combined social pay-offs of regions 1 and 2. Since the social pay-off is defined as the area under the excess demand curve, Region 2's social pay-off is the area under ED_2 (in the right hand quadrant). Region 1's social pay-off, however, is measured as the negative of the area under its excess supply. Therefore, the combined social pay-off of regions 1 and 2 is obtained by subtracting the area under ES_1 from that under ED_2 which yields the area under NN'. The trade equilibrium is obtained at the intersection of NN' and T_{12} at J in Figure 2.1. Since NN' represents the price differential for a given quantity and since the equilibrium will be at a point at which the price differential is exactly equal to T_{12} the equilibrium must be at J. Again, by construction LJ = OM = GH = EF = P_2^1S = P_1^1T. The net socail pay-off, defined as the combined social pay-offs less the total transport cost, is given by the area LIJ which is equal to the area ($P_2^0P_2^1S$ + $P_1^0P_1^1T$) which, in turn, is equal to the area (EA_1F + GA_2H).

The result obtained above can be generalized to n regions. The social pay-off for a region, as in the two region case, is still defined as the negative of the area under the excess supply curve, i.e.,

$$S_i(E_i) = \text{area under the excess demand curve}$$

$$= -\int_0^{E_i} s_i(x)dx$$

where $s_i(E_i) = P_i$ is the excess supply function

and E_i = total exports of region i (to all regions)

The net social pay-off is obtained as the sum of the n separate pay-offs minus the total transport costs of all shipments, i.e.,

$$NSP = \Sigma_i S_i(E_i) - \Sigma_i \Sigma_j t_{ij}(E_{ij})$$

Because $E_i = E_{i1} + \ldots + E_{in}$, this (NSP) is a function of all the E_{ij}'s and when we have found its maximum we have arrived at the final and unique equiliöirum trade pattern.[7]

Smith (44), some ten years after Samuelson's article was published, posed the same Cournot-Enke problem in a different light. Whereas Samuelson's net social pay-off did not have any economic meaning attached to it,[8] Smith posed the extremum problem in terms of economic rent. Smith showed that his economic rent minimization problem is the dual of Samuelson's maximization problem, differing only by a constant term.[9] Whereas Samuelson integrated over the quantity axis to obtain his social pay-off, Smith integrated over the price axis to obtain his economic rent. This suggest the duality nature of the two problems. Smith, in fact, goes on to show and compare his results to that of Samuelson's.[10]

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7. Samuelson (38), p. 292.

8. Other than to admit the natural association between social pay-off and consumer surplus, op cit., p. 287.

9. Smith (44), p. 24.

10. op.cit., pp. 29-30.

2.3 Operationalization of Samuelson's Net Social Pay-off Maximization Problem

Even though Samuelson's seminal paper set up the analytical framework for studying the spatial problem he did not set a specific technique for a solution. The studies that soon followed were specifically directed at operationalizing Samuelson's conceptual problem. It is not difficult to surmise, however, that procedures which resulted from these studies had already been suggested by Samuelson. His suggestion of an iterative procedure can be found in the following passage:[11]

> "...Once the separate pay-off functions are set up as areas or integrals of the excess supply curves and once transport-cost functions are known, a clerk could be given the task of experimentally varying exports so as to achieve a net maximum. He could proceed by trial and error, always moving in a direction that increased the net pay-off, and he would ultimately arrive at the correct equilibrium."

He also suggested a second procedure, namely quadratic programming, of solving the spatial equilibrium problem.[12]

Probably the first study to operationalize Samuelson's conceptual problem was Fox's (12) study, in which a modified quadratic programming algorithm was used, of the livestock feed economy. Using an iterative linear programming procedure, Judge and Wallace (24) studied the beef

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11. Samuelson (38), p. 290.

12. op. cit., p. 290. See his footnote 16 for a general framework of quadratic programming.

marketing sector. They assumed fixed supplies and linear demand functions. On the basis of an initial set of regional prices, which could have been chosen arbitrarily but which were instead chosen on the basis of prevailing market conditions at the time of the study and theoretical considerations, an intitial set of regional demands was established. Once the regional prices and demands were set, the regional trade flow was determined via linear programming (LP) by minimizing transportation costs subject to the linear constraints that: (1) total demand equals total supply, (2) total shipments from the surplus region does not exceed what is available, and (3) total shipments to the deficit regions are met. The dual solution, namely the shadow prices, to the LP problem was then used to determine the regional demands for the next iteration. The iterative procedure was terminated only when the prices obtained from the dual solution in the last iteration was no different from the preceding set of regional prices.

Under the assumption that all supply and demand curves are linear functions of prices the excess supply curves would also be linear functions of prices. Thus, a quadratic function in regional prices will be obtained when the excess supply function is integrated with respect to price in order to obtain the area under the excess supply function. The maximization of a quadratic function subject to a linear constraint constitutes a quadratic programming problem. Maximizing the sum of the social pay-offs -- which are quadratic functions of prices, subject to a linear transportation cost constraint -- therefore, makes up a quadratic programming problem. Takayama and Judge (46) have used quadratic programming exclusively as a solution technique in all of their studies on spatial equilibrium. In their 1964 (46) article they showed formally how Samuelson's conceptual problem could be solved using the quadratic programming procedure. Rather than integrate over quantity, as Samuelson did, their solution was obtained by integrating over price as Smith (44) had done. They further showed how the procedure can be used to solve the spatial equilibrium problem with fixed supply (demand) and linear demand (supply) function, and that of multi-product linear regional demand and supply functions with linear substitution and/or complementary terms.

In spite of the nice mathematical properties of the quadratic programming algorithm it is limited to a quadratic objective function, which implies linear demand and supply functions. However, the solution obtained from this procedure is assured of being global and unique as Takayama and Judge (46) show in their paper. There are other methods of finding the solution to the Samuelson problem. One of these is a market simulating algorithm called reactive programming (RP) procedure.

Tramel and Seale (51), who developed and named the procedure, used reactive programming to study the vegetable market in Mississippi, assuming fixed supplies and linear demand functions. They also explained the mechanics of the procedure and presented an illustrative example. In respond to the criticisms by Takayama and Judge on an earlier paper, Tramel (52) elaborated on the procedure and answered their criticisms point by point. Only two of these criticisms will be discussed in this study. The first criticism was addressed at the nonconvergence property of the procedure. Tramel's reply to this criticism was simply to note the similarity between the RP process to that of Hildreth's process; since the Hildreth process had been shown to converge so would the RP process. In respond to the other criticism - that an infinite number of iterations would be required to obtain the exact solution -- Tramel showed several short cuts that could be utilized and stated that a level of accuracy could be specified at any desired level such that a solution can be obtained at a reasonable cost of computer time. This was later confirmed by King and Ho (26). A more recent version of the program by King and Gunn (27) is even more efficient than the original version developed by King and Ho.

The reactive programming procedure is a much more generalized method of analyzing spatial equilibrium problems [13] and, thus, this procedure will be adopted for the present study. Unlike quadratic programming, the procedure is not limited to linear regional supply and demand equations. The latest version of the procedure (27) can handle the simple transportation model (that is, with fixed supplies and demands), and the spatial problem with either linear or log-linear supply and demand functions or any combination thereof. In order to highlight the concepts and mechanics of this procedure both a

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13. Tramel (52), p.13 footnote 6.

graphical and a mathematical formulation of this procedure will be presented in a later chapter. The remainder of this section presents the summaries of a few past studies that have used reactive programming to solve the spatial equilibrium problem.

One of the earliest extensions of the basic reactive prgramming approach to the spatial equilibrium problem is the study of the market for winter oranges by Zusman, Melamed, and Katzir (57). They simulated the market behavior for two varieties of winter oranges under alternative trade and tariff arrangements imposed by the EEC on the Mediterranean producing countries. They incorporated demand equations which took account of the substitutability between the two varieties by including the price of the other variety in the demand equation of each variety of winter oranges.[14] This study also contained an elucidation of the general mathematical model of which the reactive program is a special case.

Gemmill's (13) study of the international sugar economy is another extension of the basic reactive programming approach. Besides estimating the supply equations for 67 major producing countries and demand equations for 75 consuming countries Gemmill, also studied the impacts of some thirteen policy alternatives. King and Gunn (27) mentioned that Gemmill encountered convergence problems due to the size

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14. They also emphasized the conditions under which this may be done. Zusman, Melamed, and Katzir (57), pp. 29-30.

(75 x 75) of the problem and the low demand price elasticities for sugar in a number of countries.[15] Convergence was approached more rapidly, however, by assuming semi-logarithmic demand functions.[16]

A more recent application of reactive programming can be found in Boyd's (6) study of the North American lumber market. The study focused on the economic impacts of the Jones Act, which restricts shipping between U.S. ports to American-owned and operated ships, on the North American lumber market. The study also includes a lucid explanation of the mechanics of the reactive programming procedure as explained by both Tramel and Seale (51) and later Tramel (52).

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15. King and Gunn (27), p. 37.

16. loc.cit.

CHAPTER III

SPECIFICATION OF DEMAND AND SUPPLY RELATIONSHIPS

Introduction

The basis of the economic model for specifying the demand and supply and demand relationships is presented in this chapter. A brief literature review of supply and demand relationships for paper products is presented in the first section. In the second section the theoretical foundation of an international model is presented followed by the basis of the economic model developed.

3.1 Literature Review

Some studies of the demand for newsprint have incorporated price while others have not. Only those studies that have included price as an explanatory variable are discussed in the present section. While some authors, including Muller (32) and Guthrie (14), have specified newsprint demand equations following a dominant-firm price leadership model, Schaefer (39) has argued that the newsprint industry approximates a competitive structure.[1] Buongiorno (7), Nguyen (34), and McKillop (30)

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1. See Schaefer (39) p. 8.

also assumed a competitive structure. These latter studies, with the exception of McKillop's, were only concerned with estimating demand and did not attempt to estimate the supply equation. McKillop had separated paper and paperboard products into only two categories, namely all papers and all paperboards. Newsprint was grouped with all other papers in his scheme. Nguyen (34), on the other hand, classified paper and paperboard products into either consumer-oriented or industry-oriented products; newsprint was categorized as a consumer-oriented product. He did not specify a newsprint demand equation as he had included newsprint in the groundwood paper group. Schaefer and Buongiorno, however, each estimated a newsprint demand equation. Using pooled annual data for the period 1963-1973 for 43 countries, Buongiorno estimated demand equations for the same three product groups used in the present study. He estimated a static as well as a dynamic demand equation for all three product groups. Initially a demand equation of the general form

$$C_{ijt} = a_j + b_j Y_{it} + c_j P_{ijt} + d_j P'_{ijt} + e_{ijt}$$

where

C_{ijt} = consumption in kilograms of product j per capita in country i in year t

Y_{it} = gross domestic product in US dollars per capita of country i in year t

P_{ijt} = price in US dollars per metric ton of product j in country i in year t

P'_{ijt} = price in US dollars per metric ton of the most direct substitute for product j in country i in year t[2]

e_{ijt} = random term for country i for product j in year t was used. Thus, pooled data was used for estimation purposes. The estimated equations, however, revealed serious positive serial correlation for the static demand equation and a small negative serial correlation for the dynamic equation. The static and dynamic demand equations were reestimated using analysis of covariance whereby a dummy variable was created for each country except one. These estimated equations are reported in Tables 3.1 and 3.2. The equations in Table 3.1 were estimated using ordinary least squares while those in Table 3.2 were estimated by analysis of covariance. Buongiorno also estimated a set of equations by grouping the countries into low and high income countries. These equations are summarized in Table 3.3.

Newsprint is primarily used for the publication of newspapers. About 90 percent of the total is used for this purpose, with the remaining 10 percent used for handbills, comic books, shopping news flyers, and other printing purposes where the permanency of the prints is not required.

The primary considerations affecting the demand for newspapers are the reading habits of the public and the competition of other media such as magazines, television, radio, and billboards for the advertising dollar. A proxy variable for the reading habits of the public is the size and circulation of daily and Sunday newspapers. Newspaper advertising expenditures, although its growth has been less than spectacular when compared to that of television, continues to increase as the economy expands.

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2. Newsprint and other printing and writing paper were considered as substitutes for one another. No substitute was considered for other paper and paperboard, however.

Table 3.1

Buongiorno's Ordinary Least Squares Estimates of the Demand for Paper and Paperboard Products Using Pooled Data

Model and product	Coefficients of independent variables: C_{t-1}	Y_t	P_t	P'_t	Constant	R^2	rho Q	f
Static model								
Newsprint		1.15	-0.75	0.20	-4.15	0.80	0.72	379
		(.03)***	(.16)***	(.12)**			14.0	
Printing and		1.28	-0.47	0.33	-6.69	0.86	0.71	379
writing paper		(.03)***	(.11)***	(.14)**			13.8	
Other paper		1.21	-0.34		-4.15	0.80	0.88	416
and paperboard		(.03)***	(.09)***				18.2	
Dynamic model								
Newsprint	0.82	0.23	-0.31	0.14	-0.67	0.93	-0.14	378
	(.03)***	(.04)***	(.09)***	(.07)**			2.8	
Printing and	0.89	0.15	-0.12	0.06	-0.48	0.97	-0.17	378
writing paper	(.02)***	(.03)***	(.05)**	(.07)			3.3	
Other paper	0.94	0.06	-0.10		0.37	0.98	-0.12	415
and paperboard	(.02)***	(.02)***	(.03)***				2.5	

Notes: R^2, rho, Q', and f indicate the coefficient of determination, the residual autocorrelation, the standardized Von-Neumann ratio, and the number of degrees of freedom, respectively. The figures in parenthesis are standard errors of the coefficients. ***, **, * indicate coefficients significantly greater than or less than zero at the 0.99, 0.95, and our 0.90 confidence level, respectively. C_{t-1}, Y_t, P_t and P'_t indicate consumption per capita lagged one year (Kg), income per capita ($), product price ($/ton), the price of the most direct substitute, respectively.

Table 3.2

Buongiorno's Estimates of the Demand for Paper and Paperboard Products Using Analysis of Covariance

Model and product	Coefficients of independent variables				R^2	rho Q	f
	C_{t-1}	Y_t	P_t	P'_t			
Static model							
Newsprint		1.03	-0.69	0.12	0.95	0.13	337
		(.13)***	(.10)***	(.09)*		2.4	
Printing and		1.46	-0.40	0.21	0.97	0.22	337
writing paper		(.11)***	(.08)***	(.08)**		4.0	
Other paper		1.52	-0.35		0.98	0.38	374
and paperboard		(.10)***	(.06)***			7.5	
Dynamic model							
Newsprint	0.18	0.85	-0.60	0.11	0.93	0.01	336
	(.05)***	(.14)***	(.10)***	(.09)		0.1	
Printing and	0.34	0.88	-0.36	0.17	0.98	-0.06	336
writing paper	(.05)***	(.13)***	(.07)**	(.08)**		-1.0	
Other paper	0.55	0.74	-0.32		0.98	-0.04	373
and paperboard	(.04)***	(.10)***	(.05)***			-0.8	

Notes: See Table 3.1

Table 3.3

Buongiorno's Estimates of the Demand for Paper and Paperboard Products Using Analysis of Covariance and Observations Stratified According to Income Levels

Model, product, and countries group	C_{t-1}	Y_t	P_t	P'_t	R^2	rho Q	f
	Coefficients of independent variables						
Static model							
Newsprint							
High-income		0.81	-0.49	0.34	0.86	0.14	175
		(.19)***	(.30)*	(.18)*		1.9	
low-income		1.07	-0.72	0.03	0.89	0.13	158
		(.21)***	(.11)***	(.11)		1.6	
Printing and writing paper							
High-income		1.56	-0.13	0.05	0.95	0.23	176
		(.11)***	(.10)*	(.17)		3.1	
low-income		1.27	-0.49	0.21	0.88	-0.20	158
		(.20)***	(.11)*	(.11)		2.5	
Other paper and paperboard							
High-income		1.33	-0.17		0.98	0.45	178
		(.06)***	(.06)***			5.9	
low-income		1.63	-0.39		0.94	0.38	194
		(.18)***	(.09)***			3.3	
Dynamic model							
Newsprint							
High-income	0.16	0.70	-0.49	0.31	0.67	0.01	175
	(.07)***	(.19)***	(.29)**	(.18)**		0.1	
Low-income	0.17	0.89	-0.63	0.02	0.90	0.02	157
	(.07)***	(.22)***	(.12)***	(.11)		0.2	
Printing and writing paper							
High-income	0.35	1.01	-0.14	0.11	0.96	-0.10	175
	(.07)***	(.15)***	(.10)*	(.16)		-1.3	
Low-income	0.41	0.71	-0.44	0.16	0.90	-0.05	157
	(.08)***	(.22)***	(.10)***	(.10)*		-0.7	
Other paper and paperboard							
High-income	0.49	0.72	-0.15		0.98	-0.06	177
	(.06)***	(.09)***	(.04)***			-0.7	
Low-income	0.56	0.73	-0.37		0.96	-0.06	193
	(.06)***	(.18)***	(.08)***			-0.7	

Notes: See Table 3.1

Muller had estimated a newsprint demand equation for total North America, that is Canada and the United States combined, as a function of relative prices, the circulation of newspapers in the United States, and United States

gross national product in constant 1958 dollars. Commenting on Muller's (32) work Schaefer (39) argued that although Muller's demand equation may have been satisfactory for simulation purposes it was still seriously misspecified. Schaefer saw four problems with this specification.[3] First, since the demand for newsprint is a derived demand -- the output price, the price of newspapers, and advertising price should have been included. Secondly, advertising expenditures, instead of gross national product in constant dollars, should have been used as a general demand shifter since the data were available. In the third place, Muller should have adjusted the circulation variable to account for the different circulations, frequency, and size of daily and Sunday newspapers. Finally, separate United States and Canadian newsprint demand equations should have been specified in order not to obscure the above relationships if they differed between countries. Schaefer justified the last criticism on account that 30 percent of Canada's newsprint output does not go to the United States. Correcting for these problems Schaefer reported a constant elasticity demand equation (from his previous work)

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3. Schaefer (39), p.518.

$$USNPC = 6.176 + 0.07593\ CIRCA + 0.6628\ ADV - 0.3299\ XP + 0.1197\ JP + 0.3289\ ADRT$$

$$(9.36)\quad (0.95)\quad (8.75)\quad (-5.60)\quad (1.30)\quad (2.08)$$

where $R^2 = 0.9931$

DW = 1.37

t-statistics in parenthesis

USNPC = US consumption of newsprint;

CIRCA = adjusted US daily circulation;

ADV = advertising in US newspapers deflated by milline rates;

XP = US dollars price of newsprint derived from shipments data;

JP = US price index of delivered; and

ADRT = adjusted milline rates for newspaper ads.

The demand for printing paper is influenced by the writing and printing needs and habits of business firms and the public, by technological developments in paper-using equipment such as duplicating machines, billing procedures, and electronic computers, and on the general growth of the economy. Like newsprint, the demand for printing paper is a derived demand.

Only two studies have estimated the demand for printing paper -- that of Nguyen (34) and Buongiorno (7). In McKillop's study printing paper was considered as part of a broader paper category. Nguyen, however, separated printing and writing paper into two groups. He estimated separate demand equations for printing paper and for writing paper, using log-linear demand equations and annual data covering the period 1956-1975. Since a positive but statistically insignificant price coefficient for book (printing) paper was obtained, Nguyen did not include price in the final equation. The price coefficient for writing paper was found to be statistically significant at the 20 percent level of significance, however. Nguyen reported the following equation for book paper:

$$Q_t = \underset{(0.91)}{5.754} + \underset{(2.85)}{1.480}\ DPI_t - \underset{(-0.32)}{0.259}\ T$$

where $R^2 = 0.92$

t-statistics are given in parentheses

n (sample size) = 20

DW = 1.05

Q_t = per capita apparent consumption in year t

DPI_t = per capita disposable personal income in constant dollars in year t

T = a time trend variable.

All of the variables were expressed in natural logarithms. He also reported the following equation as the demand for writing paper.

$$Q_t = \underset{(3.46)}{8.180} - \underset{(-1.49)}{0.773}\ P_t + \underset{(6.47)}{1.496}\ DPI_t - \underset{(-4.44)}{0.267}\ D_1$$

where $R^2 = 0.98$

n (sample size) = 20

DW = 2.02

P_t = wholesale price index deflated by the GNP implicit deflator in year t

Nguyen did not indicate an explanation for variable D_1. His estimate of the price elasticity for writing paper was 0.77.

Boungiorno reported the following equation for printing paper on the basis of analysis of covariance:

$$C_t = \underset{(13.3)}{1.46}\, Y_t - \underset{(5.00)}{0.40}\, P_t + \underset{(2.63)}{0.21}\, P'_t$$

where $R^2 = 0.97$

rho, first order autocorrelation = .22

t-statistics are in parenthesis;

C_t = printing and writing paper consumption in kilograms per capita in year t;

P_t = price of printing and writing paper in year t;

P'_t = price of newsprint in year t; and

Y_t = gross national product in US dollars per capita in year t.

Buongiorno also found that there was a significant difference between the demand for printing paper when low and high income countries were distinguished (see Table 3.3).

The demand for paperboard, the third product category, is influenced by the needs of business firms for packaging materials; the possibilities of substituting paperboard containers for wooden, metal, or glass containers; the substitution of plastic film for paperboard; and the general level of economic activity. The enormous growth experienced by the paperboard industry is mainly attributed to the versatility of paperboard as a container. Almost all durable goods -- canned, packaged, and bottled foodstuffs, fruits and vegetables, and household supplies -- are shipped from manufacturers and processors to retail outlets in corrugated shipping containers.

Only two of the studies already cited, that of Buongiorno and Muller, estimated demand functions for the same paperboard group as used in this study. Muller (32) also considered other paper and paperboard as a single category but estimated a demand equation based on a "tariff limit price" model which explicitly recognizes tariffs as a substitute for the domestic product. Using the average tariff and the exchange rate, an index of landed prices for U.S. fine paper and paperboard was calculated. This index was used as a price for competitive products. Using annual data for the period 1956-1969 Muller reported the following equation:

$$C_t = -\underset{(2.01)}{0.4027}\,P_t + \underset{(1.79)}{0.3499}\,P'_t + \underset{(52.49)}{0.00929}\,Y_t$$

where $R^2 = 0.99$

t-statistics are given in parenthesis

C_t = value of shipments of other paper and paperboard products, deflated by P'_t

P_t = industry selling price index for other paper and paperboard products (f.o.b. mill basis) (1961 = 1.0)

P'_t = index of import limit price for other paper and paperboard products Canada (1961 = 1.0)

Y_t = real gross national product in 1961 Canadian dollars.

McKillop chose to exclude any kind of paper from his paperboard group. Nguyen specified demand equations for more specific paperboard products. He estimated separate demand equations for containerboard, boxboard, packaging and other converting paper, and construction paper and board.

Whereas Muller took account of the substitution for competitive products for paperboard, Buongiorno did not in his demand equation (see Table 3.2 and 3.3). He obtained the following equation from an analysis of covariance using pooled data (see Table 3.3)

$$C_t = \underset{(15.2)}{1.52}\, Y_t - \underset{(5.83)}{0.35}\, P_t$$

where t-statistics are given in parentheses

$R^2 = 0.98$

rho, first order autocorrelation = 0.38

Although there have been several empirical studies of demand for paper and paperboard only one study has incorporated the supply side of the market. McKillop (30) estimated a supply function for two separate categories: all papers and all paperboards for the United States. Since there are no other studies for comparison, McKillop's estimates of supply elasticities will serve as a guide in evaluating the estimates found in the present study. McKillop reported both interval as well as point estimates of these elasticities. His interval estimate of the price elasticity of paper ranged from -0.1 to 0.5 with the point estimate occurring at the lower bound. The interval estimate of price elasticity for paperboard ranged from 0.1 to 0.6 with a point estimate of 0.4. These estimates will be referred to again after presenting the estimated supply functions for the three product categories.

3.2 Model Specification

This section presents the basis for specifying the supply and demand relationships. The section is divided into three subsections. A description of two models of international trade is presented in the first subsection. Subsection two presents the model used in specifying the supply and demand relationships. Finally, the last section describes the market characteristics for paper.

3.2.1 International Trade Models

International trade models have sometimes been categorized into either 'traditional flow' models or 'spatial equilibrium' models. Both of these categories of models specify import and export equations; the distinction lies in the determination of the trade flows. With a constant share matrix being the norm, an input-output-like trade-shares matrix is used to determine the trade flows under the traditional flow approach. Variants of this basic model have been devised; the models differ only with regard to the selection of trade flows and variations in the coefficients of the trade-shares matrix. On the other hand, trade flows in the spatial, or interregional, equilibrium models are determined via the optimization of an objective function. This latter approach has been widely used for the study of international trade for many products, while the former approach has been used mainly for the study of total (that is, all products are lumped together as a single commodity) trade flows.

A spatial equilibrium model generally describes a competitive economic system, utilizing a set of equations that include aggregate demand and supply for one or more commodities, the distribution of activities over space, and the equilibrium conditions. A spatial equilibrium model is nothing more than an extension of an econometric model wherein the flows are determined via a programming algorithm whereas in the pure econometric model the flows are determined endogenously within the model via a set of 'flow' equations. A crucial assumption in the spatial equilibrium model is that of a homogeneous product; that is importers do not differentiate the product from its origin of supply.[4] The design of a spatial equilibrium model requires the specification of regional supply and demand equations as well as a programming algorithm for determining the equilibrium distribution of the product. The programming algorithm used in the present study is explained in the next chapter.

3.2.2 The Economic Model

In this study products are considered homogeneous and consumers do not differentiate the product by the source of origin. Consumption can be defined as the sum of production and imports minus exports since the product is homogeneous across regions. Since the regions being

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4. Armington (3), however, has developed a theory of demand for which products are differentiated by their source of origin. In other words importers notice either quality or technical differences in the product from different sources.

considered are either net exporters or net importers the relevant price for each regions is the unit value of exports (FOB) and unit value of imports (CIF), respectively.[5] Assume that each region is small and unable to influence the world price (a small country-case).

For a net importing region (Figure 3.1) the relevant price for decision making is the import price P_w (CIF) which is determined by world demand and supply and transportation costs which differ by country location. Initially assume that S represent the domestic supply curve and D the demand curve. As far as the importing region is concerned the supply of imports at that price is almost perfectly elastic since it cannot affect the world price if it were to import more of the product. At the given world price P_w(CIF) domestic profit maximizing producers produce Q_s while consumers demand Q_d at this price. The assumption is made that when the price of the domestic output is identical to the price of imports consumers take up all domestic production at that price, imports being the residual. Alternatively it might be assumed that the domestic product is marginally of better quality or more conveniently available than imports, so that it is this marginal difference which creates a preference for the former when the prices of the two are the same. In other words, the effective supply curve of the product for the importing region is ABEC. Notice that shifts in the domestic supply and demand curves (to S' and D') do not affect the

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5. Buongiorno (7) has shown that there is a strong correlation between unit value of imports or exports and domestic prices.

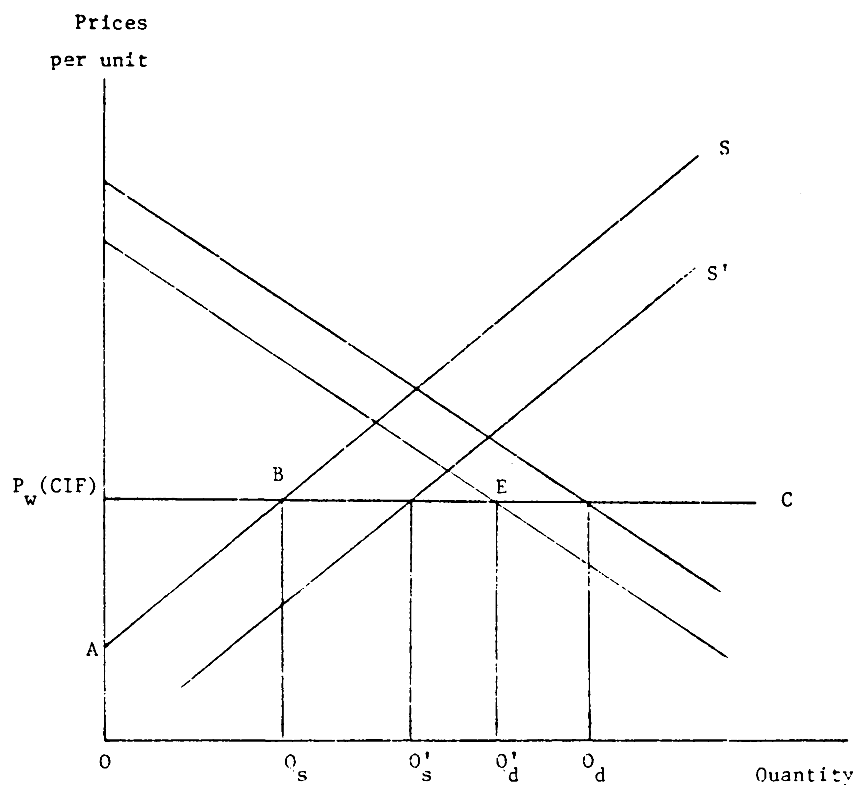

Figure 3.1

Price Equilibrium for a Net Importing Region import price, they only affect the quantity of imports; imports decrease from Q_sQ_d to $Q'_sQ'_d$. However, simultaneous shifts by all producing and consuming regions may affect the world price; hence shifting the import supply curve for an individual net importer.

