

Industry & Trade Summary

Nonwoven Fabrics

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PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.¹

This report on nonwoven fabrics covers the period 1986 through 1990 and represents one of approximately 250 to 300 individual reports to be produced in this series during the first half of the 1990s. This is the first individual summary report published to date on the textile and apparel sector.

¹ The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar subject matter.

CONTENTS

	<i>Page</i>
Preface	i
Introduction	1
Production process	1
Forming	1
Bonding	1
Finishing	3
Converting	3
End-use applications	3
U.S. industry profile	3
Industry structure	3
Vertical integration	3
Horizontal integration	3
Efficient scale of production	6
Research and development and capital investment	6
Research and development	6
Capital investment	7
Major factors of production and input market structure	7
Fibers used in nonwoven fabric production	8
Organic and inorganic chemicals	10
Capital equipment	10
Labor	10
Factors affecting demand and consumer characteristics	11
Demand for disposable nonwoven products	11
Demand for durable nonwovens products	13
Foreign industry profile	15
European industry	15
Industry in Japan and other Asian countries	16
U.S. trade measures	16
Foreign trade measures	17
U.S. market	17
U.S. consumption	17
U.S. shipments	18
U.S. imports	19
Foreign markets	19
Foreign market profile	20
U.S. exports	20
Products exported	20
Export levels and trends	20
U.S. trade balance	21
Figures	
1. The nonwoven fabric production process	2
2. Distribution of nonwoven—fabric consumption by major end uses, 1990	4
3. Nonwoven fabrics: U.S. shipments, exports of domestic merchandise, imports for consumption, and apparent U.S. consumption, 1986–90 (expressed in 1985 dollars)	18
Tables	
1. The structure of the U.S. nonwoven-fabric industry, SIC 2297, 1972, 1977, 1982, 1987, and 1990	5
2. Leading U.S. nonwoven-fabric firms, 1990	5
3. The distribution of U.S. shipments by establishment-size class, SIC 2297, 1977, 1982, and 1987	6
4. U.S. capital expenditures by establishments, SIC 2297, 1972, 1977, 1982, and 1987	8
5. U.S. shipments of manmade fiber to nonwoven-fabric firms, 1976 to 1990	9
6. U.S. employment data, SIC 2297, 1990, 1987, 1982, 1977, and 1972	11
7. Estimated U.S. nonwoven-fabric consumption by major disposable end-use products, 1988–1990	12

CONTENTS—Continued

	<i>Page</i>
Tables—Continued	
8. Estimated U.S. nonwoven-fabric consumption by major durable end-use products, 1988–1990	14
9. Nonwoven fabrics: Leading world producers, home country, 1990 sales, and plant locations	15
10. Nonwoven fabrics: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1991; U.S. exports, 1990; and U.S. imports, 1990	17
11. Nonwoven fabrics: U.S. shipments, exports of domestic merchandise, imports for consumption, and apparent U.S. consumption, 1986–90 (expressed in 1985 dollars)	18
12. Nonwoven fabrics: U.S. imports for consumption, by principal source, 1989–90	19
13. Nonwoven fabrics: U.S. exports of domestic merchandise, by principal markets, 1989–90	20
14. Nonwoven fabrics: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected country and country group, 1989–90	22
Appendix	
Explanation of tariff and trade agreement terms	A-1

INTRODUCTION

The production trend for nonwoven fabric differs significantly from the trend for total textile production. During the past two decades, production of textile products other than nonwoven fabrics has been shifting from the United States and Western Europe to countries with lower production costs and an apparel or home furnishings industry. The production of nonwoven fabric is an exception to this general trend for two important reasons. First, the production processes are highly capital-intensive and often involve the use of technically sophisticated equipment. To keep unit costs down, plants are often oriented towards large-volume production runs in order to realize economies of scale. Second, the firms typically locate close to the major end-use markets (e.g., United States, Europe, and Japan) where demand for the product exists as well as where the capital and skilled labor needed for this machinery are more readily available.

The nonwoven-fabric industry started in the 1940s, but did not experience significant growth until the early 1970s. Domestic shipments, for example, increased from \$50 million in 1972 to \$3.3 billion in 1990. In constant 1985 dollars,¹ this represented approximately a 5.3-percent real annual growth rate.² This strong growth is the direct result of the interaction of two fundamental factors affecting the supply and demand for nonwoven fabrics: technological innovation, which reduced the cost of production and increased the variety of fabrics; and demographic shifts and other demand-related factors, which greatly expanded the end-use markets for nonwoven fabrics.

Production Processes

Nonwoven fabrics are sheet or web structures of textile fibers produced through the same basic steps of forming, bonding, finishing, and converting which are illustrated in figure 1.³ However, some of the steps can be accomplished by means of several different technologies, each of which imparts specific characteristics to the final fabric.

The physical characteristics of nonwoven fabrics vary widely and often are tailored to the specifications needed for a particular end use. For example, they weigh as little as 1 ounce per square yard when they are used in surgical gowns, or as much as 100 ounces per square yard when they are used in geotextile applications. The fabrics can be thin and gossamer like

when they are used in diaper coverstock, or thick and dense when they are used in roofing materials. More important, nonwoven fabrics have many valuable properties (e.g., absorbency, repellency, flame retardancy) that make them useful in diverse end-use applications. Thus, the fabrics are found in many products that households or businesses use on a daily basis.

Forming

In the forming step, the fibers or filaments are laid to form the web or sheet by using one of several techniques. The first is the wet-laid process where the fibers are suspended in water and then collected by a screen to form a web. This process arranges the fibers in a random fashion that, as a consequence, gives the web isotropic properties; that is, tensile strength in all directions of the fabric. The second is the dry-laid process where the fibers are carded⁴ and then collected on a screen to form a web. This gives the web anisotropic properties of lengthwise tensile strength. The major difference between the wet- and dry-laid processes is these isotropic and anisotropic properties. The third process is the direct-laid, which forms the web of fibers as it is spun from molten polymers. Two similar direct-laid processes are spunbonding and meltblowing. In the spunbonding process, the fibers are extruded from a nozzle (similar to a shower nozzle) onto a moving belt to form a web. The meltblown process is similar to the spunbonding process except the fibers are shortened as they are extruded, and then, spread onto a moving belt. A third direct-laid process is film fibrillation, in which a plastic film that has been embossed with a pattern is stretched, and sometimes agitated, to produce a perforated webbed structure. The main characteristic distinguishing between meltblown fabrics and wet- or dry-laid fabrics is that the tensile strength of meltblown fabrics is relatively weaker. Consequently, meltblown fabrics are often used in combination with spunbonded fabrics to impart strength. Spunbonded fabrics are characterized by their uniformity, durability, and strength. Film fibrillation offers less strength and durability than the other modes, but offers increased permeability and porosity.

Bonding

In the bonding step, the web is processed to give it additional strength. The web made from the spunbonding process is strong because some bonding occurs during the formation process. Webs formed using other processes, however, are generally weak and require bonding to give them strength.⁵ The three types of bonding processes are mechanical, chemical, and thermal bonding.

⁴ Carding is the process where the fibers are mechanically separated and laid in a parallel arrangement.

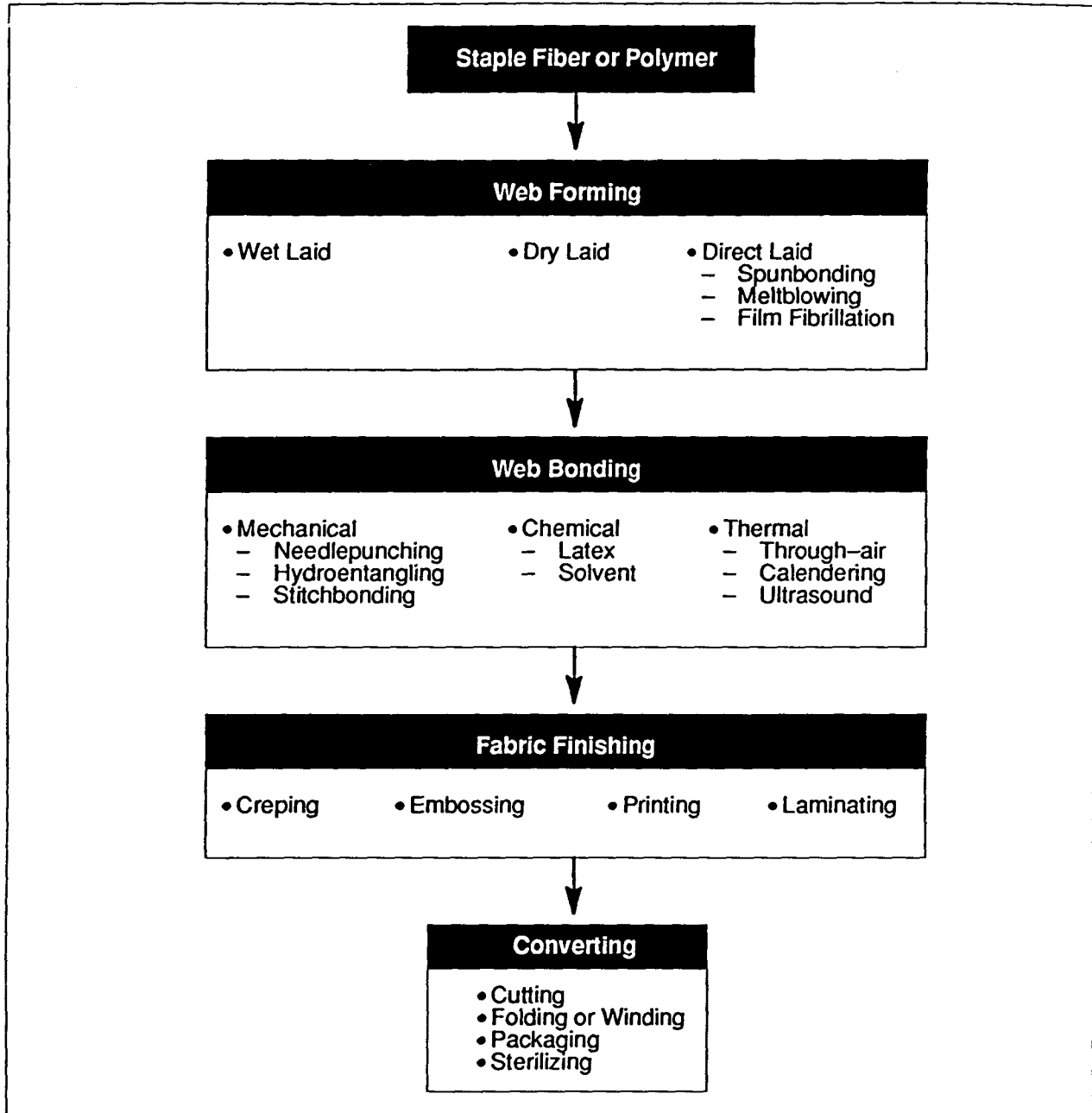
⁵ This would include webs formed using the meltblown process that are combined with the spunbonded webs.

