From Sub-Contracting to Vertical Integration: Organizational Innovation in Spanish Cotton Industry, 1830-1870

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Like in many European countries, the development of cotton industry was central to early industrial development of Spain over the 19th Century. More specifically, cotton industry was the largest employer in manufacturing and concentrated the major private-owned manufacturing firms.[1] Moreover, this industry was the first to import power-steam technology and modern machinery from abroad and was also pioneering in introducing factory-based production.[2]

The history of Spanish cotton industry is mainly concentrated in Catalonia.[3] Textiles were well established at the region, and Barcelona was an important urban textile centre, since 13th Century. However, it was during the 18th Century and, most especially after 1780s, that cotton textiles became an increasingly important dimension of the Catalan economy.[4] Moreover, Catalonia was the largest cotton textiles producer in the Mediterranean basin although this industry was minuscule when compared with Britain; by 1850s, the British cotton industry was about seventeenth times the size of the Catalan cotton industry.

The development of cotton textiles in Catalonia was gradual and was marked as much by continuity as by change. Nevertheless,

[1] For example, according to the most complete industrial guide of the period (Gimenez Guited 1862), the cotton industry concentrated more than the 60 per cent of labour in manufacturing establishments of 50 or more workers.
[2] Nadal (1974).
[3] By 1861, this region produced about the 75 of the Spanish cotton textiles. However, some years earlier these indices of concentration were even higher when Catalonia enjoyed with a practical monopoly of the factory-based cotton industry in Spain. Thus, in the 1850s, new factory-based cotton industries emerged in the South (Málaga) and the North (Vizcaya and Guipúzcoa) of the country.
[4] By 1860, cotton textiles employed about one third of Catalan industrial workforce and about one tenth of overall workforce.

transformation was not without its discontinuities. A major turning point was created by the shift from organic (hands and horses) to inanimate (steam and water) as a main source of motive power in the 1840s and 1850s. This technological breakout was accompanied by the triumph of factory-system and the transition from sub-contracting to vertical integration[5] of cotton spinning and weaving.

Precisely, this article analyses when and why this organizational change took place in Catalonia. It happened during the period of the early industrialization when local firms adopted the most modern British machinery. However, this movement from specialized to integrated firms was not determined by the adoption of technology; quite the contrary, it was the presence of transaction cost problems that generated the development of this particular form of industrial organization.

In a broad context, the arguments developed in this paper can be inserted into the debate on the role of vertical integration into the development of cotton industry. Several authors have linked the demise of Lancashire's cotton industry with a lack of vertical integration. They argue that the superiority of the U.S. cotton firms over their British counterparts was due to the massive adoption of vertical integration in the United States.[6] Although not the main issue, the results of this chapter could serve to throw light on that debate. Spanish evidence shows that intermediate markets size could account for a part of vertical integration. Consequently, regions with large (and efficient) markets for intermediate inputs like

[5] Since there is more than one definition of vertical integration, it seems convenient to clarify how this term should be interpreted throughout this article. Perry (1989: 185) defined vertical integration as the elimination of trade or contractual exchanges within the borders of the firm. Note that, due to practical reasons and the constraint of the available empirical evidence, it was assumed that the firm that possesses machinery of one production phase is vertically integrated in that phase. However, this is not completely true since full vertical integration only takes place when the firm has not bought goods that it can produce. It should also be noted that, for data constraints, this analysis ignores hybrid forms such as long-term contracts, partial ownership agreements and alliances that certainly existed among Catalan cotton textile firms.

[6] See a review of the debate in Leunig (2001).

Lancashire would not need to develop vertically integrated firms to efficiently develop their cotton industry. Instead, for regions where these markets did not work well or firms were relatively isolated vertical integration was the best option.

The paper is organised as follows. The following section introduces to the reader on the chronology and the main characteristics of the development of the Catalan cotton industry. Then, I present a detailed account of the relative importance of the vertically integrated factories whereas the fourth section investigates the major determinants of the choice between specialization and integration among Catalan cotton firms. Finally, the last section concludes and summarises.

