

SPECIALIZATION IN THE WOOLEN AND WORSTED INDUSTRY

SUMMARY

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THE woolen and worsted industry offers a most instructive field for a study of industrial organization and specialization. The term “woolen” is used hereinafter in its narrow sense to designate a particular class of fabrics, often called “carded-woolen,” to differentiate them from “worsted” fabrics which are manufactured by a somewhat different process, and usually in a separate set of mills. Altho the manufacture of both woolen and worsted goods is commonly thought of as a single industry, the line of demarkation between the two is sufficiently clear to enable the Census Bureau to compile separate sets of statistics for each. There appears to be ample justification for thus keeping them apart, inasmuch as there are pronounced differences in the character of materials used, the kinds of fabrics produced, and in the respective organizations

of the two branches. It is these differences in organization, in so far as they relate to specialization, which are the subject matter of the present paper.

The term "specialization" is sometimes, tho not properly, applied to the minute subdivision of processes, or "complex division of labor," within a single factory. It has a commonly accepted usage in two other senses: first, the limitation of the output of a mill to one particular kind or grade of goods, such as worsted coatings, cotton-warp dress goods, or all-wool blankets; and second, the subdivision of successive processes of manufacture between different mills, as for example where one mill combs, another spins, and another weaves. The first kind may be called horizontal or parallel specialization, because the processes occupy the same plane in the industrial scale from raw material to finished product. The second may be called vertical specialization, in that the various operations follow each other in an ascending scale, the product of one factory becoming the raw material of another. It is the latter kind of specialization with which this discussion is primarily concerned.

The considerations upon which the possibility or desirability of specialization in a given industry depends are either commercial or technical. Commercial considerations are such as the extent of the market, homogeneity of product, proximity of plants to each other. The technical considerations have to do with the intricacy of processes, capital requirements, size of the producing unit, and other matters which concern economy of operation. A third possible consideration is the history of the industry in question; established custom may retard the re-organization of businesses even when commercial and technical changes tend to make such re-organization advantageous.

A brief survey of the technical differences in the manufacture of woolens and worsteds is necessary to a proper understanding of the degree to which the two branches are specialized. Altho the worsted branch differs from the woolen to some extent in all the processes, the most marked differences occur in the early stages of manufacture, *i. e.* in the operations preparatory to spinning. The spinning itself is usually done on different kinds of machines, the mule (spindles) being used in making woolen yarn, and cap spindles in making worsted yarn.¹ The same loom may be, and often is, used in weaving both woolen and worsted fabrics, while the dyeing and finishing operations, altho more elaborate for woolen than for worsted goods, have little effect on the organization of the respective branches.

The principal operation in the preparation of scoured wool for spinning into woolen yarn is "carding." The carding machine opens up the matted fibres, renders them light and workable, and delivers them in the form of loose untwisted ropes, ready for the spindle. The fibres when they leave the card are crisscrossed in every conceivable direction, and are spun into yarn in this condition. The yarn is consequently fuzzy, with numberless ends of fibres protruding from the surface. When such yarn is woven, the resulting fabric is covered with a nap which is often worked up in the finishing operation so as to obscure or entirely obliterate the weave, as in broadcloths, heavy overcoatings, and blankets.

The principal feature which distinguishes worsted from woolen yarn is that in the former the fibres lie straight and parallel, instead of crisscrossed; hence

¹ In spinning worsted yarn on the "French system," a method which has been gaining ground in the United States, mule spindles are used.

they have to be "combed," an operation more complicated than carding. In fact, most wool has to be carded before the long series of combing operations begins. The wool is then passed through "gill boxes" which gradually straighten out the fibres and lay them parallel. They are then sent through the "combing machine" proper, the main object of which is to separate the short fibres from the long. The short fibres are called "noils" and are a valuable by-product from the worsted standpoint, inasmuch as they may be recarded and spun into woollen yarn. The long fibres of combed wool are delivered in thick strands called "tops," an item that has occupied a conspicuous place in tariff discussion of recent years.

But even in the form of tops the wool is not yet ready for spinning; it has to be "drawn," *i. e.* passed through a series of machines which gradually draw out and attenuate the "sliver" until it is an already partially spun thread. Not until this operation is completed is the wool ready for the spindle which imparts the twist. Since the fibres lie parallel there are few ends which protrude from the surface of the yarn, and when woven the resulting fabric has a smooth surface with very little nap, as in the case of the well known worsted trouserings, in which the weave shows clearly. Meagre and incomplete as this description is, it is sufficient to indicate the marked differences between the woollen and worsted processes.