¹ Constant dollars are derived by deflating the nominal value by the producer price index.

² See table 1. This estimate is consistent with other estimates of growth; see, for example, Michael Jacobsen, "The U.S. Nonwovens Industry," *EIU Textile Outlook International*, Mar. 1990, p. 26.

³ The term nonwoven describes fabrics that are not made by the traditional processes of knitting or weaving. The following discussion relies on "How Nonwovens Are Made," *The Nonwovens Handbook*, (New York: INDA Association of Nonwoven Fabrics Industry, 1988).

Figure 1
The nonwoven fabric production process



Source: *The Nonwoven Handbook*, 1988, pp. 51-73.

Several different mechanical techniques can be used. The first is needlepunching, which involves pulling the web through two plates as a needle loom punches the web and tufts the fibers. The second is hydroentanglement, which uses jets of water to perforate the web, which causes the web to curl and form knots. The knots give the web its tensile strength. The third is stitchbonding, which involves sewing the web into a pattern similar to a quilt.

There are several types of chemical bonding as well. For example, latex bonding involves dipping, spraying, or foaming the web with a latex solution. Solvent bonding is occasionally used to create an adhesive surface on the fibers. The advantage that chemical bonding has is that it is a faster process than mechanical bonding. The disadvantage is that it imparts less strength onto the web as compared with the mechanical technique.

Thermal bonding involves heating the fibers so that the surfaces fuse together. The three techniques for thermal bonding are through-air, calendering, and ultrasound. In the through-air process, hot air is blown or sucked through the web to produce high-loft, low-density fabrics. Calendering is used to produce low-loft, high-density fabrics.⁶ In calendering, the web is passed between heated rollers that have an engraved pattern so that only part of the web is subject to extreme heat and pressure to bond the fibers. Calendering creates strong, low-loft fabrics. Ultrasound, or high-frequency energy, can be used to fuse and bond fibers in localized areas, thus stabilizing the web. Only thermoplastic fibers (those that melt when subject to heat) can be bonded thermally without the addition of fusible binder materials such as polyethylene, polypropylene, and polyester. In addition, bonding materials are often used to add strength to the web.

Finishing

The next step involves finishing the bonded web to form a fabric. Creping or embossing, for example, makes the texture soft and increases its bulk. Printing is often applied to finish fabrics for use in home furnishings, while lamination is used to combine fabrics of different strengths. In general, however, finishing prepares the fabric for use in different end-use markets.

Converting

The final step shown in the production process is converting the fabric for sale to end-use buyers, who will then use it to make a wide range of products. Typically, this step involves cutting the fabric and folding it or winding it into rolls. The fabric is then packaged, and if required, sterilized.

End-Use Applications

Unlike the disposable applications where the top five end uses accounted for 97 percent of the fabric consumed (see figure 2), the top five in the durable applications accounted for only 66 percent. The remaining 34 percent was distributed across many relatively small end-use segments, such as in underlays for tufted carpeting, in protective backing for electrical wires, and in bedding materials. Nevertheless, the wide range of applications across disposable and durable end uses suggests that nonwoven products have many features that make them unique relative to competing products. For further information on end uses of nonwoven fabrics, refer to the section on "Factors Affecting Demand and Consumer Characteristics."

⁶ Loft refers to the properties of firmness, resiliency, and bulk of a fabric.

U.S. INDUSTRY PROFILE

In the United States, the nonwoven-fabric industry is classified under the Standard Industrial Classification (SIC) heading 2297 (Nonwoven Fabrics). Because of downstream vertical integration in this industry, some finished products are included in the data published for SIC 2297.⁷ However, most of the establishments and labor force included under this SIC are engaged primarily in fabric production.

Industry Structure

Table 1 presents summary data that describe the structure of the U.S. industry since 1972. The number of companies has increased by 63 percent while the number of establishments has increased by 59 percent. Real shipments per establishment increased by over 45 percent from \$12.7 million in 1972 to \$18.5 million in 1987.

The number of establishments per company is 1.17 for 1987, which means that on average, firms are operating a single production facility. Several of the larger firms (e.g., DuPont, Kimberly-Clark, Veratec, and Chicopee) do, however, operate multiple plants in the United States. This ratio is slightly lower than 1.21 in 1972, which suggests that the new firms that have entered since then are most likely single-plant facilities.

Vertical integration

Table 2 provides information on the vertical integration of the major U.S. nonwoven firms in 1990. The descriptions reported in this table suggest two tentative conclusions. First, several firms are integrated upstream into fiber production.⁸ DuPont, for example, produces many products that require the extensive use of fiber, and Phillips uses the Alpha olefin fiber exclusively in its needlepunching process. Upstream integration assists firms in controlling the cost, the volume and the quality of the end-use product favor. Second, almost all firms produce one or more end-use products from the nonwoven fabrics that they produce internally. However, the extent of downstream integration largely appears to be limited to end uses where the firm has some particular expertise.

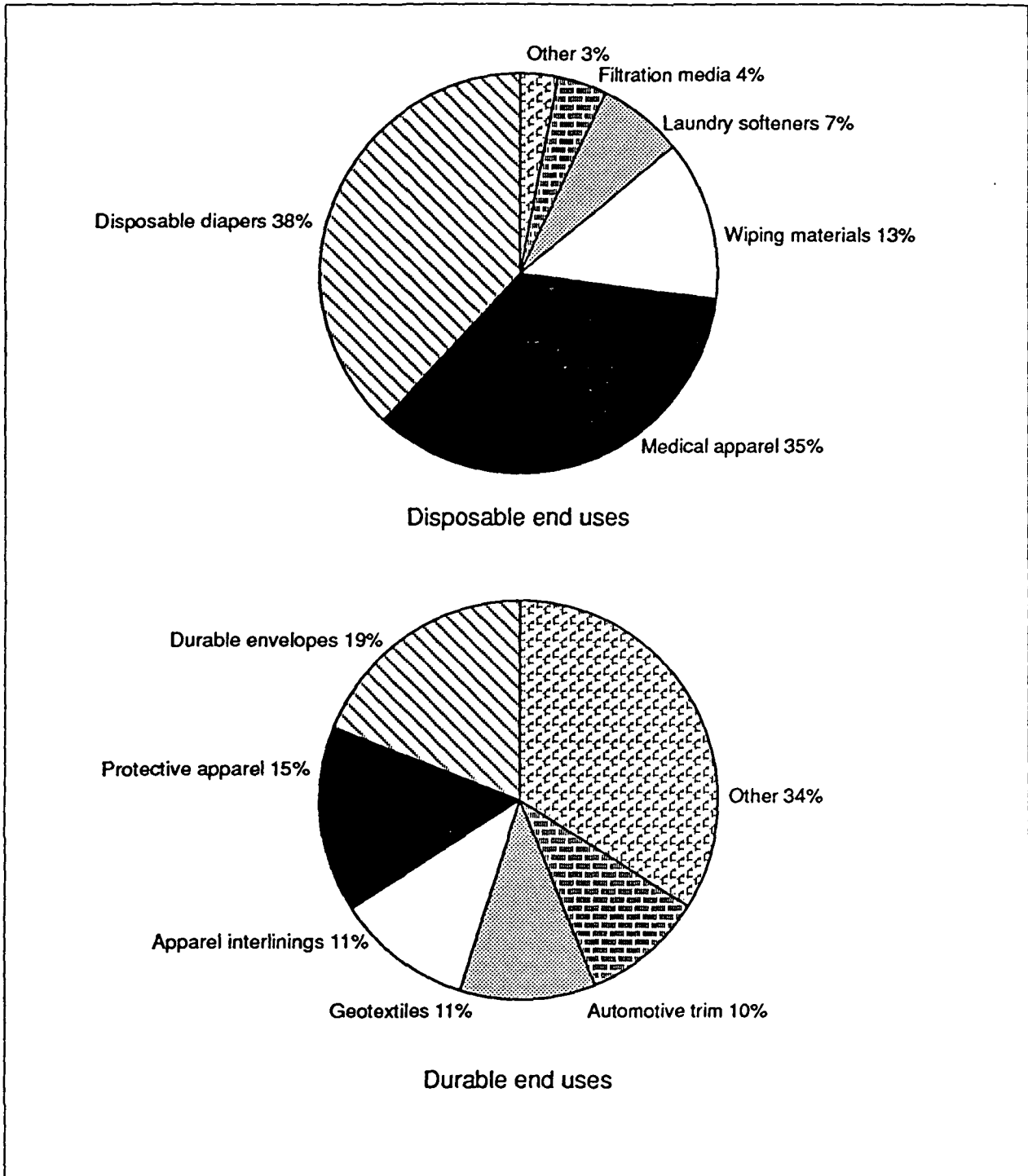
Horizontal integration

The extent of horizontal integration among the nonwoven fabric producers is very limited. In fact, many of these firms specialize in producing nonwoven products, although in several instances the scope of

⁷ SIC 2297 is comprised of—22970 (Nonwoven fabrics and related products, n.s.k.); 22971 (Nonwoven fabrics); and 22972 (Fabricated nonwoven products). Finished products (22970 pt. and 22972) account for less than 25 percent of the value of shipments in 1987. The Census data are, for the most part, only available through 1987.

⁸ Fiber is a major input used to produce nonwoven fabrics.

Figure 2
Distribution of nonwoven-fabric consumption by major end uses, 1990



Source: USITC staff.

Table 1
The structure of the U.S. nonwoven-fabric Industry, SIC 2297, 1972, 1977, 1982, 1987, and 1990

<i>Item</i>	<i>1972</i>	<i>1977</i>	<i>1982</i>	<i>1987</i>	<i>1990</i>
Number of companies	68	81	114	111	{ ¹ }
Number of establishments	82	100	132	130	{}
Number of employees (1,000 employees).	10.8	13.0	12.3	14.2	² 16.9
Number of production workers (1,000 workers).	8.8	10.4	9.5	10.7	12.7
Value of shipments (million dollars).	518	1,095	1,659	2,424	3,258
Value of shipments (constant 1985 dollars).	² 1,042	1,349	² 1,746	2,400	² 2,970

¹ Not available.

² Estimated by the staff of the U.S. International Trade Commission.

Source: Census of Manufactures, "Historical Statistics for the Industry (1987 Basis): 1987 and Earlier years;" and Annual Survey of Manufactures, "Value of Shipments of Product Classes: various years."