A symmetric situation exist for a net exporting country (Figure 3.2). The ruling price in this case, however, is the export price (FOB) which is determined by world supply and demand and transportation costs. The domestic supply and demand curves are represented by S and D, respectively. The demand for the country's exports is represented by P_w(FOB). For an exporting region, moreover, the foreign demand of its export is almost perfectly elastic so that the effective demand curve for the region is FGJH; or alternatively the export supply curve is perfectly elastic at the world price. At this price producers produce Q_s while consumers demand Q_d of the product. It is assumed that when the domestic and world price are identical that producers supply Q_s exporting Q_dQ_s with the residual going to the local market. A similar analogy to the case of the net importing country can be made here. When the domestic price equals world price, in the eyes of local producers the local market is marginally more competitive in terms of distribution since less paperwork and other transaction costs are involved. This marginal difference creates a preference for producers to ship to the local market first. Here too, shifts in the domestic supply and demand curves (to S' and D') do not affect the export price; only the volume of

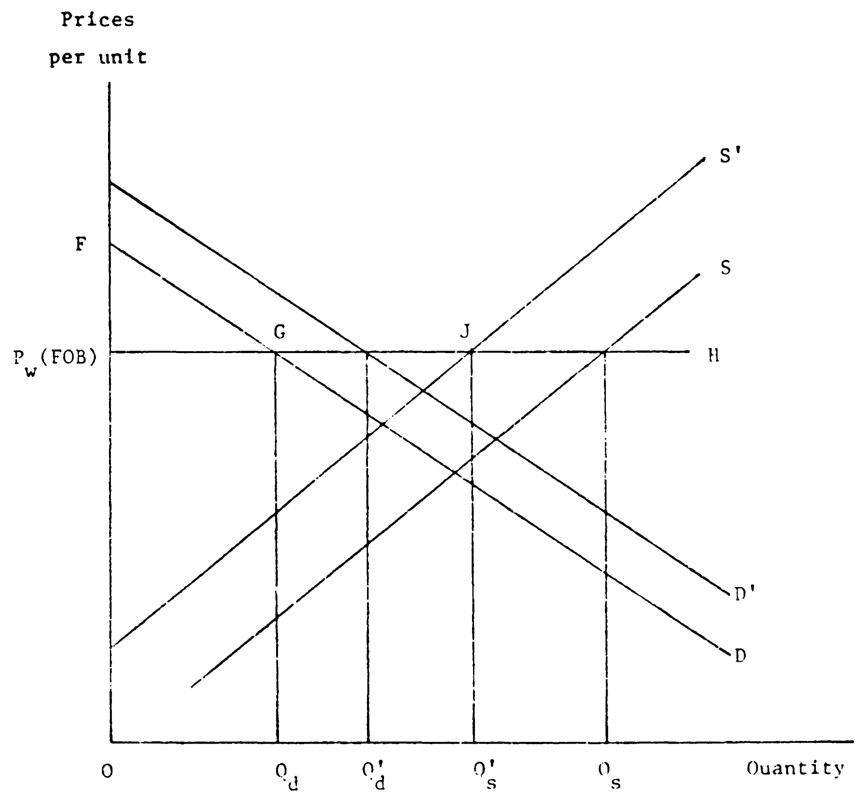

Figure 3.2

Price Equilibrium in a Net Exporting Region exports is affected. An increase in demand and a decrease in supply will reduce exports leaving the world price unaffected; exports decrease from Q_sQd to $Q'_sQ'_d$.

The specification of the regional supply and demand equations will be presented in sections four and five, respectively, of this chapter. But before presenting the specification of these equations, a description of the market for paper and paperboard products is appropriate at this time. The description should clarify why the supply and demand equations are specified as they are in the present study.

3.2.3 The Markets for Paper and Paperboard Products

The market for paper and paperboard products is very much international in character. Although the major trading partners of paper and paperboard products involve only a few regions, trading is transacted among many countries. On the North American continent, Canada tends to be the exporting region, with the United States absorbing most of Canada's exports. For example, two-thirds of the domestic newsprint needs of the United States is supplied by Canada. At the same time Canada also exports to Europe and Latin America. On the European continent, the Nordic countries tend to be the exporting region with the European Economic Community being the importing region. The Nordic countries also export minor quantities to the United States and Latin America.

While the following description is specific to the United States' paper and paperboard industry the general features of the market are applicable to the markets in other regions as well. The description draws heavily on Slatin's (42) excellent paper.[6]

In general, the markets for paper and paperboard products are competitive in nature. In other words, no one region or country is able to exert a significant influence on the world prices of these products. In the 1920's and 1930's companies concentrated on a single line of production. There were newsprint, writing paper, bag paper, and paperboard companies with only a few companies operating in more than one major sector of the paper and paperboard industry. The trend toward vertical integration which began in the late 1930's partly reflected the development of Southern Pine as pulpable wood, which led the industry to integrate pulp production with paper and paperboard production. A similar trend towards integration developed in the 1950's; producers of containerboard chose to integrate forward into the manufacture of corrugated shipping containers. New technology that permitted the pulping of chips, slabs, edgings, and similar wood residues of other forest industries, brought some of the largest lumber companies into the paper industry. These companies were mainly located in the Pacific Northwest, and, in some instances, built new pulp and paper mills.

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6. Slatin, Benjamin, "Economic Structure of the Paper Industry," Tappi 58(7), 1975, pp. 54-67.

Paper is used daily by many in the United States and many parts of the world and is such a common commodity that the majority of people never give it a second thought. Paper is still the most prevalently used material in the administration, both internally and externally, of industry, commerce, and government. The introduction of computers and word processors has somewhat reduced the volume of manual clerical work, but even these machines require paper to disseminate the information they produce. The printed word still dominates the spread of knowledge throughout the world. Despite the introduction of television, newspapers and periodicals still play a major part in the spreading of news and information. In the packaging field, paper and paperboard used for the production of wrapping and packaging materials are still of vital importance to ensure the safe passage of goods throughout the world, although it is recognized that the use of man-made synthetic materials is steadily increasing. At the same time, the recent shortages in oil have stimulated the substitution of paper products for these petroleum-based synthetic materials.

A discussion of the production process in the paper industry may identify some of the economic variables required in the specification of the supply function. Most of the major companies in the paper industry own extensive acreage of forest lands, but the paper industry depends upon fee-simple lands for only a part of their wood requirements. The rest comes from privately owned commercial forest lands as well as from public-owned forest lands. Originally, only northern softwoods could be pulped. By the 1930's the industry was pulping Southern Pine, which opened up new forest areas to pulpwood production. In the 1950's, bleached pulps were made from Southern Pine and, in the Northwest, from Douglas Fir and other species indigenous to that area. These expanding sources of pulp led to industry wood costs that were among the lowest in the world. The expansion in pulpwood sources during the period of 1930 through 1960 led the industry to concentrate on wood as its major source of fiber and shift more and more away from recycled fiber, such as cotton and linen rags. More recently, under the impetus of environmental problems in the area of solid waste, the industry has shown a rekindled interest in the use of waste-paper as a source of fiber, but wood fiber continues to be the major source of pulp furnish.

Next to wood pulp, water is another ingredient in the manufacture of paper. It takes about 50,000 gallons of water to make a ton of paper, so that the availability of water is an important element in the selection of a new mill site for pulp and paper operations. Its heavy use of water makes water pollution a major problem of the paper industry. In 1973 the industry spent about half a billion dollars on capital equipment for water and air pollution abatement. The industry is also a heavy user of chemicals and minerals.

The paper industry also is a major user of electric energy. In fact, most of the large integrated pulp and paper mills not only produce their own electricity but may also sell some as well. It is also the largest user of residual oil and the fifth largest user of all fuels in the country. Power requirements vary from region to region, however. Paper and paperboard mills in the Northeast use wastepaper as their major furnish, while the integrated pulp and paper mills in the Southern and Pacific Regions have larger power requirements. While the Pacific Region normally rely on imported fuel, the Southern Region relies on domestic fuel.

The paper industry relies heavily on railroads both for bringing raw materials to the mill and for shipping the finished products to the customer, or to the next stage of production. If both incoming and outgoing freight are considered, the paper industry supplies 10 percent of the total freight revenues of the nation's railroads. Waterways and trucks are also used as a means of transportation, where the latter is more important in the converting sectors.

Wages, salaries, and supplements account for about one-third of the total costs in the paper industry. This proportion has held since the postwar period. Wage rates and productivity have moved along with the national trend. The gains in productivity can be traced back to the rising average education attainments of the industry's employees and heavy capital investments. Although raw materials, labor, and other variable costs form an important part of the total cost structure of the primary sectors of the paper industry, it is fixed cost that seems to loom largest in the minds of management. The focus of the fixed cost is the funds set aside to meet depreciation. For the primary sectors about 5.5 percent of the value of shipments was required for depreciation.

3.3 Summary

International trade models may be categorized either as 'traditional flow' models or as 'spatial equilibrium' models. The former uses a flow matrix to determine the trade flows and has been widely used to study aggregate, but not commodity-specific trade flows. The latter approach, on the other hand, has been widely used in the study of specific commodity trade flows. The spatial equilibrium approach is adopted in this study. The ability of a particular region or country to influence world price is a significant consideration in modeling international trade. If a region is able to influence price then not only domestic but also world price has to be included in the demand and supply functions for each product and region. In this study, individual regions are considered to be unable to influence world prices.

CHAPTER IV

ESTIMATED DEMAND AND SUPPLY FUNCTIONS

Introduction

The scope of this study is presented in the first section. This section is subdivided into two subsections. Sources and limitations of the data base are presented in the first subsection. The second subsection describes the regional breakdwon for each product group. The empirical model and the results are discussed in section two. This section is subdivided into two sections; one subsection presents the the estimates of the demand functions and the other subsection presents the estimates of the supply functions. Each subsection is further divided into three sections wherein the estimates of each of the three products are presented.

4.1 Scope of the Study

The scope of this study has been limited by data availability. Although the regions had been identified early in the problem formulation, the products were not decided upon until after a preliminary investigation of various data sources. Initially newsprint, kraft linerboard, and market wood pulp were considered since trading in these products is quite substantial. However, with the exception of newsprint, data were not available for these specific products on a country-wide basis. The demand and supply relationships were estimated from annual data covering the period between 1962 and 1978.

4.1.1 Data Sources and Problems

The Yearbook of Forest Products (53), published by the Food and Agricultural Organization, contains cross-sectional time-series data for paper and paperboard products, but only for three broad categories. Thus, only the following categories of products, as categorized by the Food and Agricultural Organization, are considered in this study:

1. Newsprint (641.1) defined as uncoated paper, unsized (or only slightly sized), containing at least 60 percent mechanical wood pulp (percent of fibrous content), usually weighing not less than 40 grams per square meter and generally not more than 60 grams per square meter of the type used mainly for the printing of newspapers;
2. Other printing and writing paper (641.2) defined as paper, except newsprint, suitable for printing and business purposes, writing, sketching, drawing, etc., made from a variety of pulp blends and with various finishes. Included are such papers as those used for book and magazine, wall paper base stock, box lining and covering calculator paper, rotonews, duplicating, tablet or block, label, lithograph, banknote, tabulating card stock, bible or imitation bible, stationary, manifold, onionskin, typewriter, poster, etc.; and

3. Other paper and paperboard (EX 641) which includes construction paper and paperboard, household and sanitary paper, special thin paper, wrapping and packaging paper and paperboard and other paper and paperboard not elsewhere specified.

Henceforth, other printing and writing papers will simply be referred as printing paper and other paper and paperboard simply as paperboards.

Although data for the United States was available for a great number of specific products, the choice of regional breakdown and sample period was limited. The Current Industrial Report, Pulp and Paper, published by the U.S. Department of Commerce, contains annual data on production of individual categories of paper and paperboard products by states and regions. The earliest data published, however, were for 1962. Consequently, annual data for the period 1962 through 1978 were used for this study. The three paper and paperboard products categories were obtained for the United States by summing over the individual products as specified in the FAO classification system.

Regional data for Canada, grouped according to the three FAO product categories, proved to be surprisingly difficult to obtain. Although newsprint data were readily available on a regional basis, data for the other two categories were not. Newsprint data were obtained from the Canadian Pulp and Paper Association. Statistics Canada and the U.S. Forest Service were most cooperative in providing regional Canadian data for the other two product categories.

Data for the explanatory variables used in the demand and supply equations were obtained from several sources. Price indices were obtained from the Main Economic Indicators, published by the Organization of Economic Cooperation and Development. Data on gross national product, and exchange rates were obtained from the International Financial Statistics Yearbook, published by the International Monetary Fund.

4.1.2 Regional Demarcation

This subsection describes the regional classification adopted in the present study. The following countries or regions are considered: the United States, Canada, the European Economic Community, the Nordic countries, and Japan. For the purpose of this study, the European Economic Community consists of Belgium-Luxembourg, Denmark, the Federal Democratic Republic of Germany (West Germany), France, Ireland, Italy, the Netherlands, and the United Kingdom. Finland, Norway, and Sweden comprise the Nordic countries. The Nordic countries represents an excess supply region while the European Economic Community tends to be an excess demand region for paper and paperboard products.

Canada and the United States are further separated into two and three regions, respectively. Canada is divided into British Columbia and the rest of Canada. For the purpose of this study the latter region is simply referred as Ontario. This was done in order to reflect not only the geographical but also the institutional differences between the two regions. These two regions not only differ in terms of the production of paper and paperboard but they are also differ in terms government administration and in forest types. Moreover, forest policy for the two regions are not the same. British Columbia mainly produces newsprint and printing paper, with a small amount of paperboard production. For newsprint and paperboard the United States was separated into the North, the South, and the West. Although still consisting of three regions, for printing paper the United States was divided into the Northeast, the North Central, and the rest of the United States.[1] However, since the South accounts for 90 percent of printing and writing paper production in rest of the United States, this region will simply be referred to as the South hereafter. The United States has different regional breakdowns because data were not available for the same regions for all products. Since individual products were aggregated according to the FAO product categorization scheme it was not possible to have the same regional breakdown for printing paper. The regional demarcation for the three product groups are summarized in Table 4.1.

4.2 Empirical Results

Ideally, the spatial equilibrium model developed in this study should include a demand equation for each product and each country. Initially, a supply and demand function for each product for each

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1. The regional classification of the United States by states is given in Appendix A.

Table 4.1

Regional Demarcation for Newsprint, Printing Paper, and Paperboard

Product	Supply	Demand
Newsprint	Japan Nordic British Columbia Ontario U.S. North U.S. South U.S. West	Japan EEC U.S. East U.S. West
Printing Paper	Japan EEC Nordic Ontario U.S. North East U.S. North Central U.S. South	EEC Nordic Canada U.S. East U.S. West
Paperboard	Japan EEC Nordic Canada U.S. North U.S. South U.S. West	Japan EEC U.S. East U.S. West

country was specified. This involved estimating equations for each country in the European Economic Community and the Nordic countries. However, the estimates obtained for some products for some countries proved either to be contradictory to theoretical considerations or were statistically unsatisfactory. Data for individual countries in the European Economic Community were pooled and pooled cross-section times-series analysis was performed on each group. This was also done for the Nordic countries. A pooled cross-section time series analysis produced unsatisfactory estimates for the European Economic Community and the Nordic countries for the three product categories. In light of these results, it was decided that these two sets of countries will each be considered as a single region, each with a single demand and supply point. Quantity data were summed over all the countries in each region and unit value data were weighted accordingly. Another objective in the specification of equations in general was that a common set of variables be incorporated across regions whenever possible. To a certain extent this objective automatically reduced the number of variables that could be used in the equations, due to the limited number available for all regions. As a result, the final set of variables selected are similar to that of Buongiorno's (7) work, since a similar data base was used in both studies.

All of the demand equations presented will have the following general form

$$C_{ijt} = a_{ij} + b_{ij}P_{ijt} + c_{ij}G_{jt} + d_{jt}Z_{ijt}$$

where

C_{ijt} = apparent consumption of product i in region j in year t

P_{ijt} = price of product i in region j in year t

G_{jt} = gross national product in region j in year t

Z_{ijt} = a vector of predetermined variables for product i in region j in year t; and

$b_{ij} < 0$, $c_{ij} > 0$.

The price variable employed is either unit value of exports or unit value of imports for the particular product considered. For a net importing country the unit value of imports is used and for a net exporting region the unit value of exports is used. The subscripts i and j have been dropped since the equations are presented by product category and by region. The unit values were computed by dividing the total value of imports/exports in US dollars by the volume imports/exports for any given year. These values were then converted to real U.S. dollars with a base year of 1975. The gross national products of the various regions were also converted to constant 1975 U.S. dollars. The dependent variable, C_{ijt}, is expressed in thousand metric tons. The predetermined variables may include lagged consumption and a dummy variable to account for years after 1970. Lagged consumption was specified to account for the persistence of habit in the demand for the three product groups. Since the literature review revealed that studies on the demand of paper and paperboard products during the 1960's did not produce significant price variability but studies since then have, the dummy variable was incorporated to account for a structural change in the demand of the three product. Moreover, the period since 1971 had seen a period of price fixes and the oil crisis which may affect prices not previously affected. The following definition is used for all the demand equations

$C = P + I - E$

where C = apparent consumption

P = total production

I = imports

E = exports.

4.2.1 Demand for Paper Products

The results of the estimated demand relationships for the three product groups are presented in this section. The first subsection presents the estimated demand functions for newsprint for the regions considered in this study. The second subsection presents the estimated demand functions for printing paper for regions selected in this study. Finally, the third subsection contains a presentation of the estimated paperboard demand for selected regions.

4.2.1.1 Demand for Newsprint

Despite the similarity between the present study's and Buongiorno's data base, there are minor differences in the specification of the newsprint and printing paper demand equations. Whereas Buongiorno saw fit to assume these two products to be substitutes for one another the present study makes no such assumption. A commodity is considered a substitute for another either because it has a similar use or because the two commodities are produced from a common input. In this study newsprint and printing paper is judged to fit neither of these criteria sufficiently to be treated as substitutes. Newsprint cannot be substituted in usage for most printing papers since the former does not require the permanency of the printing as do the latter. Moreover, while groundwood is the major raw material used in the production of newsprint, printing paper uses a combination of mechanical and chemical wood pulps, grass (esparto), cotton fiber pulp, or selected reclaimed paper stock for raw material.

The unit value of newsprint exports was used as own price variable for Japan and Canada, while the unit value of imports was used for the European Economic Community and the United States, since Japan and Canada are net exporters and the latter two regions are net importers. The equations were estimated using ordinary least squares using annual data for a sample period of 1962 through 1978. Where serial correlation was found, the equations were corrected using 'Proc Autoreg' from the Statistical Analysis System (SAS) package. Out of the three estimated equations reported (see Table 4.2) two were corrected for serial correlation. The demand equations for both the European Economic Community and the United States were corrected for negative serial correlation. It is assumed that regional consumption is proportional to total consumption in the same measure as that of regional income to total income, that is

$$\frac{Q^w}{QT} = \frac{Yw}{YT}$$

where Q^w is consumption in region w;

Table 4.2

Estimated Newsprint Demand Equations for Selected Regions [1]

	Coefficients of Explanatory Variables						
Region	Intercept	Price	GNP	Dummy	DW	rho	R^2
Japan	1461.297 (303.584)	-1.709144 (0.905579)	1.877699 (0.413125)	236.140 (161.155)	1.303		0.9140
EEC[2]	2963.881 (265.277)	-4.701201 (0.753042)	2.024547 (0.297355)	-91.692 (142.821)		-0.461	0.9484
Total U.S.[2]	5187.928 (417.763)	-13.862099 (1.412209)	4.907248 (0.237894)	-113.142 (102.891)		-0.584	0.9919
U.S. East[3]	3740.496	-10.008993	3.538125	-81.575			
U.S. West[3]	1447.432	-3.873106	1.369122	-31.567			

1. Standard error are reported in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.
2. Corrected for serial correlation.
3. These equations are obtained as a proportion of Total U.S. demand equation.

Y^w is income in region w;

Q^T is total consumption; and

Y^T is total income

The demand equations for U.S. East and U.S. West were obtained by multiplying the demand equation for total United States by 0.72 and 0.28, respectively. These proportions are the means of historical and projected proportions of regional disposable incomes in relation to the total for the United States. Both the price and GNP coefficients for all three regions were significant at the 1 percent level. While it can be stated confidently that structural change did indeed occur in Japan before and after 1970, the same cannot be said with confidence for the European Economic Community and the United States. No estimates for the Nordic countries and Canada are reported since the coefficients of both price and gross national product were statistically insignificant. Moreover, the statistical fits were poor for both linear and as log-linear functional forms.

Not surprisingly, the demand for newsprint for all of the regions were found to be quite inelastic at the sample means, ranging from -0.27 to -0.38 (see Table 4.3).[2] This means that consumers are rather reluctant to change their current level of consumption given a percentage change in the price of newsprint. This may indeed be the

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2. Previous studies have also shown the demand for newsprint to be price inelastic. The preferred comparison would have been to that Buongiorno's estimates since a similar data base was used; however, Buongiorno did not report short term price elasticities, only long term estimates.

Table 4.3

Derived Demand Price Elasticities for Newsprint
at the Sample Means, Selected Regions

Regions	Mean Apparent Consumption	Price: Elasticity	Price: Sample Mean	GNP: Elasticity	GNP: Sample Mean
Japan	1783.6247	-0.27	282.8644	0.39	369.9523
EEC	3956.8641	-0.29	243.5510	0.55	1077.9995
USA	8695.6888	-0.38	236.7119	0.79	1394.6941

case since many publishing houses in the United States, for example, have contracts with producers over the Canadian border. In some cases the paper mills in Canadian are subsidiaries of American interests. The elasticity of gross national product may be construed as an 'income elasticity' of some sort. The elasticities, in general are rather inelastic; a percentage change in gross national product will be associated with a less than proportionate increase in newsprint consumption. Since the demand for newsprint is a derived demand for newspapers a low 'income' elasticity should not be surprising. Newspaper is more of a reading habit than anything else; moreover, since it constitutes a small part of the consumer's budget increases in income levels would not affect the level of consumption by much.

4.2.1.2 Demand for Printing Paper

The demand equations for printing paper are reported in Table 4.4. The unit value of imports was used as a price variable for the European Economic Community and the United States since these regions are net importers of printing paper while the unit value of exports was used as the price variable for the Nordic countries since this region is a net exporter. The estimated equations for printing paper for Japan did not have significant coefficients on either price or GNP. Estimated demands for the Nordic countries, Canada, and the United States had price and GNP coefficients significant at the 1 percent level. The equation for the European Economic Community was corrected for negative serial correlation. The reported equation for Canada was estimated by

Table 4.4

Estimated Printing Papers Demand Equations for Selected Regions [1]

Region	Intercept	Price	GNP	Dummy	lag	DW	rho	R^2
	Coefficients of Explanatory Variables							
EEC[2]	1146.431 (947.667)	-6.673968 (2.015834)	5.386828 (1.678230)	-543.089 (464.385)	0.454083 (0.192547)		-0.528	0.9686
Nordic	316.069 (202.470)	-1.249167 (0.484530)	7.264458 (2.985768)	-17.098 (123.712)		2.021		0.7190
Canada[3]	328.116 (51.211)	-1.664082 (0.260330)	1.719481 (0.268997)	103.848 (16.246)				0.7315
Total U.S.	-2791.024 (1326.508)	-5.757734 (2.700733)	10.593223 (0.895559)	-267.145 (407.360)		2.199		0.9680
U.S. East[4]	-2012.328	-4.151328	7.637714	-192.612				
U.S. West[4]	-778.328	-1.606408	2.955509	-74.533				

1. Standard error are reported in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.
2. Corrected for serial correlation.
3. Estimates of principal components.
4. These equations are obtained as a proportion of Total U.S. demand equation.

principal component analysis. Structural change is observed with confidence for the demand for printing paper for Canada. The same assumption about regional consumption for newsprint is also made for printing paper demand in the United States. The demand for printing paper for the European Economic Community also showed strong habit persistence for European consumers.

In general, the demand price elasticities of printing paper are less inelastic than that of newsprint ranging from -0.14 to -0.73. This result concurs with Buongiorno's finding. The United States' demand for printing paper, however, is very inelastic at a value of -0.14. The 'income' elasticities were also found to be higher for this product category; they were in the elastic range (see Table 4.5). The income elasticities range from 0.40 to 1.48 with Canada having the most inelastic demand and the United States the most elastic demand. This is consistent with Buongiorno's observation that the income elasticity of printing paper was higher for high income countries. Although reading habits still play an important role in determining the level of consumption, the amount spent on reading material in relation to the total budget will be higher as the level of of income rises. The effect at the retail level trickles down to the lower level of the marketing chain thus affecting the derived demand for printing paper. Moreover, as the size of the economy (as reflected by the GNP) increases so does the size of businesses and often times also the size of governments.

Table 4.5

Derived Demand Price Elasticities for Printing Papers
at the Sample Means, Selected Regions

Regions	Mean Apparent Consumption	Price		GNP	
		Elasticity	Sample Mean	Elasticity	Sample Mean
EEC	6516.5882	-0.46	447.3025	0.89	1077.9995
Nordic	567.1176	-0.73	333.0852	1.19	92.9420
Canada	557.2353	-0.69	230.4400	0.40	128.2583
USA	9998.6341	-0.14	242.5882	1.48	1394.6941

The printing and writing needs of big institutions are a lot larger than those of smaller economies. All of these effects rationalize the higher 'income' elasticity for the more developed economies.

3.4.1.3 Demand for Paperboard

Finally, the estimates of the demand for paperboard and their elasticities will be discussed. The unit value of imports was used as a price variable for the demand of the European Economic Community because this region is a net importer of paperboard while the unit value of exports was used for the other regions since they were net exporters. The coefficient on GNP for all four regions were significant at the 1 percent level (see Table 4.6). For two of the regions, the European Economic Community and Canada, the price coefficients were significant at the 1 percent level. The demand for paperboard for the European Economic Community also appears to be influenced by habit persistence or contractually dependent as was the case for the demand for printing paper. Structural changes have affected the demand for paperboard for Japan and Canada while they are not significant in affecting the demands for the European Economic Community and the United States.

Turning to elasticities, it was found that the demand for paperboard is very price inelastic (see Table 4.7) ranging from -0.05 to -0.33. It appears that the demand for paperboard is even more inelastic than that of newsprint. This result is contrary to Buongiorno's finding that printing paper was the more inelastic demand than the other two products. The United States' demand for paperboard is especially

Table 4.6

Estimated Paperboard Demand Equations for Selected Regions [1]

	Coefficients of Explanatory Variables							
Region	Intercept	Price	GNP	Dummy	lag	DW	rho	R^2
Japan[2]	-4799.930 (782.307)	-2.980916 (2.196539)	4.678762 (0.625196)	1520.730 (166.330)	0.321669 (0.033629)			0.8898
EEC[2 3]	8418.200 (2569.063)	-13.073679 (4.241948)	4.583911 (2.604791)	64.436 (955.601)	0.464910 (0.207880)		-0.409	0.9197
Canada[2]	144.202 (116.721)	-0.807943 (0.177938)	4.208424 (0.926844)	267.350 (58.880)				0.5789
Total U.S.	7055.282 (3477.220)	-4.713831 (4.070611)	19.782311 (2.627242)	-641.562 (1176.427)				0.9278
U.S. East[4]	5086.858	-3.398672	14.263046	-462.566				
U.S. West[4]	1968.424	-1.315159	5.519265	-178.996				

1. Standard error are reported in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.
2. Corrected for serial correlation.
3. Estimates of principal components.
4. These equations are obtained as a proportion of Total U.S. demand equation.

Table 4.7

Derived Demand Price Elasticities for Paperboard at the Sample Means, Selected Regions

Regions	Mean Apparent Consumption	Price Elasticity	Price Sample Mean	GNP Elasticity	GNP Sample Mean
Japan	7548.4706	-0.17	441.1085	0.23	369.9523
EEC	14825.0588	-0.33	378.9673	0.33	1077.9995
Canada	2244.6471	-0.09	258.6276	0.25	134.0282
USA	32823.9000	-0.05	322.4010	0.84	1394.6941

inelastic, at a value of -0.05. Canada is also very price inelastic in demand at a value of 0.09. Of the three products considered, paperboard has the most income inelastic demand ranging from 0.23 to 0.84. The United States had the least income inelastic demand but it had the most price inelastic demand.