In the United States the woollen industry may be said to have begun when the country was first settled, whereas the worsted industry did not become established until the Civil War. In 1860 there were but three establishments making worsted goods; since that time, however, the development has been phenomenal, until in 1900 the production of worsted goods exceeded

in value the production of woolen goods. Since that date the rapid progress of the worsted branch has continued unabated, while the woolen industry has barely held its own. In 1909 the value of products of worsted mills was \$312,625,000 and of woolen mills \$107,119,000. In Massachusetts alone the worsted manufacture increased from \$51,974,000 in 1904 to \$106,099,000 in 1909; and in the same time the woolen manufacture decreased from \$44,654,000 to \$32,217,000.

As for the distribution of the two branches in the United States, worsted mills are much more localized than woolen. Woolen mills exist in nearly every state of the Union; worsted mills existed in only twelve states in 1904. The three leading states in woolen manufacturing produce only 57 per cent of the total output of the country; the three leading worsted states turn out 75 per cent of the total. In Massachusetts, Lawrence produces at least half of the total worsteds for the state; and in Rhode Island and Pennsylvania the cities of Providence and Philadelphia, with their outlying districts, produce much more than this proportion of their respective state totals. Likewise, in New Jersey, Passaic stands pre-eminent in the worsted manufacture; in New York, Jamestown; and in Ohio, Cleveland. In the woolen branch, on the other hand, no city or limited district predominates, with the possible exception of Philadelphia; and even in that city, if carpet mills and spinners of carpet and hosiery yarns are eliminated, the concentration would probably not be so marked as one might expect. The reasons for the greater localization of the worsted branch will appear in the discussion of specialization below.

The most interesting difference between the organizations of these two branches of wool manufacture is the higher degree of specialization in the worsted than in

the woolen. The typical woolen mill performs every step in the manufacturing process: it scours, cards, spins, weaves, and finishes. The ordinary worsted mill, however, performs only one or two of the important processes. Wool scouring is done to some extent in a separate set of mills, but most spinning mills scour

WORSTED MILLS CLASSIFIED ACCORDING TO OPERATIONS PERFORMED¹

Classification	Number		Per cent of Total	
	1909	1904	1909	1904
Establishments, total ²	324	226	100 0	100 0
Combing Machines, total	1,925	1,312	100 0	100 0
Spindles, total	1,995,622	1,216,930	100 0	100 0
Looms, total	45,270	30,910	100 0	100 0
Establishments that comb only	4	2	1.2	0.9
Combing machines	61	25	3 2	1.9
Establishments that comb and spin	60	59	18 5	26 1
Combing machines	683	584	35 5	44 5
Spindles	517,619	375,643	25 9	30 9
Establishments that spin only	38	14	11.7	6.2
Spindles	163,096	61,928	8.2	5.1
Establishments that comb, spin, and weave	45	36	13 9	15.9
Combing machines	1,181	703	61 3	53.6
Spindles	1,138,361	710,717	57.0	58 4
Looms	27,769	20,963	61.4	67.8
Establishments that spin and weave	42	23	13 0	10 2
Spindles	176,546	68,642	8 9	5.6
Looms	5,490	2,578	12 1	8.4
Establishments that weave only	134	91	41.4	40.3
Looms	12,011	7,369	26.5	23.8
Miscellaneous establishments	1	1	0.3	0.4

¹ This table and the one on the following page were compiled under the supervision of the writer while connected with the Bureau of the Census. Permission to use them in this place has been granted by the Director of the Census.

² An "establishment," according to the Census Bureau, is a mill, or set of mills, in one locality under common ownership and operated as a single plant, with one set of books.

WOOLEN MILLS CLASSIFIED ACCORDING TO OPERATIONS PERFORMED

Classification	Number		Per cent of Total	
	1909	1904	1909	1904
Establishments, total ¹	587	792	100 0	100 0
Spinnles, total	1,557,572	2,011,493	100 0	100 0
Looms, total	27,262	32,957	100 0	100 0
Establishments that spin only	85	104	14 5	13.1
Spindles	167,278	246,880	10 7	12 3
Establishments that spin and weave	450	612	76 6	77.3
Spindles	1,390,294	1,764,613	89 3	87 7
Looms	26,738	31,614	98 1	95 9
Establishments that weave only	10	23	1 7	2.9
Looms	524	1,343	1 9	4 1
Miscellaneous establishments	42	53	7.2	6.7

their own wool, and in this respect there is but little difference between woollen and worsted mills. Moreover, in both branches the finishing is also as a rule done in the mills that weave the cloth.