Table 2
Leading U.S. nonwoven-fabric firms, 1990

<i>Firm</i>	<i>Downstream integration</i>	<i>Upstream integration</i>
DuPont	No.	Yes: fiber production and chemical processing.
Kimberly-Clark	Yes: disposable diapers, disposable medical apparel, industrial wipes, and protective apparel.	No.
Veratec	Yes: disposable medical apparel, wipes, and home furnishing materials.	Yes: bleached cotton processing. (Natural Fibers Group)
Dexter Nonwovens	Yes: filtration media and packaging wraps.	No.
Chicopee	Yes: captive supplier for J & J products.	No.
Reemay	No.	Yes: long-term contract with DuPont for resin purchases.
Freudenberg	Yes: apparel interlinings, filtration media, roofing materials, wipes, and carpet tufting.	No.
Scott Nonwovens	Yes: wipes and protective apparel.	No.
Phillips Fibers	Yes: geotextile products, roofing, and automotive products.	Yes: fiber production and chemical processing.
Foss Manufacturing	Yes: carpet cushions, geotextiles automotive products, and roofing.	Yes: solution-dyed polyester.

Sources: Michael Jacobsen, "The U.S. Nonwovens Industry," *EIU Textile Outlook International*, Mar. 1990; Michael Jacobsen, "The Top Companies," *Nonwovens Industry*, Sept. 1990; and staff interviews.

their respective product lines extends beyond the use of nonwoven fabrics. For example, Kimberly-Clark, Veratec, and Scott Nonwovens, all produce a range of paper materials that compete with the nonwoven fabrics used in wiping materials. Thus, there is some diversification across competing materials.

Although the trend in these data is not conclusive, there is some indication that production has shifted toward larger establishments.

Research and Development and Capital Investment

Efficient scale of production

Table 3 presents U.S. shipment data by size class of establishment for 3 years in which the data are available. These data indicate that only two classes of size show a marked increase in the percentage of shipments accounted for by that class. For example, establishments with 50 to 99 employees increased their share from 8.6 percent in 1977 to 11.1 percent in 1987, while during the same period, the largest establishments (i.e., 500 to 999) increased their share by approximately 11 percentage points to 29.3 percent. In contrast, the 100 to 249 establishment-size class lost considerable share while all other size classes essentially maintained their respective shares.

Research and development

The nonwoven fabric industry is actively involved in R&D aimed at developing new production processes and new fabrics. The two most recent technological developments that have been commercialized are hydroentanglement and meltblown processes. DuPont first developed the hydroentanglement process in the 1960s and then commercialized it in the early 1970s. In 1976, DuPont relinquished five of its key patents related to the process and, as a consequence, the technology spread rapidly throughout the industry. Notwithstanding the relatively high investment costs (\$30 million), several industry analysts expect this process to emerge as a major production technology in

Table 3
The distribution of U.S. shipments by establishment-size class,¹ SIC 2297, 1977, 1982, and 1987

<i>Year and establishment size</i>	<i>Number of establishments</i>	<i>Value of shipments</i>	<i>Share²</i>
		<i>Million dollars</i>	
1977:			
1-4	8	1.4	0.2
5-9	6	1.8	0.2
10-19	12	18.8	2.2
20-49	17	38.3	4.4
50-99	14	74.2	8.6
100-249	29	359.5	41.6
250-499	9	212.5	24.6
500-999	5	158.1	18.3
Total	100	864.4	100.0
1982:			
1-4	17	3.8	0.3
5-9	5	5.4	0.4
10-19	19	29.8	2.3
20-49	29	76.0	5.9
50-99	27	156.8	12.3
100-249	17	283.0	22.1
250-499	16	723.9	56.6
500-999	2	(3)	(3)
Total	132	1,278.7	100.0
1987:			
1-4	14	4.7	0.2
5-9	9	8.5	0.4
10-19	14	26.9	1.4
20-49	30	90.0	4.7
50-99	24	210.4	11.1
100-249	22	520.9	27.4
250-499	10	483.3	25.4
500-999	7	558.3	29.3
Total	130	1,903.0	100.0

¹ Establishment size is based on the number of employees. A firm may own one or more establishments.

² Totals may not equal 100.0 because of rounding.

³ Not available.

Source: Census of Manufactures, "Industry Statistics by Employment Size of Establishment," various years.

the 1990s.⁹ Hydroentanglement provides an "unlimited opportunity" for new product innovation.¹⁰ Specifically, the process allows the producer to tailor the fabric to meet a customer's exact requirements in different end-use applications and shows promise because of its versatility.

The meltblown process was commercialized during the 1980s and compared to the hydroentanglement process it is relatively new. This process offers several distinct advantages: (1) low production costs; and (2) flexibility to combine the meltblown process with other processing technologies (e.g., spunbonding) to produce composite fabrics.¹¹ Several large firms have started to combine the various technologies to produce well-known composite fabrics. Kimberly-Clark's composite fabric, for example, is the technological leader in medical nonwovens. Similarly, Dexter's "Hydraspun" technology is emerging as a leader in the industrial apparel and home furnishings end uses. Thus, analysts expect to see the meltblown process emerging as a technological leader in the 1990s.

Several more recent events underscore the rapid changes in the technological evolution of the industry.¹² First, Sodoca (part of the Fiberweb Group) is expected to introduce a new technology (called Sodoca S-TEX) to produce spunbonded fabric. The major innovation is that this process is capable of using different polymers and is capable of varying the denier of the fiber used in spunbonded fabric.¹³ Second, Reifenhauser GmbH & Co. has introduced new equipment that will produce either spunbonded or meltblown fabric in a continuous process. This new equipment should enhance the cost effectiveness of fabric production, since larger volumes can be achieved in shorter periods of time. Third, there is work in the development stage that would reduce the energy requirements for producing spunlaced (or hydroentangled) fabric. Although this fabric has many attractive properties, it is expensive to make relative to other fabrics. Consequently, a reduction in energy consumption when producing this fabric would make it a more efficient technology for firms to use. All in all, the R&D horizon bodes well for nonwoven firms and consumers as new technologies promise to deliver a wider range of higher quality fabrics.

⁹ See, for example, Colin White, "Hydroentanglement Technology: A Review and Projection of Markets," *Nonwovens Industry*, Oct. 1990, and Michael Jacobsen, "The U.S. Nonwovens Industry," Mar. 1990.

¹⁰ See Colin White.

¹¹ See Michael Jacobsen, "A Crystal Ball Look At The Nonwovens Industry In The Year 2000," *Nonwovens Industry*, Dec. 1990.

¹² The following discussion is based on Derek Ward, "Radical Changes of Ownership," *Textile Month*, Mar. 1991.

¹³ Denier is the weight per unit length of fiber.

Capital investment

Investment in new capital equipment is a key factor in promoting industry growth, and it is especially critical to a capital-intensive industry like nonwovens. The data presented in table 4 provide an overview of U.S. new capital expenditures made by nonwoven establishments.

There are two separate but related trends shown in this table. First, real capital expenditures increased by 133 percent during 1972-87, from \$35.9 million to \$83.6 million. New capital spending on machinery and equipment accounted for the largest part of the increase as it rose from \$29.2 million in 1972 (or 81 percent of the total) to \$74.4 million in 1987 (or 89 percent of the total). In contrast, new capital expenditures on buildings only increased modestly from \$6.7 million in 1972 to \$9.2 million in 1987. These data suggest that existing firms were investing a great deal in machinery and equipment, while investing very little in new establishments. However, the data in table 1 indicate that there was an increase in the number of establishments during this period. Thus, the change in establishments most likely reflects new entrants since the expenditure data do not reflect spending by new firms that are just entering the industry. Second, real depreciation charges show a similar pattern from 1977 to 1987. The data for depreciation give a rough estimate of the expenditures that nonwoven establishments must make in order to maintain their existing capital stock. If these data are subtracted from new capital expenditures, the difference represents net investment or net spending on new plant and equipment. These data (reported in table 4) reveal that total net investment decreased by almost 95 percent in real terms from 1977 to 1987. This is mainly the result of the large decrease in net investment in buildings (negative in 1987) and the less precipitous decline in net investment in machinery and equipment.

One reason for the apparent decline was the relatively high real interest rates during the early 1980s.¹⁴ The high costs of borrowing funds made it too costly for firms to replace their capital as it depreciated, and the result was the declining patterns of investment that are shown in table 4. Another explanation is the shift to new capital-intensive production technologies. For example, as equipment aged, firms replaced outdated equipment with a newer vintage that was less costly to maintain and more productive.

Major Factors of Production and Input Market Structure

The major factors of production in the nonwoven-fabric industry are: (1) fibers, which are

¹⁴ See, for example, Robert J. Barro, *Macroeconomics*, 2d ed., 1987, pp. 175-177 for a discussion of the relatively high real interest rates during the 1980s.

Table 4
U.S. capital expenditures by establishments, SIC 2297, 1972, 1977, 1982, and 1987

(In millions of dollars)

	Current value	Real value	Current value	Real value
	1972		1977	
New capital expenditures	¹ 15.0	35.9	39.6	65.3
Building	2.8	6.7	10.1	16.7
Machinery and equipment	12.2	29.2	29.5	48.7
Depreciation charges	(²)	(²)	23.5	38.8
Buildings	(²)	(²)	3.8	6.3
Machinery and equipment	(²)	(²)	19.7	32.5
Net Investment	(²)	(²)	16.1	26.6
Buildings	(²)	(²)	6.3	10.4
Machinery and equipment	(²)	(²)	9.8	16.2
	1982		1987	
New capital expenditures	71.5	74.1	¹ 94.9	83.6
Building	14.8	15.3	10.5	9.2
Machinery and equipment	56.7	58.8	84.4	74.4
Depreciation charges	47.4	49.1	93.0	81.9
Buildings	7.1	7.4	15.7	13.8
Machinery and equipment	40.3	41.8	77.3	68.0
Net Investment	24.1	25.0	1.9	1.7
Buildings	7.7	8.0	(5.2)	(4.6)
Machinery and equipment	16.4	17.6	7.1	6.3

¹ Estimated by the staff of the U.S. International Trade Commission.

² Not available.

Sources: 1987 Census of Manufactures, "Gross Book Value of Depreciable Assets, Capital Expenditures, Retirements, Depreciation, and Rental Payments: 1987;" 1982 (1977) Census of Manufactures, "Supplemental Industry Statistics Based on Sample Estimates: 1982 (1977);" and 1972 Census of Manufactures, "Detailed Statistics: 1972."

used to form the fabric; (2) organic and inorganic chemicals, which are used for binding and finishing the fabric; (3) capital equipment; and (4) labor.