4.2.2 Supply of Paper Products

The estimated supply for the three product groups are presented in this section which is divided into three subsections one for each product. The first subsection presents the estimated newsprint supply for selected regions. Estimated supplies for printing paper for selected regions are presented in the second subsection. Finally, the third subsection presents the estimated paperboard supply functions for selected regions.

4.2.2.1 Supply of Newsprint

The results are presented in the same order as had been done for the demand equations: newsprint first, printing paper second, and finally paperboard. Six supply equations were estimated for newsprint (see Table 4.8). Only for two regions, the Nordic countries and U.S. West, were the supply price coefficients statistically significant at the 10 percent level. The coefficient of determination were also relatively high; the lowest R^2 obtained was .5849 for the U.S. West supply equation. The estimated supply function for Japan and U.S. West

Table 4.8

Estimated Newsprint Supply Equations for Selected Regions [1]

Region	Coefficients of Explanatory Variables				
	Intercept	Price	lag	Pulp	Wage
Japan	9.015 (110.936)	0.110333 (0.331776)	1.224032 (0.061954)	-7.131337 (2.828169)	-12.128759 (5.561403)
Nordic	1684.372 (621.693)	2.136721 (1.672679)	0.611897 (0.130220)	-52.401236 (23.013666)	
British Columbia	3650.281 (762.890)	5.129630 (10.559453)	-0.237277 (0.189904)		-1185.161 (636.934)
U.S North	152.280 (181.027)	1.850351 (1.846193)			
U.S. South	548.490 (576.490)	0.863504 (3.106653)			
U.S. West	514.537 (261.790)	3.007015 (2.228911)			

1. Standard errors are reported in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.

Table 4.8 Continued

Region	Coefficients of Explanatory Variables				DW	rho	R^2
	Chemical	Fuel	Capacity	Dummy			
Japan				-141.250 (57.582)	2.000	-0.562	0.9969
Nordic				47.500 (119.320)			0.9346
British Columbia	-2521.356 (1791.505)			513.362 (157.226)			0.8839
U.S North	-594.313 (437.829)		0.930867 (0.157248)	-20.769 (30.999)			0.8677
U.S. South		-616.607 (414.836)	0.754938 (0.108885)	8.116 (70.530)			0.9639
U.S. West	-769.448 (490.498)			141.608 (45.689)		0.550	0.5849

1. Standard errors are in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.

were corrected for serial correlation. [3] Although the price coefficients of the supply functions for Japan, the Nordic countries, and British Columbia were not very significant, these equations are still useful inputs in the reactive programming algorithm, they still show some supply response. Moreover, it is not that producers do not response at all to prices -- only that over a period of one year they are not sensitive to price changes. Notice that the coefficients on lagged production for the there producing regions mentioned earlier are all significantly different from zero. Pulp prices (proxy variables for prices of groundwood) have greater influence on the supply of newsprint for Japan and the Nordic countries than the other regions. In the case of Japan it is the scarcity of the raw material domestically that makes pulp prices an important factor. In a similar vein the Nordic countries face forest management policies which restrict domestic producers from overcutting their forest resources. Whereas lagged production is an important factor in the supply of newsprint for Japan, the Nordic countries, and British Columbia, capacity plays a significant role in the supply for two of the U.S. producing regions. Chemicals also contribute in determining the level of production of newsprint for U.S. North and U.S. West. Only production in the U.S. South region seems to affected by fuel prices. Structural change may have affected newsprint production in Japan, British Columbia, and the U.S. West.

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3. The procedure 'Autoreg' of the Statistical Analysis System (SAS) package was used.

The short run supply price elasticities of newsprint for the producing regions range from an almost perfectly inelastic Japan at 0.02 and an elastic U.S. West at 1.15 (see Table 4.9). The Nordic countries and U.S. South also possess inelastic supply curves. British Columbia and U.S. North are quite close to being elastic supplies. Since three of the producing regions have dynamic supply functions the long run elasticities of their supply can be discussed. Out of the three regions, only the Nordic countries possess a long run elasticity greater than its short run elasticity; the long run elasicity is 0.54. Canada has a long run elasticity of 0.73 while Japan's long run elasticity turns negative.

4.2.2.2 <u>Supply of Printing Paper</u>

Seven supply equations were estimated for printing paper. Although all of these equations had satisfactory statistical fits, a coefficient of determination of .62 or better was obtained for each of the equations, the price coefficients for two producing regions were not statistically very significant (see Table 4.10). Only four of these equations, the supply for the European Economic Community, the Nordic countries, U.S. North Central, and U.S. West yielded significant price coefficients at the 1 percent level; the remaining equations were significant at between the 5 to 15 percent level. Although Japan's supply function did not have a statistcally significant price coefficient, the function was retained since lagged production was statistically significant. For four producing regions lagged production

Table 4.9

Derived Supply Price Elasticities for Newsprint at the Sample Means, Selected Regions

Regions	Production Mean	Price Elasticity	Price Mean
Japan	1769.4300	0.02	282.8644
Nordic	2564.7359	0.21	249.9130
British Columbia	1311.2447	0.90	230.4400
US North	627.1116	0.70	236.7119
US South	1452.1714	0.14	236.7119
US West	618.6650	1.15	236.7119

Table 4.10

Estimated Printing Papers Supply Equations for Selected Regions [1]

Region	Coefficients of Explanatory Variables				
	Intercept	Price	lag	Pulp	Wage
Japan	161.862 (335.380)	0.115528 (0.458348)	1.213318 (0.197152)		-46.695 (5.561403)
EEC	11713.092 (2161.592)	5.721989 (2.270941)	0.469664 (0.104014)	-115.746 (37.945)	
Nordic	1791.651 (542.369)	3.276504 (2.053904)	0.402894 (0.255823)	-88.550146 (34.696719)	
Ontario	266.028 (825.603)	2.437280 (2.538452)	-0.402791 (0.308950)	-0.933419 (1.334645)	
U.S North East	859.309 (846.500)	1.771133 (2.907971)		-1.946412 (1.919777)	
U.S. North Central	382.127 (728.371)	3.846656 (2.514950)		-4.232696 (1.755174)	
U.S. West	-439.087 (489.248)	3.685690 (2.165225)		-2.567921 (1.398195)	

1. Standard errors are reported in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.

Table 4.10 Continued

Region	Chemical	Fuel	Capacity	Dummy	DW	rho	R^2
	Coefficients of Explanatory Variables						
Japan		-350.858 (256.302)		-353.377 (264.980)	2.000		0.9534
EEC	-3831.523 (1486.136)			253.389 (515.408)	2.000		0.8731
Nordic				643.110 (296.110)			0.9215
Ontario		-690.426 (492.201)		623.628 (198.618)		-0.364	0.6204
U.S. North East			0.795057 (0.184206)	-368.187 (291.539)			0.7957
U.S. North Central			0.901062 (0.195373)	-252.493 (263.435)			0.8603
U.S. South			1.025687 (0.078295)	-291.867 (200.569)		0.550	0.9818

1. Standard errors are in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.

plays an important role in determining the level of production. Pulp prices also appeared to be a key factor in determining the level of production for many of the producing regions. It also appears that the printing paper sector of the paper industry had undergone structural change before and after 1970 since this factor is statistically significant for all of the producing regions.

All regions, except Ontario, had price inelastic supply functions (see Table 4.11). Short run supply price elasticities range from 0.03 to 2.10 with Japan and U.S. North East having the more inelastic supplies. Ontario had a short run supply price elasticity of 2.10. The long run supply price elasticities for the European Economic Community and the Nordic countries are greater than their short run elasticities, with the former possessing a price elasticity of 0.82 and the latter 0.99. Although the long run elasticity for Ontario still remains elastic it is less elastic than its short run elasticity -- at a value of 1.50. As in the case of newsprint, the long run elasticity of supply for Japan becomes negative valued at -0.14.

4.2.2.3 <u>Supply of Paperboard</u>

As was the case for the supply for printing papers, structural change is believed to have occurred in the paperboard sector of the paper industry (see Table 4.12). Although the price coefficients of supply for Japan and the Nordic countries are not very significant they are retained because they might help in the allocation part of the study. Moreover, the coefficient of pulp prices are significant thus

Table 4.11

Dervied Supply Price Elasticities for Printing Papers at the Sample Means, Selected Regions

Regions	Production Mean	Price Elasticity	Price Mean
Japan	2163.0588	0.03	559.3188
EEC	5911.8235	0.43	447.3025
Nordic	1847.6471	0.59	333.0852
Ontario	392.0793	2.10	338.3836
U.S. North East	3624.8124	0.16	322.8584
U.S. North Central	3098.2865	0.40	322.8584
U.S. South	3216.4900	0.37	322.8584

Table 4.12

Estimated Paperboard Supply Equations for Selected Regions [1]

Region	Coefficients of Explanatory Variables						
	Intercept	Price	Pulp	Chemical	Dummy	DW	R^2
Japan	8706.232 (1756.630)	0.937261 (3.863141)	-107.807 (59.876)		4985.323 (264.960)	1.271	0.7737
EEC	13493.503 (1408.199)	12.737416 (6.487845)	-268.683 (72.775)		1289.437 (552.009)		0.8370
Nordic	7078.750 (763.170)	1.686513 (3.523197)	-145.029 (47.276)		1316.295 (264.683)	2.358	0.8507
Canada	6285.207 (1068.776)	2.615539 (2.375329)		-4797.818 (1467.772)	417.969 (169.269)	1.707	0.8032
U.S. South	12276.510 (2847.010)	4.312072 (3.918390)		-9204.788 (3779.468)	-1396.208 (1021.090)		0.9571

1. Standard errors are reported in parentheses, DW is the Durbin-Watson statistics, rho is the first order autocorrelation, and R^2 is the unadjusted coefficient of determination.

allowing the supply function to shift through time in the reactive program. The price coefficient for the European Economic Community is significant at the 1 percent level while that of Canada and U.S. South are significant only at the 15 percent level.

The short run price elasticities of paperboard are quite inelastic ranging from 0.05 to 0.42. Japan and U.S. South appears to have the more inelastic supply curves out of the five producing regions (see Table 4.13). Unlike the previous two products, supplies of paperboard are not dependent on the lagged production indicating that inventory built ups are not as crucial in determining the level of production.

4.3 Summary

Initially, five consuming regions - the United States, Japan, Canada, the Nordic countries, and the European Economic Community - and eight producing regions - Japan, the Noridc countries, British Columbia, Ontario (representing the rest of Canada), U.S. North, U.S. South, and U.S. West - were considered for the three product groups - newsprint, printing paper, and paperboard. This regional breakdown, however, was altered either because data were not available or because meaningful equations could not be obtained. The final regional breakdown for each product is summarized in Table 3.1; four consuming and seven producing regions for newsprint, and five consuming and seven producing regions for printing paper and paperboard.

Table 4.13

Derived Supply Price Elasticities for Paperboard for Selected Regions at the Sample Means

Regions	Production Mean	Price Elasticity	Price Mean
Japan	7724.0000	0.05	441.1085
EEC	11523.5294	0.42	378.9673
Nordic	4960.1765	0.12	349.8670
Canada	2564.2353	0.26	258.6276
US South	18592.8765	0.07	322.4010

Several studies of the demand for paper have included own price as an explanatory variable in the demand function. All of these studies, except for Buongiorno, adopted a product classification scheme different from the present study. Both the Buongiorno and this study used a similar data base; the difference between the two studies lies in the coverage of the sample period and model specification. Whereas Boungiorno specified newsprint and printing paper as substitutes for one another, this was not done in the present study.

Not surprisingly, good-fitting demand functions for large net importers and good-fitting supply equations for large net exporters were obtained. The unit value of imports was used as a price variable for net importers and the unit value of exports was used as the price variable for net exporters. It is assumed that for large importers/exporters that the unit value of imports/exports should be highly correlated with the domestic price. The price coefficient for newsprint for all regions considered were significant at the 1 percent level. The short run own price demand elasticity, at the sample means, for newsprint were in the inelastic range. The 'income' coefficient for Japan, the European Economic Community, and the United States were all highly significant, at the 5 percent level. Not only is the demand price elasticity inelastic but the income elasticity is also inelastic.

The price coefficients for the demand for printing paper for the European Economic Community, the Nordic countries, and the United States were all significant at the 1 percent level. In general, the short run demand price elasticity for printing paper is less inelastic than that of newsprint. The United States demand price elasticity at -0.14 was especially inelastic. The income coefficients for printing paper for the four regions were also highly significant. However, the income elasticities were much higher than that for newsprint; in fact, they were in the elastic range, except for Canada which had an elasticity of 0.40.

While the European Economic Community's demand price coefficient for paperboard was significant at the one percent level, that of the United States and Japan were only significant at the 10 percent level. The demand price elasticity for paperboard for all regions were inelastic with the United States being more inelastic, a value of -0.05. Not unlike the income coefficient for newsprint and printing paper the income coefficient for paperboard is also highly significant. The income elasticity for paperboard were all inelastic; they were more inelastic than the income elasticity for newsprint.

Statistical fits for newsprint supply for the six producing regions were quite high. The price coefficients for British Columbia, U.S. North, and U.S. South were significant at the 10 percent level. It is quite clear that factor costs play an important role in determining the quantity supplied by each producing region. The price elasticity of supply for all the regions, other than U.S West which had a price elasticity of 1.15, were all inelastic.

Although the supply equations for printing paper obtained fit well statistically, the price coefficients for many of them were only significant at the 10 percent level. Only the supply equations for the European Economic Community and the Nordic countries had price coefficients significant at the 1 percent level. Again, input costs appear to be important in determining the quantity supplied by each producing region. The supply price elasticity for printing paper was found to be quite inelastic, in general. Only the supply price elasticity of Ontario, at a value of 2.10, was elastic. Japan's price elasticity, at 0.03, was the most inelastic supply among the producing regions.

The price coefficients for the supply equations for paperboard, in general, were significant at the 5 percent level at the least. Input cost have an important role in determining the amount of quantity supplied by each producing region. Structural change appears to have a great influence on the supply of the printing papers and paperboard sectors of the paper industry. The supply of paperboard was found to be inelastic, with Japan having the least inelastic supply and U.S. South having the most inelastic supply among the producing regions.

The price elasticities of supply and demand obtained in this appear to agree with the results of past studies. In general, the price elasticity of supply and demand for paper products are inelastic. The price elasticity of demand of printing paper is less inelastic than that of newsprint. This result concurs with Boungiorno's findings. The demand for newsprint and paperboard are both income inelastic but while the present study found paperboard to be the more inelastic demand Boungiorno found newsprint to be the more income inelastic demand instead. Supply price elasticities for paper products tend to be very inelastic. This result agrees with the findings of McKillop (30).

CHAPTER V

SPECIFICATION OF THE TRADE MODEL AND REACTIVE PROGRAMMING ALGORITHM

Introduction

A brief literature review of spatial studies specific to forest products is discussed in the first section. In the second section the reactive programming algorithm is presented. The mathematical formulation of the spatial problem and the computational peculiarities of the algorithm are also discussed in this section. This section also includes a graphical demonstration of the iterative nature of the algorithm. Finally, a summary of the chapter is presented in the third section.

5.1 Literature Review of Forestry Spatial Studies

The earliest attempt at spatial modeling in the forestry literature was by Holland and Judge (19), who developed a spatial model of the lumber industry. Other researchers since have modeled various sectors of the forestry industry. Holley (20) modeled the softwood plywood sector, Hallberg and Clemente (15) modeled the Northeast pulp and paper sector, Davis, Lyons and Burkhart (10) modeled the southern Appalachian hardwood lumber-using sector, and Holley, Haynes, and Kaiser (20) modeled the softwood sector. All of these studies adopted the basic transportation model approach; given fixed quantities of supply and demand linear programming was used to determine the least cost routes.

Holland and Judge divided the United States into 29 regions. Regional demands, supplies, and the resulting surpluses or deficits of hardwood and softwood lumber were estimated for each of these regions for the year 1958. Initially the ratio of regional to national construction expenditure was computed. Regional demand was simply computed as this ratio multiplied by the national demand since regional consumption data was not available.[1] Holley also used the linear programming approach to analyze the disparity between the actual 1965 flows and the flows suggested by the optimal solution. He also computed the necessary shifts required to bring about the most efficient location of the softwood plywood industry for the projection year of 1975. Hallberg and Clemente also solved for the optimal interregional flows based on 1975 projections of consumption and production of softwood and hardwood pulpwood for 33 regions. Davis, Lyons, and Burkhart used the transshipment model, an extension of the standard linnear programming algorithm, to obtain the least cost spatial organization for four wood products distributed over 22 regions. They then compared the results based on alternative scenarios for raw material supplies, final demand,

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1. This is not an uncommon practice in many spatial studies where regional consumption data is not available.

production costs, and transportation costs. A recent study by Holley, Haynes and Kaiser (21) incorporated more regions and products into their analysis. They included 17 supply and 25 demand regions for 11 products. Assuming fixed supplies and demands, they employed linear programming to determine the least-cost, most efficient geographical pattern of industrial location and timber harvest over time. Processing costs and import and export constraints were also incorporated in the model. Haynes, Holley and King (18) extended the earlier work of Holley, Haynes, and Kaiser (21) by including sloping demand functions in the study thereby forcing prices and consumption to be determined endogenously within their model. The same set of products and regions used in the latter study were analysed in the former study.

Other researchers have taken the econometric approach to study the international trade problems in forest products rather than the linear programming route. McKillop (31) adopted the econometric approach to model Japanese-North American trade in logs and lumber. Using quarterly data for the period 1950-1970, McKillop estimated export demand equations for Japanese demand for U.S. logs, U.S. lumber, and Canadian lumber; and export supply equations for U.S. supply of logs and lumber and Canadian supply of lumber to Japan. The supply and demand for logs were estimated using ordinary least squares while the remaining four equations for lumber were estimated simultaneously. Manning (29) developed a simultaneous system of four equations - one domestic demand, two export, and one supply equation - to study the Canadian softwood lumber industry. Manning used annual data for the period 1951-1971. Thevenon (50) formulated an econometric model of international trade for kraft linerboard using quarterly data for the period 1961-1969. The model was formulated on the basis of Armington's (3) theory of demand in which a commodity is differentiated by its source of origin. Many trade flows were not considered on a priori grounds; the only markets considered were the United States domestic market, United States shipments to the United Kingdom and Germany, and Swedish shipments to the United Kingdom and Germany. Two stage least squares were used to solve the simultaneous set of export supply and demand equations.

A combination of the econometric and reactive programming approaches is found in the work of Adams and Haynes (2), which is an outgrowth of the previous works of Adams (1) and Haynes (17), on a spatial model of North American softwood lumber, plywood and stumpage markets.[2] Their work is described in greater detail than the other studies alluded to earlier since the analytical framework of the present study corresponds to theirs. Specifying nine stumpage and final product supply regions, and six final product demand regions, Adams and Haynes linked the stumpage sector to the final product sector by a block recursive set of simultaneous equations.[3] Regional demand functions for

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2. Adams and Haynes coined the term "quasi-spatial market models" for models using the econometric approach such as McKillop (31) and Thevenon (49). Their study also contained a comprehensive description of previous efforts to model and project forest products markets. See pp. 3-9.

3. Op. cit.,p. 11.

softwood plywood were estimated but because regional consumption data was not available, regional demand functions for lumber and stumpage were not estimated by conventional econometric means but rather by an elaborate scheme of computation. These regional demand functions formed an integral part in locating the equilibrium points in their projections.

The regional functions were obtained in a stepwise manner. Initially, estimates of national price and consumption were computed. After imposing certain restrictions about the elasticity of demand, the slope of the regional demand functions were obtained. National projections were based on annual data for the period 1950-1976. The mean of a multi-period moving average was used to arrive at a price trend for softwood lumber while no price trend was assumed for softwood plywood. Consumption levels were computed as the product of end-use ratios and end-use activity levels. Thus, projections of the end-use ratios and end-use activity levels were made, judgmental or otherwise. The price trends previously computed served as a judgmental guideline in evaluating shifts in these projections.

The price coefficients of the regional demands were obtained in the following steps. Initially a national elasticity of demand of -0.35 was assumed from another study. The first step involved estimating a functional relationship between the producer price index and the wholesale price at lumberyards in each demand region yielding

$$\lambda_i = \frac{P_i}{P} \qquad i = 1,\ldots,n$$

where P = producer price index

P_i = wholesale price at lumberyards in demand region i

λ_i = coefficient of proportionality for demand region i

The regional demand elasticity was assumed to be proportional to the national elasticity by the factor λ_i, thereby yielding

$$\varepsilon_i = \lambda_i(-0.35)$$

where ε_i is the demand price elasticity for region i. Total consumption in region i was obtained as the product of per capita consumption in region i and the population in region i, that is,

$$Q_i = PCQ_i \times POP_i$$

where Q_i = total consumption in region i

PCQ_i = per capita consumption in region i

POP_i = population in region i

Since the regional elasticity of demand is defined as

$$\varepsilon_i = \frac{\beta_i P_i}{Q_i}$$

the regional price coefficient, β_i, can be solved in the following manner

$$\beta_i = \frac{\varepsilon_i Q_i}{P_i}$$

$$= \frac{\lambda_i(-0.35)Q_i}{P_i}$$

These coefficients were used as data in the allocation algorithm. Reactive program was employed to determine the optimal distribution of the products among the various supply and demand regions.

Despite the numerous attempts at spatial modeling in the forestry literature, only the Adams and Haynes (2) and Boyd (6) studies have made any attempt to recognize international trade. Even then, Canada was included in the Adams and Haynes model more as a natural extension of the Pacific Northwest than as an effort to fully incorporate international trade into the model. Credit should be given to Boyd, however, for explicitly incorporating international trade aspects into his analysis. Boyd adopted estimates of demand based on the econometric model by Robinson (37) for the United States, but supply was assumed to be predetermined. Boyd used reactive programming to solve the spatial distribution of lumber. Like Boyd's study, the focus of the present study is on international trade flows.

5.2 Reactive Programming

Reactive programming is a special case of mathematical programming in its most generalized form. A mathematical programming problem involves choosing nonnegative values of a vector x so as to maximize or minimize an objective function, $f(x)$, subject to a vector of inequality constraints, $g(x) > b$, where b is a vector of parameters.[4] Nonlinear programming can be considered as a special case of mathematical programming in which the objective function $f(x)$, is a polynomial of degree $k > 2$ and the constraints, $g(x)$, are of degree $j > 1$.[5] The case

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4. See Intriligator (23), p. 44.

5. See Takayama (45), p. 56-60.

in which both the objective function and the constraints are linear constitutes a linear programming problem.

The term "transportation problem" is used to refer to a special type of linear programming problem in which fixed supplies in each of M regions are allocated to meet fixed demands in N markets so as to minimize total transfer costs.[6] Mathematically, the transportation problem can be expressed as

$$\text{Minimize } T = \Sigma_i \Sigma_j T_{ij} Q_{ij} \qquad i = 1,\ldots,M; \quad j = 1,\ldots,N$$

$$\text{subject to } \Sigma_j Q_{ij} < S_i \qquad i = 1,\ldots,M$$

$$\Sigma_i Q_{ij} < D_j \qquad j = 1,\ldots,N$$

$$Q_{ij} > 0$$

where T_{ij} = per unit transportation cost of shipping from region i to region j

Q_{ij} = volume of shipments from region i to j

S_i = total available supply in region i

D_j = total fixed demand in region j.

The dual of the transportation problem above is then[7]

$$\text{Maximize } R = \Sigma_j P_j D_j - \Sigma_i C_i S_i$$

$$\text{subject to } P_j - C_i < T_{ij} \qquad \text{for all } i,j$$

$$S_i,\ D_j > 0 \qquad \text{for all } i,j$$

where P_j = market price in region j

C_i = supply price in region i.

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6. King and Gunn (27), p. 12.

Reactive programming is simply an extension of the dual of the transportation problem. Whereas the P_j's and C_i's in the dual are exogenous to the system of equations, they are endogenous to the system in reactive programming. They are now functions of quantity. There is a price-dependent demand function in each market. That is

$$P_j = F_j(D_j)$$

where $D_j = \Sigma_i Q_{ij}$.

There is also a price-dependent supply function in each producing region. That is

$$C_i = G_i(S_i)$$

where $S_i = \Sigma_j Q_{ij}$.

Notice that reactive programming now emerges as a nonlinear programming problem with a nonlinear objective function

$$R' = \Sigma_j F_j(D_j)D_j - \Sigma_i G_i(S_i)S_i$$

with a set of linear and/or nonlinear constraints

$$P_j - C_i < T_{ij}$$

$$P_j = F_j(D_j)$$

$$C_i = G_i(S_i)$$

$$\Sigma_j Q_{ij} = S_i$$

$$\Sigma_i Q_{ij} = D_j$$

$$Q_{ij} > 0$$

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7. The coefficient on S_i is negative since the constraint in the primal was set up as being less than S_i.

depending on the functional forms of F_j and G_i. By substituting terms this nonlinear programming problem maybe rewritten as a revenue maximization problem with

$$\text{Maximize } R' = \Sigma_j F_j(\Sigma_i Q_{ij})\Sigma_i Q_{ij} - \Sigma_i G_i(\Sigma_j Q_{ij})\Sigma_j Q_{ij}$$

subject to a contraint that limits the feasible set to a price differential greater than the per unit transportation costs

$$F_j(\Sigma_i Q_{ij}) - G_i(\Sigma_j Q_{ij}) > T_{ij}$$

This set of equations can then be transformed into a Lagrangian function

$$L = \Sigma_j F_j(\Sigma_i Q_{ij})\Sigma_i Q_{ij} - \Sigma_i G_i(\Sigma_j Q_{ij})\Sigma_j Q_{ij} + \Sigma_j \Sigma_i (\lambda_{ij}(F_j(\Sigma_i Q_{ij}) - G_i(\Sigma_j Q_{ij}) - T_{ij}))$$

The Kuhn-Tucker conditions for this nonlinear programming problem are

$$\frac{\partial L}{\partial Q_{ij}} = F_j(\Sigma_i Q_{ij}) - G_i(\Sigma_j Q_{ij}) + \lambda_{ij}\left(\frac{\partial F_j}{\partial Q_{ij}} - \frac{\partial G_i}{\partial Q_{ij}}\right) = 0$$

$$\frac{\partial L}{\partial Q_{ij}} \times Q_{ij} = (F_j(\Sigma_i Q_{ij}) - G_i(\Sigma_j Q_{ij}) + \lambda_{ij}\left(\frac{\partial F_j}{\partial Q_{ij}} - \frac{\partial G_i}{\partial Q_{ij}}\right)) \times Q_{ij} = 0$$

$$\frac{\partial L}{\partial \lambda_{ij}} = F_j(\Sigma_i Q_{ij}) - G_i(\Sigma_j Q_{ij}) - T_{ij} = 0$$

$$\frac{\partial L}{\partial \lambda_{ij}} \times \lambda_{ij} = (F_j(\Sigma_i Q_{ij}) - G_i(\Sigma_j Q_{ij}) - T_{ij}) \times \lambda_{ij} = 0$$

This set of conditions will be met at the optimal set of shipments. Although the Kuhn-Tucker conditions characterize a solution they do not provide a constructive method for obtaining a solution.[8] The roles played by these conditions in the reactive algorithm will become clear

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8. Intriligator (23), p. 62.

when the algorithm is explained in more detail. Many solution algorithms exist, and reactive programming is only one such algorithm.

The mechanics of reactive programming, accompanied by a graphical analysis, occupies the remainder of this section. In their original paper, Tramel and Seale (51) demonstrated the procedure for a problem consisting of demand functions and fixed supplies. With the exception of the graphical analysis, the ensuing presentation is based on Tramel's (52) rebuttal to Takayama and Judge's (46) criticism and Boyd's (6) lucid explanation. Starting with the equilibrium (Kuhn-Tucker) conditions, the problem is that of initiating a path towards the optimal solution.

The optimal solution, however, must satisfy four restrictions before the solution can be interpreted meaningfully in economic terms. First of all, all shipments must be nonnegative, that is, all Q_{ij}'s must be greater than or equal to zero. Secondly, to guarantee that no losses are made, the average revenues defined as

$$R_{ij} = F_j(\Sigma_i Q_{ij}) - T_{ij} \qquad \text{for all } i,j$$

must also be nonnegative.[9] These two restrictions are acutally the first two Kuhn-Tucker conditions presented earlier. The second Kuhn-Tucker condition condition holds true if L/Q_{ij}, Q_{ij}, or both are equal to zero. At the optimal solution marginal revenue (the first Kuhn-Tucker

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9. Since supplies are assumed fixed, that is

$$G_i(\ _jQ_{ij}) = 0$$

it is, therefore, absent in the formula.

condition) equals zero. For positive shipments the product of marginal revenue at the optimal solution and the shipment is also equal to zero (the second Kuhn-Tucker) condition. However, this product may still be zero even if marginal revenue is not to zero but shipments, the Q_{ij}'s, will have to be zero such that the second condtition is satisfied. The third restriction requires that for any producing region i, all the R_{ij}'s for consuming regions for which shipments are made are equal and at the same time greater than the R_{ij}'s for region's in which no shipments are made. This restriction ensures that higher profits cannot be achieved through a reallocation of shipments. The third restriction implicitly assumes the third and fourth Kuhn-Tucker conditions. At the optimal solution, market price exceeds the supply price by exactly the unit transport costs as given by the third Kuhn-Tucker condition. λ_{ij} is the 'shadow price' of changing the per unit net return. The interpretation of conditions three and four combined is analogous to the explanation of the relationship between marginal revenue and shipments. Finally, the total shipments from any producing region cannot exceed its fixed supply, that is

$$\Sigma_j Q_{ij} \leq S_i.$$

The computational steps will not be presented here since they have been described elsewhere.[10]

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10. See Tramel and Seale (51) pp. 1013-1014 and Boyd (6), pp. 47-49.