It is in the intermediate processes that specialization exists in the worsted branch. Thus, one set of mills is engaged in combing and spinning only, or spinning alone, while another set is engaged solely in weaving. However, a few worsted mills, — and these comparatively large ones, — perform all three of the cardinal processes of combing, spinning, and weaving. The Census Bureau has had compiled two tables which show the degree of specialization in the two main branches of the industry. They show the number of mills engaged in each of the principal processes of manufacture, together with their capacity as measured by the number of combs, spindles, and looms.

¹ An "establishment," according to the Census Bureau, is a mill, or set of mills, in one locality under common ownership and operated as a single plant, with one set of books.

Of the 324 worsted mills reported in 1909 only 45, or 13.9 per cent of the total, were engaged in performing every operation; four did combing alone, 60 combined combing and spinning; and 134, or 41.4 per cent of the total, did only weaving. A glance at the woolen mill table shows that of the total of 587 mills, 450, or 76.6 per cent performed both operations of spinning and weaving, leaving 85 that spun only and 10 that did only weaving. (It must be remembered that there is no combing in the woolen process.) These figures suffice to show the greater degree of specialization in worsted mills than in woolen mills. But explanation of some of the items will demonstrate that the differences between the two branches are even more marked than the figures seem to indicate.

In comparing the proportion that each class of worsted mills formed of the total for the years 1904 and 1909, it will be seen that in each case where only one operation is performed, the per cent of the total increased. This is especially noticeable in the case of spinning mills and weaving mills. In each class where two or more operations are combined, the proportion of the total diminished, with one exception, — that of mills which combine spinning and weaving, — where the number increased from 23 to 42 and the proportion from 10.2 per cent to 13.0 per cent. The explanation of this increase is that many mills originally equipped with woolen machinery have changed over to the weaving of worsted goods. Looms intended for the weaving of woolen fabrics may be used in weaving worsteds, as mentioned above, but woolen spindles cannot be utilized in spinning worsted yarn; hence these mills have gone into the market to buy worsted yarn but have continued at the same time to spin some woolen yarn. If these mills were eliminated, or

thrown with the mills that weave only, the number that both spin and weave would have been about the same in the two years, and the proportion would have fallen appreciably. Altho the interval of time between the two census years is short for drawing general conclusions, the tendency toward a greater degree of specialization in the worsted manufacture is unmistakable.

Attention is called to the fact that altho only 45 of the 324 worsted mills reported in 1909 performed all processes, they contained well over half of all the combs, spindles, and looms in the industry. It might be inferred from this that the figures relating to number of establishments are misleading as a measure of the extent of specialization. As a matter of fact, these 45 mills include some very large ones, in many of which combing, spinning, and weaving are carried on in separate buildings, located in close proximity to each other. The mere fact that they are under a common ownership, and are thus reported by the census as a single establishment, does not mean that they are any less specialized than if the various departments were situated in different localities, and owned by independent corporations.

The existence of only four combing mills in 1909 is of particular interest, in view of the specialization in this branch in foreign countries. Here again the figures of the table are somewhat misleading, because a few of the very large establishments reported in the table as performing every process make a business of manufacturing tops for the market as well as for their own requirements. This explains how there can be 38 mills which spin only, because obviously the four combing mills with only 61 combing machines could not supply this large number of mills with tops. There are also three or four mills in the United States which

make their principal business that of scouring wool, but which also do some combing on commission. On the whole it has always been the usual practice in this country to combine combing with spinning. That there is a distinct tendency, however, to specialize in wool combing is evident first, from the fact that the number of separate combing mills, altho still small, is increasing; second, because the number of spinning mills has been increasing very rapidly (from 14 to 38 in five years); and third, because the quantity of wool tops purchased by spinners increased from 5,261,000 pounds in 1899 to 20,269,000 pounds in 1909. The table clearly shows that the combing departments of the large combined establishments, alluded to above, are undertaking this specialized top making to a greater extent than separate and independent top mills, because the number of combing machines in the mills that combine all three processes increased from 703 in 1904 to 1,181 in 1909, or from 53.6 per cent to 61.3 per cent of the respective totals. The proportion of spindles and looms, on the other hand, decreased, indicating that these establishments must have been increasing their output of tops more and more in excess of their own requirements.

As for the woolen branch, it must be remembered that we are dealing with an industry that is declining in number of establishments and barely holding its own in value of products. It will be observed that the proportion of spinning mills has slightly increased. Of the 85 such mills reported in 1909, however, there were no less than 18 or 20 which spun only carpet yarns, and many others which spun only yarn for knitting mills. The fact that the number of weaving mills declined from 23 in 1904 to 10 in 1909 is sufficient evidence that in the manufacture of woolen cloths there has been no tendency to increasing specialization.