1. The Development of the Spanish Cotton Industry

Before to proceed further it may be helpful to offer a brief description of cotton processing, and to review the process of technological advance in this industry. From the technical point of view, the production of cotton goods can be divided into three phases: (1) preparation and spinning, (2) weaving and (3) finishing. The spinning sector converts raw cotton into yarn or thread, which can then be woven or knitted into cloth, or used for sewing or lace. Yarns are classified by their fineness, with high numbers ("counts") indicating a finer yarn, and as "warp" or "weft". Warp yarns, which are stronger than weft, are held in position during weaving while weft yarns are interlaced between them to make cloth. The weaving sector transforms yarn into cloth. A single package of weft yarn is placed in a weaving shuttle; that shuttle is then shot back and forth between the warp threads in order to make cloth. The different types of cloth are elaborated with different combinations of weft and warp yarn and with different counts of yarn. Commonly, finer-quality cloth is elaborated with fine yarn and lower-quality cloth with coarse yarn. After weaving, the woven cloth was usually grey, but

consumers wanted white fabrics, and hence the grey cloth had to be bleached. Once bleached, cloth can also be printed with different colours and designs.

At the very beginnings of the nineteenth century the fine-spinning branch was the most technologically advanced and the first in applying steam-power to the machinery.[7] These substantial improvements cheapened finer yarns, which had noticeable effects on both exports and cloth fashion in Britain.[8] The first factories also appeared in fine cotton spinning although on the shop floor of these factories sub-contracting dominated other forms of labour management.[9] By the 1830s, however, technological leadership moved to the production of coarse cloth.[10] The improvements in the application of power to cotton textiles production had large consequences on the costs of production of coarse cloth because coarse spinning was very power-intensive.[11] In particular, the new steam engines helped the adoption of the self-acting Mule, cheapening the production of coarse yarn. In coarse spinning, labour force was less skilled, which went hand in hand with the adoption of foremanship.[12]

Technological change was slower in weaving than in spinning. Although introduced at the end of the 18th century, the first profitability power looms dated back 1813. Early power looms were best suited for weaving lower-quality cloth, which was wowed with coarse yarn. In the 1840s and 1850s, the adoption of high-pressure steam engines, and the subsequent decrease in power costs, extended the range of cloth that

[7] It is well known that a great part of the progress in cotton technology during the period was due to British engineers. On the British advances during the period see, for example, Chapman (1987), Von Tunzelmann (1978), Ellison (1968), and Mann (1968).
[8] Von Tunzelmann (1978), p. 224.
[9] Cohen (1990), pp. 35ff. and Huberman (1996).
[10] Von Tunzelmann (1978), pp. 184ff.
[11] Von Tunzelmann (1978), pp. 186ff.
[12] Huberman (1996) and Clark (1994).

could be produced efficiently with power looms.[13] This signified the progressive demise of hand weaving, which survived in the fancy segments of the market. It is also important to note that power looms required high-strength yarn, which was more economically produced with Throstles or Self-Acting Mules.

As in cotton spinning and weaving, technological advance modified drastically finishing processes during the second half of 18th Century.[14] Bleaching had been traditionally been carried out on bleaching fields, using sunshine and primitive acids. The use of sulphuric acid by mid-century and later on, by the 1790s, the introduction of chlorine reduced the time taken for the process from several months to little more than a day. Moreover, water and steam power were applied to various types of machinery including dash wheels, drying machines and calenders. In printing, hand processes with wooden blocks and copper plates being replaced by engraved copped rollers mechanically powered by mid-1780s. These new machinery increased dramatically the speed of printing and labour productivity. However, similar to weaving, block prints still had to be used in finishing patterns on fine goods after cylinders had printed most of the design.

The early history of the Spanish cotton industry is well known thanks to an abundant literature.[15] The first enterprises devoted to printing cotton cloth were established in Barcelona in the late 1720s.[16] These calicoes were sold in the protected markets of the *Peninsula* and the

[13] See Von Tunzelmann (1978), chapter 7. Instead, Farnie (1979) and Lyons (1987) gave importance to the development of the Blackburn plain loom in 1841.
[14] This paragraph is based on Timmins (1996).
[15] Ferrer Vidal (1875), Figuerola (1968), Gutiérrez (1837), Ronquillo (1851-1857) and, more recently, Agustí (1983), Nadal (1974), Sánchez (1989)(1996)(2000) and Thomson (1992).
[16] On the history of the cotton industry in Catalonia before 1830 see Thomson (1992), Sánchez (1989)(1992) and Delgado (1995).