In response to criticisms by Takayama and Judge (46), Tramel modified the originial algorithm to allow for both demand and supply functions to be incorporated into the algorithm. The only major change made was in the calculation of the shipments, the Q_{ij}'s. A much quicker method of computation, Newton's method of approximation, was used to calculate the shipments. The following formula was used:

$$^{(k)}Q_{ij} = {}^{(k-1)}Q_{ij} - \frac{R_{ij}}{(F'_j - G'_i)}$$

where k = number of iterations,

F'_j = the derivative of the price-dependent demand equation with respect to quanitity, and

G'_i = the derivative of the price-dependent supply equation with respect to quantity.

to adjust shipments from any producing region i to all consuming regions j for positive average net revenue, that is R_{ij} 0.

The simplicity of the reactive programming algorithm can be highlighted with reference to a graphical analysis of a one-product, two-region case. The problem is further simplified by assuming linear demand and supply functions. [11]

It is easy to demonstrate graphically how the reactive programming algorithm proceeds to arrive at the spatial equilibrium solution. The algorithm proceeds by a trial-and-error process towards the equilibrium solution. Initially an arbitrary set of regional production and

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11. Different functional forms involved corresponding changes in the adjustment of the shipments. See King and Gunn (27), p. 34.

consumption is chosen such that aggregate production, that is the sum of production in all producing regions, equals aggregate consumption, the sum of consumption in all consuming regions.[12] The origin of Region 1 has been shifted vertically to the horizontal line TT by a vertical distance of OT (see Figure 5.1). Thus, the supply and demand curves of Region 1 have both been shifted by an equal vertical distance. In other words unit costs of shipping from Region 1 to 2 has been added on to both the demand and supply prices in Region 1. Let OA and OA' be the initial (but arbitrary) production points for Region 1 and 2, respectively. Aggregate production is, therefore, measured as the horizontal distance BC (= OA + OA').[13] Since aggregate production equals aggregate consumption in equilibrium, (the first restriction described earlier in this section) aggregate consumption can be found by locating a horizontal distance measuring BC between the two demand curves. The horizontal line FG (= OE + OE') meets this criterion, that is FG = BC. However, to ensure that no losses are incurred the average net revenue, defined as demand price minus supply price minus the transport cost (or

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12. Production and consumption in each region either have to be provided or they may be solved using the Equilibrium subroutine if linear functions are specified. See King and Gunn (27), pp. 15-17.

13. This is another simplification in the graphical demonstration. The initial production and consumption allocations in both regions need not have been chosen to coincide at the same price; all that is required is that aggregate production equals aggregate consumption. However, if the initial allocation were not at the same price then this would have meant drawing too many lines on the same graph. Moreover, the number of iterations required to reach the spatial equilibrium would have increased; this also means increasing the number of lines on the graph.

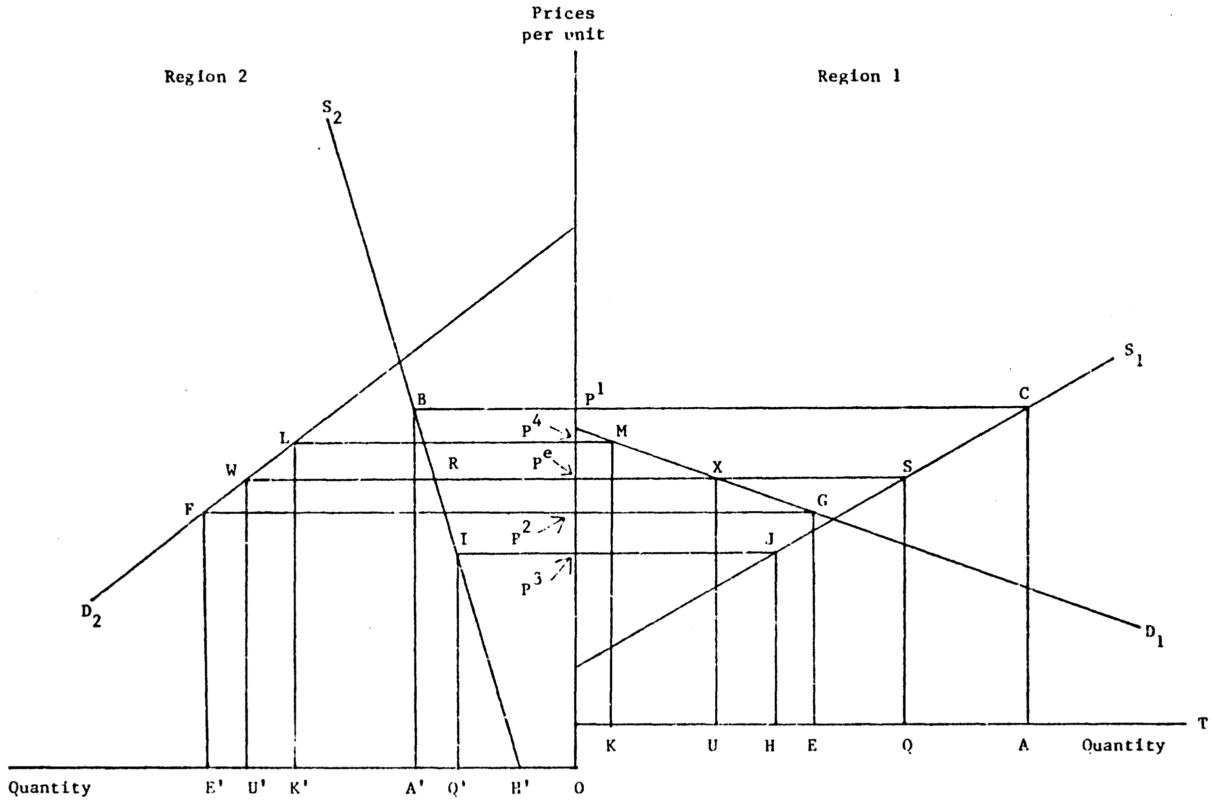

Figure 5.1

Spatial Equilibrium for Two Regions by Iteration
by Equating Total Supply to Total Demand

the Rij's), must be nonnegative (the second restriction). For the initial selection the net average revenue is

$P2 - P1 > 0$

since P^1 is greater than P^2 (see Figure 5.1). Therefore, Region 1 will not export to Region 2 since it is not profitable to do so.[14] Select another arbitrary set of regional production and consumption points such that the first restriction is met. Let production be OH and consumption be OK in Region 1 and let OH' and OK' be production and consumption in Region 2. Aggregate production, IJ (= OH + OH'), equals aggregate consumption, LM (= OK + OK'). This time average net revenue

$(P4 - P3) > 0$

is positive since P^4 is greater than P^3. By construction the demand price for both regions is P^4 and the supply price is P^3. Hence production exceeds consumption by KH in Region 1. This amount will be shipped to Region 2. At the same time consumption exceeds production by K'H' in Region 2. Part of Region 2's consumption is imported from Region 1, that is KH - K'H', while the remainder, OH', is supplied domestically. These results may be deduced from the equality between aggregate production and consumption, that is IJ = LM.

Therefore,

$OH + OH' = OK + OK'$

which implies

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14. The algorithm sets shipments to zero when net average revenue is negative.

KH = OH - OK = OK' - OH' = K'H'.

Since producers in both regions accrue profits they will increase production. As it will become evident later, the magnitude of the adjustment in the shipping program will very much depend on the relative magnitudes of the slopes of the supply and demand functions in each region. Recall the shipment adjustment formula presented earlier

$$^{(k)}Q_{ij} = {}^{(k-1)}Q_{ij} - \frac{R_{ij}}{(F'_j - G'_i)}$$

where k = number of iterations,

F'_j = the derivative of the price-dependent demand equation with respect to quanitity,

G'_i = the derivative of the price-dependent supply equation with respect to quantity, and

$R_{ij} = F_j - G_i - T_{ij}$

Rather than cluttering up Figure 5.1 with more lines it is reproduced, with only the relevant information needed to illustrate the adjustment mechanism vis-a-vis the above formula, as Figure 5.2. Three observations pertaining to the current problem should be pointed out before proceeding any further. First, notice that the slope of the demand curve in Region 1 is less steep than that of the demand curve for Region 2. This means that for an equal change in quantity demanded, the price change in Region 2 is more than that in Region 1. Therefore, producers tend to ship to Region 1 more than to Region 2. Secondly, the supply curve in Region 1 is also less steep than Region 2's supply curve. This indicates that producers in Region 1 need relatively

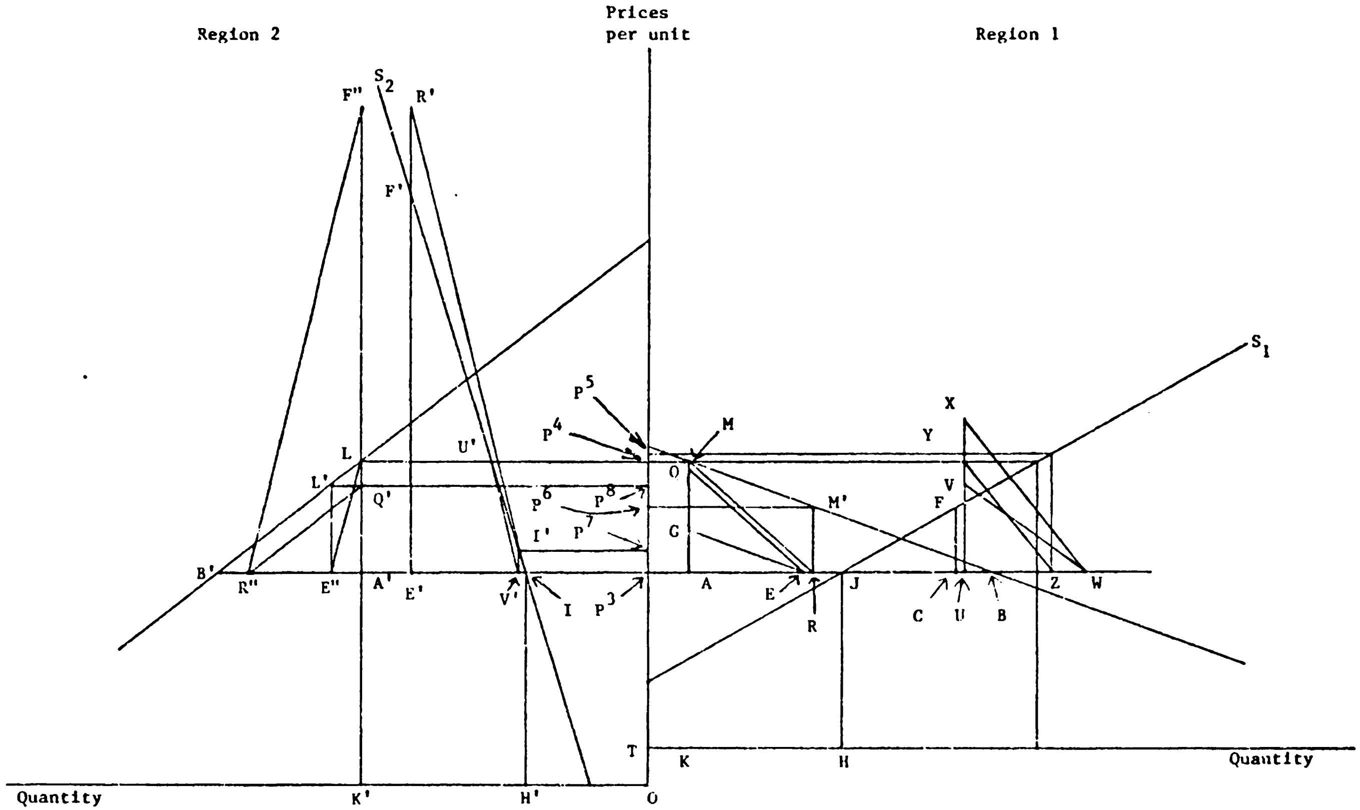

Figure 5.2

First Step of the Iterative Process for Determining
Spatial Equilibrium for Two Regions

smaller price changes in order to supply more of the product. Finally, it is more profitable for producers in Region 1 to supply the domestic market since they do not have to incur transport costs in doing so. These observations suggests that Region 1 should initiate the adjustment program.

Let AE be a unit change in quantity for Region 1 (see Figure 5.2). A segment of Figure 5.2 is enlarged by two times and is reproduced as Figure 5.3 in order to clarify the following explanation. Consumers expect the market price to drop by AG if they were to increase purchases by AE. On the other hand, producers expect the price to climb by FC if they were to produce an equal amount JC (= AE) (see Figure 5.3). Applying the formula given earlier we obtain Region 1's new shipment as

$$^{(2)}Q_{11} = {}^{(1)}Q_{11} - \frac{p4 - p3}{F'_1 - G'_1}$$

$$= OK - \frac{MA}{\frac{-AG}{AE} - \frac{FC}{JC}}$$

$$= OK + \left(\frac{MA}{AG + FC}\right) x\ AE \qquad \text{since } AE = JC$$

Since region one's new domestic shipment is in addition to its original shipment, FC is added on to AG such that FC = GQ. For a price differential of AG, producers would supply an additional amount AE to the domestic market. Producers would, therefore, supply AR to the

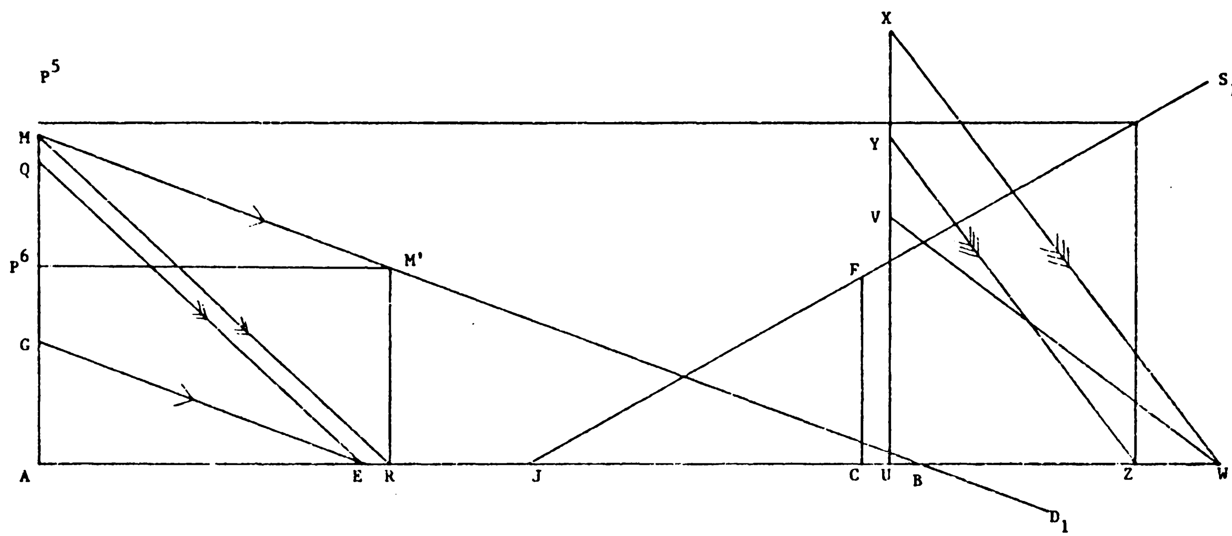

Figure 5.3

Determining the Magnitudes for Region 1 in the First Iteration domestic market since the price differential is MA.[15] Thus, producers would ship

$$^{(2)}Q_{11} = OK + AR$$

to the domestic market. Region one's shipment to Region 2 can be obtained similarly; it is given by:

$$^{(2)}Q_{12} = {}^{(1)}Q_{12} - \frac{p4 - p3}{F'_2 - G'_1}$$

$$= KH - - \frac{MA}{\frac{VU}{\overline{UW}} - \frac{FC}{\overline{JC}}}$$

Region one's total supply is obtained by adding a horizontal distance of KH (= RU) has been added on to point R. The unit change in quantity (AE) is maintained throughout the present demonstration, that is A'C' = AE = JC = UW (see Figure 5.2). The distance UV has been constructed such UV equals to A'Q'. The slope of region two's demand curve is given by -VU/UW (= - A'Q'/A'C'). The new shipment to Region 2 can therefore be rewritten as

$$^{(2)}Q_{12} = KH + \left(\frac{MA}{VU + FC}\right) x\ UW$$

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15. Using the familiar result of similar triangles in geometry
AQ = MA
AE = AR
Therefore, (MA/AQ) x AE = AR.

Add a vertical distance of FC (= VX) to UV. Hence, for a price differential of UX, producers in Region 1 would ship UW of the product. For a smaller price differential of YU (= MA), producers would only ship UZ. The latter is obtained by constructing a line parallel to XW (a result of similar triangles in plane geometry). Therefore,

$$^{(2)}Q_{12} = KH + UZ.$$

Region one's total supply is therefore,

$$S_1 = {}^{(2)}Q_{11} + {}^{(2)}Q_{12}$$

$$= OK + AR + KH + UZ$$

or the point Z, on the horizontal axis. The new domestic shipment for Region 2, $^{(2)}Q_{22}$, can be obtained using the same analysis described above, that is

$$^{(2)}Q_{22} = {}^{(1)}Q_{22} - \frac{P^4 - P^3}{\dfrac{-A'Q'}{C'A'} - \dfrac{F'E'}{E'I'}}$$

$$= OH' + \left(\frac{LA'}{F'E' + F'R'}\right) x\ E'I \qquad \text{where } F'R' = A'Q'$$

The second term of the right-hand side of the above equation can be obtained by constructing a line parallel to line R'I (see Figure 5.4).[16] Therefore, the new shipment is

$$^{(2)}Q_{22} = OH' + IV'$$

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16. A segment of Figure 5.2 has been enlarged by two times and reproduced as Figure 5.4.

17. These adjustments are done by the subroutine RPCALC in current version of reactive programming.

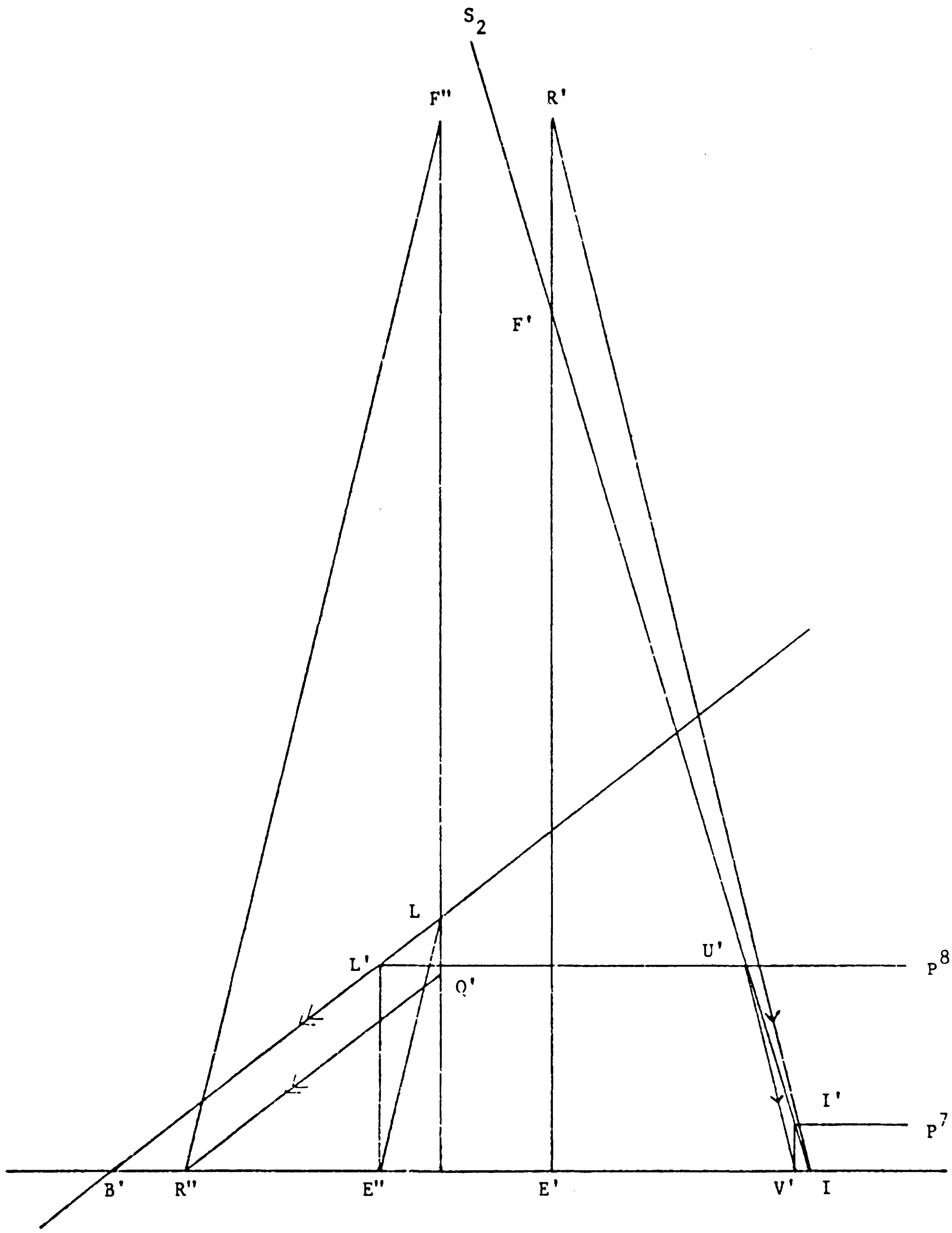

Figure 5.4

Determining the Magnitudes for Region 2 in the First Iteration which is also equal to Region Two's total supply.[17] Aggregate supply and demand have both increased in magnitude. Aggregate supply is now

$S_1 + S_2 = OK + KH + AR + UZ + OH' + IV'$.

Moreover, market and supply prices are no longer at the initial level. Supply price is at P^5 while demand price is at P^6 in Region 1. At the same time, supply price is at P^7 and market price at P^8 in Region 2. Since market prices in both regions are lower than Region 1's supply price producers in this region will decrease their shipments to both regions. Producers in Region 2, on the other hand, will increase their domestic shipments. New supply and market prices in each region will be established as a result of the readjustments. These readjustments will persist, as long as producers find it profitable to do so. When profits can no longer be made by readjustment of shipments, all regional supply and market prices become a singleton. At this unique price, P^e (see Figure 5.1), aggregate supply and demand are equal (RS = WX), and also Region 1's exports equals Region 2's imports (XS = WR).

The adjustment procedure for the two-region case presented above becomes slightly more complicated when generalizing to the case with more than two supply and demand regions. Since a region may have several shipping routes, the decision as to whether to increase or decrease shipment to a particular route is no longer simply based on the net return to that route, but rather is based on a comparison between the net return to that route in relation to the weighted average net

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return, defined as

$$R_i = \frac{\Sigma_j R_{ij} Q_{ij}}{\Sigma_j Q_{ij}} \qquad \begin{array}{l} i = 1,\ldots,M \\ j = 1,\ldots,N \end{array}$$

The deviation of net return from this weighted average net return

$D_{ij} = R_{ij} - R_i$ determines the required adjustment to be made. The adjustment formula defined earlier is modified to

$$^{(k)}Q_{ij} = {}^{(k-1)}Q_{ij} - \frac{D_{ij}}{F'_j - G'_i}$$

where D_{ij} has been substituted for R_{ij}. The net return to all consuming regions is calculated for each producing region. Considering only one producing region at a time, adjustments are made where positive net returns are obtained using the above formula. When the adjustments for the first producing region are completed, the new market prices in each consuming region are computed from the given demand equations since these prices would change because shipments have been adjusted. These market prices will be used to compute the net returns for the next producing region.[18] These computations are repeated until the last producing region has also been considered. The iteration continues until the shipments from the last iteration is no different from the current set of shipments program.

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18. See King and Gunn (27), pp. 19-25, for the steps involved in these calculations.

Before concluding this section, several capabilities of the reactive programming algorithm to handle modification's of the basic single product spatial equilibrium problem will be mentioned. First of all, the current version of the algorithm can handle not only linear but also log-linear and semilogarithmic demand and supply functions. This only involves a slight modification to the adjustment formula.[19] In fact, the assumption of perfect competition may be relaxed as long as the corresponding supply and demand equations are properly specified. Secondly, the algorithm is capable of handling two products simultaneously. Hence, twice the number of supply and demand regions in the single product case is obtained for the two product case. Finally, the algorithm is also capable of handling multi-period problems; the number of time periods is not restricted to two, however. The transfer cost matrix is slightly modified, containing several submatrices; large transfer costs are entered in order to block shipments from later time periods back to earlier ones.

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19. See King and Gunn (27), p. 34.

CHAPTER VI

HISTORICAL SIMULATION OF TRADE FLOWS

Introduction

The supply and demand equations used as inputs into the reactive program are reported in the first section. The problems peculiar to the computations in reactive programming are also discussed in this section. The determination of supply and demand points, the distances between supply and demand points, and the corresponding transportation costs are discussed in the second section. In section three, the results of the historial simulation are discussed. This section is divided into three subsections in which the results of of each of the three products are discussed. These results are then compared to the actual trade flows. Finally, a summary of the chapter is presented in section four.

6.1 Supply and Demand Equations Used in the Reactive Programming Algorithm

Supply and demand functions estimated for each product and each region have already been reported in the previous chapter. These equations were quantity-dependent with, generally, several independent variables. The reactive programming algorithm, however, recognizes only price-dependent functions and only the coefficients on quantity and intercepts need to be provided. Hence, explanatory variables other than the quantity have to be collapsed into the intercept term. The conversion of the quantity-dependent equations into the form specified by the algorithm may be generalized in the following manner. The quantity-dependent function

$$Q_t = a_0 + a_1X_{it} + a_2X_{2t} + a_3X_{3t}$$

where Q_t = total apparent consumption on total production.

X_{1t} = price of the product

X_{2t}, X_{3t} = other explanatory variaoles,

with a_1, a_2, a_3 taking the appropriate sign for either a demand or a supply function. The function is transformed so that only an intercept term and the price coefficient are present. This is done by multiplying the value for X_{2t} and X_{3t} by a_2 and a_3, respectively. The sum of these products is then aded to the intercept term, a_0, resulting in the following equation

$$Q_t = a'_0 + a_1 X_{it}$$

where $a'_0 = a_0 + a_2 X^o_{2t} + a_3 X^o_{3t}$

X^o_{2t} = value for X_{2t}

X^o_{3t} = value for X_{3t}

This equation is then inverted to obtain the price-dependent function

$$X_{1t} = \frac{-a'_0}{a1} + \frac{Q_t}{a1}$$

Before presenting the equations used in the algorithm, a problem that arose in the estimation stage must be mentioned. Recall from the previous chapter that several demand equations were not specified for some products and regions. Specifically, demands for newsprint for the Nordic countries and Canada, demand for printing paper for Japan, and demand for paperboard for the Nordic countries, were assumed to be fixed. The reactive programming algorithm, however, cannot handle fixed demand quantities.[1] This is because the algorithm will not consider routes that yield negative net returns (since the market price is zero). This is only logical since producers will incur losses, instead of profits, by shipping to routes with negative returns. This shortcoming can be overcome by specifying excess supply functions for the products and regions where demand quantities are assumed fixed. Consequently, the total number of demand regions for each product will be reduced by the number of regions where demand quantities need to be assumed fixed; namely, newsprint consists of four demand regions, and printing paper and paperboard consists of five regions.

The excess supply functions may be specified in two alternative ways. Ideally, an excess supply function should be estimated. For a demand equation of the form

$$D_t = a_0 - a_1 P_t + a_2 Y_t$$

where D_t = total apparent consumption in year t.

P_t = price in year t

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1. See King and Gunn (27), p.30.