Another marked difference between worsted and woolen mills is the greater average size of the former. In 1909 there were 324 worsted mills, producing \$312,625,000 worth of goods, an average output of \$963,040; there were 587 woolen mills which produced goods to the value of \$107,119,000, an average output of \$182,486. Worsteds mills employed an average of 343 wage earners per establishment; woolen only 89. The average number of worsted spindles working together was 10,787, while the average number of woolen spindles was only 2,911. There are comparatively few small worsteds mills, while in Lawrence, Massachusetts, there are three mills which are among the largest in the world. On the other hand, there are many small woolen mills scattered throughout the country districts the inclusion of which reduces the average size; if these were eliminated the disparity in size would not be so extreme, tho it would still be marked. Large-scale production therefore exists to a much greater degree in worsteds than in woolen mills, a condition which is to be expected in an industry which is highly specialized; in fact the reasons underlying specialization largely account for the varying size of producing units.

Another feature of the organization of the industry is the existence of what has been referred to above as horizontal specialization. In the worsteds branch it is the rule for weaving mills to specialize on particular kinds of fabrics. One mill makes only serges for men's wear; another, fancy worsteds; a third, light-weight worsteds for women's wear. Even in the manufacture of a particular class of fabrics, mills may be further subdivided according to the quality of goods produced, or, what amounts to the same thing, the quality or fineness of yarns used. Still other mills devote their energy exclusively to the manufacture of cotton-warp

goods. It is, of course, common for a mill to turn out different kinds of fabrics and different qualities of the same fabric, but in general it may be said that there is in this respect a marked degree of specialization in the worsted manufacture. Conditions are different in the woolen branch; specialization in fabrics is not so common. Woolen goods are of such endless variety that there are few staple or standard fabrics in the trade. Each mill turns out various grades of goods and uses various combinations of different kinds of wool, and of mixtures of wool with shoddy and cotton. Only when woolen goods are manufactured on a very large scale, as in the case of the American Woolen Company, is it possible to allow a single mill to work exclusively on one class or on a narrow range of fabrics. The practice of carrying out this "plant specialization" to the uttermost extent is an important feature of the American Woolen Company's organization.

Before inquiring into the reasons for the different degrees of specialization in the two branches, let us compare the organization of the industry in the United States with that in Europe. In England, where the wool manufacture has reached the highest development, we find, as in this country, the two distinct branches, woolen and worsted. The worsted branch, instead of being of recent development as in the United States, is old, and it became subjected to the factory system before the woolen branch.¹ Until shortly before the industrial revolution, the worsted trade was concentrated in and about Norwich in the East of England, where it had been in existence for centuries. Since the advent of the factory system, however, the industry has all but disappeared from the

¹ Clapham; *Economic Journal*, vol. xvi, p. 517. I am indebted to Professor Clapham for much of my material on the organization of the industry abroad.

East of England and has become concentrated in the West Riding of Yorkshire. There Bradford, Leeds, Huddersfield and the neighboring cities constitute the leading wool manufacturing center in the world. So far as the worsted branch is concerned, this section has almost a monopoly in England; of the 2,823 combing machines in the United Kingdom in 1904, all but 280 were in the West Riding.¹ The woolen trade is also heavily concentrated in this district, altho there are many mills in Scotland, Ireland, the West of England, and other sections, — a condition corresponding to the relative distribution of the two industries in the United States.

As for specialization, the same in general is true in England as in the United States: the worsted manufacture is subdivided into its various processes, while the woolen manufacture is marked by combined businesses. But in both branches, especially the worsted, specialization is carried further than in the United States. In the worsted branch there are two types of independent mills which exist to a very limited extent in this country — combing mills, and dyeing and finishing establishments. We have seen that in the United States it is the custom for spinners either to comb their own wool, or to buy their tops from large mills which make them in excess of their own requirements. In England, altho some combing is done in combined establishments, the great bulk of it is performed in a separate set of factories called "top mills," which usually comb wool on commission for spinners or, more commonly, for merchants, — the so-called "top makers." Furthermore, it is unusual for a worsted spinning or weaving mill to dye or finish its own goods. Whether the wool be dyed "in the yarn,"

¹ Clapham, *Woolen and Worsted Industries*, p. 20.

or "in the piece," it is generally done on commission by a separate set of establishments. The principal dyeing and finishing plants are combined into the Bradford Dyers' Association, which Professor Clapham, in his *The Woolen and Worsted Industries* characterizes as "probably the most successful of British industrial combines."¹ In the United States it is the almost universal custom for wool manufacturers to dye and finish their own goods, altho there are a few yarn dyers who do business in a small way, especially in Philadelphia, where specialization has been carried further than anywhere else in the country.²