Fibers used in nonwoven-fabric production

The primary fibers used to produce nonwoven fabrics are polyester, olefin, rayon, and cotton.¹⁵ The major considerations affecting the producer's choice of a particular fiber are price, production technology, physical properties, and the end-use application. In addition, different fibers can be used to form a fabric for the same end use. For example, rayon is the chief fiber used to produce the fabric for laundry softener substrates, although olefin and polyester are used as well. In wet-laid fabrics, which are used in filtration media, rayon, olefin, and polyester are the principal fibers used. Thus, there is some substitutability among the types of fiber used in the production processes.

Table 5 presents data related to manmade fiber use in nonwoven-fabric production for selected years, and offers an approximation of the total quantity of fiber used during a particular year.¹⁶ Data for cotton is not included since its use is very small in the industry.

¹⁵ Several other types of fibers are used to a lesser extent: nylon, acrylic, and acetate.

¹⁶ In the following discussion, it is assumed that any fiber shipped to the industry is used to produce fabric and is not resold.

Polyester and olefin's share of the total fiber used since 1976 has increased significantly while rayon's share has decreased during the same time period. In 1976, for example, polyester and olefin accounted for 19.4 percent and 8.8 percent respectively of the total fiber used. By 1990, however, polyester's share had increased to 43.8 percent while olefin's share had increased to 42.5 percent. In contrast, rayon's share had decreased from 70.3 percent in 1976 to 13.2 percent in 1990. One explanation for this dramatic shift was the increase in the relative price of rayon. In 1984, for example, the ratio of rayon to polyester prices was 1.06. By April 1991, however, the ratio had risen to 1.72.¹⁷ This change in relative prices explains part of the change in the relative quantities of fiber used during the past several years. However, it does not explain the secular decline in rayon use that has occurred during the past 14 years.

The secular decline is most likely the result of the shift toward new production technologies (e.g., meltblown processing) that utilize fibers other than rayon. For example, the meltblown process makes extensive use of polypropylene (olefin) and to a lesser

¹⁷ These price data are taken from the USDA's *Cotton and Wool Situation Outlook*, table A-14, May 1991.

Table 5¹
U.S. shipments of manmade fiber to nonwoven-fabric firms, 1976 to 1990

Year	Rayon		Polyester		Olefin ²		Nylon		Total shipped
	Million pounds	Percent of total shipped	Million pounds	Percent of total shipped	Million pounds	Percent of total shipped	Million pounds	Percent of total shipped	Million pounds
1990	³ 72	13.2	239.9	43.8	232.5	42.5	2.9	0.5	547.3
1989	³ 98	17.3	271.5	47.9	194.8	34.4	2.4	0.4	566.7
1988	122.3	22.3	244.1	44.4	180.9	32.9	2.1	0.4	549.4
1987	124.4	23.5	204.2	38.6	198.0	37.5	1.9	0.4	528.5
1986	125.4	26.7	175.3	37.4	166.2	35.4	2.1	0.4	469.0
1985	113.5	27.4	162.5	39.2	135.8	32.8	2.5	0.6	414.3
1984	126.3	29.7	177.2	41.6	119.2	28.0	2.8	0.7	425.5
1983	119.0	32.8	177.4	48.9	61.5	17.0	4.9	1.4	362.8
1982	111.9	36.1	155.2	50.1	39.0	12.6	3.8	1.2	309.9
1981	124.6	38.9	149.3	46.6	42.7	13.3	3.5	1.1	320.1
1980	147.3	41.9	166.6	47.4	34.6	9.8	3.2	0.9	351.7
1979	160.3	45.2	153.6	43.4	36.7	10.4	3.8	1.1	354.4
1978	166.2	55.8	98.5	33.1	28.6	9.6	4.3	1.4	297.6
1977	174.3	65.4	57.4	21.5	30.6	11.5	4.1	1.5	266.4
1976	173.2	70.3	47.9	19.4	21.6	8.8	3.8	1.5	246.5

¹ Represents wet- and dry-laid and needled batts only.

² Data includes olefin and nylon for the years 1976 to 1986.

³ Estimate taken from David Harrison, "Fibers For Nonwovens," *Nonwovens Industry*, June 1991.

Sources: "Table 18: Staple + Tow Domestic Shipments," *Fiber Organon*, March 1991; "Table 23: Staple + Tow Domestic Shipments," *Textile Organon*, March 1988; "Table 23: Staple + Tow Domestic Shipments," *Textile Organon*, March 1986; "Staple + Tow Domestic Shipments," *Textile Organon*, March 1983; and "Staple + Tow Domestic Shipments," *Textile Organon*, May 1980.

extent polyester.¹⁸ In addition, Hoechst Celanese has recently introduced two new polyester fibers that have good absorption properties, a property shared with rayon. Although these developments are just beginning to emerge, they do suggest that the technology has been shifting away from the consumption of rayon fiber.

The use of cotton fiber to produce nonwoven fabric is relatively small, although it has been increasing due to recent technological advancements.¹⁹ The industry has adopted both the continuous and kier bleaching techniques to process cotton for use in nonwoven production. Several firms in the industry have in-house operations to bleach the cotton fiber. Veratec, for example, which owns Natural Fibers Group, has two plants dedicated to this process and plans to build a third. In addition, Stearns Technical Textiles has recently reopened their bleaching line after 15 years of inactivity. The sudden reemergence of this technology in the nonwoven-fabric industry is attributable to several factors. First, it appears that there is sufficient capacity to meet the current demands made by the nonwoven firms.²⁰ Second, the technology has been refined to the point where the bleached cotton fibers are easily processed using the existing production equipment.²¹ In the past, difficulties in processing the fiber made the bleaching process too costly for firms to use. Third, the increase in demand for cotton nonwovens (e.g., diaper coverstock, fabric softener, and wet wipes) has resulted in an increase in the demand for cotton.

A recent article in *Nonwovens Industry* lists 34 firms in the United States and abroad that currently sell fiber to nonwoven firms.²² Four firms on this list are fiber producers that are integrated into the production of nonwoven fabric.

*Organic and inorganic chemicals*²³

Organic and inorganic chemicals are primarily used to bond and finish the fabric. In bonding, the major chemicals used are acrylics, styrenebutadiene, vinylacetate, and polyvinyl chloride. The major function of these chemicals is to bind the fibers together; however, they are used to impart other

characteristics onto the fabric such as flame retardancy, softness, and elasticity. The major chemicals used in finishing are fatty acid esters, surfactants, fluorochemicals, silicones, inorganic salts, organic phosphates, and aramids, to name a few. The major function of these chemicals is to improve wettability, increase repellency, soften, reduce static electricity, to improve abrasion resistance, and impart flame retardancy. In general, there are many sources of organic and inorganic chemicals in the United States and abroad.

Capital equipment

In the early stages of development, much of the equipment used to produce nonwoven fabric was modified from that used to produce paper and from machinery used in certain processes in the traditional textile mill industry.²⁴ Now the machinery used to produce nonwoven fabrics is often designed for that purpose. Production of spunbonded and meltblown fabrics uses technology from manmade fiber production. Many of the world's leading producers of these types of equipment now make machinery specifically for use by nonwoven fabric producers. Additionally, as technology is an important feature in the development of new fabrics, many of the leading nonwoven fabric producers are involved in designing equipment for the industry.

Labor

Employment increased from 8,800 employees in 1972 to 12,700 in 1990, while the number of employees per establishment decreased from 107 in 1972 to 82 in 1987 (table 6).²⁵ These trends reflect—(1) changes in real wages relative to the changes in the real price of substitute inputs; (2) changes in technology, which affect the intensity of labor use; and (3) changes in the demand for nonwoven fabric.

The increase in total employment is the direct result of the increase in the demand for nonwoven fabric and the subsequent entry of new firms. For example, the real value of shipments increased by 5.3 percent per annum from 1972 to 1990 (a rough approximation for demand growth). At the same time, the number of establishments increased by 58.5 percent.²⁶ As a consequence, total employment increased.

On the other hand, the decrease in employment per establishment is the net result of changes in another factor. Production in the industry has increasingly used high-speed, high-volume equipment that tends to be

¹⁸ There are new meltblown technologies being developed that would use more olefin and polyester fiber. See, for example, Derek Ward, "Radical Changes of Ownership," *Textile Month*, Mar. 1991, pp. 27-30.

¹⁹ Michael Jacobsen, "Cotton: A Natural Move Into Nonwovens," *Nonwovens Industry*, June 1990.

²⁰ *Ibid.*

²¹ Ellen Noonan, "Picking The Cotton Market: A Natural Progression Into Nonwovens," *Nonwovens Industry*, June 1991.

²² Worldwide, there are 122 manufacturers of rayon and 302 manufacturers of polyester; see *Fiber Organon*, June 1990, p. 107. Besides, the duty on imported rayon and acetate is 4.9 percent the duty on imported polyester is 4.9 percent and the duty on imported olefin is 5.0 percent.

²³ This discussion follows "Raw Materials," *The Nonwovens Handbook*, 1988.

²⁴ Bale opening, fiber blending, and carding machinery are examples of this equipment.

²⁵ The establishment data for 1990 are unavailable.

²⁶ The number of companies increased by 63.3 percent.

Table 6
U.S. Employment data, SIC 2297, 1990, 1987, 1982, 1977, and 1972

Year	Production workers 1,000	Production workers per establishment ¹	Average hourly earnings Constant 1982-84 dollars ¹	Value added per production worker hour (²)
1990.....	¹ 12.7	(²)	(²)	(²)
1987.....	10.7	82	8.25	33.63
1982.....	9.5	72	7.54	30.17
1977.....	10.4	104	7.84	30.18
1972.....	8.8	107	7.39	24.55

¹ Estimated by the staff of the U.S. International Trade Commission.

² Not available.

Source: 1987 Census of Manufactures, "Historical Statistics for the Industry (1987 Basis): 1987 and Earlier Years;" and 1987 Census of Manufactures, "Selected Operating Ratios for the Industry (1987 Basis): 1987 and Earlier Years."

capital intensive rather than labor intensive. The decrease in employees per establishment within the industry is consistent with a shift toward capital-intensive production processes.

During this period, real wages increased by 11.6 percent. As firms invested in more productive capital equipment, the marginal productivity of labor increased, which increased the real wages paid to labor. Data are not available to determine what impact new equipment had on the marginal productivity of labor. However, one might use the real value added per production worker hour to evaluate the productivity of production workers, recognizing that it is a very crude measure. These data show that this value increased from \$24.55 in 1972 to \$33.63 in 1987.