Spanish colonies in America.[17] Because for most of the eighteenth century all cotton yarn was imported, as well a large part of the grey cloth consumed, cotton spinning and weaving were not important. Particularly, local cotton spinning and weaving industry did not launch up to the 1780s. The first spinning jennies appeared in Barcelona in 1784 imported by French technicians.[18] By 1792, an English engineer introduced an enhanced jennie (with 78 spindles instead of the common 40 spindles) and a new card machine.[19] Simultaneously, several Water-frames, also from England, were imported into Catalonia.[20] The diffusion of Jennies among local producers was immediate.[21] More prominently, local technicians not only were able to produce copies of the original spinning jennies but also developed a large jenny with more spindles (sometimes it had up to 120), which received the name of Bergadana.[22] From 1797, the first Water-frames, which were powered by water wheels or horses, became installed in Catalonia.[23]

A further impulse to the local production of cotton yarn and cloth was given by the ban of foreign imports in 1802. Moreover, in 1806, several Mule-Jennies also powered by water wheels and horses, but wood made, arrived from France and were rapidly copied and installed into local mills. [24] In the thirty years that followed the ban, Catalan production of cotton yarn expanded rapidly although mainly based on small domestic units. The majority of the industry tended to remain dispersed in the remote villages and small towns of the Pre-Pyrenees, where they could rely upon a good supply of cheap female and child

[17] There is a large debate on the role played by the colonial and home markets in the development of Catalan cotton industry. On this aspect see the review of the literature in Delgado (1995).
[18] See a detailed account of this introduction in Thomson (2003).
[19] Thomson (1992), pp. 253-254.
[20] Thomson (1992), p. 249-250.
[21] Sánchez (2000), pp. 495-496.
[22] Ferrer Vidal (1875), p. 101.
[23] Sánchez (2000),cuadro 4.
[24] Sánchez (1989), p. 38; Thomson (1992), pp. 263-264.

labour, rather than becoming concentrated in the calico centre of Barcelona.[25] Due to its unskilled workforce, Catalan spinning concentrated on the low grades of yarn (below 20 count). This domestic industry experienced a certain technological progress since Bergadanas replaced Jennies.[26] At the same time, several new mills powered by water wheels or horses and equipped with Mule-Jennies and Throstles were established. As the table 1 shows, the number of spindles grew from about 95.000 (of which 13.000 were mechanical) in 1807 to more than 1.1 million (of which 128.000 were mechanical) in 1830.

Table 1.
Evolution of spinning machinery in Catalan cotton industry, 1807-1861

	1807	1830	1841	1850	1861
Hand Spindles	82,870	1,034,048	725,787	180,058	7,366
Mechanical Spindles					
Water-frames	10,980				
Throstles		32,020	34,680	51,040	57,297
Mule-jennies	2,040	96,169	281,640	376,810	133,693
Self-actings				96,328	572,970
Total	13,020	128,189	316,320	524,178	763,960
Total	95,890	1,162,237	1,042,107	704,236	771,326

Sources: 1807: Sánchez (2000); 1830: Rosés (1998); 1841: Madoz (1846), Sayró (1842); 1850 : Junta de Fábricas (1850); 1860: Gimenez Guited (1862) and Comisión Especial arancelaria (1867).