The most interesting and important difference, however, is the existence of the highly specialized wool-combing branch, which has always existed in the worsted trade in England. The combing of wool, altho at first blush apparently simple, is one of the most difficult and intricate of the processes of wool manufacture, and it was the last to be taken over by machinery. Mechanical combing was not perfected until between 1842 and 1853 as a result of the inventions of Lister, Heilmann, Donisthorpe, Holden, and Noble. Prior to that time practically all combing was done by hand, which undoubtedly accounts for the non-existence of the industry in the United States prior to 1860. This country has never paid much attention to the manufacture of combing machines except such as are suitable for the manufacture of carpet yarns, and even today about eighty per cent of those in use in the worsted industry are of foreign manufacture.

Inasmuch as combing was already a separate occupation in England, and had been for centuries, it was only

¹ P. 151.

² The industry reported as "dyeing and finishing" in the census reports is composed principally of mills which dye, bleach, print, and finish goods for the cotton trade.

natural that it should have continued so when it became subjected to mechanical manipulation. Furthermore, some of the inventors of combing machines, after successfully staving off, through litigation, infringement and usurpation of their patents, established top mills and worked their own combs on commission for spinners. The firm of Isaac Holden and Sons, which has large combing mills in Bradford, as well as on the Continent, is a case in point. To this day, Holden combs are confined almost exclusively to these mills. Professor Clapham assigns as further reasons for the existence of a specialized wool combing industry in England the greater economy due to the specialized knowledge of managers and foremen in this delicate and complicated series of processes; the possibility of running combing mills both day and night; and the growing practice among spinners of buying tops instead of wool. The tendency in England is toward greater specialization in this branch of the industry, and there have been a number of instances in Yorkshire of late years where combined combing and spinning plants have split apart.

In the woolen trade in England specialized spinning and weaving plants are comparatively scarce, and while it is the general rule for woolen mills to do their own dyeing and finishing, many have this work done on commission, as in the worsted trade. It is in this respect that the woolen trade may be said to be more highly specialized in England than in this country. There are a few specialized English woolen spinning plants, but they have been declining in number, and many of those that still exist make yarns for carpet and knitting mills, rather than for weavers of woolen cloths; a condition analogous to that in the United States.

On the Continent there is the same difference in organization between the two branches. In France

worsted predominate over woollens to a marked degree; in 1904 the proportion of worsted to woollen spindles was roughly as six to one. The industry is highly centralized, tho not to the same extent as in England. Its headquarters are at Roubaix-Tourcoing on the Belgian border near Lille, this district performing over 80 per cent of the combing and about half of the spinning and weaving for the whole country. The tendency is towards greater specialization and localization. In and about Reims, the second most important worsted section, there was but one mill in 1904 that combined spinning and weaving,¹ and this subdivision of processes is typical of the other worsted sections. The woollen trade is much more scattered, and is not marked by specialization.

An interesting feature of the industry in France is the existence of an active future market in tops at Roubaix where this commodity is bought and sold for speculative purposes. This is the only form from raw state to finished cloth in which wool may be sufficiently standardized to be dealt in speculatively; but even in the case of tops there is much opportunity for "mixing in" inferior wools which defy detection, and consequently abuses have crept in. There has been criticism of the operations of the Roubaix top market, but a movement to abolish it a few years ago resulted only in a tightening of the legal regulations. A similar market exists in Belgium at Antwerp, and there was formerly one at Leipsic which was abolished in 1899 by the German Government at the request of the trade.

In Germany the conditions, so far as specialization is concerned, are about the same as in France and England. The worsted branch shows the greater development

¹ Clapham, *Woolen and Worsted Industries*, p. 226.

during recent years, and this is made up of separate combing, spinning, and weaving mills. Combing and spinning are sometimes combined, but spinning and weaving very rarely. The industry is not yet full-grown, because it has never been able to spin enough yarn to supply the weaving mills; consequently large quantities of worsted yarn are imported from England, a fact which helps to make spinning a separate business in both countries. The industry is not concentrated in any one locality as in England and France but has four or five principal wool-combing "centers," about which the mills are segregated, much as in the United States. The woolen trade is not as specialized as the worsted, altho in 1897 only half the woolen yarn used was spun in combined spinning and weaving mills¹ thus showing a much higher degree of specialization than in the United States. The prevalence of an extensive hand-weaving trade is one reason for the existence of separate spinning mills.

Two questions arise from this review of the organization of the industry at home and abroad: first, why is the worsted branch more highly specialized than the woolen branch; and second, why it is that in the worsted manufacture combing has become more highly specialized in Europe than in the United States? Since the reasons underlying specialization largely account for the differences in relative size of plants and in the distribution of the two branches, these two features will not be considered separately.