Factors Affecting Demand and Consumer Characteristics

The demand for nonwoven fabrics is derived from the various end-use products in which these fabrics are used.²⁷ For several end uses described below, the quantity of fabric sold in the merchant market is small because many of the fabric producers are vertically integrated downstream. However, the merchant market for other end uses is quite large, and tends to be for segments where competing products use other types of fabric or materials.

Nonwoven fabric is used to make two types of end-use products; disposables and durables. In 1989, disposable products (e.g., diapers, medical apparel, and household/industrial wiping materials) accounted for 60 percent of the nonwoven-fabric shipments (by value) and more than 80 percent of the fabric consumed (in quantity) in North America. In 1989, the estimated total consumption was 7.6 million square yards, of which roughly 6.1 million square yards were used to produce disposable products. In comparison, durable products (e.g., protective envelopes,

automobile carpet underlays, and geotextiles) accounted for 40 percent of the shipments and less than 20 percent of the fabric consumed.²⁸ One industry analyst expects that this division between disposable and durable products will remain constant during the 1990s.²⁹

Demand for disposable nonwoven products

Table 7 reports the U.S. consumption of nonwoven fabric by the major disposable end-use products, identifies the major buyers in the merchant market, and lists several competing products.

Disposable diapers and adult incontinence pads account for the largest share of nonwoven fabric consumed in 1990. One industry analyst has reported that unit volume for diaper coverstock is increasing 1 to 2 percent per annum.³⁰

Growth of demand for disposable diapers is not likely to increase because of several economic and demographic factors. For example, since 1960, the birth rate in the United States has declined, which has led to a reduction in demand for diapers. On the other hand, increases in the value of time during the past two decades have made cloth diapers relatively more expensive than disposables, which has most likely increased the demand for disposable diapers. However, the recent environmental concerns associated with disposable diapers has helped to offset the shift away from cloth diapers. In comparison, the growth in adult-incontinence products is most likely to increase as a result of a different demographic change. In 1960, the portion of adults aged 45 and older was 29 percent. In 1987, however, it had increased to 31 percent, and is expected to continue to increase in the 1990s as baby boomers age.³¹ Thus, the decline in the birth rate and

²⁸ See Michael Jacobsen, "The U.S. Nonwovens Industry," Mar. 1990, pp. 26-27.

²⁹ Ibid, p. 26.

³⁰ Ibid, p. 44.

³¹ These estimates are computed from the population data reported in the *Economic Report of the President*, Feb. 1991.

²⁷ See George J. Stigler, *The Theory of Price* 4th ed., 1987.

Table 7
Estimated U.S. nonwoven-fabric consumption by major disposable end-use products, 1988-1990

<i>End-use products</i>	<i>Consumption of nonwoven fabric</i>			<i>Buyers</i>	<i>Competing products</i>
	<i>1990</i>	<i>1989</i>	<i>1988</i>		
	<i>Million square yards</i>				
Disposable diapers, feminine hygiene products, and adult incontinence pads.	3,995	3,885	3,777	K-C ¹ , P & G, Weyerhaeuser, Pope & Talbot, J & J ¹ , IDC Confab, Associated Hygienic, and several small private label producers.	Cloth diapers.
Medical apparel and related products.	3,675	3,500	3,224	Baxter, J & J ¹ , K-C ¹ , and numerous small converters.	Woven and paper.
Household/industrial wiping materials.	1,378	1,300	1,170	Scotts Nonwovens ¹ , Freudenberg ¹ , Veratec ¹ , Dow Brands, K-C ¹ , James River, IFC, J & J ¹ , American Cyanamid, Fort Howard, and several small producers.	Woven and paper wiping material; used clothing.
Laundry softeners	679	600	571	P & G, Lever Brothers, and private label converters.	Liquid softener.
Filtration media	460	441	420	Freudenberg ¹ , Tex Tech, Dexter ¹ , and 300 speciality firms.	Woven media.
Total	10,187	9,726	9,162		

¹ Firm is integrated and, therefore, buys its own output.

Sources: Michael Jacobsen, "The U.S. Nonwoven Industry," *EIU Textile Outlook International*, March 1990; Michael Jacobsen, "The U.S. Nonwoven Industry," *EIU Textile Outlook International*, March 1989; *Nonwovens World Factbook*, 1991; and staff interviews.

the environmental problems related to disposable diapers have offset growth in other disposable products, contributing to the limited growth in nonwoven fabric consumed in this particular end use.

The major users of fabric for disposable diapers and adult incontinence pads are Procter & Gamble and Kimberly-Clark, which, according to one industry analyst, account for 80 percent of the disposable diaper output.³² Strictly speaking, Kimberly-Clark does not buy diaper coverstock in the merchant market since it produces and consumes its output internally. Several smaller firms purchase coverstock in the merchant market to produce private label brand diapers.

Disposable medical nonwoven products (e.g., surgical caps, gowns, and storage wraps) account for the second-largest share of fabric consumed in the United States. In 1990, for example, this end use consumed an estimated 3.7 billion square yards of nonwoven fabric. Two factors have contributed to the growth of this end-use segment. First, there is the convenience and security of using disposable products. Second, nondisposable products have become relatively more expensive, and this has induced some substitution toward products made from nonwoven fabrics. For example, one industry analyst reports that nonwoven medical products have displaced the traditional cloth products used in hospitals.³³ The reason is that the nonwoven products offer more advantages (e.g., absolute sterility) per dollar spent.

The third-largest end use for disposable nonwoven fabric is household-industrial wiping materials, which accounted for roughly 1.4 billion square yards of fabric consumed in 1990. This includes cleaning "cloths" that cannot be used indefinitely without wearing out like the well-known Handi Wipe product, which is often used several times before discarding. The major factor affecting the derived demand appears to be competition among nonwoven, woven, and paper related wiping products. The large number of substitutes for nonwoven wiping materials suggests that the derived demand for nonwoven fabric would be relatively elastic.

The fourth-largest end use is laundry softeners, which accounted for an estimated 679 million square yards of fabric consumed in 1990. In this particular end use, the nonwoven fabric acts as a substrate that "carries" fabric softener or antistatic treatment. There are many substitutes available for this end-use product, so demand is relatively elastic.

The number of buyers of fabric softener sheets appears to be relatively small. The two largest buyers are Procter & Gamble and Lever Bros., which, according to one industry analyst, together account for 70 percent of the fabric softener sheets output.³⁴ However, a large number of fringe firms produce private label brand sheets.

³² Ibid.

³³ See Clare Haddad, "Nonwovens: Textile Substitution In Hospital Operating Rooms," *Textile Outlook International*, July 1987.

³⁴ Jacobsen, Ibid.

Filtration media account for the fifth-largest use of disposable nonwoven fabric in 1990. In this particular application, nonwovens compete with several materials such as paper, woven, and nontextile materials. Given the relatively large number of substitutes available, the derived demand for fabric is likely to be elastic.

Demand for durable nonwoven products

Table 8 reports the U.S. consumption of nonwoven fabric by the major durable end-use products, identifies the major buyers in the merchant market, and lists several competing products.

Durable envelopes (e.g., computer diskette envelopes, and mailing envelopes), packaging materials, and art canvas account for the largest share of nonwoven fabric consumed to make durable products. In 1990, for example, these end uses consumed an estimated 396 million square yards of nonwoven fabric. Nonwoven envelopes compete with envelopes made from other materials like paper and cloth. The protective apparel industry accounts for the second-largest share, and these nonwoven products are in direct competition with many disposable products. Consequently, one would expect that the derived demand for nonwoven fabric would be relatively elastic. In addition, there are numerous buyers of nonwoven fabric for this particular end use.

Apparel interlinings ranked third in 1990. Nonwoven fabric now has a 63-percent share of the U.S. apparel interlining market, and has replaced woven fabric in many garments. Nonwoven interlinings are light, stable, and lofty, and can be made to adhere to a garment very easily.³⁵

Geotextile products (e.g., drainage systems, filtration applications, and asphalt underlays) accounted for approximately 220 million square yards of nonwoven fabric consumed in 1990. Nonwovens represented about 30 percent of the geotextile market while wovens accounted for approximately 70 percent. To a large extent, Federal spending on highways, on railroads, and on the containment of hazardous waste drives the demand for this use of fabric. Competition with woven products is an important determinant of the demand for nonwoven products. In addition, many producers of geotextile products buy their fabric in the merchant market.

The U.S. automobile industry was fifth in terms of fabric consumed in 1990. The fabric is used in door panels as a backing material, in trunks as padding, in oil and air filters as a filtration media, and in the interior upholstery. This particular end use represents a growing segment for nonwoven fabric producers primarily because the demand for automobiles, although very cyclical, grew secularly during the 1980s. Moreover, as the Japanese build additional plants in the United States, the demand for nonwoven fabric should continue to grow into the 1990s. The nonwoven fabric firms compete with several other types of material in this broad end-use segment. For example, nonwoven fabric competes with woven and knit fabrics in the upholstery segment.

³⁵ *Nonwovens World Factbook 1991*, p. 176.

Table 8
Estimated U.S. nonwoven-fabric consumption by major durable end-use products, 1988-1990

<i>End-use products</i>	<i>Consumption of nonwoven fabric</i>			<i>Buyers</i>	<i>Competing products</i>
	1990	1989	1988		
	— Million square yards —				
Durable envelopes	396	370	346	James River, Oliver Products, Specialty Paperboard, and Dexter ¹ .	Paper and plastic envelopes.
Protective apparel	304	265	252	Baxter, Albany, Lantor, National Felt, Tex-Tech, Northern Safety, Angelica, K-C ¹ , Dura Fab, Lakeland, and Liberty.	Woven and knit apparel.
Apparel interlinings	232	225	218	Freudenberg ¹ and numerous apparel manufacturers.	Woven interlinings.
Geotextiles	220	210	190	Chicopee ¹ , Phillips ¹ , Foss ¹ , GFF, Marshall, National Felt, Spartan, U.S. Felt, and Timcorp.	Woven and knit apparel geotextiles.
Automobile felts, pads, and carpet underlinings.	210	200	190	Ford, GM, Chrysler, Japanese auto firms, Phillips ¹ , and Foss ¹ .	Woven material.
Total	1,362	1,270	1,204		

¹ Firm is integrated and, therefore, buys its own output.

Sources: Michael Jacobsen, "The U.S. Nonwoven Industry," *EIU Textile Outlook International*, March 1990; Michael Jacobsen, "The U.S. Nonwoven Industry," *EIU Textile Outlook International*, March 1989; *Nonwovens World Factbook*, 1991; and staff interviews.

Overall, the nonwoven-fabric producers typically sell into end-use segments in which several products compete. As a result, the residual demand curve facing an individual firm is probably very elastic.