The first steam-powered mill appeared in 1833 when the company "Bonaplata, Vilaregut, Rull and Cía." began producing cloth made on power looms.[27] In the 1830s, the diffusion of steam-power and power-looms progressed slowly in Catalan cotton industry. By 1841 (see table 2), the

[25] Gutiérrez (1834)(1837), Sánchez (1989) and Thomson (1992).
[26] Sánchez (2000), p. 505.
[27] Ferrer Vidal (1875), Nadal (1974)(1983) and Thomson (1992).

power-steam was clearly the less important instrument of power: Of 2,014 HP employed in the Catalan mills in that year only 289, or 14 percent, was derived from steam. Nine years later the total HP employed in the industry had increased to 3,755 and the proportion attributable had soared to about 60 percent. Simultaneously, the amount of hand spindles declined dramatically from about one million in 1830 to 180,058 in 1850 (see table 1). By 1861, the demise of hand spinning was complete since cotton yarn was largely produced with modern steam or water-powered machinery. The total HP employed in the industry had increased to 5,800 and the proportion attributable to steam-power had also augmented to 67 percent.

Table 2.
Evolution of Power sources in Catalan cotton industry, 1807-1861

	1807	1830	1841	1850	1861
Horses	11	423	1,182	241	0
Water (HP)	39	186	543	1,374	1,914
Steam (HP)	0	0	289	2,140	3,886
Total	51	609	2,014	3,755	5,800
Proportion of steam to total power (percent)	0.00	0.00	14.35	56.99	67.00

Sources: See table 1.

The diffusion of the new machinery paralleled the increase in the quality of local production since the average count increased to 30 count from about 15 count.[28] In comparative terms, Spanish cotton cloth was coarser than British but finer than those produced in Italy and the United States.[29]

[28] Figuerola (1968), and Madoz (1846).
[29] Rosés (2000).

During the pre-steam period (from mid 1780s to 1830s), hand-weavers proliferated in the major Catalan manufacturing towns.[30] Catalan cotton cloth was also coarse due to the ban on cotton yarn imports. Nevertheless, skilled hand-weavers produced a wide range of qualities, and fancy goods, by using other textile fibres such as wool, linen and silk. The first power-looms were introduced in 1828.[31] By 1841, however, the balance between handlooms and power-looms remained clearly favourable for the hand machinery. In effect, for each power-loom in use, it was more than 100 handlooms. Nine years later (1850), the amount of power-looms had multiplied by twenty-five while the number of handlooms remained roughly the same. By 1861, the demised of hand-weaving was quite obvious given that the number of hand-looms halved with respect to 1850 figures while the number of power-looms multiplied by 1.7. Of the total cotton cloth wowed in that year in Catalonia only 24 percent was made by hand-weavers.[32]

For many different reasons, cotton printing was an extraordinary industry within the Catalan context of the 18th century. Since its beginnings, the industry was concentrated in Barcelona.[33] Moreover, the industry was based on centralised units of production although having several managerial structures, from capitalistic firms to artisans' co-operatives.[34] Thus, the typical unit of production was formed by several work-teams, which were composed of several masters, artisans and apprentices, and labourers. Consequently, the industry was established on the basis of medium-large establishments and extensive division of labour.[35] In the

[30] Sánchez (1989).
[31] Ferrer Vidal (1875).
[32] To estimate the production of the looms I assume that power-looms produced four pieces per week and handlooms one following Von Tunzelmann (1978). Lyons (1987) furnished a different figure: five pieces for the power-looms and one piece for hand-looms.
[33] Thomson (1992).
[34] Thomson (1992).
[35] See Grau and López (1975), Thomson (1992) and Sánchez (1989)(1992).

work-teams the workforce was highly skilled and practically all male. Despite the presence of skilled artisans the industry escaped the control of guilds and could be considered pioneer in the adoption of capitalist forms of organisation.[36]

However, calico printing was scarcely mechanised before the 1830s because few establishments had adopted the new British and French machinery.[37] Over the next thirty years, the process of adoption of the new machinery in calico printing was as slow as it was in cotton weaving; thus, by the 1860s, many hand-driven workshops and factories survived. It is necessary to underline that the new machinery in calico printing had large consequences for the skills of the labour force. In the hand-driven calico factories the quality of the final product was in the hands of the artisans since the homogeneity of colours and the perfect reproduction of drawings were a question of skills and experience. In sharp contrast, the new machinery simplified the process of printing and the skills required to obtain homogeneous coloration. With the new machines, colours were mixed before the process of printing and the drawings were stamped with metal plates. Thus, colours and drawings were more uniform and could be easily reproduced. Workers did not participate in the process but simply controlled the machines. One chemist with a few (unskilled) assistants prepared the colours for the whole factory. In other words, the new machinery transformed the highly skilled printers into unskilled workers. A contemporary observer, Ildefons Cerdá, stated that the old skilled printers were converted into simple labourers by the new printing machines.[38]