It will be remembered that the main difference in organization between the two branches is that in the worsted manufacture spinning and weaving are done largely in separate plants, while in the woolen they are ordinarily combined in the same mill. In 1906

¹ Clapham, p. 248.

there appeared in the *Economic Journal*¹ an article by Professor Clapham in which he dealt with this very difference between the two branches, and sought reasons therefor. He gave as his first reason the historical fact that the factory system became established in the worsted branch a generation earlier than in the woolen; that specialization existed even before the advent of the factory system; and that mechanical worsted spinning and weaving were common while woolen spinning and weaving were still a combined household industry. It was only natural, therefore, that worsted should have continued as a specialized business, and that the woolen process should have been taken over *in toto* by factories when they were finally organized. If we attempt to apply this explanation to the difference as it exists in America, we find at once that it does not apply, because, as has been pointed out above, the worsted manufacture was practically non-existent before 1860, and did not become prominent until after the War, while the woolen industry had existed since early colonial times, and had been subjected to power spinning and weaving before the worsted branch appeared. Not only is this explanation inapplicable to the United States, but the experience in this country would seem to indicate that it does not deserve the importance attributed to it as an explanation of the difference in England. Professor Clapham himself has modified his views; for in his excellent book on *The Woolen and Worsted Industries* (1907) he treats the historical fact as subordinate, and says in speaking of the woolen branch:² "mere tradition would not have kept the combined businesses in existence, had technical and commercial considerations favored subdivision."

¹ Vol. xvi, p. 515.

² P. 149.

In this later work, Professor Clapham lays particular emphasis on the external demand for worsted yarn as causing specialized spinning in England. Power worsted spinning started in Yorkshire while hand weaving was still carried on in the East of England, causing a considerable demand for Yorkshire-spun yarn in that section. When this demand subsided with the disappearance of the weaving industry in the East, an immense export trade in worsted yarn gradually developed, and has continued in increasing quantity ever since; in 1905 the exports of worsted yarn from England were valued at over \$25,000,000. In addition, there is also a considerable demand for worsted yarns among knitting mills. The importance attached to this explanation by Professor Clapham is evident from his statement that "it is the continuance of this external demand in various forms which, more than anything else, has favored specialization."¹

Yet again, when we attempt to apply the explanation to American conditions, we find the external demand for worsted yarn to be meagre. There is practically no exportation, and a low tariff would undoubtedly lead to heavy importations. There is some demand on the part of hosiery and knitting mills, but in 1909 they bought only 10,370,000 pounds, while worsted mills purchased 53,327,000 pounds. Some of the worsted spinning mills also provide yarn to carpet manufacturers, but the principal demand is from worsted weavers themselves. The existence of an external demand for yarn does, of course, encourage separate spinning mills, and accounts for specialization to a certain extent both in England and the United States. But there are other considerations which are more fundamental, and which would undoubtedly cause a

¹ Clapham, *Woolen and Worsted Industries*, p. 141.

separation of the two processes if there were no external demand at all. The explanation must be sought within the industry itself.

It is an industrial commonplace that a high degree of specialization is possible only where there is a large output of and continuous demand for a uniform or standard product. When a mill makes a great variety of products, and especially when any degree of individuality is necessary to success, specialization is rendered difficult, or even impossible. This very difference exists between the worsted and woolen trades. A large proportion of worsted fabrics are "staples," the most important today being the highly popular "serge." Many large worsted mills operate on a single class of fabrics year in and year out, and use practically the same kind and quality of worsted yarn. There are therefore standard grades of worsted yarn constantly in demand. In the woolen trade there are almost no staple products. The mills produce "fancies," and the fabrics made by woolen mills have individual characteristics of their own. The success of the woolen manufacturer depends to a large extent on the quality and character of the yarn he uses, and there are hardly two woolen weavers who use yarns exactly alike. The blending of different kinds of wool is an important item; shoddy may be, and very commonly is, mixed with virgin wool in making woolen yarn; oftentimes cotton is carefully mixed with wool in the carding operation. All these things require the manufacturer's personal supervision, and render it necessary for him to spin his own yarn.

The difference in the character of the yarns goes far to explain the absence of specialization in the woolen trade, and the possibility of specialization in the worsted manufacture. It accounts also in part for

the greater average size of worsted mills, and their concentration within comparatively small areas. Homogeneous and uniform output, with a constant and ready market, is always conducive to large-scale production; while the fabrication of goods of varying qualities and innumerable patterns requires more individual attention and tends to curtail the scale of operations.