FOREIGN INDUSTRY PROFILE

The world's leading producers of nonwoven fabrics are virtually all multinational in their operations. Of the top 10 worldwide producers in 1990, only 2, Reemay and Japan Vilene, had manufacturing plants only in their home country (table 9).

U.S.-based firms provided over 50 percent of total world wide sales in 1990. Coupling this with the U.S. market accounting for about one-half of the world market, gives an indication of the strong influence the U.S. industry has on that of the world industry. In this context, differentiation between the U.S. nonwoven fabric industry and the foreign nonwoven fabric industry is somewhat of a misnomer. The foreign industry, therefore, will be defined as those companies whose production is primarily concentrated in Western Europe, Japan, and the other Asian countries, particularly Taiwan, Korea, and China, in which the nonwoven fabric industry is emerging as a significant sector.

European firms had worldwide sales of \$1.9 billion in 1990, and were the first-, sixth-, and eighth-leading firms in 1989. The world's largest firm,

Freudenberg—based in Germany—had 1990 sales of \$950 million. In 1990 for the first time, a Japanese firm was one of the world's top 10 producers of nonwoven fabrics; 4 other Japanese firms were ranked 15, 16, 22, and 23.

European Industry

Led by Freudenberg, Germany is the leading producer of nonwoven fabrics in Europe, accounting for about one-third of total European production. Leading producing countries and their share of total European production are as follows (in percent):

Germany	33
Benelux countries	20
France	15
Scandinavian countries	12
United Kingdom	10

Production in Europe increased by about 10 to 15 percent annually during 1975–89, reaching 360,000 tons in 1989.

In respect to production processes, dry-laid fabrics account for about half of European production, spunbonded fabrics for 33 percent, and wet-laid fabrics for the remaining 12 percent. Production of spunbonded fabrics is expected to show the largest growth in the next few years, with annual increases in production of 7.5 percent. Production of dry-laid

Table 9
Nonwoven fabrics: Leading world producers, home country, 1990 sales, and plant locations

<i>Company (home country)</i>	<i>1990 sales</i>	<i>Plant locations</i>
	<i>Million dollars</i>	
Freudenberg (Germany)	950	Germany, United Kingdom, Spain, France, Sweden, Argentina, Brazil, South Africa, United States, Japan, Korea, Taiwan.
DuPont (U.S.)	600	United States, Luxemborg, China.
Kimberly-Clark (U.S.)	340	United States, Puerto Rico, Australia, Brazil, Canada, Columbia, El Salvador, France, Germany, Indonesia, Korea, Malaysia, Mexico, Netherlands, Panama, Singapore, Philippines, Thailand, United Kingdom.
Veratec (U.S.)	325	United States, Canada, United Kingdom, Japan.
Dexter Nonwovens (U.S.)	255	United States, Scotland, Sweden, Japan.
Fiberweb Group (Switzerland)	250	France, Sweden, United States.
Chicopee (U.S.)	220	United States, Netherlands.
Hoechst (Germany)	200	Germany, United States.
Japan Vilene (Japan)	186	Japan.
Reemay (U.S.)	175	United States.
Scott Nonwovens (U.S.)	130	United States, Germany.

Source: *Nonwoven Industry*, Sept. 1991.

fabrics is expected to grow at an annual rate of about 6 percent and continue as the dominant method of production. Production of wet-laid fabrics is predicted to be stable.³⁶

Differing from the United States, where disposable end uses account for the majority of production, in Europe, durable uses are primary. Among the chief uses are civil engineering projects such as road building and soil containment, household products, air filtration, apparel interlining, shoes, electronic equipment, automotive components, and agriculture. Benefits of the single European market such as the expected general economic expansion should stimulate demand for nonwoven fabrics for such uses as filtration, roofing, and protective garments. Removal of customs and transportation barriers will facilitate and expand the already established trade, although these effects will be somewhat diminished by the current multinational structure of the industry. In addition, the anticipated need for improved rail and road transportation infrastructure should increase demand for geotextile nonwoven fabrics.

The Industry in Japan and Other Asian Countries

Production of nonwoven fabrics in Japan amounted to 133,000 tons in 1989, an increase of 22 percent from 1985.³⁷ Needlepunch fabrics dominated this production with a 36-percent share, followed by spunbonded fabrics and dry-laid fabrics with 25-percent and 24-percent shares, respectively.

Durables dominate the market in Japan, largely as a result of the cultural tendency to avoid throw-away products. As a result of this tendency, Japan's nonwoven industry has not benefited from the growth in demand for disposable products that fueled the growth of the American and European industries. The distinguishing characteristic of the industry in Japan has been the development of its own technology to produce fabrics for specific markets. The emphasis has been on developing specialized properties in fabrics at the expense of costs and production speeds. As a result, much of the production of nonwoven fabrics in Japan are high in quality and in price.

Needlepunched carpets account for the largest share, 28 percent, of Japan's production of nonwoven fabrics. The next largest share of production is of interlining fabrics at 9 percent. Other nonwoven fabrics produced in Japan are for coverstock for diapers and sanitary napkins, filters, agriculture uses, geotextiles, roofing, electronic equipment, automotive components, and medical uses.

For the smaller Asian producers of Korea, Taiwan, and China, production and the percent growth during 1985-89 are as follows:

Producer	Production	Growth (Percent)
Korea	22,700 tons	22
Taiwan	17,700 tons	22
China	17,300 tons	22

For all three countries, dry-laid fabrics dominate production with a 90-95 percent share.³⁸ In Taiwan, some production is of spunbonded fabrics, primarily in a Freudenberg plant that was built to serve the entire Pacific Rim and that began production in 1988.³⁹ A spunlaced plant started in Taiwan in 1989 and is expected to reach full production by the end of 1991. Most nonwoven fabrics produced in all three countries are for interlining, garment padding, shoes, geotextiles and carpets. Economic growth in these countries is predicted to lead to continued growth in production of and demand for nonwoven fabrics. A leading industry consultant has predicted that China has the potential to become the largest Asian producer of nonwoven fabrics by the year 2000.⁴⁰ The Chinese Government is trying to improve the quality and volume of its production of nonwoven fabrics both to meet the needs of its domestic market and for export.

U.S. TRADE MEASURES

Rates of duty for nonwoven fabrics effective January 1, 1991, are given in table 10. Nonwoven floor covering underlays are identified as a separate tariff provision. Laminated nonwoven fabrics are provided for in order to have the rate of duty for these fabrics comparable with the rate of duty for similar laminated fabrics of knit and woven fabrics that are classified in chapter 59 of the Harmonized Tariff Schedules.

The principal nontariff measure regulating U.S. imports of textile products, including most nonwoven fabrics, is the Multifiber Arrangement (MFA).⁴¹ The United States does not impose restraints under the MFA on imports from the Western European countries that are leading foreign producers of nonwoven fabrics, but does have an agreement with Japan, another significant producer. In this agreement, nonwoven fabrics are not now subject to quotas but are identified as consultation categories. Nonwoven fabrics are not covered by specific limits in any of the other U.S. bilateral agreements. However, in some agreements they are subject to limits covering a group of products or an aggregate limit covering all MFA products.

³⁸ Vaughn, pp. 35-36.

³⁹ Locations of other plants in Asian countries owned by the leading U.S. and European producers are found in table 9.

⁴⁰ Thomas Dunn, "Nonwovens in the Far East", *Nonwovens Industry*, Sept. 1990, p. 48.

⁴¹ See app. A for more information regarding the MFA. Nonwoven floor covering underlays except those of wool and fine animal hair are excluded from MFA coverage.

³⁶ Edward Vaughn, *Nonwovens World Factbook 1991*, p. 35.

³⁷ Vaughn, p. 36.

Table 10
Nonwoven fabrics: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1991; U.S. exports, 1990; and U.S. imports, 1990

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1991		U.S. exports, 1990	U.S. imports, 1990
		General	Special ¹		
5603.00.10	Nonwoven floor covering underlays, whether or not impregnated, coated, covered or laminated.	3.4%	Free (B) 1% (IL) 2.3% (CA)	16.5	3.5
5603.00.30	Nonwoven laminated fabrics, whether or not impregnated, coated or covered, nesi.	16%	4.8% (IL) 11.2% (CA)	84.1	1.1
5603.00.90	Nonwoven fabrics, whether or not impregnated, coated or covered, nesi.	12.5%	Free (B,IL) 8.7% (CA)	256.1	156.1

¹ Programs under which special tariff treatment may be provided, and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn, are as follows: Generalized System of Preferences (A); Automotive Products Trade Act (B); Agreement on Trade in Civil Aircraft (C); United States-Canada Free-Trade Agreement (CA); Caribbean Basin Economic Recovery Act (E); and United States-Israel Free-Trade Area (IL).

Source: U.S. exports and imports compiled from data of the U.S. Department of Commerce.

FOREIGN TRADE MEASURES

In most of the major markets for nonwoven fabrics, a single rate of duty applies to all types of nonwoven fabrics. The rate of duty for U.S. shipments of nonwoven fabrics to Canada, a leading market, is currently 24.8 percent. However, under provisions of the United States-Canada Free-Trade Agreement (FTA) that became effective in January 1989, this base rate of duty for imports to Canada from the United States is being reduced in 10 annual stages. For 1989, the first year of staged reductions, the rate of duty was 22.3 percent. In 1990, it was 19.8 percent, and in 1991 was 17.4 percent. The duty is scheduled to be reduced by 2.3 percentage points annually until it becomes free in 1998. The rate of duty for imports of nonwoven fabrics to Mexico is 15 percent ad valorem. Most imports of nonwoven fabrics into the European Community, including those from the United States, are subject to a 6.7-percent rate of duty. The rate for imports into Japan is 6.4 percent and for Korea the rate is 20 percent.

No significant nontariff measures restrict U.S. exports of nonwoven fabrics. Some countries that are significant markets for U.S. exports, particularly those in Asia, impose licensing requirements on imports of most textile products. However, U.S. industry representatives have indicated that these requirements

generally have not hindered shipments of nonwoven fabrics.

U.S. MARKET

Table 11 presents data that describe several measures of economic performance of the U.S. nonwoven fabric industry in domestic markets during 1986-90. These data, after being converted to nominal dollars, are graphically illustrated in figure 3.

U.S. Consumption

The world market for nonwoven fabrics is dominated by the North American market, with the United States as the leading consumer, accounting for about one-half of the approximately \$6 billion sales in 1990. The data in table 11 indicate that U.S. consumption (expressed in constant 1985 dollars) increased by 2.6 percent between 1989 and 1990.⁴² This increase is close to that of real disposable income which increased by 2.4 percent during this time, which

⁴² Because of the switch from the TSUS classification system to the HTS classification system, the import/export data for earlier years are not directly comparable and are therefore not reflective of industry trends.