Despite all these progresses, Spanish cotton industry was not competitive in international markets during this early period and remained heavily protected by tariffs. This absence in international markets not only is

[36] Thomson (1992).
[37] On the mechanisation of calico printing see Nadal and Tafunell (1992).
[38] Cerdá (1968).

attributable to relatively lower efficiency than British industry but also larger input costs.[39] Consequently, the home protected market and the Spanish colonies were the unique market for Catalan cotton goods over the period and that market fluctuated severely following the cycles of agrarian production.

2. The Importance of Vertical Integration

Before the arrival of the vertically integrated factories by the early 1830s, the family-firm craft-shop, the putting-out or outwork system, the concentrated manufactures and the one-phase factories cohabited as forms of business organisation in the Catalan cotton industry. Two of these business institutions were based on decentralised small units and little division of labour. Under artisan production, a master craftsman with a few assistants, who were sometimes members of his family, ran a small unit-of-production. In these shops the extent of the division of labour was little and, hence, the same worker performed several different tasks and could make the whole product. The putting-out system was characterised as a decentralised production organisation where the producers used their own tools, and where work was localised to their own homes. In Catalonia, the two main types of putting-system were present. In the *verlag-system* the putter-out puts out raw materials or semi-finished goods to a producer and, at least to some extent, plays a supervisory role. In the *Kauf-system* the entrepreneur only collects the finished wares and sometimes supplies the producer with credit.

The concentrated manufactures predominated in the production of calicoes, mainly located in Barcelona, although they were also present in cotton weaving and spinning. They arrived at its height by 1768-1786, well before the advent of vertically integrated cotton factories. Since the early

[39] Rosés (2001).

19th century, Catalan cotton spinning industry became increasingly mechanized with the imports of hand-mules and few primitive Arkwright-type throstles. This leads to the development of many one-phase factories.

How these different types of firms structured their business relations? Jordi Maluquer has argued that in the Catalan cotton industry a kind of 'industrial district' predominated, where some capitalists controlled the production and where firms co-operated. He argues that the demand for textile goods in Spain, which was very volatile, provoked sub-contracting and that out-working was widespread. In other words, large-scale firms were not competitive. The industry was organised hierarchically since some capitalists controlled large putting-out and sub-contracting webs. According to Maluquer, this hierarchical structure served to avoid the fluctuations in the demand for cotton goods. At the peaks of the business cycle capitalists increased the number of sub-contractors, whereas the contrary held in the trough years. Finally, he argues that this system was very positive and efficient since it eased the development of the industry, the adoption of the new machinery, and did not reduce competition among firms.

The first Catalan vertically integrated firms in cotton spinning and weaving appeared in the last years of the eighteenth century[40] although this type of firm organization did not become relatively important up to the 1840s. According to the 1850 survey,[41] vertical integration was rather common among cotton spinning: 181 firms with 9,389 spinners were devoted exclusively to cotton spinning, and 56 firms with 4,235 spinners had integrated vertically into cotton spinning and weaving (see table 3).

[40] See Thomson (1992) and Sánchez (1989)(1996).

[41] This survey was conducted by the same employers organization, the Junta de Fabricas de Cataluña. The survey was divided in three parts: the first devoted to the cotton spinning establishments, the second to the cotton and mixed-fabrics weaving established and the third to printing establishments. It seems that survey covered all the establishments located in whatever part of Catalonia. For each category, the survey listed name of the proprietor/s, location of the establishment, the amount and type of machinery in use and operatives. Also, in the case of cotton and mixed fabrics weaving, the survey collected the amount of machinery stopped by the industrial crisis.