Y_t = income in year t

$a_1, a_2 \quad 0$

and a supply equation of the form

$$S_t = b_0 + b_1P_t - b_2Z_t$$

where S_t = total production in year t

Z_t = price of input in year t

$b_1, b_2 \quad 0$

the excess supply function will be

$$ES_t = C_0 + C_1P_t - b_2Z_t - a_2Y_t$$

where $ES_t = S_t - D_t$

$C_0 = b_0 - a_0$

$C_1 = b_1 - a_1$

$C_1 \quad 0$

with the slope of the excess supply function being steeper than the supply function and the coefficient of income being negative. Excess supply functions for the products and regions alluded to earlier were estimated with disappointing results. This method was, therefore, abandoned. Instead, the alternative was used, in which the estimated supply function and a fixed demand is used to obtain the excess supply function. Suppose the esimated supply equation is

$$S_t = d_0 + d_1P_t - d_2Z_t$$

where the variables are as defined earlier and demand is fixed at D^o, then the excess supply function becomes

$$S_t = d_0 - D^0 + d_1P_t - d_2Z_t$$

Note that in the present situation the price coefficient of the excess supply function is exactly that of the supply function. This excess supply function has to be transformed so that an intercept term and the price coefficient are the only parameters in the equation, that is

$$S_{t1} = e_0 + d_1 P_t$$

where $e_0 = d_0 - Do - d_2 Z_t$

Z_t = the sample mean of Z_t

upon inversion, this equation becomes

$$P_t = \frac{1}{d1}\left(-e_0 + S_t\right)$$

Thus, in the price-dependent form, assuming demand quantities fixed simply shifts the supply curve vertically upwards along the price axis. Four excess supply functions were specified using this approach. These functions were for newsprint for the Nordic countries and British Columbia, printing paper for Japan, and paperboard for the Nordic countries.

Demand quantities were not the only ones that were assumed fixed, supply quantities for newsprint for Ontario and the European Economic Community, printing paper for British Columbia, and paperboard or U.S. North and U.S. West were also assumed fixed. The reactive programming algorithm handles fixed supply quantities by equating supply prices to zeroes. This does not jeopardize the adjustment mechanism since positive net returns are still possible.

6.2 Regional Location and Transfer Costs

In this section the selection of the supply and demand points for all regions for each of the product group is discussed. The derivation of transportation costs between all routes for each product group is also discussed in this section. In addition, tariffs are also incorporated into the analysis.

Paper products, like many other products, are transported among trading nations via ocean freight. As such, the locations of the supply and demand point is restricted to major ports. Since data on railway freight rates for most countries, other than the United States, are not readily available, the destination (demand) and supply points were assumed to be located at the same point except for the United States and Canada. [2] Trade flows within the United States were assumed to be shipped via railway since data for railway freight rates were available. The locations of the supply and destination points for each product group are summarized in Table 6.1. Yokohama was chosen to be both the supply and demand point for Japan, Hamburg was chosen for the European Economic Community, Stockholm for the Nordic countries for all three product groups. Stockholm represents an excess supply point for the Nordic countries for both newsprint and paperboard. New York was selected to represent the demand point for the United States East and

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2. If railway freight rates had been available it would not have been necessary to locate not only supply points but also destination points at the major ports because it would have been possible to measure the economic distance (transport costs) between the points.

Table 6.1

Location of Supply and Demand Points, by Product Group

Product	Supply	Demand
Newsprint	Yokohama (Japan) Stockholm (Nordic) Vancouver (British Columbia) Montreal (Ontario) New York (U.S. North) New Orleans (U.S. South) Portland (U.S. West)	Yokohoma (Japan) Hamburg (EEC) New York (U.S. East) Los Angeles (U.S. West)
Printing Paper	Yokohama (Japan) Hamburg (EEC) Stockholm (Nordic) Montreal (Ontario) New York (U.S. Northeast) Chicago (U.S. North Central) New Orleans (U.S. South)	Hamburg (EEC) Stockholm (Nordic) New York (U.S. East) Los Angeles (U.S. West)
Paperboard	Yokonama (Japan) Hamburg (EEC) Stockholm (Nordic) Montreal (Canada) New York (U.S. North) New Orleans (U.S. South) Portalnd (U.S. West)	Yokohama (Japan) Hamburg (EEC) New York (U.S. East) Los Angeles (U.S. West)

Los Angeles as the demand point representing the United States West for all three product groups. Montreal represents the demand point for Canada for newsprint, and an excess supply point for Ontario for printing paper and paperboard. For newsprint and paperboard, New York, New Orleans, and Portland represents the supply points for U.S. North, U.S. South, and U.S. West, respectively; for printing paper, New York represents U.S. Northeast Region, and Chicago represents U.S. North Central Region and the U.S. South is represented by New Orleans.

Data on distances between all routes were obtained from Distances Between Ports (11) published by the U.S. Defense Mapping Agency. The distances are measured in nautical miles (see Table 6.2). The shortest possible route between any two points was chosen. The route distances include inland U.S. waterway distances. Thus, international routes from and to Chicago were routed through Montreal.

No attempt was made in this study to specify or estimate transport cost functions. Instead, the ocean freight cost functions from the study of Wisdom (56) were used to compute the ocean freight rates. Concerned about the paucity of studies on transportation costs, especially in forestry studies, Wisdom developed three conceptual models. A justification often proferred for the scarcity of transportation cost studies is that transportation costs reflect unalterable geographic factors. However, Wisdom cited the work of Binkley and Harrar (5) who pointed out that policies directed at improving shipping technology, port facilities, and government subsidies

Table 6.2

Distances between Selected Ports
(Nautical Miles)

From / To	New York	Chicago	Portland	Montreal	Vancouver	Stockholm	Hamburg	Yokohama
New Orleans	1708	4069	5302	2391	5465	5613	5100	9115
New York		2538	5887	1460	6050	4187	3674	9700
Chicago			8151	1078	8314	4787	4274	11964
Portland				7073	371	9487	8974	4323
Montreal					7236	3709	3196	10886
Vancouver						9650	9137	4262
Stockholm							594	13300
Hamburg								12787

Source: Distances Between Ports, 1976, Pub. 151, U.S. Defense Mapping Agency aimed at improving exports all can influence the comparative advantage held by countries through geographic differences.

Wisdom (56) suggested two factors - unit value of the commodity, and stowage factor as the key variables affecting freight rates for different commodities on a given route.[3] He specified three models. For different commodities on the same route Wisdom specified:

(i) $Fr_{ij} = f(UV_i, S_i, Q_{ij})$

where FR_{ij} is the freight rate of commodity i on route j in dollars per metric ton

UV_i is the unit value of commodity i in dollars per metric ton

S_i is the stowage factor for commodity i in cubic feet per metric ton

Q_{ij} is the quantity of commodity i shipped on route j, in thousand metric tons;

For the same commodity on different routes Wisdom specified:

(ii) $FR_{ij} = f(DI_j, TV_j, Q_{ij})$

where FR_{ij} and Q_{ij} are defined as before

DI_j is the distance of route j in nautical miles, and

TV_j is the total volume of goods shipped on route j, in thousand metric tons

and a linear combination of (i) and (ii);

(iii) $FR_{ij} = f(UV_i, S_i, DI_i, TV_j, Q_{ij})$

where the variables have been defined previously.

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3. The stowage factor is defined as the number of cubic feet per ton occupied by a commodity in a ship's hold.

Using 1980 data on ocean freight rates obtained from the Federal Maritime Commission and route distances from the Defense Mapping Agency publication, Wisdom reported equations by product and by route.

Not all of Wisdom's estimated equations are reported in this study. Only those equations that are used to compute the ocean freight costs for each product group are reported. Wisdom obtained the following equation

$$FR = -39.752 + 0.02\ DI + 0.041\ UV - 1.133\ TV$$
$$\qquad\qquad (17.21) \quad (7.23) \quad (1.99)$$

where $R2 = 0.91$

n (sample size) = 91, and

t-statistics are given in parenthesis.

for all paper products on a route from the United States to Europe. This equation was used in this study to obtain the ocean freight costs for all routes used for newsprint. The equation was reduced to be dependent only on distance by evaluating unit value and total volume at the sample mean of US $1182 and 8,490 metric tons, respectively, and collapsing the sum in the intercept term yielding

$$FR = -0.9092 + 0.02\ DI$$

as the cost function for newsprint on all routes. Wisdom estimated the following equation for printing and writing paper on a route from the United States to Europe:

$$FR = 33.53 + 0.021\ DI - 2.352\ TV$$
$$\qquad\qquad (15.72) \quad (3.97)$$

where $R^2 = 0.86$

n (sample size) = 30, and

t-statistics are in parenthesis.

Evaluating this equation at the mean of total volume (=9,690 metric tons), the following cost function was adopted for printing paper on all routes:

$$FR = 10.7391 + 0.021\ DI$$

Wisdom's cost function for linerboard from the United States to Europe was used as the cost function for paperboard for all routes in this study. The cost function is as follows

$$FR = 8.005 + \underset{(8.34)}{0.012}\ DI$$

where $R^2 = 0.78$

n (sample size) = 38, and

t-statistics are parenthesis.

Ocean freight rates for 1980 for the three product groups on the different routes were obtained by substituting the distances in the corresponding equations (see Tables 6.3, 6.4, 6.5).

For the purpose of historical simulation, the calculated ocean freight costs were linked to a common world freight index, with a base year of 1966, published by the Norwegian Shipping News (35). However, the earliest data available for the index was for 1970; thus limiting the historical simulation to a period of 1970 to 1978. The index is based on trip charters for dry cargo.

Interregional trade within the United States is mainly transported by rail. Railway freight rates were obtained from the Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture.

Table 6.3

Ocean Freight Rates for Newsprint, 1980
(Dollars per metric ton)

To / From	Japan	EEC	U.S. East	U.S. West
Japan	0	254.83	193.09	85.57
Nordic	265.09	10.97	82.83	94.83
British Columbia	84.33	181.83	120.09	6.51
Ontario	216.81	63.01	216.81	140.55
U.S. North	193.09	72.57	0.00	97.71
U.S. South	181.39	101.09	33.25	86.01
U.S. West	85.57	178.57	97.71	0.00

Table 6.4

Ocean Freight Rates for Printing Paper, 1980
(Dollars per metric ton)

To / From	EEC	Nordic	Canada	U.S. East	U.S. West
Japan	279.27	290.04	239.35	214.44	101.54
EEC	0.00	23.21	100.49	87.89	199.19
Nordic	23.21	0.00	88.63	98.67	209.97
Canada	77.86	88.63	0.00	41.40	159.27
U.S. Northeast	87.89	98.67	41.40	0.00	114.29
U.S. North Central	100.49	111.27	33.38	64.04	107.59
U.S. South	117.84	128.61	73.55	46.61	102.01

Table 6.5

Ocean Freignt Rates for Paperboard, 1981
(Dollars per metric ton)

From \ To	Japan	EEC	Canada	U.S. East	U.S. West
Japan	0.00	161.45	138.64	124.41	59.89
EEC	161.45	0.00	46.36	52.09	115.69
Nordic	167.61	15.13	52.51	58.25	121.85
Canada	138.64	46.36	0.00	25.53	92.88
U.S. North	124.41	52.09	25.53	0.00	67.18
U.S. South	117.39	69.21	43.90	28.50	60.16
U.S. West	59.89	115.69	92.88	67.18	0.00

These rates are set by zones and are not a function of distance. The original data were given in terms of dollars per hundred pounds. The rates were multiplied by a factor of 22.0462 to yield rates expressed in dollars per metric ton. The original data were effective since September 1981 and were assumed to grow at an annual rate of 4.7 percent. The rates for paper and fiberboard for 1981 are presented in Table 6.6. Data since 1970 were computed by dividing the 1981 data by $(1.047)^n$, where n is the number of years before 1981. The freight rate for paper was employed as the rate for newsprint and printing paper and the rate for fiberboard was used as the rate for paperboard.

Inasmuch as transportation costs influence what products are traded, which nations trade, and the direction of trade, it is only one of many forms of a trade barrier which gives nations a trading comparative advantage over other nations. Nations form tariffs and nontariff barriers either to buffer domestic producers from foreign competition or to strengthen local producers' competitive edge over other exporters.[4] Many forms of tariffs and non-tariff barriers exist but the following discussion is limited to ad valorem taxes since this is the type of tariff used by trading nations for paper products. Printing paper and paperboard are taxed on an ad valorem basis, as a percent of total value, by the nations/regions analysed in the present study. These rates vary from as low as 2 percent to as high as 15 percent of the total value of imports (see Table 6.7). Newsprint is

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4. The reasons why nation form trade barriers and the effectiveness of each type of barrier can be found elsewhere. See Corden(9),

Table 6.6

Railway Freight Rates for U.S. Regions,
for Paper and Fiber Board, 1981
(Dollars per metric ton)

To / From	U.S. East		U.S. West	
	Paper	Fiber Board	Paper	Fiber Board
U.S North East	39.02	26.23	243.61	109.35
U.S. North Central	74.52	54.67	204.05	85.32
U.S. South	166.01	56.00	167.11	69.89
U.S. West	222.01	123.02	49.38	49.60

Table 6.7

Ad Valorem Tax Rate for Printing Paper and and Paperboard, by Regions, prior to 1982 (percent)

Product	Japan	Canada	USA	EEC	
				EFTA	Non-EFTA
Printing Paper	8.00	13.75	2.0	4.875	9.75
Paperboard	12.00	15.00	5.5	7.510	10.00

Source: Sedjo and Redcliffe (42).

Chacholiades(8), and Kreinin (28).

exempt from any tax.

Ad valorem taxes are incorporated into the analysis since these rates were in effect during the sample period. Trade flows for the period 1970 to 1978 were simulated so that they may be compared to the actual trade flow. This historical simulation is done as a means of validating the specified model. Although the simulated trade flows are not expected to duplicate the values from the actual flows, incorporating all relevant information, including ad valorem taxes, will bring the simulated flows closer to the actual flows. Following the Tokyo Round of the Multilateral Trade Negotiations the present rate of taxes will change effective January 1, 1982. Since projections of trade flows will be made up to the year 2030 this change in the rates will have to be recognised in order that the projections be more realistic.

Although the incorporation of tariffs into spatial equilibrium models has been done in numerous studies, these studies have not elaborated on the procedure other than to mention that either the rates are added to transportation costs or that supply and demand curves have to be shifted. Thus, before presenting the results of the historical simulation in the next section the procedure for incorporating taxes into the reactive programming will occupy the remainder of this section.

The earliest suggestion that taxes may be incorporated into the reactive programming algorithm was made by Seale and Tramel (41). They did not specifically addressed the problem of tariffs, but discussed that of premiums and discounts.

> ".....If the premiums or discounts are absolute amounts, the demand functions become P = a + bQ + C where C is the premium or discount for individual supply points. If the premiums and discounts are on a percentage basis, the demand function becomes P = (a + bQ)(C) where C is 1 plus the premium or 1 minus the discount for individual supply points."[5]

Later Bawden (4) suggested ways of incorporating various forms of tariffs into international trade models.[6]

Basically, there are two ways of incorporating tariffs into a spatial equilibrium analysis. When tariffs are fixed, in the manner of a discount or a premium, they simply can be added to transportation costs. However, when tariffs are calculated as a percentage of total value, price, or quantity, the demand and supply curves have to be shifted. It will be shown that the two methods are equivalent under a certain condition -- regions/countries are small enough such that they are unable to affect prices. In other words, the market is perfectly competitive; hence, all regions are price takers. The equivalence of the two methods is best demonstrated by a partial equilibrium graphical and mathematical presentation.

Consider the case of a net importing region. Let S and D represent the supply and demand curves, respectively, of this region (see Figure 6.1). M represents the supply of imports to this region. Since the market is perfectly competitive, the region can import all it can afford at a constant world price of P_w. Suppose this country/region decides to

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5. Seale and Tramel (41), p.55

6. Bawden (4), pp. 865-868.

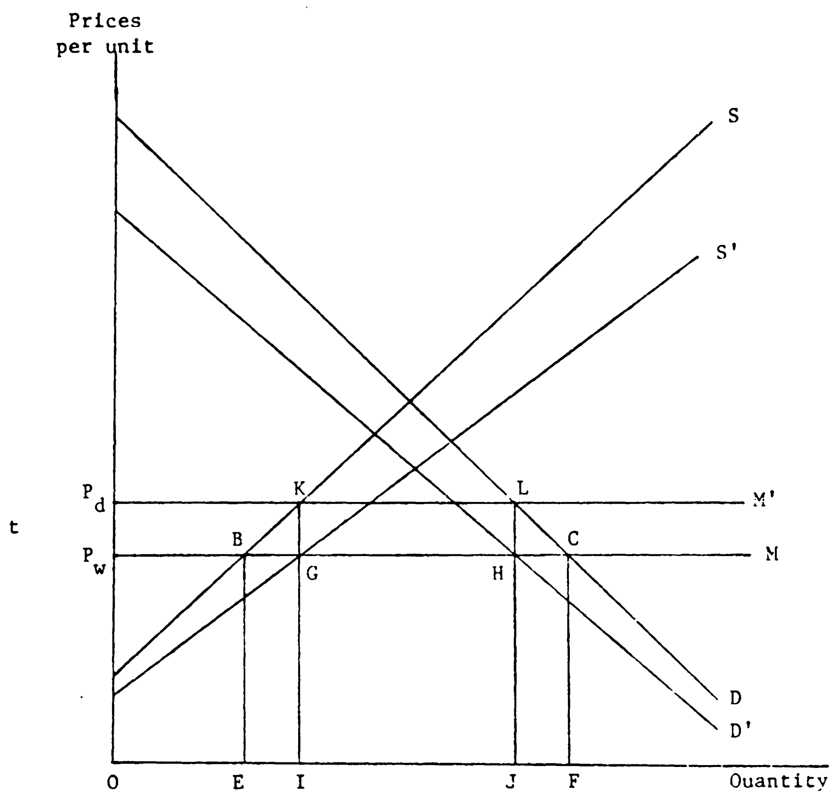

Figure 6.1

Partial Equilibrium Analysis - Incorporating
Ad Valorem Tax for a Small Country

levy, for one reason or another, an ad valorem tax of t percent of the total value of imports. Total tax collected at the customs gate is

$$A = P_w \times Q \times \frac{t}{100}$$

where A is the total ad valorem tax

P_w is the world price

t is the ad valorem tax rate, in percent, and

Q is the quantity of imports

In order to show the effect of the tax levied in the graph, taxes have to be expressed in per unit measure. The per unit ad valorem tax may be obtained easily by dividing A by Q resulting in

$$a = \frac{A}{Q} = P_w \times \frac{t}{100}$$

Notice that a is invariant with respect to quantity. Therefore, in the P-Q space, the per unit tax rate, a, can be represented as a vertical distance. Effectively, the imposition of the tax raises the import supply curve, M, to M' by a vertical distance of a.

There are several points to note when taxes are in effect. Domestic prices, P_d are no longer equal to the world price, P_w. Instead, domestic consumers pay a price

$$P_d' = P_w + t$$

and have reduced their purchase of the product from OF to OJ. Meanwhile, local producers have increased their supply to the local market from OE to OI. Imports, therefore, have been reduced from EF to

IJ, while leaving world price unaffected although domestic prices have increased.

One means of incorporating ad valorem taxes into the analysis is by adding the per unit tax to transport costs. Note that this method is only valid when the supply curve of imports, M, is perfectly elastic. For if M were sloping upwards, then a per unit ad valorem tax would not be independent of quantity. In either case, the spatial equilibrium price (world price) has to be known before the per unit tax can be added to transportation costs. In the context of reactive programming this approach may prove to be too cumbersome.

Initially, the problem has to be solved without tariffs. Then, the world price has to be solved. This involves summing the regional demand and supply functions over price such that aggregate supply equals aggregate demand. Since the reactive program solution provides the quantity of aggregate demand and supply, the world price can be calculated by substituting the quantity of aggregate demand into the aggregate demand function. Tariffs for each region are obtained by multiplying the ad valorem tax rate of that region by the world price. The results can then be added to transportation costs.

A simpler method can be employed by shifting the regional supply and demand curves proportionately (by a factor equal to the ad valorem tax rate). From the previous analysis it was found that an imposition of an ad valorem tax effectively reduces imports. For the time being it is asserted that the demand and supply curves shift from D to D' and S to S', respectively. This is done by multiplying both curves by the reciprocal of $(1 + a/100)$. The new supply curve intersects M at G and the new demand curve intersects M at H which implies that imports equal GH which equals IJ. A mathematical analysis is invoked to prove the assertion made earlier. The analysis will be made using a simple example. Let the demand function be

$$P = 800 - 4Q$$

and the supply function

$$P = 20 + Q.$$

Solving for the quantity

$$800 - 4Q = 20 + Q$$

$$\text{i.e. } Q = 780/5 = 156.$$

At this quantity price is 176. Suppose an ad valorem tax of 10 percent is imposed by the importing region. Therefore, the new demand curve is given by

$$P' = 0.91\ (800 - 4Q)$$

$$= 727.27 - 3.64Q$$

and the new supply curve by

$$P' = 0.91\ (20 + Q)$$

$$= 18.18 + 0.91$$

by equating the demand and supply equations, that is

$$727.27 - 3.64\ Q = 18.18 + 0.91$$

or

$$Q = (727.27 - 18.18)/4.55 = 156$$

Therefore,

$P' = 160.$

Notice that the equilibrium quantity is identical under the original and the new set of supply and demand conditions and that the new equilibrium price is exactly 0.91 of the original equilibrium price.

To prove the assertion that the supply and demand curves shift in proportion to the ad valorem tax, the same set of supply and demand equations will be reused. Suppose world price is at 100. At this price producers will supply $100 = 20 + Q$ or $Q = 80$ units of the product. At the same time, consumers will purchase $100 = 800 - 4Q$ or $Q = 700/4 = 175$ units of the product. This means that $175 - 80 = 95$ will be imported. When an ad valorem tax of 10 percent is levied domestic price is no longer equal to world price; domestic price will increase to 110. At this higher price producers increase their supply to $110 = 20 + Q$ or $Q = 90$ while consumers decrease their purchases to $110 = 800 - 4Q$ or $Q = 172.5$. This means that imports will have decreased to $172.5 - 90 = 82.5$. The same set of values will be obtained when the shifted curves are evaluated at the original world price. The quantity supplied is given by

$$100 = 18.18 + 0.91\ Q$$

$$\text{or } Q = 90$$

and the quantity demanded by

$$100 = 727.27 - 3.64\ Q$$

$$\text{or } Q = 172.5$$ [7]

Therefore, shifting the supply and demand curves vertically downwards proportionately by the reciprocal of one plus the ad valorem tax rate is equivalent to adding the ad valorem tax rate to the world price.

The second method is adopted in this study since it is less cumbersome than the first. Moreover, the second method does not require prior knowledge of the spatial equilibrium price. For each region the supply and demand equation is shifted down by the reciprocal of $(1 + a_i/100)$ where a_i is the ad valorem tax rate levied by region i.

6.3 Historical Simulation

The results of the historical simulation for the period 1970 to 1978 are presented in three subsections. The results for newsprint are presented in the first subsection; the results for printing paper are presented in the second subsection; and finally, the results for paperboard is presented in the third section. Historical simulation could not be carried out for the period prior to 1970 because data was not available for indexing ocean freight rates. Results from the historical simulation are compared to the actual data for 1970-1978. Simulated trade flows for printing papers, however, could not be compared to actual data since these flows are not reported. Simulated intraregional flows within the United States also cannot be compared to the actual as the data does not exist.

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7. The answer may differ only because of rounding error.

6.3.1 Newsprint

Since newsprint is not levied any tariff at all, the supply and demand functions were not adjusted. The market for newsprint consist of seven producing regions and four consuming regions. The United States is divided into three and Canada into two producing regions (refer to Table 3.4). The Nordic countries is an excess supply region. The supply for Ontario is fixed in quantity. The supply and demand curves are shifted through time via the changes in the values of the explanatory variables, other than price, in the supply and demand functions. These values are combined as a single shifter in the equations used in the reactive programming. The equilibrium regional prices, production, consumption, and trade flows are presented in Appendix B as Table B.1. Note that quantities and dollar values are expressed in thousands.

Over the period 1970 through 1978 the simulation predicted increased in total production for the seven producing regions (also equal to total consumption), average costs, and average market prices. Total production increased at an annual rate of 2.7 percent, average costs at 7.3 percent, and average market prices at 6.8 percent where average costs are calculated by dividing the sum of revenues of all the producing regions by total production and average market prices are calculated by dividing the sum of costs in all consuming regions by total consumption.

Througnout the simulation period Japan was self sufficient in newsprint consumption; it even managed to export a small amount to the western part of tne United States market with the except for 1970. Actual data revealed no shipments coming in from Japan. Contrary to actual data, the simulation predicted the European Economic Community as the largest consumer of newsprint when actual data shows the United States as the largest consumer. Meanwhile, Ontario is simulated as the largest exporter of newsprint to the European Economic Community when in fact the Nordic countries is the largest exporter to the Common Market. The simulation also tended to overestimate the exports of the Nordic countries and Ontario while underestimating the exports from the Canadian producing regions to the United States. When in reality the U.S. producing regions ship only small quantities to the European Economic Community, the simulation showed no shipments from the U.S. South and U.S. West and all of the U.S. North's production being shipped to the EEC. While the western producing region supply the western market the southern region supplies the eastern market of the United States market for newsprint.

For five of the seven producing regions further shipments (mainly to the EEC) were not possible because of capacity limitations. Actual production was used as the measure of capacity so that the admissible solution set would not be too unrealistic. All five producing regions are on the North American continent. Had capacity been left unbounded the EEC probably would have imported more from the U.S. North and Ontario since these were the most profitable routes.

6.3.2 Printing Paper

The supply and demand functions of the producing and consuming regions for printing paper were adjusted to take account of the tariffs. Five consuming and seven producing regions are considered and Japan is considered an excess supply area. The five consuming regions are the European Economic Community, the Nordic countries, Canada, U.S. East, and U.S. West. The producing regions are Japan, the European Economic Community, the Nordic countries, Ontario, U.S. Northeast, U.S. North Central, and U.S. South. The equilibrium regional production, consumption, prices, and trade flows for each year are presented in Table B.2. in Appendix B. Trade flows obtained from the historical simulation, however, cannot be compared to the actual flows since data is not published for this product group.

Simulation showed total production (and consumption) to rise at annual average rate of 3.3 percent, average costs to rise 18.6 percent, and average market prices to rise by 15.6 percent. Annual production declined, however, for 1974 through 1976; average costs declined in 1976; and average market prices declined in 1977.

Although simulated trade flows cannot be compared to the actual flows, regional prices, production and consumption can be compared. The simulation tended to slightly overestimate the production and consumption of printing paper in the European Economic Community and the Nordic countries. Canada's production is also slightly overestimated while Canada's consumption is severly underestimated. While the actual data show Canada absorbing most of its production, the simulation shows all of Canada's production being shipped to both the U.S. East and U.S. West markets. All of the producing regions except Japan and U.S. South ship to the U.S. East market. By 1973 even the U.S. South was shipping to this market. The simulation indicated that Ontario, U.S. North Central, and the U.S. South as the major suppliers to the United States western market.

6.3.3 Paperboard

The market for paperboard products consists of five consuming and seven producing regions. The consuming regions are Japan, the EEC, Canada, U.S. East, and U.S. West while the producing regions are Japan, the European Economic Community, the Nordic countries, Canada, U.S. North, U.S. South, and U.S. West. The demand and supply functions were adjusted to account for the tariffs imposed by the consuming regions. During the simulation period, total production averaged an annual increase of 2.5 percent although in 1974 and 1975 production declined instead of rising. Simulation showed average costs to have wide fluctuations during the period so much so that average annual increase for the period was very high, at a rate of 93.5 percent. A similar fluctuation resulted for average market prices; an annual rate of 58.2 percent was predicted.

The results of the historical simulation for paperboard can be compared to the actual data since trade flows data for this product group is published in the Yearbook of Forest Products. A comparison between the actual and simulated data is presented in Table B.3 in Appendix B. Although the simulation picked up the general direction of the trade flows it tended to either overestimate or underestimate the size of the flows. However, the simulation predicted the shipments from the Noridc countries to the European Economic Community quite closely. The simulation also tended to underestimate all of the regional costs and market prices. Japan's production was slightly overestimated by the simulation while consumption is underestimated. On the other hand, the simulation tended to underestimate production of the European Economic Community while only slightly underestimating consumption. The simulation do, however, show that the European Economic Community as being a net importer with shipments from the Nordic countries and U.S. North, the European Economic Community's two largest suppliers. But the actual data reveal the Nordic countries and Canada as the major suppliers. Instead, the simulation predicts Canada to ship to the U.S. markets. Although the total production from Canada is only slightly overestimated, Canadian consumption and shipments are grossly underestimated and overestimated, respectively. The simulation slightly underestimated total production and consumption for the United States but grossly overestimated the shipments of U.S. producing regions. While actual data shows U.S. South as the largest exporter of paperboard among U.S. producing regions, the simulation shows U.S. North as the largest exporter.