Table 11
Nonwoven fabrics: U.S. shipments, exports of domestic merchandise, imports for consumption, and apparent U.S. consumption, 1986–90 (expressed in 1985 dollars)

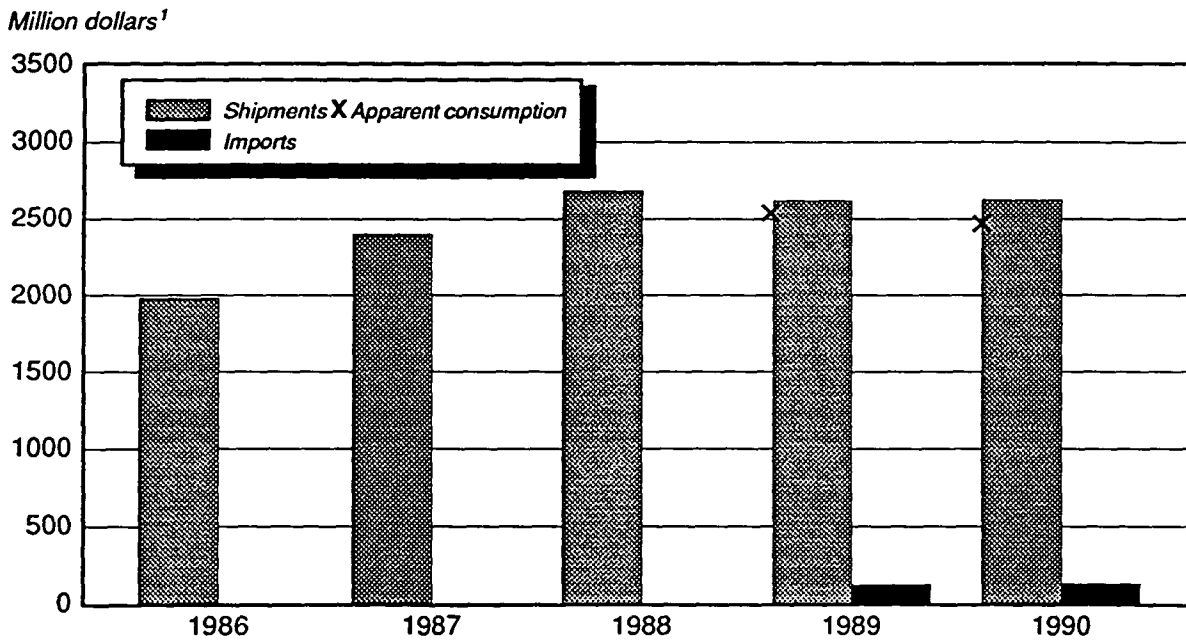
Year	U.S. shipments	U.S. exports	U.S. imports	Apparent U.S. consumption	Ratio of imports to consumption
	Million dollars			Percent	
1986	1,981	(1)	(1)	(1)	(1)
1987	2,400	(1)	(1)	(1)	(1)
1988	2,693	(1)	(1)	(1)	(1)
1989	² 2,828	206	120	2,742	4.4
1990	² 2,970	288	130	2,812	4.6

¹ Not available.

² Estimated by the staff of the U.S. International Trade Commission.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Figure 3
Nonwoven fabric: U.S. imports, domestic shipments, and apparent consumption



¹ This graph illustrates the data from table 11 in nominal dollars.

Source: USITC staff.

would have likely increased the demand for most nonwoven end-use products. At the same time the real nonwoven fabric price index rose by 1 percent, only slightly increasing prices. The rise in consumption indicated by these 2 years is believed to be indicative of the longer term trend for the nonwoven-fabric industry.

U.S. Shipments

U.S. shipments increased by 7.3 percent per annum in real terms during 1986 to 1990. Exports were increasing as well, at least for the 2 years in which

these data are available. The economic growth of Japan and Canada during 1986–90 suggests that exports to those markets had been increasing before 1989–90. In Japan, for example, the average growth rate in real GNP was 4.8 percent per annum, while the average growth rate in Canada was 3.2 percent per annum.⁴³ Also, the U.S. dollar vis-a-vis other currencies had depreciated, which made U.S. exports

⁴³ These averages were computed from annual average growth rates reported in *The Economic Report of the President*, Feb. 1991.

relatively less expensive in foreign markets.⁴⁴ Thus, strong growth abroad and a relatively weak dollar were two factors that contributed to the rapid increase in U.S. exports of nonwoven fabric. In 1989, for example, U.S. exports (measured in 1985 dollars) were \$206 million and rose to \$288 million in 1990, a 39.8-percent increase.

U.S. Imports

The data in table 11 also show that U.S. imports of nonwoven fabric increased in real terms by approximately 8.3 percent from 1989 to 1990. Moreover, imports expressed as a percentage of domestic consumption rose from 4.4 percent in 1989 to 4.6 in 1990. Although these data are for only 2 years, the increase in imports is consistent with the strong growth in the U.S. economy during the late 1980s. The value of imports in nominal terms increased by 13 percent to \$161 million from 1989 to 1990, as shown in table 12.

Luxembourg and Japan were the leading sources, by far, for U.S. imports of nonwoven fabrics in 1989-90. Together they accounted for about 60 percent of imports each year. A sizeable share of the imports from Luxembourg are believed to have been imports of Tyvek⁴⁵. The need for these imports has been alleviated by DuPont's expansion of capacity to produce Tyvek at its U.S. facilities in 1990 and probably will lead to decreased imports of nonwoven fabrics from Luxembourg. The imports from Japan are predominately high-valued, low-volume specialty products. The extent of this is shown by comparing the relative prices of imports from Japan to those from other sources. The imports from Japan during 1990 had an average value of \$25.46 per kilogram compared with the average unit value of \$4.17 for imports from all other sources. Demand for these Japanese fabrics in the U.S. market is expected to continue, as should Japan's importance as an import source. Other leading sources of imports are mainly European countries and the imported products are primarily for specialized niche markets.

FOREIGN MARKETS

Consumers in foreign markets purchased about one-half of total world sales, or \$2.5 billion, in 1989,

⁴⁴ In 1986, the peso/dollar exchange rate was 611.8; the dollar (Canada)/dollar (US) rate was 1.39; the franc (Belgium)/dollar rate was 44.66; and the yen/dollar rate was 168.4. In 1990, however, the peso/dollar exchange rate was 2,813; the dollar (Canada)/dollar (US) rate was 1.17; the franc (Belgium)/dollar rate was 33.42; and the yen/dollar rate was 145.00. In all cases except Mexico, the dollar had depreciated relative to these currencies. These data were taken from the U.S. Department of Labor, Bureau of Labor Statistics, "Exchange Rates," 1991.

⁴⁵ Tyvek is a spunbonded polyolefin nonwoven fabric produced by DuPont. One of its more common applications is in durable envelopes used by express mail services.

the latest year for which data are available for these markets. The European nations dominated the foreign market. Sales in Europe were about \$1.5 billion in 1989, with the next ranked market of Japan accounting for about \$.8 billion in sales. The remaining \$.2 billion in world-wide sales was primarily in the markets of Pacific Rim nations where domestic producers provided much of the nonwoven fabrics used in their respective industries. The decisions made by many of the leading multinational producers to locate production facilities near major markets resulted in a lesser need for trade of nonwoven fabrics; however, countries continue to trade finished products.

Table 12
Nonwoven fabrics: U.S. Imports for consumption, by principal source, 1989-90

Source	1989	1990
<i>Quantity</i> (1,000 kilograms)		
Luxembourg	9,959	12,015
Japan	1,822	1,639
Germany	3,423	2,440
Belgium	371	1,601
Canada	2,985	4,302
Israel	1,377	2,453
United Kingdom	817	789
Netherlands	734	438
Italy	702	796
France	537	756
All other	1,131	2,164
Total	23,858	29,393
<i>Value</i> (1,000 dollars)		
Luxembourg	41,558	50,874
Japan	42,222	41,729
Germany	18,654	14,166
Belgium	2,779	9,713
Canada	7,793	8,658
Israel	4,400	7,673
United Kingdom	6,503	6,257
Netherlands	6,825	5,476
Italy	3,435	4,281
France	2,373	3,922
All other	5,627	8,125
Total	142,169	160,874
<i>Unit value</i> (per kilogram)		
Luxembourg	\$4.17	\$4.23
Japan	23.17	25.46
Germany	4.69	4.98
Belgium	7.48	6.07
Canada	2.61	2.01
Israel	3.19	3.13
United Kingdom	7.96	7.93
Netherlands	9.30	12.50
Italy	4.92	5.38
France	4.42	5.18
All other	4.98	3.75
Average	5.95	5.47

Source: Compiled from official statistics of the U.S. Department of Commerce.

Foreign Market Profile

Demand in the foreign markets was initially for inexpensive nonwoven substitutes for traditional textile materials. A large share of the products using these fabrics was for the consumer market. New markets were developed for products in the geotextile, construction, horticultural, and agricultural sectors. The market has increasingly become directed at high-technology items, many with unique properties for specialized applications.⁴⁶ The foreign markets are increasingly demanding nonwoven fabrics produced for these specialized applications that are used mostly in the industrial markets and which compete on the basis of performance rather than price. With the shift from relatively simple-to-produce commodity fabrics for consumer products to nonwoven fabrics for high-technological applications, the competition in the market among the producers of nonwoven fabrics has intensified. Earlier competition in the market chiefly had been between producers of the nonwoven products and producers of traditional textile products.

U.S. Exports

Exports of nonwoven fabrics accounted for a small share of U.S. nonwoven fabric production until 1989. In 1989 exports accounted for about 11 percent of U.S. producer's shipments. In 1990, exports increased by nearly 40 percent and accounted for about 15 percent of production.

Products exported

Exports cover a wide range of nonwoven fabrics. Industry representatives have indicated that much of the growth in exports during 1989 and 1990 was of fabrics for automotive uses including body liners and insulation, backing for carpeting, and upholstery. This is particularly true of the growth in exports to Canada and Mexico. A large share of exports to Japan reportedly have been for use in the automotive industry. Industry sources have stated that this market is expected to decline in the near future as Japan increasingly meets its demand for nonwoven fabrics with domestic production and with imports from nearby Asian sources. For example, Freudenberg has built a plant in Taiwan largely to supply the Japanese market as well as the entire Pacific Rim.⁴⁷ By early 1991, the plant had begun production but was not yet operating at full capacity.

Export levels and trends

As shown in table 13, exports of nonwoven fabrics amounted to \$243 million in 1989. Japan, Canada and Belgium were the leading markets that year, based on value, with their combined share amounting to

⁴⁶ *Textile Outlook International*, Nov. 1989, pp. 65-73.