One reason that has been urged for the combination of all processes in woolen mills is that when they were first established in this country, they were necessarily so far apart, and transportation facilities were so poor, each mill was obliged to perform every step. But the absence of any tendency toward subdivision of processes today, when there are a hundred woolen mills in Massachusetts alone, indicates the weakness of this explanation. The fact is that woolen weaving mills are practically forced to do their own spinning because standardization of woolen yarns is impossible and hence there is no need of their being near to other mills. In the worsted manufacture, on the other hand, where the product of one set of mills becomes the raw material of another, there is ample reason why they should be concentrated within small areas.

Conclusive as this reasoning may be for the non-existence of specialized woolen spinning, it does not sufficiently account for the separation of spinning and weaving in the worsted branch. Even tho worsted yarns are capable of standardization, this fact would not prevent their being made in a combined mill. And this brings us to more technical considerations. It has already been pointed out that the preparatory processes are more complicated in worsted than in woolen spinning. In the latter, except for a few minor steps, the wool goes straight from the carding

engine to the spinning mule. In the former the wool, before it is ready for the spindle, has to go through a series of gill boxes, then through the combing machine proper, then through perhaps a couple more gill boxes, and finally through a number of machines for the drawing operation. There are thus a number of distinct steps in the preparation of wool for worsted spinning, while wool destined for the woolen spindle goes through but one. All these operations require careful supervision and concentration of energy, and it follows that much better results can be obtained — both as to quality and economy — if all are done in a separate establishment, rather than in a mill where the weaving and finishing operations are also carried on.

Furthermore, the complicated nature of worsted spinning makes necessary a much larger capital outlay, both because of the additional machinery required and the necessity of carrying larger stocks of wool and other materials. Only large corporations have sufficient capital at their command to equip a worsted mill thoroly for performing every operation from scouring the wool to finishing the cloth on a scale large enough to insure economical operation. It is interesting to note that during the stagnation in the wool trade in 1911 many of the failures among worsted mills were of comparatively small establishments which attempted to carry on all operations under one roof. To operate a small worsted mill which combines all operations would be somewhat analogous to attempting the production of structural steel from iron ore, in a small plant. The scale of operations possible in a plant equipped with one blast furnace, a single open-hearth furnace, a small rolling mill and a machine shop to match, would never justify the capital outlay. This

line of thought therefore furnishes another reason for the greater average capacity of worsted mills than of woolen mills.

In a worsted mill which combines all operations, the amount of capital tied up in the shape of raw wool and semi-manufactured products is an important item. Various grades of wool have to be kept on hand, and large quantities are constantly in process of manufacture, because sorting, scouring, combing, drawing, and spinning must be carried on simultaneously. Moreover, yarns of different counts and different colors must be kept in stock ready for the weavers. A concern which specializes in weaving alone buys only such yarns as it needs, and when it needs them. The spinner likewise buys his tops as the occasion demands. Neither is obliged to carry any quantity of semi-manufactured articles, and the consequent saving undoubtedly encourages the building of comparatively small specialized plants.

Still another reason for the existence of specialization in the worsted industry is the fact that many worsted weaving mills use not only different counts and grades of worsted yarn, but often considerable quantities of cotton, silk, and mohair yarns. Altho not a fundamental reason, this practice on the part of some mills undoubtedly encourages the purchase of worsted yarn from outsiders, rather than the manufacture of it within the mills themselves. As fabrics become more diversified, and as competition increases, weavers demand a greater and greater assortment of yarns, and they consequently suffer an increasing disadvantage if they try to do their own spinning. Even if a manufacturer does combine spinning and weaving, he is often obliged to seek in the open market certain grades of yarn which it does not pay to produce in his own mill.

One other contributing cause is undoubtedly to be found in the fact that many so-called worsted mills were formerly woolen mills, and that since they could use their woolen looms in weaving worsted fabrics, they naturally bought worsted yarn from those already in the business. It is fair to assume that when mills equipped with woolen cards, spindles, and looms have abandoned the manufacture of woolens and taken up the manufacture of worsteds, they have done so because the woolen manufacture had proved unprofitable; and it is not likely that they would have been in a position to raise the large amounts of capital necessary for the installation of worsted combing, drawing, and spinning machinery. The fact that woolen looms may be used in weaving worsteds has undoubtedly saved many mills from failure during the change in popular demand from woolens to worsteds.

There are therefore abundant reasons why woolen mills should combine spinning and weaving, and why worsted mills should devote themselves to one or the other of these processes. There remains to be explained the fact that the worsted manufacture has become even more highly specialized in Europe, where there exists a separate set of top mills.