6.4 Summary

The estimated quantity-dependent supply and demand functions were transformed into price-dependent functions since this was the format requirement of the reactive programming. The method of doing this was presented in the first section. The chosen supply and demand points were presented in the second section. Once the supply and demand points were chosen, distances between supply and demand points were measured and the corresponding transport costs were calculated. The calculated transport costs were based on the estimated functions made by Wisdom. Levies are imposed on imports of printing paper and paperboard while no levy is imposed on newsprint imports. Supply and demand functions were adjusted by multiplying the price-dependent functions by the ad valorem tax rate. Results of the historical simulation were presented in section three.

Although the simulation picked up the direction of many of the trade flows, in general, the magnitudes of regional production, consumption, and trade flows were either underestimated or overestimated. Instead of indicating the United States as the largest consumer and importer of newswprint, the simulation had the European Economic Community as the largest consumer and importer of newsprint. The simulation had Ontario as the largest exporter of newsprint when in fact the Nordic countries are. Exports from the Nordic countries and Ontario to the EEC were overestimated while exports from the Canadian regions to the United States were underestimated. Simulated trade flows for printing paper could not be compared to actual data since this data were unavailable. However, simulated production and consumption were compared to actual data since this data were available. Production and consumption for the EEC and the Nordic countries were overestimated . While Canadian production was slightly overestimated consumption was severely underestimated. Simulated production, consumption, and trade flows for paperboard were also either overestimated or underestimated. There is one exception -- the exports from the Nordic countries to the EEC were predicted closely.

CHAPTER VII

PROJECTIONS OF TRADE FLOWS

Introduction

The estimated economic model was validated by historical simulation. Although the results did not match actual data exactly they do resemble the actual data. The simulation predicted the correct direction of many of the trade flows but the magnitudes of these flows often were underestimated or overestimated. Disparity between actual and simulated magnitudes, however, are not unexpected since the choice of supply and demand points, hence transportation costs between locations, affects not only the trade flows but also regional prices, production, and consumption. The projections that follow should, therefore, be taken is this perspective -- they are not point estimates. These projections can serve only as guidelines for policy makers and business executives in the paper industry with regard to the future conditions. Projections of regional distribution of prices, production, consumption, and trade flows for each of the product groups are presented in this chapter.

The choice of the projection horizon is presented in the first section. This section also includes a justification for these projections. Projections of the regional distribution, however, is contingent upon obtaining a set of values of the predetermined variables for the projection period. The procedure for obtaining these values is the topic of discussion in the second section. Initially, the general procedure for obtaining these values is discussed. This is followed by a discussion of the projections of the shifters for both the demand and supply functions. The procedure for obtaining the values of the transfer costs is presented in the remainder of this section. The third section contains the results of the projections for each of the three product groups. The section is further divided into three subsections, one for each of the three scenarios to be presented later. Each subsection is further divided into three subsections for each product group. The results based on the mean growth rates are compared to the projections made by the Food and Agricultural Organization (FAO) and the one made by Data Resources Inc. (DRI). A summary of this chapter is presented in the last section.

7.1 Projection Period

The projections span a period between 1982 and 2030 but instead of projecting annually over the entire projection period only a few years were selected. A total of seven projections were performed for each scenario for each product group. Beginning with 1982, projections at four-year intervals were performed through 1990 and at ten-year intervals subsequently. Specifically projections for the following years: 1982, 1986, 1990, 2000, 2010, 2020, and 2030 were made.

Projections of future conditions provide decision makers, whether they be public policy makers or business executives in the paper industry, some information upon which to act. Of course, the usefulness of these projections will depend on the decision makers belief in the model specified. Projections based on the mean growth rates are compared with the results of other studies that have included projections about future supply and demand of paper products. In particular the results are compared to the results obtained by FAO and by DRI.

7.2 Predicting Predetermined Variables

Predicting the regional distribution of prices, production, consumption, and trade flows involves shifting the regional supply and demand function through time. However, values of the demand and supply shifters in the future are not known. One, therefore, has to come up with some value for the shifters before one is able to make predictions about the future regional magnitudes. One way of obtaining these values is by assuming the values calculated in other studies or assuming the growth rates from other studies. This option, however, was not open to the present study since the shifters specified in the model have not been used elsewhere; only the growth rate for gross national product has been used widely elsewhere.

Another way of predicting future values of the predetermined variables is by making use of the information contained in the sample period. The following method was adopted for computing the values of the predetermined variables for the projection period. Annual growth rates, g_t, for each of the explanatory variables in the sample period 1962 - 1978 was calculated using the following equation

$$g_t = \frac{x_t}{x_{t-1}}$$

The average of the annual growth rate, g, from the historical data was assumed for the projection period where g is defined as

$$g = \frac{\sum_{t=2}^{n} g_t}{n-1}$$

Values for specific projection years were calculated by multiplying the actual value for 1978 by the average growth rate, g, raised to the power of n, where n is the number of years away from the projection year. Mathematically, the following equation is used to calculate the value

$$Y_{t+n} = Y_{1978} \times (g)^n$$

Three scenarios were set up for the projections. Besides the mean growth rate, growth rates one standard error above and below the mean were also computed.

Demand was assumed to be either fixed or a function of price, constant dollar gross national product, lagged consumption, and a dummy variable for years after 1970. When no estimable equation was obtained, consumption was assumed to grow at a constant rate as outlined earlier in this section. The same assumption is applied for fixed supply. Recall that when demand was assumed fixed, these values were substituted into the supply equation and the result was an excess supply equation. Thus, the excess supply equation incorporates both the supply and the demand shifters. Both ocean and railway freight rates are assumed to grow at an annual of 4.7 percent for all three scenarios.

7.3 Projections

This section is divided into three subsections. The projections based on the three growth rates are presented in each subsection. Each subsection is further divided into three subsections in which the projections of each product group is discussed. The projections based on mean growth rates are compared to the projections made by FAO and DRI. Comparisons to other studies for the low and high growth rates are not made since both FAO and DRI made only one set of projections; it is assumed that these projections were made at some mean growth rate. For the purpose of comparison between each projection year, the following definitions are used. Average cost is defined as the sum of producer revenues for all regions divided by the sum of production for all regions, that is

$$AC = \frac{\Sigma_i S_i P_i}{\Sigma_i P_i}$$

where AC is average costs

S_i is production in region i

P_i is supply price in region i

Average market price is defined as the sum of consumer expenditures for all consuming regions divided by the sum of consumption for all regions, that is,

$$APM = \frac{\Sigma_i \; C_i P_i}{\Sigma_i \; P_i}$$

where APM is average market price

C_i is consumption in region i

P_i is demand price in region i

These weighted averages are compared for each projection year rather than comparing the magnitude for each region for each projection year. The weighted averages reflect the general trend in price increases. Hereafter,all growth rates refer to compounded annual growth rates.

7.3.1 Projections Based on Low Growth Rates

This section is divided into three subsections. The first subsection presents the projections for newsprint. The second subsection presents the reults of the projections for printing paper and the third subsection presents the projections for paperboard.

7.3.1.1 Newsprint

Over the entire projection period average costs are projected to increase at a rate of 4.0 percent and average market prices at a slightly higher rate of 4.2 percent. Total production, that is, total production of all regions, increases at a rate of 2.2 percent. Japanese consumption is projected to increase slowly, remaining self-sufficient for the years 1982 and 1986. By 1990, however, consumption overshoots local production making it necessary for Japan to begin importing from British Columbia (see Table C.1, Appendix C). A phenomenal growth in the size of imports from British Columbia is projected beginning with 70.4 thousand metric tons in 1990 and increasing to 4565.4 thousand metric tons, or about one and one-half times the size of local production, in 2030.

The largest consumer and importer of newsprint is the European Economic Community (EEC). Consumption for the EEC rises at 3.4 percent annually, slightly higher than the weighted average for all regions, over the projection period. The largest exporter to the EEC is Ontario, with the Nordic countries trailing closely. British Columbia and U.S. North also export to the EEC. By the year 2010, even U.S. West is projected to export to the EEC. By this time too, British Columbia no longer ships to the U.S. East market; instead, U.S. South emerges as the leading supplier to this market. Producing regions in the United States are projected to ship more and more to the EEC by year 2020 at the expense of the domestic markets.

7.3.1.2 Printing Papers

Total production, average costs, and average market prices are projected to increase at about the same rate over the projection period. Total production increases at a rate of 2.8, average costs at 2.1, and average market prices at 2.4 percent annually. Total production decreases for the period between 2010 and 2030 and average costs for the period between 2010 and 2030. Although average market prices are projected to increase between 2010 and 2030, the rate of increase is lower than that in previous periods.

The U.S. East market specifically, and the United States as a whole, are projected to be the largest consumers of printing paper throughout the projection period (see Table C.2, Appendix C). The United States, as a market, is so big and attractive that all foreign producers, with the exception of Japan, export to this market. Prior to the twenty-first century the Nordic countries are projected as the largest supplier to the U.S. East market, with the EEC coming in a close second. The U.S. South continually leads all other regions in being the largest supplier to the U.S. West market. Instead of being a net importer, the EEC is projected to be a net exporter prior to 2010. However, beginning in 2010, thereafter, the EEC emerges as net importer.

By this time, the Nordic countries reduce their shipments to the U.S. East market and divert shipments to the European market. For the years 2020 and 2030 the U.S. North Central region is also projected to ship to the European market. As time progresses towards the twenty-first century, the U.S. South region is projected to emerge as a much bigger supplier to the local markets. Although Ontario remains a supplier to the U.S. East market, both the Nordic countries and the EEC no longer are suppliers to this market.

7.3.1.3 Paperboard

Over the duration of the projection period total production is expected to increase at a rate of 2.3 percent. Meanwhile, average costs and market prices are expected to increase at roughly equal rates for the entire projection period; average costs are expected to increase by 4.0 percent and market prices at 4.1 percent.

The United States is the largest consumer of paperboard with the EEC coming in second (see Table C.3, Appendix C). The American market is projected to grow at such a high rate that even the EEC slowly increases its shipments to the American market. Such is the case that by the year 2030 more than two-thirds of the Community's production is shipped to the eastern American market. The Nordic countries no longer ship to the European market but instead diverts its excess supply to the eastern market too.

At the same time, the Japanese market for paperboard is also growing at a tremendous rate. Local production is continually diverted away from foreign markets and more towards the domestic market. By the year 2030, the U.S. West region is projected to supply the Japanese market. The U.S. South is the largest supplier in the eastern American market while the western supply region is the largest supplier to the western market.

7.3.2 Projections Based on Mean Growth Rates

Projections for newsprint and paperboard can be compared to the projections made by the FAO and DRI. Year-to-year comparisons can be made only to the DRI projections. The FAO projected for the following years: 1980, 1985, and 1990. Therefore, only the last year can be compared on a one-to-one correspondence basis. For the purpose of this study, 1982 projections from the present study are compared to the 1980 FAO projections and the 1986 projections of the present study are compared to the 1985 FAO projections. As should be expected, the rates of growth for total production, average costs, and average market prices are much higher than those obtained when low growth rates are assumed for the demand and supply shifters.

7.3.2.1 Newsprint

The projected total production, average costs, and average market prices increases at a much higher rate than those projected on the basis of low growth rates. Total production is projected to rise at a rate of 3.4 percent, average costs at 5.2 percent, and average market prices at 5.3 percent.

The EEC emerges as the largest consumer of newsprint (see Table D.1, Appendix D). It remains the largest consumer well into the twenty-first century. The United States role as the second largest consumer will diminish and by 2010 no shipments are made to this market at all. At the same time, Japan emerges as an important market, especially for British Columbia.

The major suppliers to the EEC in the earlier years of the projection period are Ontario, the Nordic countries, and U.S. North, with Ontario as the largest supplier. British Columbia joins the ranks of major suppliers to this market by year 2000. A decade later, the European market is so profitable that the two remaining producing regions, U.S. South and U.S. West, ship to this market too. While the European market becomes more attractive to producers, the American market becomes less so. British Columbia and Ontario, the two foreign suppliers to the American market, divert their shipments away from the American market to the European market. Besides increasing its shipment to the European market, British Columbia also increases its shipment to the Japanese market.

The projections of the present study tend to be more conservative than the projections of either the FAO and DRI (see Table 7.1). Projections of Japanese production and consumption are quite close to those of the FAO and DRI. The net imports of the EEC are overestimated in comparison to the projections of the other studies. The projections of the consumption for the United States are quite different from the projections of either the FAO or DRI. The projections of the present study are about one-half of the size projected by the other two studies. The projections of Canadian production of newsprint is also slightly higher than those projected by DRI while the United States production is about half the size of the projections of DRI. Although the magnitudes of regional production and consumption are either underestimated or

Table 7.1

Comparisons of Projections of Regional Production and Consumption for Newsprint for 1982, 1986, and 1990

		Present Study		FAO[1,2]		DRI	
Region	Year	Production	Apparent Consumption	Production	Apparent Consumption	Production	Apparent Consumption
		million metric tons					
	1982						
Japan		2.59	2.59	2.85	2.71	n.a.	2.87
EEC		n.a.	(11.50)	2.14	4.70	n.a.	3.80
Canada		11.48	0.00	12.54	11.52	8.87	1.06
USA		2.47	6.78			4.47	10.60
	1986						
Japan		2.54	2.77	n.a.	3.29	n.a.	3.45
EEC		n.a.	(13.77)	n.a.	5.15	n.a.	4.24
Canada		12.97	0.00	n.a.	13.08	9.53	1.20
USA		3.06	6.60			6.31	11.45
	1990						
Japan		2.49	3.01	4.30	3.99	n.a.	3.92
EEC		n.a.	(16.52)	2.40	5.88	n.a.	4.72
Canada		14.70	0.00	15.40	15.04	10.37	1.51
USA		3.73	6.28			5.85	12.41

Notes: n.a. not available
Figures in parentheses represent net imports.
1. 1980 FAO data is used to compare to 1982 results and 1985 FAO data is used to compare to 1986 results.
2. FAO lumps Canada and USA as a single region - North America.

Sources: 1. Pulp and Paper Review 4(2), Data Resources Inc., 1986.
2. World Pulp and Paper Demand, Supply and Trade, Volume 1, FAO Forestry Paper 4/1, Food and Agricultural Organization of the United Nations, 1977.

overestimate the projections do indicate shipments from Canada to the United States and the EEC. The projections even picked up flows going from the U.S. North to the EEC.

7.3.2.2 Printing Paper

Total production increased at a higher rate than that projected at the low growth rate. Total production increases at an average rate of 5.8 percent. Average costs and market prices, however, are projected to increase at a lower rate than that projected on the basis of the low growth rate; the annual increases in average market prices are 1.7 percent and 0.7 percent for average costs.

Although the United States remains the largest consumer of printing paper throughout the projection period it is not the most profitable market for producers for the entire projection period (see Table D.2, Appendix D). The eastern American market is the most attractive market for most producing regions for the projection period prior to 2010. The Nordic countries is the largest foreign supplier to this market. The EEC and Ontario are the other two foreign suppliers. The U.S. South is the sole supplier to the western section of the American market; it remains so throughout the entire projection period.

Beginning in 2010, the EEC becomes the most profitable market and all producing regions ship to this market. The U.S. South does not ship to the European market prior to 2010 but ships to that market in 2020 and 2030. By then the U.S. South emerges as the largest producing region in the world. By 2030 it is the sole supplier to all markets.

In comparison to the projections of the other two studies, the projections of the present study are closer to the projections of DRI than those of the FAO (see Table 7.2). Projections of production for the Nordic countries are higher than the projections of both the FAO and DRI while the projections of United States production is well below those of FAO and DRI. Projections of consumption for the EEC and the United States from the present study are a lot closer to the projections of the DRI than those of the FAO. The present study did not project Japan to ship to any of the available markets since its projected costs were much too high.

7.2.3.3 Paperboard

For the entire projection period, total production increases at an average rate of 3.1 percent. The rate of increase between projection years increases from a rate of 2.5 percent in 1982 to 3.8 percent in 2030. Although the growth rates for average costs and market prices are also projected to increase between projection years, the rates of increase start to decline by 2020. Average costs and market prices increase at a rate of 3.8 and 3.9 percent annually, respectively, on the average over the projection period.

The largest consumer of paperboard over the entire projection period is the United States (see Table D.3, Appendix D). While the EEC is the second largest consumer in the earlier phase of the projection period, it does not hold this position towards the later phase of the period. Instead, Japan emerges as the second largest consumer of

Table 7.2

Comparisons of Projections of Regional Production and Consumption for Printing Papers for 1982, 1986, and 1990

		Present Study		FAO[1,2]		DRI	
Region	Year	Production	Apparent Consumption	Production	Apparent Consumption	Production	Apparent Consumption
		- - - - - - - - - - - - - - - million metric tons - - - - - - - - - - - - - -					
	1982						
Japan		0.00	0.00	2.84	4.04	n.a.	4.57
EEC		12.03	8.59	7.11	10.20	n.a.	9.43
Nordic		5.14	0.69				
Canada		1.28	0.00	14.40	16.35	1.89	1.07
USA		5.46	14.63			16.68	17.41
	1986						
Japan		0.00	0.00	n.a.	5.56	n.a.	5.58
EEC		12.44	9.52	n.a.	12.35	n.a.	10.83
Nordic		3.65	0.69				
Canada		0.73	0.00	n.a.	21.28	2.43	1.25
USA		8.24	16.85			19.18	20.15
	1990						
Japan		0.00	0.00	7.80	8.06	n.a.	6.41
EEC		12.42	11.17	12.40	16.63	n.a.	12.22
Nordic		6.04	0.76				
Canada		1.96	0.00	24.00	28.81	2.77	1.43
USA		11.28	19.78			21.73	22.87

Notes: n.a. not available
1. 1980 FAO data is used to compare to 1982 results and 1985 FAO data is used to compare to 1986 results.
2. FAO lumps Canada and USA as a single region - North America.

Sources: 1. Pulp and Paper Review 4(2), Data Resources Inc., 1980.
2. World Pulp and Paper Demand, Supply and Trade, Volume 1, FAO Forestry Paper 4/1, Food and Agricultural Organization of the United Nations, 1977.

paperboard. The largest exporter to the United States is the EEC. The Nordic countries and Canada also ship to the United States. Canada also ships to the growing Japanese market while the U.S. South is the sole supplier in the American market.

The only projection from the present study that comes close to the projections of the other two studies is that of paperboard consumption for the United States and paperboard production of the Nordic countries (see Table 7.5). Projection of production for the United States is also well below those made by FAO and DRI -- it is less than a third of the size projected by the FAO. On the other hand, the present study projects European production of paperboard to be about forty percent higher, on the average, in magnitude than the projection of FAO and DRI for the entire projection period.

7.3.3 Projections Based on High Growth Rates

This section is divided into three subsections; one for each product group as was done for the previous two sets of projections. As should be expected, the rates of growth for total production, average costs, and average market prices are much higher when high growth rates are assumed for the demand and supply shifters.

7.3.3.1 Newsprint

Total production increases by 4.7 percent annually over the projection period. The rates of increase tend to get higher as the projection horizon is approached. This tendency is also true for the

Table 7.3

Comparisons of Projections of Regional Production and Consumption for Paperboard for 1982, 1986, and 1990

		Present Study		FAO[1,2]		DRI	
Region	Year	Production	Apparent Consumption	Production	Apparent Consumption	Production	Apparent Consumption
		million metric tons					
	1982						
Japan		0.00	0.64	13.70	13.08	n.a.	8.26
EEC		24.24	8.98	16.03	19.49	n.a.	13.75
Nordic		(8.35)	n.a.	6.80	2.24	n.a.	n.a.
Canada		5.70	0.00	44.50	42.98	3.32	2.81
USA		11.84	40.49			39.45	37.29
	1986						
Japan		0.00	1.02	n.a.	16.58	n.a.	9.44
EEC		27.01	8.43	n.a.	22.17	n.a.	15.51
Nordic		(8.17)	n.a.	n.a.	2.54	n.a.	n.a.
Canada		6.38	n.a.	n.a.	46.68	3.64	3.16
USA		13.70	45.80			43.71	40.94
	1990						
Japan		0.00	1.50	21.40	20.39	n.a.	10.72
EEC		30.18	7.82	22.20	25.89	n.a.	17.32
Nordic		(7.94)	n.a.	8.20	2.97	n.a.	n.a.
Canada		7.15	0.00	62.00	57.48	4.01	3.57
USA		15.95	51.91			47.41	44.19

Notes: n.a. not available

Figures in parenthesis are net exports.

1. 1980 FAO data is used to compare to 1982 results and 1985 FAO data is used to compare to 1986 results.
2. FAO lumps Canada and USA as a single region - North America.

Sources: 1. Pulp and Paper Review 4(2), Data Resources Inc., 1980.

2. World Pulp and Paper Demand, Supply and Trade, Volume 1, FAO Forestry Paper 4/1, Food and Agricultural Organization of the United Nations, 1977.

growth rates for average costs and market prices. Average costs increases by 6.45 percent and average market prices by a slightly higher rate of 6.50 percent.

The largest consumer and importer of newsprint is the EEC (see Table E.1, Appendix E). The United States remains the second largest consumer but by the beginning of the twenty-first century Japan assumes this role. By year 2010 no shipments, including those from domestic suppliers, are made into the United States market. Instead, all shipments go to either Japan or the EEC, predominantly to the latter.

The largest supplier to the European market is Ontario with the Nordic countries being the second largest supplier. Initially, British Columbia does not ship to Europe but by year 2000 it does ship to this market. British Columbia ships to Japan as early as 1982 and continues increasing its shipment in subsequent periods. As the markets of Japan and Europe grow bigger, suppliers from all regions find it more profitable to ship to these markets and divert flows from the American market.

British Columbia and Ontario ship to the American market prior to year 2000 but discontinue shipping to this market after that year. British Columbia expands its shipment to Japan while Ontario expands its shipment to Europe. The American market initially is supplied by U.S. South and U.S. West but by 1990 only the West continues shipping to both sections of the American market. Some thirty years later even U.S. West stops shipping to the American market and instead starts shipping to the European market.

7.3.3.2 Printing Paper

Projected total production increases at an average rate of 6.5 percent over the entire projection period. The rates tend to increase as the projection horizon draws closer. The growth rates for average costs and market prices, on the contrary, tend to decline as the projection horizon draws nearer. The decline is so great for the period between the projection years 2020 and 2030 that a negative growth rate is obtained when the growth rate is averaged over the entire projection period.

Average costs are expected to decrease at a rate of 2.2 percent on the average while average prices decline at a rate of 3.8 percent. The decline is because many of the quantity-dependent supply functions included lagged production or capacity (with a positive coefficient) as an argument so that when the function is inverted into a price-dependent supply function lagged production now has a negative coefficient. When this term is suppressed into the intercept term of the price-dependent supply function with only quantity as the argument the intercept term becomes a large negative number, that is, the supply curve is shifted downwards. This results in negative costs and market prices as equilibrium solutions. The reactive programming algorithm, moreover, allocates only on the criterion that net returns are positive, that is, so long as market prices are greater than costs net of transport costs it continues making adjustments in the shipments program; the algorithm ignores whether prices are positive or negative.

The United States is the biggest consumer of printing paper up to year 2020 by which time the EEC assumes this role. The EEC remains the largest producer only until year 1990 (see Table E.2, Appendix E). Starting in 1990, the U.S. South emerges as the largest producer and by year 2030 it holds such a cost advantage over other regions that it is the sole supplier to all the available markets. In its quantity-dependent form, the supply function for the U.S. South included capacity as an explanatory variable. The growth rate for U.S. South's capacity for printing paper is high resulting in a large negative number as the intercept of the price-dependent supply function as explained earlier.

For the years up to year 2000 the Nordic countries, followed by the EEC, are the two largest suppliers to the American market (see Table E.2, Appendix E). Both suppliers only ship to the eastern section of the market. The U.S. South begins shipping more to both sections of the American market. By year 2000 the South increases its shipment to the U.S. East market by fivefold and foreign suppliers no longer ship to this market. Instead, the Nordic countries and Ontario switch shipments from the American to the European market. U.S. North Central begins shipping to the European market. Ontario and the Nordic countries continue shipping to the EEC until year 2020. By this time the only other supplier, other than U.S. South, is the Nordic countries which supply their own domestic market.

7.3.3.3 Paperboard

While the growth rates between each projection year for total production tend to increase as the projection horizon is approached, the growth rates for average costs and market prices tend to decrease. Total production average an annual increase of 3.5 percent while average costs and market prices both average increases of 5.4 percent.

The largest markets, in descending order, are U.S. East, U.S. West, and the EEC (see Table E.3, Appendix E). This is true up to year 2010 at which time Japan replaces the EEC as the third largest consumer. On the supply side, the EEC, U.S. South, and the Nordic countries are the largest suppliers, in descending order, of paperboard. By year 2000, however, Canada replaces the Nordic countries as the third largest producer of paperboard.

In the initial phase of the projection period the outlets for the excess supplies of producing regions are limited to U.S. East and U.S. West markets. The EEC and the Nordic countries ship to U.S. East while Canada and Japan ships to the U.S. West market. Canada also begins to ship to Japan by year 2000. As the South's shipments to both domestic markets increase, shipments from foreign sources begin to dwindle except for the EEC which still finds the eastern section of the American market a very profitable one. By the end of the projection period the U.S. South finds the Japanese export market a profitable one to ship to. Meanwhile, Canada stops shipping to the American market and diverts almost all of its shipments to the Japanese market. At the same time U.S. South is the only local supplier to both U.S. markets.

7.4 Summary

Before projections of regional prices, production, consumption, and trade flows could be made, projections of the shifters of the regional demand and supply functions were performed. These latter projections are based on the average annual growth rates of the shifters prevalent during the sample period of 1962 - 1978. Two additional scenarios about future conditions were obtained by projecting one standard error above and below the mean annual growth rates.

Misdirection of trade flows and underestimation or overestimation of the regional production, consumption, and prices during the historical simulation phase are perpetuated into the projections of the future. Projections based on all three growth rates indicated the EEC as the largest consumer of newsprint and Ontario as the largest exporter. Projections based on all three scenarios also indicated that the Japanese market becomes an important market in the future and that the U.S. South becomes an important supplier to both the domestic and export markets. On the basis of low growth rate the United States is projected to be an important market for printing paper throughout the projection period, but on the basis of mean and high growth rates the EEC assumes the position of the largest market after 2010 and 1990, respectively. The U.S. South consistently emerges as a leading supplier of printing paper to both the domestic and export markets in all three scenarios. By the end of the projection period the South becomes the sole supplier of this product group. In all three scenarios the U.S.

South emerges as the leading supplier of paperboard towards the end of the projection period. Growth of the Japanese and United States markets for paperboard becomes apparent in all three scenarios.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Despite the significant role of international trade in the market for paper products, studies in the role of trade have been scarce. A growth in the importance of the U.S. South and a continued reliance on foreign markets, for both exports and imports, necessitates a study of the economic forces affecting the international market for paper products as it affects the United States market for paper products. Since the paper industry is highly capital intensive, planning for the future is of grave importance to decision makers, whether in the public or the private sector. Local as well as global conditions become important information for decision makers. The future of the paper industry remains uncertain. Projections of the future supply and demand of paper will help decision makers to make plans for the future.

Until recently, the demand for paper products was believed to be insensitive to price changes. Many studies regressed the quantity demanded of paper products on non-price variables such as population, per capita income, and gross national product. Recent fluctuations in prices, especially during the mid-seventies, have necessitated an explanation for these variations. Although the demands for paper have been found to be inelastic, at least they are responsive to price changes. The degreee of sensitivity of the demand for paper to price changes still remain in doubt. Ascertaining the degree of sensitivity serves to clear some of the doubt as well as provide a basis for projecting future demand.

The responsiveness of supply to price changes is even less certain. Only one study, that of McKillop (30), has considered modeling supply when analyzing the market for paper products. Ascertaining the sensitivity of supply to price changes is an important information in itself, but it also helps in projecting future supply.

Changing economic conditions affect the supply and demand of the main producing and consuming regions. Although each region may not be able to affect the world market, simultaneous changes among all regions affect the world market, which in turn affect the individual regions through the world price. To take into account this effect necessitates an understanding of the international trade model for paper products.

An analytical framework for understanding such a model is the spatial equilibrium model presented in Chapter II. Following Samuelson's (38) seminal work on spatial price equilibrium models, several methods of operationalizing his concept were introduced, one of which is the reactive programming algorithm. This algorithm was adopted in this study since it is a more flexible program than quadratic programming and can handle nonlinear supply and demand functions. In either case, supply and demand functions have to be properly specified.

The specifications and estimations of the supply and demand functions for each product group and each region were presented in Chapter III. The results of the estimation of these functions were presented in Chapter IV. Not unexpectedly, the demand for paper products was found to be inelastic. The demand for paperboard appears to be the most inelastic of the three product groups. Its elasticity ranged from -0.05 to -0.33. The demand for newsprint was less inelastic ranging from -0.27 to -0.38. Printing paper had the least inelastic demand of the three product groups. Its elasticity ranged from -0.14 to -0.73. Not only does paperboard have the most price inelastic demand among the three product groups it is also the most income inelastic, thereby contradicting Buongiorno's finding. Boungiorno found newsprint to be the more income inelastic demand among the three product groups. The income elasticities ranged from 0.23 to 0.84 with the latter being the income elasticity of demand for the United States. However, both the present and Buongiorno's study found the income elasticity of printing paper to be more income elastic among the three product groups.