⁴⁷ Conversation with Lee Sullivan, president, Freudenberg Spunweb, Raleigh NC on Jan. 30, 1991.

Table 13
Nonwoven fabrics: U.S. exports of domestic merchandise, by principal markets, 1989-90

Source	1989		1990	
	Quantity (1,000 kilograms)			
Mexico	5,041		21,844	
Canada	10,181		12,759	
Belgium	4,006		4,276	
Japan	10,584		8,119	
United Kingdom	5,219		3,577	
Hong Kong	2,117		3,175	
Germany	4,512		3,523	
Netherlands	1,431		1,546	
Italy	917		875	
Haiti	1,427		653	
All other	8,370		7,425	
Total	53,377		68,054	
			Value (1,000 dollars)	
Mexico	16,709		109,180	
Canada	34,321		59,939	
Belgium	32,258		55,740	
Japan	58,878		37,727	
United Kingdom	5,219		3,577	
Hong Kong	12,251		14,099	
Germany	16,497		13,504	
Netherlands	6,275		5,942	
Italy	4,397		4,218	
Haiti	5,428		3,711	
All other	39,001		36,704	
Total	243,477		357,238	
			Unit value (dollars per kilogram)	
Mexico	\$3.31		\$5.00	
Canada	3.37		4.70	
Belgium	8.05		13.04	
Japan	5.56		4.65	
United Kingdom	3.35		4.61	
Hong Kong	5.79		4.44	
Germany	3.66		3.83	
Netherlands	4.39		3.83	
Italy	4.80		4.82	
Haiti	5.44		3.96	
All other	4.66		4.94	
Average	4.56		5.25	

Source: Compiled from official statistics of the U.S. Department of Commerce.

51 percent or \$125 million. Secondary export markets were the United Kingdom, Germany, Hong Kong, Korea, and Australia. In 1990, exports of nonwoven fabrics increased by 47 percent from 1989, to \$357 million. Mexico, a minor market prior to 1988, accounted for the largest share of this growth.

In 1990, exports to Mexico were \$109 million, more than six times the previous year's exports to that market. Much of the increase is attributed by U.S. industry sources to shipments by or on behalf of a U.S. auto manufacturer. These imports were reportedly

reportedly fabric to be used in the manufacture of autos in Mexico for sale in the U.S. market.⁴⁸

Mexico's import data for 1988 show that the United States supplied 98 percent of its imports of nonwoven fabrics.⁴⁹ Exports to Canada, the second-ranked market in 1990, increased in that year to \$60 million from \$34 million the previous year. In the Canadian market, the United States was the leading foreign supplier, providing 85 percent of imports in 1990. Other suppliers to Canada were Luxembourg, Japan, and the United Kingdom, with no one of these supplying more than 4 percent of Canada's imports. Exports to Japan declined from \$59 million in 1989 to \$38 million in 1990. This decline occurred as Japan was increasing its production of nonwoven fabrics and becoming less dependent on imports to meet its domestic demand as well as shifting sourcing of its imports to the growing industries in other Asian countries. During this same period, exports from the United States to Belgium increased from \$32 million to \$56 million, an increase of 75 percent.

During the early stages of development of the nonwoven industry, when the bulk of production was of commodity fabrics, the high costs of shipping relative to production costs for these low-valued

⁴⁸ Mexico's nonwoven fabric industry is small and has little modern equipment. Much of its equipment has been purchased second-hand from U.S. manufacturers that were selling machinery that was being replaced by new technology.

products made it economical to locate production facilities near the market. This is generally still the case. However, as demand in foreign markets for nonwoven fabrics for specific applications has increased, individual producers are tending to rationalize production using expensive high-technology equipment in one or a few locations worldwide. They then are shipping these nonwoven fabrics to the market where they are required. Other exports are of nonwoven fabrics purchased by U.S. manufacturing firms such as auto producers for their plants in foreign countries.

U.S. TRADE BALANCE

The U. S. trade surplus in nonwoven fabrics almost doubled from 1989 to 1990 as it rose from \$100 million to \$196 million (table 14). The major factor contributing to the increase was the \$92 million increase in exports to Mexico, which is discussed in the U.S. exports section. Increases in the trade surpluses with Canada and Belgium also contributed to the gain. The only major partner with which the U.S. trade balance deteriorated from 1989 to 1990 was Japan, for which the \$17 million surplus of 1989 became a deficit of \$4 million in 1990. This decline was the result of decreased exports to that market, reportedly evidence of Japan's increasing domestic production of these fabrics as well as its sourcing from the increasing production of nearby Asian producers.

⁴⁹ More recent statistics are not available.

Table 14
Nonwoven fabrics: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected country and country group, 1989-90¹

(Million dollars)

<i>Item</i>	<i>1989</i>	<i>1990</i>
U.S. exports of domestic merchandise:		
Mexico	17	109
Japan	59	38
Canada	34	60
Belgium	32	56
Luxembourg	0	0
Germany	16	14
United Kingdom	17	16
Hong Kong	12	14
Netherlands	6	6
Italy	4	4
All other	46	40
Total	243	357
EC-12	84	105
OPEC	1	1
ASEAN	3	5
CBERA	9	6
Eastern Europe	0	0
U.S. imports for consumption:		
Mexico	1	1
Japan	42	42
Canada	9	9
Belgium	3	10
Luxembourg	42	51
Germany	19	14
United Kingdom	7	6
Hong Kong	0	0
Netherlands	7	6
Italy	3	4
All other	10	18
Total	143	161
EC-12	82	95
OPEC	0	0
ASEAN	0	0
CBERA	0	0
Eastern Europe	1	1
U.S. merchandise trade balance:		
Mexico	16	108
Japan	17	-4
Canada	25	51
Belgium	29	46
Luxembourg	-42	-51
Germany	-3	0
United Kingdom	10	10
Hong Kong	12	14
Netherlands	-1	0
Italy	1	0
All other	36	22
Total	100	196
EC-12	1	10
OPEC	1	1
ASEAN	3	5
CBERA	8	6
Eastern Europe	-1	-1

¹ Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S. trade with East Germany is not included in "Eastern Europe."

Source: Compiled from official statistics of the U.S. Department of Commerce.

APPENDIX A
EXPLANATION OF TARIFF AND TRADE AGREEMENT TERMS

TARIFF AND TRADE AGREEMENT TERMS

The *Harmonized Tariff Schedule of the United States* (HTS) replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989. Chapters 1 through 97 are based on the internationally adopted Harmonized Commodity Description and Coding System through the 6-digit level of product description, with additional U.S. product subdivisions at the 8-digit level. Chapters 98 and 99 contain special U.S. classification provisions and temporary rate provisions, respectively.

Rates of duty in the *general* subcolumn of HTS column 1 are most-favored-nation (MFN) rates; for the most part, they represent the final concession rate from the Tokyo Round of Multilateral Trade Negotiations. Column 1-general duty rates are applicable to imported goods from all countries except those enumerated in general note 3(b) to the HTS, whose products are dutied at the rates set forth in *column 2*. Goods from Armenia, Bulgaria, the People's Republic of China, Czechoslovakia, Estonia, Hungary, Latvia, Lithuania, Moldova, Mongolia, Poland, Russia, the Ukraine and Yugoslavia are currently eligible for MFN treatment. Among articles dutiable at column 1-general rates, particular products of enumerated countries may be eligible for reduced rates of duty or for duty-free entry under one or more preferential tariff programs. Such tariff treatment is set forth in the *special* subcolumn of HTS column 1. Where eligibility for special tariff treatment is not claimed or established, goods are dutiable at column 1-general rates.

The *Generalized System of Preferences* (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 and renewed in the Trade and Tariff Act of 1984, applies to merchandise imported on or after January 1, 1976, and before July 4, 1993. Indicated by the symbol "A" or "A*" in the special subcolumn of column 1, the GSP provides duty-free entry to eligible articles the product of and imported directly from desig-

nated beneficiary developing countries, as set forth in general note 3(c)(ii) to the HTS.

The *Caribbean Basin Economic Recovery Act* (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98-67, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984; this tariff preference program has no expiration date. Indicated by the symbol "E" or "E*" in the special subcolumn of column 1, the CBERA provides duty-free entry to eligible articles the product of and imported directly from designated countries, as set forth in general note 3(c)(v) to the HTS.

Preferential rates of duty in the special subcolumn of column 1 followed by the symbol "IL" are applicable to products of Israel under the *United States-Israel Free-Trade Area Implementation Act* of 1985, as provided in general note 3(c)(vi) of the HTS. When no rate of duty is provided for products of Israel in the special subcolumn for a particular provision, the rate of duty in the general subcolumn of column 1 applies.

Preferential rates of duty in the special duty rates subcolumn of column 1 followed by the symbol "CA" are applicable to eligible goods originating in the territory of Canada under the *United States-Canada Free-Trade Agreement*, as provided in general note 3(c)(vii) to the HTS.

Preferential nonreciprocal duty-free or reduced-duty treatment in the special subcolumn of column 1 followed by the symbol "J" or "J*" in parentheses is afforded to eligible articles the product of designated beneficiary countries under the *Andean Trade Preferences Act* (ATPA), enacted in title II of Public Law 102-182 and implemented by Presidential Proclamation 6455 of July 2, 1992 (effective July 22, 1992), as set forth in general note 3(c)(ix) to the HTS.

Other special tariff treatment applies to particular *products of insular possessions* (general note 3(a)(iv)), goods covered by the *Automotive Products Trade Act* (general note 3(c)(iii)) and the *Agreement on Trade in Civil Aircraft* (general note 3(c)(iv)), and *articles imported from freely associated states* (general note 3(c)(viii)).

The *General Agreement on Tariffs and Trade* (GATT) (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) is the multilateral agreement setting forth basic principles governing international trade among its more than 90 signatories. The GATT's main obligations relate to most-favored-nation treatment, the maintenance of scheduled concession rates of duty, and national (nondiscriminatory) treatment for imported products. The GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency) actions, anti-dumping and countervailing duties, and other measures. Results of GATT-sponsored multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as schedule XX.

Officially known as "The Arrangement Regarding International Trade in Textiles," the *Multifiber Arrangement* (MFA) provides a framework for the negotiation of bilateral agreements between importing and producing countries, or for unilateral action by importing countries in the absence of an agreement. These bilateral agreements establish quantitative limits on imports of textiles and apparel, of cotton and other vegetable fibers, wool, manmade fibers, and silk blends, in order to prevent market disruption in the importing countries—restrictions that would otherwise be a departure from GATT provisions. The United States has bilateral agreements with more than 30 supplying countries, including the four largest suppliers: China, Hong Kong, the Republic of Korea, and Taiwan.