The reasons assigned by Professor Clapham for the existence of a specialized top industry in England have already been noted, — the pre-factory organization of the worsted industry when hand combing was a separate and important occupation; the exploitation of patents by the inventors themselves; the greater economy resulting from specialized knowledge of managers and foremen; the possibility of running top mills both day and night; and the growing custom among spinners of purchasing wool in the form of tops rather than in the raw state. England also has an important

export trade in tops, as well as in yarns, and this is another factor which tends to specialization in combing. It will be observed that the first two reasons are historical, and that in so far as they account for the separation of combing from spinning in England, they also account for their combination in the United States. There was no hand-combing occupation in existence in this country when the worsted factories were started, and hence it was inevitable that the few pioneers who risked their capital in the early spinning mills should comb their own wool. When the future of the worsted industry was still problematical, it is unthinkable that either independent combing or spinning mills should have been established; since there was neither a sure market for tops nor a certainty on the part of spinners that they could procure tops from outside sources. The market for worsted yarn was also uncertain, because even during the seventies, when worsted suitings¹ were being manufactured for the first time on a large scale, it was the opinion of many in the trade that the business was precarious, and that a change of fashion might cause the industry to wane. The fact that combing and spinning machinery, as well as artisans to operate them, had to be imported from England also possibly encouraged the combination of the two processes in one mill. Furthermore, there were no American inventors of combing machines to exploit their own patents, and no foreign capital ventured into the worsted industry in this country, as it has done in recent years.

These reasons explain the combination of combing and spinning in the early days of the industry, and the custom became so firmly fixed that it has retarded

¹ The common worsted suitings which have become the great staple of the trade were not manufactured in this country until about 1869. Prior to that time worsted fabrics consisted mainly of dress goods for women's wear.

a development which, for technical reasons, might have begun earlier. The manufacture of tops for the open market did not begin in this country until about 1894 when the Arlington Mills of Lawrence, Massachusetts, ran their combs day and night in order to make a surplus of tops with which to test the market. Encouraged by the success of the experiment, by the demand for tops shown by the importation of foreign-made tops under the low twenty per cent duty of the Wilson Bill, and very likely by the thought that the next tariff revision would render the duty on tops prohibitive (as it had been previous to 1894), the Arlington Mills built a separate top mill to provide combed wool for worsted spinners. In 1898 this company published a little volume entitled *Tops: a New American Industry*, which gave a description of the new mill and the principal reasons for embarking on the enterprise. Since that time, as has already been pointed out, the trade in tops has increased rapidly, and altho there were only four independent mills in 1909 which combed exclusively, there were a number of large factories like the Arlington Mills which operated separate combing departments and made tops in excess of their own requirements.

There must, therefore, be commercial and technical reasons, more important than tradition, which account for the continued separation of combing from spinning in foreign countries, and for the tendency towards greater separation in this country; and these are exactly analogous to the reasons already advanced for the separation of worsted spinning from weaving. In the first place, tops, even more than worsted yarn, are a homogeneous and staple product and can be traded in with a fair degree of security, as is shown by the existence of future markets in Europe. Worsteds

mills are concentrated in small areas in the United States; good transportation facilities exist; and there has already grown up a body of merchants to act as middlemen between factories. Commercial conditions are therefore ripe for greater specialization. Again, the preparatory processes are so complicated and involve so many separate steps that greater economy may be attained by splitting them in two — combing in one plant, and drawing and spinning in another — just as technical reasons have led to a separation of spinning and weaving.

In European countries keen competition has undoubtedly hastened the tendency toward separation of combing and spinning. The margin of profit has unquestionably been higher in the worsted industry in this country than it has been abroad, and there has not been the same necessity for effecting the additional savings which would accrue from specialized combing. With a growing diversification of fabrics in recent years there have come into use a greater variety of blends of different wools, and as the spinner has to vary the quality of his yarns in accordance with the varying demand of the weaver, he must necessarily use different qualities and grades of tops. To attempt to carry in stock the different wools, and to make a small quantity of this grade of top and that grade, as the occasion demands, would necessarily be expensive. In other words, the spinner finds it cheaper to buy his combed wool from top specialists than to attempt to manufacture it himself. This increasing diversification of the industry is extremely important in its effect on specialization, especially in Europe. The English mills are not only adaptable to new conditions but they are continually devising new fabrics for their foreign trade. American mills have not been troubled by

foreign competition nor by a need of holding foreign markets; consequently there has been less diversity of fabrics and less demand for a variety of tops and yarns. Competition at home, however, has been bringing about gradually a state of affairs similar to that abroad, and as the industry develops, and as a greater variety of fabrics is produced, we may look not only for a greater degree of specialization in regard to spinning and weaving, but also for a separate and well established wool-combing branch.

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