The supply of paper products is also price responsive. The supplies of all three product groups appear to be price inelastic in general and the supply of paperboard is the most price inelastic. The supply price elasticity for paperboard ranged from 0.05 to 0.42, for newsprint from 0.22 to 1.15, and for printing paper from 0.03 to 2.10. These results compare favorably with the results of McKillop (30) who found the price elasticities of paper ranging from -0.1 to 0.5 and that of paperboard ranging from 0.1 to 0.6. Input costs, lagged production, and structural change play an important role in determining the amount of paper products supplied. Inputs such as fuel, chemicals, wood pulp, lagged production, and capacity were statistically significant explanatory variables in explaining the level of supply for a given region.

The iterative nature of the reactive programming algorithm was illustrated both graphically and mathematically in Chapter V. Since it possible to incorporate tariffs into the spatial equilibrium analysis, the manner of doing this was illustrated in Chapter VI. By way of validation, historical simulation over the period 1970 - 1978 was performed for all three product groups. The results were compared to actual data in Chapter VI. In general, the direction of many of the trade flows were duplicated, although the magnitudes of the simulation did not duplicate those of the actual flows.

Using the mean annual growth rates from the sample period of 1962 - 1978, projections of the supply and demand shifters were calculated. In a similar fashion, projections of fixed supplies and/or demand were also computed. Since all explanatory variables other than quantity were suppressed in the intercept term of the price-dependent supply and demand functions used in the reactive programming algorithm, these projections locate the supply and demand curves in the price-quantity space for the projection period. The procedure for doing the projection and the results obtained were presented in Chapter VII. Results of the projections based on the mean growth rate were compared to the projections of the FAO and DRI. The results from the present study differ somewhat from the results of these two studies. Negative supply and demand prices were obtained for the projections based on high growth rates for paperboard indicating the world market is saturated with paperboard. Such a solution is possible because the reactive programming algorithm does not care if supply and demand prices are negative just so long as demand is greater or equal to supply price.

In specifying an economic model that cuts across countries, one faces the problem of obtaining a consistent set of data suitable for estimating supply and demand functions with a common set of variables. One of the criteria followed in specifying the supply and demand equations was that a common set of variables across regions be used. In doing so the choice of variables was limited. Had domestic prices for the three product groups been readily available, they would have been the proper variables to use.

The demand for and the supply of paper products generally are price responsive but the relative changes in quantities demanded or supplied due to price changes are rather small. Therefore, changes in other factors such as gross national product and contractual (or persistence) demand are more important in determining the level demand for a particular market. Similarly, factors such as the prices of fuel, chemicals, wood pulp, and capacity or inventory levels are more important than product price in determining the level of supply of paper products for a given region.

This is quite apparent from the results of both the historical simulation and future projections. Although magnitudes of regional prices, production, consumption, and trade flows obtained from the historical simulation were often underestimated or overestimated in comparison to the actual data, the direction of trade flows were often correctly predicted. These tendencies will be perpetuated into the projection and therefore policy makers, executives in the paper industry, and other users are forewarned not to regard the projected magnitudes of the regional prices, production, consumption, and trade flows as point estimates but rather as "ballpark" figures. However, changes in the direction of trade flows in the future should be carefully noted since the model has predicted the direction of the major trade flows quite well. It should also be noted that the results of future projections based on the mean growth rate are also more conservative estimates in comparison to the projections of the FAO and DRI. Projections of future regional magnitudes, therefore, may be slightly higher than those projected in this study.

The growing importance of the U.S. South region as a producing region was mentioned very early in the description of the problematic situation in Chapter I. The projections indicated that the South will indeed be an important producer of all three product groups. Not only will the South be an important supplier to the domestic market, it will also be an important supplier to export markets. Policy makers and business executives in the paper industry should be aware of the growth of the markets in the Europeand Economic Community and Japan. Japan's growth may be underestimated since its growth rate from the historical data was adjusted downward. This was done to make the projections more realistic because the growth rate for Japan's gross national product during the historical period was a lot higher than those of the other regions.

One shortcoming of this study is that no account was given to the other 25 percent of the world market nor was expansion in the market for or the supply of paper products considered. The developing countries are increasingly becoming more important in the global picture. These countries are potential market areas for which the major producing regions may wish to penetrate. Latin America is another area that is increasingly becoming an important potential market. As the potential markets develop, so do potential suppliers. Brazil is expanding as a supplier of wood pulp, a major ingredient in the making of paper and paperboard. It would be interesting to see what the effects of introducing one or more producing and consuming regions are on the regional distribution of prices, production, consumption, and trade flows.

Divergencies between simulation and actual trade flows can be faulted on the specification of the demand and supply functions, the specification of the transportation costs, which depends on the number of routes considered, or both. It is the author's judgement that misdirection of some on the trade flows were due to using unrepresentative transportation costs and supply and demand points, and not including enough supply and demand points. It would have been tempting to adjust the transportation costs for specific routes such that the actual trade flows would have been duplicated but there are probably thousands upon thousands of combinations that would yield the same actual flows. The question then becomes which one to have confidence in. No attempt as made, therefore, to adjust the transportation costs.

These problems suggest that further studies on the role of transportation costs in affecting trade flows need to be closely studied. The pilot study by Wisdom (56) has demonstrated that such studies are possible. A detail study along the lines of Wisdom's work would be useful in the analysis of trade flows of forest products. Studies should not be restriced to ocean freight costs only but should also include studies on rail and truck rates, especially for the United States where potential supply and demand points are numerous and dispersed all over the country. The U.S. Forest Service should consider collecting rail and truck rates that are commodity specific. Incorporating transportation costs that are functions of volume should also be considered. This entails incorporating transport costs as part of the solution algorithm. Such cost functions can be incorporated not only in econometric studies of trade flows but also in spatial equilibrium studies.

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APPENDICES

APPENDIX A

Regional Demarcation for United States for Newsprint, Printing Paper, and Paperboard, by States

For newsprint and paperboard, the United States was divided into the following regions:

A. U.S. North comprises the following states:

(1) Northeast:

(i) New England states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut;

(ii) Middle Atlantic states: New York, New Jersey, and, Pennsylvania;

(2) North Atlantic states:

(i) East North Central: Ohio, Indiana, Illinois, Michigan, and Wisconsin;

(ii) West North Central: Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

B. U.S. South consists of the following states:

(1) South Atlantic states: Delaware, Maryland, Virginia, West Virginia, North and South Carolina, Georgia, and Florida;

(2) South Central:

(i) East South Central states: Kentucky, Tennessee, Mississippi, and Alabama;

(ii) West South Central: Arkansas, Loiusiana, Oklahoma, and Texas.

C. U.S. West:

(1) Mountain: Montana, Wyoming, Colorada, and New Mexico;

(2) Pacific: Alaska, Washington, Oregon, California, and Hawaii.

For printing paper the regions were classified as follows:

A. U.S. North East comprising of the New England and Middle Atlantic states as defined above;

B. North Central comprising of the eastern and western North Central states as defined above; and

C. The rest of the United States, which is simply referred to as U.S. South, consits of states not already included in the two categories defined in (A) and (B).

APPENDIX B

RESULTS OF THE HISTORICAL SIMULATION

Table B.1

A Comparison Between Actual and Simulated Regional Prices, Production, Consumption, and Trade Flows of Newsprint, for Selected Regions, for 1970 to 1978[1]

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
				1970					
Japan	346.85	1714.74	346.85					174.83	333.03
	(221.62)	(1917.00)	(221.62)						(214.96)
Nordic[2]	340.83			2559.30	346.90				
	(200.62)			(1497.40)	(191.43)	(282.30)	(214.96)		
Canada[3]	275.30			3216.02	346.90	3501.96	327.37	1192.00	333.03
	(215.70)			(519.30)	(191.43)	(5635.60)	(214.96)		(214.96)
U.S. North	202.85			616.00	346.90				
	(214.96)			(9.32)	(191.43)				
U.S. South	226.33					1718.00	327.37		
	(214.96)			(3.18)			(214.96)		
U.S. West	249.72							806.00	333.03
	(214.96)								(214.96)

1. Actual data are given in parentheses. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.
2. Actual shipments from the Nordic countries is assumed to go to U.S. East market only.
3. Actual shipments from Canada are assumed to go to U.S. East market only. Simulated shipments for Canada are obtained by summing the individual shipments from British Columbia and Ontario.

Table B.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1971					
Japan	326.03 (216.34)	1832.24 (1951.00)	326.03 (216.34)					174.83	358.61 (209.63)
Nordic[2]	379.53 (200.72)			2759.40 (1508.10)	382.96 (195.39)	(268.30)	(209.63)		
Canada[3]	318.19 (217.32)			3531.87 (519.30)	382.96 (195.39)	3161.88 (5954.50)	376.54 (209.63)	976.25	358.61 (209.63)
U.S. North	198.02 (209.63)			631.00 (0.00)	382.96 (195.39)				
U.S. South	235.38 (209.63)					1711.00	376.54 (209.63)		
U.S. West	244.57 (209.63)							804.00	358.61 (209.63)

Table B.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1972					
Japan	349.08 (202.66)	1957.25 (2060.00)	349.08 (202.66)					84.11	378.96 (208.47)
Nordic[2]	418.72 (197.23)			3054.87 (1672.00)	420.38 (201.23)	(295.00)	(208.47)		
Canada[3]	349.71 (217.59)			3872.65 (519.30)	420.38 (201.23)	3036.58 (5797.00)	416.72 (208.47)	1091.77	378.96 (208.47)
U.S. North	192.62 (208.47)			684.00	420.38 (201.23)				
U.S. South	233.05 (208.47)					1720.00	416.72 (208.47)		
U.S. West	240.86 (208.47)							811.00	378.96 (208.47)

Table B.1 Continued

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
				1973					
Japan	393.12 (255.19)	2048.36 (2106.00)	393.12 (255.19)					119.76	443.74 (211.84)
Nordic[2]	492.52 (211.45)			3205.05 (1822.00)	513.40 (220.72)	 (319.00)	 (211.84)		
Canada[3]	405.73 (212.94)			5509.87 (509.00)	513.40 (220.72)	1448.13 (6264.00)	489.72 (211.84)	1091.77	443.74 (211.84)
U.S. North	190.46 (211.84)			678.00 (6.44)	513.40 (220.72)				
U.S. South	291.15 (211.84)					1773.00	489.72 (211.84)		
U.S. West	240.86 (211.84)					414.50	489.72 (211.84)	393.50	443.74 (211.84)

Table B.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1974					
Japan	281.70 (388.41)	2159.00 (2213.00)	281.70 (388.41)					34.05	378.59 (241.56)
Nordic[2]	499.23 (293.10)			3011.05	510.43 (309.90)				
Canada[3]	409.09 (236.37)			5622.77	510.43 (309.90)	1795.44	485.10 (241.58)	1243.79	378.59 (241.58)
U.S. North	238.45 (241.58)			678.00 (12.32)	510.43 (309.90)				
U.S. South	455.84 (241.58)			(0.43)	(309.90)	1874.00	485.10 (241.58)		
U.S. West	279.77 (241.58)							817.00	378.59 (241.58)

Table B.1 Continued

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
				1975					
Japan	425.39 (285.58)	2314.56 (2219.59)	425.39 (285.58)					403.70	482.45 (257.73)
Nordic[2]	561.44 (333.85)			2707.69 (1709.00)	568.67 (316.23)	(13.00)	(257.73)		
Canada[3]	470.93 (247.52)			5294.81	568.67 (316.23)	1753.34 (5104.00)	545.45 (257.73)	374.64	482.45 (257.73)
U.S. North	274.63 (257.73)			650.00 (4.61)	568.67 (316.23)				
U.S. South	523.35 (257.73)			(0.10)	(316.23)	1927.39	545.45 (257.73)		
U.S. West	333.65 (257.73)							890.00	482.45 (257.73)

Table B.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1976					
Japan	361.56 (262.73)	2084.12 (2434.84)	361.56 (262.73)					333.33	417.39 (266.27)
Nordic[2]	495.16 (290.06)			2642.67 (1742.00)	500.54 (252.39)	(20.00)	(266.27)		
Canada[3]	419.40 (237.25)			5062.71 (540.00)	500.54 (252.39)	2788.36 (5676.00)	477.74 (266.27)	767.29	417.39 (266.27)
U.S. North	268.53 (266.27)			684.00 (10.48)	500.54 (252.39)				
U.S. South	456.22 (266.27)					1865.58	477.74 (266.27)		
U.S. West	342.24 (266.27)							934.00	417.39 (266.27)

Table B.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1977					
Japan	393.33 (248.42)	2202.44 (2468.93)	393.33 (248.42)					461.11	446.70 (271.05)
Nordic[2]	520.61 (286.18)			2784.74 (1550.00)	527.35 (301.61)				
Canada[3]	445.60 (242.77)			5217.47 (547.00)	527.35 (301.61)	2804.68 (5749.00)	505.63 (271.05)	666.54	446.70 (271.05)
U.S. North	257.64 (271.05)			678.00 (11.26)	527.35 (301.61)				
U.S. South	484.99 (271.05)			(0.01)	(301.61)	1886.75	505.63 (271.05)		
U.S. West	327.98 (271.05)			(2.37)	(301.61)			916.00	446.70 (271.05)

Table B.1 Continued

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
				1978					
Japan	468.99 (267.83)	2511.93 (2604.30)	468.99 (267.83)					105.22	527.63 (247.62)
Nordic[2]	572.42 (273.33)			3110.87 (1715.00)	575.06 (305.80)	(7.00)	(247.62)		
Canada[3]	484.29 (242.65)			6220.08 (562.00)	575.06 (305.80)	2369.60 (6405.00)	552.94 (247.62)	799.09	527.63 (247.62)
U.S. North	244.71 (247.62)			662.00 (9.81)	575.06 (305.80)				
U.S. South	531.13 (247.62)					2138.03	552.94 (247.62)		
U.S. West	325.34 (247.62)			(6.19)	(305.80)			938.00	527.63 (247.62)

Table B.2

A Comparison Between Actual and Simulated Regional Prices, Production, Consumption, and Trade Flows of Printing Paper, for Selected Regions, for 1970 to 1978 [1]

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1970						
Japan	5738.11										
	(444.36)										
EEC	56.08	7454.50	56.08					1631.04	105.28		
	(379.53)	(6541.00)	(379.53)								
Nordic	50.05			862.65	50.05			738.47	105.28		
	(283.28)			(571.00)	(283.28)						
Ontario	82.11							2734.93	105.28	333.51	145.71
	(321.90)					(556.00)	(321.90)				
U.S. North East	81.74							2734.93	105.28	534.73	145.71
	(280.84)										
U.S. North Central	60.32							2352.53	105.28		
	(280.84)										
U.S. South	88.61					344.79	158.87			2414.35	145.71
	(280.84)						(321.90)	U.S. East		U.S. West	

1. Actual data are given in parentheses. Quantitiy data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1971						
Japan	2075.93										
	(440.18)										
EEC	79.96	7655.74	79.96					1514.06	113.42		
	(375.66)	(6324.00)	(375.66)								
Nordic	75.86			850.08	75.86			818.41	113.42		
	(166.35)			(593.00)	(166.35)						
Ontario	97.66							288.99	113.42		
	(319.24)					(583.00)	(319.24)				
U.S. North East	68.77							2352.39	113.42	993.79	132.28
	(278.91)										
U.S. North Central	68.48					404.28	139.03	2352.53	113.42		
	(278.91)						(319.24)				
U.S. South	95.68									3097.12	132.28
	(278.91)										

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1972						
Japan	3425.42 (474.65)										
EEC	93.37 (382.26)	8039.11 (6924.00)	93.37 (382.26)					1528.89	124.07		
Nordic	89.61 (274.87)			892.25 (711.00)	89.61 (274.87)			967.66	124.07		
Ontario	109.61 (300.94)					(595.00)	(300.94)	182.27	124.07		
U.S. North East	98.25 (267.66)							2579.39	124.07	993.79	138.18
U.S. North Central	79.64 (267.66)					412.99	144.37 (300.94)			2293.19	138.18
U.S. South	107.79 (267.66)									3384.62	138.18

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1973						
Japan	5594.78 (454.77)										
EEC	112.41 (449.49)	9143.61 (7513.00)	112.41 (449.49)					875.08	124.07		
Nordic	104.25 (300.87)			980.28 (927.00)	104.25 (300.87)			1002.59	124.07		
Ontario	147.61 (335.51)					(639.00)	(335.51)	207.97	124.07		
U.S. North East	151.93 (288.30)							3846.30	124.07	993.79	138.18
U.S. North Central	127.35 (286.30)							3063.47	124.07		
U.S. South	143.67 (288.30)					252.23	238.69 (333.51)	36.13	124.07	3384.82	138.18

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1974						
Japan	7380.31										
	(807.21)										
EEC	149.42	8582.32	149.42					203.68	266.86		
	(589.15)	(7907.00)	(589.15)								
Nordic	166.06			948.77	166.06			1080.10	266.86		
	(412.49)			(641.00)	(412.49)						
Ontario	224.57							466.69	266.86		
	(323.89)					(731.00)	(323.89)				
U.S. North East	238.57							3735.51	266.86		
	(363.77)										
U.S. North Central	212.83							2905.94	266.86		
	(363.77)										
U.S. South	219.24					61.63	347.46	246.70	266.86	3247.78	323.45
	(363.77)						(323.89)				

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1975						
Japan	3868.94 (546.00)										
EEC	210.99 (565.26)	8488.85 (5847.00)	210.99 (565.26)					1181.01	269.50		
Nordic	203.82 (429.84)			966.51 (499.00)	203.82 (429.84)			807.84	269.50		
Ontario	241.94 (319.41)					(550.00)	(319.41)	98.09	269.50		
U.S. North East	239.88 (387.29)							3614.63	269.50		
U.S. North Central	212.93 (387.29)							2599.77	269.50		
U.S. South	238.47 (387.29)					101.16	322.02 (319.41)	184.88	269.50	3223.42	306.38

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1976						
Japan	5613.69 (848.42)										
EEC	14.11 (508.37)	7590.37 (7261.00)	14.11 (508.37)					477.63	302.15		
Nordic	240.08 (366.53)			907.42 (765.00)	240.08 (366.53)			831.18	302.15		
Ontario	276.11 (318.70)					(706.00)	(318.70)	501.10	302.15		
U.S. North East	271.14 (371.12)							3594.81	302.15		
U.S. North Central	242.92 (371.12)							2944.37	302.15		
U.S. South	272.83 (371.12)					67.08	351.79 (318.70)	636.65	302.15	3420.04	337.01

Table B.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1977						
Japan	4149.27 (754.07)										
EEC	192.03 (489.95)	8525.49 (7499.00)	192.03 (489.95)					1546.40	246.75		
Nordic	185.32 (359.27)			949.69 (618.00)	185.32 (359.27)			1026.12	246.75		
Ontario	220.97 (312.80)					(816.00)	(312.80)	353.06	246.75		
U.S. North East	214.28 (396.63)							3919.48	246.75		
U.S. North Central	184.74 (396.63)							2923.62	246.75		
U.S. South	217.73 (396.63)					158.21	351.79 (312.80)	135.21	246.75	3775.93	281.24

Table B.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1978						
Japan	6573.46 (622.92)										
EEC	217.72 (475.28)	9445.98 (8233.00)	217.72 (475.28)					1096.27	246.75		
Nordic	210.65 (358.06)			940.69 (866.00)	210.65 (358.06)			1369.07	246.75		
Ontario	220.97 (318.30)					 (616.00)	 (318.30)	359.04	246.75		
U.S. North East	241.37 (389.47)							4171.75	246.75		
U.S. North Central	210.44 (389.47)							3106.24	246.75		
U.S. South	244.80 (389.47)					90.08	351.79 (318.30)	305.89	246.75	3968.07	281.24

Table B.3

A Comparison Between Actual and Simulated Regional Prices, Production, Consumption, and Trade Flows of Paperboard, for Various Regions, for 1970 to 1978[1]

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1970						
Japan	-53.79 (356.41)	826.96 (8359.00)	-53.79 (356.41)	 (2.00)	 (333.12)			2709.43 (4.00)	15.84 (190.93)	7652.13	-20.27
EEC	29.17 (333.12)			9059.21 (12086.00)	29.17 (333.12)						
Nordic	20.70 (300.44)			4047.46 (3412.90)	29.17 (333.12)			 (69.00)	 (190.93)		
Canada	-27.23 (219.88)			 (355.30)	 (333.12)	692.14 (2220.00)	-27.23 (219.88)			1711.92 (298.30)	-20.27 (190.93)
U.S. North	0.01 (190.93)			6519.57 (17.76)	29.17 (333.12)			2793.83	15.84 (190.93)		
U.S. South	-0.12 (190.93)			 (840.95)	 (333.12)			18506.23	15.84 (190.93)		
U.S. West	(190.93)			(84.96)	(333.12)						

1. Actual data are given in parentheses. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.
2. Actual shipments from Japan is assumed to go to the U.S. East market only.
3. Actual shipments from the Nordic countries is assumed to go to to the U.S. East market only.
4. Actual shipments from Canada is assumed to go to the U.S. West market only.

Table B.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1971						
Japan	-17.41	1129.11	-17.41					1306.55	29.95	7709.44	5.40
	(358.90)	(8420.00)	(358.90)	(2.00)	(317.01)						
EEC	33.22			8458.70	33.22						
	(317.01)			(11836.00)	(317.01)						
Nordic	27.46			3935.21	33.22						
	(296.05)			(3485.20)	(317.01)			(62.9)	(236.47)		
Canada	0.66					719.93	0.66			1845.29	5.40
	(204.51)			(355.30)	(317.01)	(2314.00)	(204.51)			(360.20)	(236.47)
U.S. North	13.39			7486.31	33.22			3436.69	29.95		
	(236.47)								(236.47)		
U.S. South	19.10							19445.34	29.95		
	(236.47)								(236.47)		
U.S. West	0.01							415.13	29.95		
	(236.47)								(236.47)		

Table 8.3 Continued

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1972						
Japan	-15.97	1553.29	-15.97					390.98	27.47	8067.92	4.95
	(395.28)	(8835.00)	(395.28)	(6.00)	(325.42)			(5.0)	(197.86)		
EEC	28.33			9217.23	28.33						
	(325.42)			(12360.00)	(325.42)						
Nordic	27.46			4051.09	28.33						
	(295.93)			(3842.00)	(325.42)			(65.0)	(197.86)		
Canada	0.61					766.04	0.61			1933.39	4.95
	(219.90)			(583.00)	(325.42)	(2554.00)	(219.90)			(432.00)	(197.86)
U.S. North	10.14			7196.45	28.33			2348.94	27.47		
	(197.86)				(325.42)				(197.86)		
U.S. South	17.55							20619.45	27.47		
	(197.86)								(197.86)		
U.S. West	0.003							2405.66	27.47		
	(197.86)								(197.86)		

Table B.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1973						
Japan	-30.61	2213.59	-30.61							7620.00	14.74
	(570.23)	(10875.00)	(570.23)	(15.00)	(368.39)			(1.0)	(288.08)		
EEC	80.84			9880.84	80.84						
	(368.39)			(13490.00)	(368.39)						
Nordic	69.39			3973.57	80.84						
	(372.68)			(4299.00)	(368.39)			(115.0)	(288.08)		
Canada	5.30					805.19	5.30			1964.92	14.74
	(236.54)			(364.00)	(368.39)	(2826.00)	(236.54)			(461.00)	(288.08)
U.S. North	41.40			7162.26	80.84			4883.04	59.56		
	(288.08)			(25.91)	(368.39)				(288.08)		
U.S. South	17.53							21147.61	59.56		
	(288.08)			(714.28)	(368.39)				(288.08)		
U.S. West	0.01							778.92	59.56	851.51	14.74
	(288.08)			(90.26)	(368.39)				(288.08)		

Table B.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1974						
Japan	2.38	2560.81	2.38							7020.95	63.58
	(674.07)	(10356.00)	(674.07)								
EEC	158.24			8124.42	158.24						
	(491.67)			(13490.00)	(491.67)						
Nordic	69.39			3202.59	158.24						
	(372.68)			(4299.00)	(491.67)						
Canada	50.83					800.29	50.83			1518.93	63.58
	(330.71)					(2981.00)	(330.71)				
U.S.	41.40			9073.29	158.24			2278.31	124.04		
North	(308.33)			(42.58)	(491.67)				(308.33)		
U.S.	17.53							20390.95	124.04		
South	(308.33)			(795.63)	(491.67)				(308.33)		
U.S.	0.01							3839.20	124.04	1809.49	63.58
West	(308.33)			(58.51)	(491.67)				(308.33)		

Table B.3 Continued

Region	Supply Price	Japan Quantity	Japan Price	EEC Quantity	EEC Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
						1975					
Japan	121.02 (714.02)	1990.64 (8373.00)	121.02 (714.02)	(10.00)	(489.95)					6966.44	160.88
EEC	215.02 (489.95)			9662.34 (11433.00)	215.02 (489.95)						
Nordic	204.94 (507.71)			2767.63 (2927.00)	215.02 (489.95)						
Canada	152.60 (333.95)			(261.00)	(489.95)	684.67 (2981.00)	152.60 (333.95)			1681.42 (316.00)	160.88 (367.04)
U.S. North	180.34 (367.04)			7331.01 (34.91)	215.02 (489.95)			2094.59	200.26 (367.04)		
U.S. South	181.29 (367.04)			(167.26)	(489.95)			20105.68	200.26 (367.04)		
U.S. West	0.01 (367.04)			(17.29)	(489.95)			3802.41	200.26 (367.04)	1468.80	160.88 (367.04)

Table B.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1976						
Japan	4.71	1901.69	4.71							7335.21	42.39
	(422.99)	(9784.00)	(422.99)	(28.00)	(407.41)						
EEC	91.52			9185.90	91.52						
	(407.41)			(13345.00)	(407.41)						
Nordic	204.94			2916.80	91.52						
	(395.34)			(3774.00)	(407.41)			(83.00)	(367.04)		
Canada	34.55					848.83	34.55			1308.14	42.39
	(261.67)			(350.00)	(407.41)	(2421.00)	(261.67)			(454.00)	(367.04)
U.S.	58.74			7356.44	91.52			3558.56	79.60		
North	(350.04)			(39.27)	(407.41)				(367.04)		
U.S.	61.68							20106.26	79.60		
South	(350.04)			(540.96)	(407.41)				(367.04)		
U.S.	30.12							3961.46	79.60	2098.58	42.39
West	(350.04)			(79.59)	(407.41)				(367.04)		(367.04)

Table B.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1977						
Japan	34.39 (443.73)	2686.63 (10951.00)	34.39 (443.73)	(15.00)	(381.36)					6683.13	71.67
EEC	119.09 (381.36)			9990.95 (13315.00)	119.09 (381.36)						
Nordic	204.94 (348.76)			3607.16 (3795.00)	119.09 (381.36)			(182.00)	(326.50)		
Canada	63.92 (227.97)			(361.00)	(381.36)	785.51 (2192.00)	63.92 (227.97)			1308.14 (581.00)	71.67 (326.50)
U.S. North	86.66 (326.50)			7017.96 (34.67)	119.09 (381.36)			3558.56	108.50 (326.50)		
U.S. South	90.76 (326.50)			(520.40)	(381.36)			20106.26	108.50 (326.50)		
U.S. West	59.53 (326.50)			(80.17)	(381.36)			3961.46	108.50 (326.50)	2098.58	71.67 (326.50)

Table B.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1978						
Japan	109.95 (538.60)	3613.65 (10571.00)	109.95 (538.60)	 (15.00)	 (367.84)					4440.29	149.23
EEC	199.32 (367.84)			11450.56 (13580.00)	199.32 (367.84)						
Nordic	189.40 (348.76)			4014.74 (4117.00)	199.32 (367.84)			 (182.00)	 (326.50)		
Canada	141.07 (227.97)			 (315.00)	 (367.84)	691.83 (2356.00)	141.07 (227.97)			1965.63 (581.00)	149.23 (326.50)
U.S. North	165.16 (326.50)			5107.67 (26.22)	199.32 (367.84)			6564.03	188.03 (326.50)		
U.S. South	90.76 (326.50)			 (529.61)	 (367.84)			22182.93	188.03 (326.50)		
U.S. West	59.53 (326.50)			 (79.06)	 (367.84)			935.25	188.03 (326.50)	5133.76	149.23 (326.50)

APPENDIX C

RESULTS OF PROJECTIONS BASED ON LOW GROWTH RATES

Table C.1

Projections of Regional Prices, Production, Consumption, and Trade Flows of Newsprint Based on Low Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030 [1]

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1982					
Japan	514.41	2636.09	514.41						
Nordic	621.49			4367.35	632.08				
British Columbia	482.73					2201.08	598.59	682.13	507.47
Ontario	571.29			6067.89	632.08	2043.05	598.59		
U.S. North	562.06			665.08	632.08				
U.S. South	566.51					414.74	598.59		
U.S. West	489.91							1473.62	507.47

1. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table C.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1986					
Japan	656.22	2668.54	656.22						
Nordic	725.18			4630.71	737.90				
British Columbia	558.43	33.97	656.22			2849.51	697.66	436.07	588.15
Ontario	664.85			7152.25	737.90	1221.36	697.66		
U.S. North	653.76			873.88	737.90				
U.S. South	659.11					498.47	697.66		
U.S. West	567.04							1756.22	588.15

Table C.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1990					
Japan	767.191	2695.43	767.19						
Nordic	850.06			4934.23	865.35				
British Columbia	649.69	178.64	767.19			3501.13	816.99	127.12	685.40
Ontario	777.56			8351.21	865.35	293.59	816.99		
U.S. North	764.24			1114.41	865.35				
U.S. South	770.66					598.56	816.99		
U.S. West	660.03							2082.58	685.40

Table C.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2000					
Japan	1117.23	2759.93	1117.23						
Nordic	1308.05			5985.88	1332.25				
British Columbia	931.26	710.63	1117.23	2342.38	1332.25	2119.58	1196.10		
Ontario	1193.29			9361.82	1332.25				
U.S. North	1172.20			1947.80	1332.25				
U.S. South	1122.77					911.89	1196.10		
U.S. West	938.45					725.38	1196.10	2296.08	978.63

Table C.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2010					
Japan	1634.48	2823.19	1634.48						
Nordic	1936.55			7381.37	1974.85				
British Columbia	1340.09	1531.88	1634.48	5470.88	1974.85				
Ontario	1754.88			10138.30	1974.85				
U.S. North	1721.51			3028.44	1974.85				
U.S. South	1643.23					1370.46	1759.31		
U.S. West	1351.47			1059.00	1974.85	1026.60	1759.31		

Table C.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2020					
Japan	2384.54	2882.94	2384.54						
Nordic	2862.69			9398.06	2923.31				
British Columbia	1918.53	2808.09	2384.54	6688.67	2923.31				
Ontario	2575.12			10979.20	2923.31				
U.S. North	2522.29			4562.70	2923.31				
U.S. South	2364.69			1710.17	2923.31	292.17	2548.42		
U.S. West	1936.55			4080.79	2923.31			2093.11	2037.19

Table C.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2030					
Japan	3586.77	2945.97	3586.77						
Nordic	4343.68			12589.73	4439.64				
British Columbia	2849.12	4565.42	3586.77	8996.79	4439.64				
Ontario	3888.47			11889.80	4439.64				
U.S. North	3804.84			6978.83	4439.64				
U.S. South	3555.37			3039.50	4439.64				
U.S. West	2677.64			7802.21	4439.64			1257.19	3036.94

Table C.2

Projections of Regional Prices, Production, Consumption, and Trade Flows of Printing Paper Based on Low Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030 [1]

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1982						
Japan	11784.70										
EEC	465.50	8608.35	465.50					3982.21	550.38		
Nordic	455.13			757.18	455.13			4149.21	550.38		
Ontario	510.40							1214.93	550.38		
U.S. North East	509.53							60.62	550.38	677.27	619.88
U.S. North Central	472.29							1167.02	550.38		
U.S. South	521.57									3301.31	619.88

1. Quantitiy data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table C.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1986						
Japan	19932.5										
EEC	530.19	9577.45	530.19					3987.64	632.14		
Nordic	517.71			814.76	517.71			4279.75	632.14		
Ontario	584.16							1419.59	632.14		
U.S. North East	583.04							907.05	632.14		
U.S. North Central	538.45							1583.01	632.14		
U.S. South	587.37									4592.54	705.63

Table C.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					1990						
Japan	30073.30										
EEC	604.33	10687.91	604.33					3797.63	726.77		
Nordic	589.30			879.29	589.30			4430.42	726.77		
Ontario	669.05							1649.91	726.77		
U.S. North East	667.69							1094.11	726.77		
U.S. North Central	614.04							2040.40	726.77		
U.S. South	661.84							965.01	726.77	5283.12	804.02

Table C.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					2000						
Japan	67663.70										
EEC	812.13	14527.38	812.08					2113.18	1005.97		
Nordic	788.35			1107.75	788.35			4800.28	1005.97		
Ontario	914.67							2299.48	1005.97		
U.S. North East	912.57							1612.97	1005.97		
U.S. North Central	827.54							3308.67	1005.97		
U.S. South	903.23							5486.90	1005.97	7393.88	1128.25

Table C.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2010						
Japan	132715.00										
EEC	1036.45	18595.10	1036.45								
Nordic	955.56	1914.05	1036.45	1538.69	955.56			2957.93	1300.04		
Ontario	1155.57							2920.39	1300.04		
U.S. North East	1152.23							2111.78	1300.04		
U.S. North Central	1017.73							4548.41	1300.04		
U.S. South	1137.44							15080.49	1300.04	10372.81	1128.25

Table C.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2020						
Japan	132715.00										
EEC	998.42	18357.94	998.42								
Nordic	870.01	2429.10	998.42	1636.63	870.01			2087.79	1415.19		
Ontario	1186.37							3001.92	1415.19		
U.S. North East	1181.13							2163.61	1415.19		
U.S. North Central	968.26							4355.75	1415.19		
U.S. South	1157.58							15525.92	1415.19	10002.54	1721.18

Table C.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2030						
Japan	245349.00										
EEC	1468.91	21680.46	1468.91								
Nordic	1265.90	5311.54	1468.91	2032.00	1265.90						
Ontario	935.43							2309.10	1297.50		
U.S. North East	927.14							1767.91	1297.50		
U.S. North Central	590.06	1227.03	1468.91					2247.75	1297.50		
U.S. South	889.82							33810.90	1297.50	14742.74	1782.14

Table C.3

Projections of Regional Prices, Production, and Consumption, and Trade Flows of Paperboard Based on Low Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030 [1]

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1982						
Japan	402.47	3205.80	402.47							5381.11	460.25
EEC	475.71			16089.11	475.71						
Nordic	461.12			1569.37	475.71			5782.66	517.32		
Canada	448.24					509.77	448.24			3258.56	460.25
U.S. North	489.86							11376.60	517.32		
U.S. South	489.83							9217.23	517.32		
U.S. West	441.44							4638.15	517.32	3436.34	460.25

1. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table C.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1986						
Japan	468.87	3764.40	468.87							5201.26	538.30
EEC	546.53			17902.38	546.53			234.03	606.91		
Nordic	539.39			1569.37	546.53			7213.67	606.91		
Canada	523.86					554.20	523.86			3774.63	538.30
U.S. North	573.91							10994.70	606.91		
U.S. South	573.88							10933.19	606.91		
U.S. West	515.73							4964.29	606.91	4404.37	538.30

Table C.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						1990					
Japan	549.24	4409.36	549.24							4931.31	632.68
EEC	642.52			17984.44	642.52			2306.47	715.10		
Nordic	633.94							7062.33	715.10		
Canada	615.33					600.92	615.33			4303.71	632.68
U.S. North	675.44							10625.60	715.10		
U.S. South	675.39							12815.26	715.10		
U.S. West	605.53							5260.38	715.10	5607.22	632.68

Table C.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2000						
Japan	834.94	6479.43	834.94							3812.19	967.02
EEC	982.61			17816.38	982.61			8494.67	1097.50		
Nordic	969.04							6630.92	1097.50		
Canada	939.56					721.44	939.56			5778.40	967.02
U.S. North	1034.72							9756.21	1097.50		
U.S. South	1034.64							18573.94	1097.50		
U.S. West	924.05							6019.94	1097.50	9729.66	967.02

Table C.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					<u>2010</u>						
Japan	1251.87	9562.65	1251.87							1720.39	1460.95
EEC	1485.64			17325.09	1485.64			16561.75	1667.50		
Nordic	1464.15							6056.76	1667.50		
Canada	1417.47					871.56	1417.47			7519.28	1460.95
U.S. North	1568.13							8957.94	1667.50		
U.S. South	1568.00							26432.08	1667.50		
U.S. West	1392.94							6734.26	1667.50	16090.44	1460.95

Table C.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2020						
Japan	2283.68	12810.16	2283.68								
EEC	2144.91			17426.72	2144.91			25791.88	2432.77		
Nordic	2110.89							5162.80	2432.77		
Canada	2036.97					1127.30	2036.97			9442.73	2105.80
U.S. North	2275.47							8224.99	2432.77		
U.S. South	2275.27							37245.61	2432.77		
U.S. West	1998.16							9018.71	2432.77	24059.44	2105.80

Table C.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2030						
Japan	3368.84	14322.87	3368.84								
EEC	3077.22			17676.49	3077.22			38366.32	3532.90		
Nordic	3023.38							3899.45	3532.90		
Canada	2906.36					1487.65	2906.36			11873.95	3015.31
U.S. North	3283.90							7552.01	3532.90		
U.S. South	3283.59							52851.59	3532.90		
U.S. West	2844.94							10591.62	3532.90	10591.62	3015.31

APPENDIX D

RESULTS OF PROJECTIONS BASED ON MEAN GROWTH RATES

Table D.1

Projections of Regional Prices, Production, Consumption, and Trade Flows of Newsprint Based on Mean Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030[1]

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1982					
Japan	572.86	2589.14	572.86						
Nordic	636.08			4333.86	646.66				
British Columbia	497.32					2201.08	613.18	695.13	522.05
Ontario	585.87			6501.77	646.66	2111.18	613.18		
U.S. North	576.65			664.46	646.66				
U.S. South	581.10					353.93	613.18		
U.S. West	504.49							1451.65	522.05

1. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table D.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1986					
Japan	700.48	2543.94	700.48						
Nordic	782.17			4575.92	769.45				
British Columbia	602.70	230.25	700.48			2751.02	741.93	337.93	632.42
Ontario	709.12			8304.65	769.45	1349.41	741.93		
U.S. North	698.03			894.88	769.45				
U.S. South	703.38					353.10	741.93		
U.S. West	611.31							1809.55	632.42

Table D.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1990					
Japan	850.94	2492.53	850.94						
Nordic	933.86			4879.72	949.15				
British Columbia	733.47	514.54	850.94			3373.49	900.77		
Ontario	861.36			10465.44	949.15	345.56	900.77		
U.S. North	848.05			1176.81	949.15				
U.S. South	854.45					361.05	900.77		
U.S. West	738.00					62.03	900.77	2135.01	763.37

Table D.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2000					
Japan	1363.17	2330.26	1363.17						
Nordic	1553.99			6062.71	1578.19				
British Columbia	1177.20	1539.61	1363.17	3413.16	1578.19	841.40	1442.04		
Ontario	1439.23			14346.70	1578.19				
U.S. North	1418.15			2244.13	1578.19				
U.S. South	1368.71					411.66	1442.04		
U.S. West	1184.40					1606.58	1442.04	1948.89	1224.56

Table D.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2010					
Japan	2213.06	2107.20	2213.06						
Nordic	2515.11			7933.46	2553.41				
British Columbia	1918.66	3141.57	2213.06	5885.09	2553.41				
Ontario	2333.45			19038.80	2553.41				
U.S. North	2300.08			3888.16	2553.41				
U.S. South	2200.51			528.84	2553.41	41.76	2316.58		
U.S. West	1930.04			4546.38	2553.41			1266.99	1993.63

Table D.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2020					
Japan	3878.71	1820.13	3878.71						
Nordic	4356.84			11633.20	4417.47				
British Columbia	3412.69	5193.96	3878.71	10666.61	4417.47				
Ontario	4069.28			25265.50	4417.47				
U.S. North	4016.46			7075.91	4417.47				
U.S. South	3858.85			1207.50	4417.47				
U.S. West	3430.70			10341.21	4417.47				

Table D.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2030					
Japan	6774.89	1417.09	6774.89						
Nordic	7531.76			18113.90	7627.73				
British Columbia	6037.22	8159.79	6774.89	19997.14	7627.73				
Ontario	7076.56			33528.50	7627.73				
U.S. North	6992.94			12595.03	7627.73				
U.S. South	6743.47			2568.14	7627.73				
U.S. West	6065.73			18309.83	7627.73				

Table D.2

Projections of Regional Prices, Production, Consumption, and Trade Flows of Printing Paper Based on Mean Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030 [1]

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1982						
Japan	14631.60										
EEC	518.11	8586.68	522.18					3444.51	601.49		
Nordic	511.59			692.50	455.13			4444.08	601.49		
Ontario	561.55							1283.35	601.49		
U.S. North East	562.19							741.62	601.49		
U.S. North Central	514.53							710.02	601.49	453.26	667.75
U.S. South	569.34									3550.04	667.75

1. Quantitiy data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table D.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1986						
Japan	28527.30										
EEC	686.93	9518.42	686.93					2925.33	788.82		
Nordic	674.42			690.27	674.42			4955.03	788.82		
Ontario	383.26							730.00	788.82		
U.S. North East	739.72							969.85	788.82		
U.S. North Central	695.06							1797.51	788.82		
U.S. South	734.85							847.31	788.82	4625.94	853.18

Table D.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1990						
Japan	47604.50										
EEC	816.19	11168.35	816.19					1256.58	938.62		
Nordic	801.16			755.69	801.16			5285.58	938.62		
Ontario	880.83							1958.03	938.62		
U.S. North East	879.69							1119.98	938.62		
U.S. North Central	825.92							2238.33	938.62		
U.S. South	873.74							2496.76	938.62	5429.17	1015.95

Table D.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2000						
Japan	132672.00										
EEC	1268.55	12146.91	1268.55								
Nordic	1217.50	4930.99	1268.55	988.18	1217.50			1422.81	1435.17		
Ontario	1343.91							2921.33	1435.17		
U.S. North East	1341.81							1640.88	1435.17		
U.S. North Central	1256.36							3758.44	1435.17		
U.S. South	1332.39							11451.17	1435.17	8002.72	1557.40

Table D.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2010						
Japan	321646.00										
EEC	1859.54	10638.51	1859.54								
Nordic	1778.55	7670.54	1859.54	1424.28	1778.55						
Ontario	1587.79	3237.81	1859.54								
U.S. North East	1552.78	1611.51	1859.54								
U.S. North Central	1508.81	4637.79	1859.54								
U.S. South	1504.42							33031.95	1667.17	12467.64	1860.51

Table D.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						2020					
Japan	742464.00										
EEC	1852.99	2158.43	1852.99								
Nordic	1724.65	5763.36	1852.99	3163.06	1724.65						
Ontario	1422.73	2388.12	1852.99								
U.S. North East	1367.21	738.76	1852.99								
U.S. North Central	1297.60	3845.01	1852.99								
U.S. South	1201.92	37457.01	1852.99					52295.04	1459.43	19738.25	1765.59

Table D.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2030						
Japan	1681053.00										
EEC	3672.82										
Nordic	-1132.54										
Ontario	716.04										
U.S. North East	1354.07										
U.S. North Central	234.70										
U.S. South	-2558.09	116935.82	-1527.33	9463.20	-1433.05	5779.70	-1460.30	93865.47	-2150.50	35533.05	-1665.92

Table D.3

Projections of Regional Prices, Production, and Consumption, and Trade Flows of Paperboard Based on Mean Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030[1]

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						1982					
Japan	7402.02										
EEC	1125.81			8981.94	1125.82			15254.09	1176.06		
Nordic	1119.87							8345.44	1176.06		
Canada	1194.57	641.95								5059.20	1206.59
U.S. North	1141.78										
U.S. South	1148.56							5626.50	1176.06	6209.18	1206.59
U.S. West	1187.80										

1. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table D.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						1986					
Japan	6584.63										
EEC	1296.47			8429.13	1296.47			18578.81	1356.86		
Nordic	1289.33							8169.59	1356.86		
Canada	1379.10	1024.19	1447.67							5356.22	1393.54
U.S. North	1315.66										
U.S. South	1323.81							6311.09	1356.86	7387.34	1393.54
U.S. West	1370.96										

Table D.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						1990					
Japan	5661.43										
EEC	1499.74			7816.73	1499.74			22365.21	1572.29		
Nordic	1491.15							7937.62	1572.29		
Canada	1599.02	1503.17	1681.42							5649.45	1616.38
U.S. North	1522.79										
U.S. South	1532.58							7164.04	1572.29	8789.55	1616.38
U.S. West	1589.24										

Table D.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						2000					
Japan	2145.80	4360.29	2145.80							572.73	2277.89
EEC	2093.22			7422.08	2093.22			31700.41	2208.09		
Nordic	2079.64							6829.49	2208.09		
Canada	2250.41									9342.28	2277.89
U.S. North	2129.74										
U.S. South	2145.23							13412.61	2208.09	10087.16	2277.89
U.S. West	2234.94										

Table D.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					<u>2010</u>						
Japan	3627.49	2534.67	3627.49								
EEC	3172.16			5248.32	3172.16			49191.76	3354.01		
Nordic	3150.67							5030.93	3354.01		
Canada	3421.01	4177.03	3627.49							8774.71	3464.51
U.S. North	3230.00										
U.S. South	3254.51							17663.80	3354.01	18894.42	3464.51
U.S. West	3396.52										

Table D.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						2020					
Japan	6354.31										
EEC	4795.27			3609.81	4795.27			73351.47	5083.12		
Nordic	4761.25							1577.26	5083.12		
Canada	5189.19	12208.55	5516.04							5994.80	5258.03
U.S. North	4886.82										
U.S. South	4925.62							25305.89	5083.12	32557.58	5258.03
U.S. West	5150.40							9018.71	5083.12	24059.44	5258.03

Table D.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2030						
Japan	13493.60										
EEC	7027.99			6703.32	7027.99			100893.98	7483.65		
Nordic	10176.10										
Canada	7651.57	22506.38	8168.95			183.09	7651.57			2680.91	7760.53
U.S. North	7172.92										
U.S. South	7234.33							40311.49	7483.65	51588.73	7760.53
U.S. West	7590.16										

APPENDIX E

RESULTS OF PROJECTIONS BASED ON HIGH GROWTH RATES

Table E.1

Projections of Regional Prices, Production, Consumption, and Trade Flows of Newsprint Based on High Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030[1]

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1982					
Japan	593.78	2533.03	593.78						
Nordic	636.08			4299.75	661.76				
British Columbia	497.32	74.30	593.78			2113.43	628.28	645.50	537.15
Ontario	585.87			6946.88	661.76	2205.04	628.28		
U.S. North	576.65			663.79	661.76				
U.S. South	581.10					288.31	628.28		
U.S. West	504.49							1490.09	537.15

1. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table E.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1986					
Japan	748.27	2380.63	748.27						
Nordic	817.24			4487.59	829.96				
British Columbia	650.49	467.87	748.27			2629.22	789.72	226.66	680.21
Ontario	756.91			9586.91	829.96	1511.89	789.72		
U.S. North	745.82			914.12	829.96				
U.S. South	751.17					167.18	789.72		
U.S. West	659.11							1864.62	680.21

Table E.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				1990					
Japan	945.66	2174.45	945.66						
Nordic	1028.57			4712.76	1043.86				
British Columbia	828.17	974.49				3015.40	995.48		
Ontario	956.07			13003.42	1043.86	456.48	995.48		
U.S. North	942.76			1241.62	1043.86				
U.S. South	949.16					0.20	995.48		
U.S. West	832.71					333.91	995.48	2004.96	858.08

Table E.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				<u>2000</u>					
Japan	1666.44	1277.55	1666.44						
Nordic	1857.29			5500.27	1881.48				
British Columbia	1480.48	3065.59	1666.44	3511.23	1881.48				
Ontario	1742.52			21799.70	1881.48				
U.S. North	1721.44			2579.89	1881.48				
U.S. South	2579.10								
U.S. West	1487.68			1183.92	1881.48	1549.66	1745.32	1441.98	1527.84

Table E.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2010					
Japan	8682.26								
Nordic	3536.91			6985.99	3575.20				
British Columbia	2940.46	6007.36	3234.86	7027.16	3575.20				
Ontario	3344.24			35307.10	3575.20				
U.S. North	3321.88			5422.11	3575.20				
U.S. South	5876.96								
U.S. West	2951.84			8424.06	3575.20			1266.99	2696.70

Table E.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2020					
Japan	47783.40								
Nordic	6972.23			9827.64	7032.86				
British Columbia	6028.09	8217.74	6494.10	19247.47	7032.86				
Ontario	6634.67			57138.70	7032.86				
U.S. North	6631.85			11408.32	7032.86				
U.S. South	12543.50								
U.S. West	6046.10			17549.35	7032.86				

Table E.1 Continued

Region	Supply Price	Japan		EEC		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
				2030					
Japan	130078.00								
Nordic	13602.97			14372.90	13698.94				
British Columbia	12108.43	11295.93	12846.08	45429.35	13698.94				
Ontario	13147.77			92615.40	13698.94				
U.S. North	13064.15			23149.53	13698.94				
U.S. South	26045.20								
U.S. West	12136.93			35656.39	13698.94				

Table E.2

Projections of Regional Prices, Production, Consumption, and Trade Flows of Printing Paper Based on High Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030[1]

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1982						
Japan	17681.50										
EEC	575.23	8603.01	575.15					2808.55	660.07		
Nordic	564.79			669.93	564.79			4632.81	660.07		
Ontario	620.08							1368.74	660.07		
U.S. North East	619.30							588.89	660.07	156.57	729.57
U.S. North Central	581.98							1242.42	660.07		
U.S. South	631.25									3848.22	729.57

1. Quantitiy data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table E.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1986						
Japan	38707.30										
EEC	820.47	9717.90	820.47					757.67	922.35		
Nordic	807.96			622.37	807.89			5440.16	922.35		
Ontario	874.33							1849.61	922.35		
U.S. North East	873.20							929.19	922.35		
U.S. North Central	828.51							1795.16	922.35		
U.S. South	868.42							1611.00	922.35	4687.05	986.68

Table E.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1990						
Japan	70554.80										
EEC	1127.46	8848.30	1127.36								
Nordic	1094.94	2356.45	1127.36	578.40	1095.00			4024.23	1232.35		
Ontario	1174.66							2420.53	1232.35		
U.S. North East	1173.35							1109.72	1232.35		
U.S. North Central	1119.68							2381.84	1232.35		
U.S. South	1167.41							4505.09	1232.35	5462.84	1309.47

Table E.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2000						
Japan	241882.00										
EEC	2501.96										
Nordic	2193.90	10039.79	2245.04	352.66	2193.98						
Ontario	2073.25	4043.19	2245.04					18.98	2164.49		
U.S. North East	2071.10							1247.17	2164.49		
U.S. North Central	2023.49	3572.04	2245.04								
U.S. South	2061.66							20587.76	2164.49	8257.99	2286.62

Table E.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2010						
Japan	728741.00										
EEC	9648.26										
Nordic	2603.81	9984.27	2684.84	1688.82	2603.73						
Ontario	2413.02	3878.62	2684.84								
U.S. North East	3010.58										
U.S. North Central	2345.38										
U.S. South	2273.54	27783.94	2684.84					37924.20	2436.24	14360.68	2629.64

Table E.2 Continued

Region	Supply Price	EEC		Nordic		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2020						
Japan	2116365.00										
EEC	28104.90										
Nordic	-213.42			2871.52	-213.42						
Ontario	1549.24										
U.S. North East	6266.06										
U.S. North Central	4897.62										
U.S. South	-924.21	113871.85	-273.08	5244.83	-213.42	3509.42	-230.67	77114.26	-666.68	29342.35	-360.52

Table E.2 Continued

Region	Supply Price	EEC Quantity	EEC Price	Nordic Quantity	Nordic Price	Canada Quantity	Canada Price	U.S. East Quantity	U.S. East Price	U.S. West Quantity	U.S. West Price
					2030						
Japan	6079854.00										
EEC	75979.20										
Nordic	-1132.54										
Ontario	2434.25										
U.S. North East	12748.30										
U.S. North Central	10130.80										
U.S. South	-18769.84	335490.59	-17739.08	34052.26	-17644.88	36987.34	-17672.10	191214.21	-18362.15	73204.43	-17877.50

Table E.3

Projections of Regional Prices, Production, and Consumption, and Trade Flows of Paperboard Based on High Growth Rates, for Selected Regions, for Selected Years, 1982 to 2030 [1]

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1982						
Japan	1039.68	1449.29	1039.67							6105.13	1097.46
EEC	1016.69			10836.04	1016.69			11248.11	1066.94		
Nordic	1010.74							8056.52	1066.94		
Canada	1085.44	641.95				10.18	1085.43			5227.04	1097.46
U.S. North	1032.65										
U.S. South	1039.45							10792.07	1066.94	273.13	1097.46
U.S. West	1078.67										

1. Quantity data are given in thousand metric tons. Prices are given in dollars per metric ton.

Table E.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1986						
Japan	1349.17										
EEC	1321.56			8429.13	1321.56			18578.81	1381.93		
Nordic	1314.41							8169.59	1381.93		
Canada	1404.17	1024.19	1349.17							5356.22	1418.62
U.S. North	1340.74										
U.S. South	1348.88							6311.09	1381.93	7387.34	1418.62
U.S. West	1396.04										

Table E.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					1990						
Japan	1727.92	2112.43	1727.92							373.65	1811.37
EEC	1694.72			7072.22	1694.72			23290.65	1767.28		
Nordic	1685.13							7584.64	1767.28		
Canada	1794.01	1503.17	1727.92							7133.16	1811.37
U.S. North	1717.78										
U.S. South	1727.57							8381.80	1767.28	7625.06	1811.37
U.S. West	1784.23										

Table E.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
						2000					
Japan	13331.40										
EEC	2801.34			4144.13	2801.34			39895.47	2916.22		
Nordic	2787.76							5558.03	2916.22		
Canada	2958.53	3836.88	3088.97							6444.19	2986.01
U.S. North	2837.87										
U.S. South	2853.36							10980.02	2916.22	15299.69	2986.01
U.S. West	2943.06										

Table E.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2010						
Japan	42760.40										
EEC	4504.46			3680.39	4504.46			61870.69	4684.30		
Nordic	4482.96							394.99	4684.30		
Canada	4753.30	8723.96	3088.97							6466.28	4796.80
U.S. North	4562.29										
U.S. South	4586.81							20175.04	4684.30	25286.81	4796.80
U.S. West	4728.80										

Table E.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2020						
Japan	104209.40										
EEC	7016.86			12012.26	7016.86			85720.09	7304.71		
Nordic	14290.40										
Canada	7410.79	19293.34	7737.63			2944.54	7410.78			2944.54	7479.63
U.S. North	7108.41										
U.S. South	7147.21							36473.35	7304.71	44105.08	7479.63
U.S. West	7372.00										

Table E.3 Continued

Region	Supply Price	Japan		EEC		Canada		U.S. East		U.S. West	
		Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price
					2030						
Japan	232516.00										
EEC	11002.97			37238.34	11002.97			112271.33	7304.71		
Nordic	35116.90										
Canada	11718.72	33093.72	7737.63			1354.94	7410.78				
U.S. North	11147.91										
U.S. South	11209.33	6639.82	7737.63					69700.94	7304.71	70044.83	7479.63
U.S. West	11565.16										

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AN INTERNATIONAL TRADE ANALYSIS FOR SELECTED PAPER PRODUCTS

by

Abdul Aziz Bin Abu Hassan

(ABSTRACT)

The future of the American paper industry remains uncertain. A growing South and the nation's continued reliance pn trade for a significant proportion of its domestic needs is of concern to the industry and the nation. The probable consequences of past and potential changes in the demand for and supply of newsprint, printing paper, and paperboard concern businesses and public agencies in the paper industry. However, these probable consequences on the American paper industry have to be considered in relation to the world market since paper products are substantially traded on the international market.

A competitive model of the world market for newsprint, printing paper, and paperboard was developed. Estimates of supply and demand functions based on annual data for the period 1962 to 1978 were obtained for each of these products for the major producers and consumers which include Japan, Canada, the European Economic Community, the Nordic countries, and the United States. Based on these estimates, the historical data was simulated using reactive programming. Projections about the future market conditions were also made using the same algorithm.

Inelastic price elasticities of paper for both supply and demand confirmed the findings of more recent research. Thus, factors other than prices would be more responsible for changes in the quantity demanded or supplied. Three sets of projections for selected years up to year 2030 were performed. These projections assumed that the historical trend will continue into the future. Historical simulation indicated that many of the direction of trade flows were correct but the magnitudes di not come close to the actual data. The European Economic Community and Japan are the major markets and the U.S. South the major producer of paper products in the future.

Obtaining a consistent and reliable set of data across countries was a problem. Not including potential markets such as the less developed countries and Latin America, which is also a potential supplier, is a shortcoming of the study. Unrepresentative transportation costs is suspected for the divergency in magnitude between actual and simulated data. Further research on the role of transportation costs in affecting trade flows of paper products is needed.