These firms also employed about half of the power installed and more than one third of mechanical spindles. Particularly relevant was their share in Self-acting Mules since they employed the 68 percent of that type of modern spinning machinery. In cotton weaving, the share of vertically integrated firms was less than in cotton spinning due to the abundance of very small firms, all hand-powered, in that industry. However, like in cotton weaving, vertically integrated firms concentrated the most recent machinery. For example, more than the 83 percent of power-looms were installed in vertically integrated firms. For that reason, more than the 40 percent of cloth production was in hands of these firms, even though they employed only the 15 percent of weavers.

Table 3.
The diffusion of vertical integration in cotton spinning and weaving, 1850

A. Spinning	Steam-power (HP)	Water-power (HP)	Horses	Spindles	Firms	Spinners
Specialized	1119	704	79	390172	181	9389
(percent)	52.7	52.8	79.8	64.3	76.4	68.9
Integrated	1003	630	20	216702	56	4235
(percent)	47.3	47.2	20.2	35.7	23.6	31.1
Total	2122	1334	99	606874	237	13624
B. Weaving	Power Looms	Jacquard Looms	Hand Looms	Production	Firms	Weavers
Specialized	582	977	16753	20058	891	37323
(percent)	16.4	85.3	92.1	59.8	94.1	84.4
Integrated	2965	168	1429	13457	56	6892
(percent)	83.6	14.7	7.9	40.2	5.9	15.6
Total	3547	1145	18182	33515	947	44215

Notes and sources: See text. From the table it had been excluded firms with less than 10 workers and hand-powered in cotton spinning.

In the 1850s, the vertically integrated cotton mills continued their expansion capturing the market for medium-coarse cloth. However, well before the 1860s, some horizontal spinning mills and domestic hand-

weavers survived by producing for more fashion-oriented segments of the market.[42] According to the industrial guide for 1861,[43] vertically integrated firms employed more than the 60 percent of spindles, more than the 80 percent of power-looms and produced the 64 percent of cotton cloth (see table 4). Moreover, in eleven years the number of vertically integrated firms had multiplied by 1.9 while the number of specialized firms decreased by about 20 percent in cotton spinning and more than halved in weaving.

Table 4.
The diffusion of vertical integration in cotton spinning and weaving, 1861

A. Spinning		Preparation	Spindles	Firms
Specialized		1145	293068	149
(percent)		40.2	39.1	58.2
Integrated		1701	457313	107
(percent)		59.8	60.9	41.8
Total		2846	750381	256
B. Weaving	Power-looms	Hand-looms	Production	Firms
Specialized	1713	9431	16283	411
(percent)	19.5	90.0	35.6	79.3
Integrated	7094	1049	29425	107
(percent)	80.5	10.0	64.4	20.7
Total	8807	10480	45708	518

Notes and sources: See text. From the table it had been excluded firms with less than 10 workers and hand-powered in cotton spinning. Preparation is the number of card machines working in the firm.

In comparison with England vertical integration was much more important in Catalonia.[44] According to Farnie (1979: 317) English vertically

[42] Comisión especial arancelaria (1867).
[43] The industrial guide for 1861 (Gimenez Guited, 1861) collected data on all cotton firms located in Catalonia. Unlike the census for 1850, it did not separate workers across the different phase since aggregate them by establishment and firm. Moreover, it did not furnish information on the different types of machinery indicating only if was hand-powered or mechanical-powered. Like the previous census, machinery was enumerated only when it was in use.
[44] To correctly compare Catalonia and England it is necessary to convert the Catalan evidence to the British standards. For this reason, only power and water-driven factories

integrated mills employed the 52.9 percent of workers, the 63.9 percent of power-looms and the 41.8 percent of mechanical spindles in 1861. Instead, in Catalonia these same type of mills employed the 65.8 percent of workers, the 80.2 percent of power-looms and the 55.2 percent of spindles.

The diffusion of vertical integration was not equal among the phases of the cotton industry because it was more common in cotton spinning and weaving than in finishing.[45] In 1850, only 4 of 57 firms devoted to printing also integrated vertically cotton spinning, weaving and printing. These vertically integrated firms had the 9 percent of workers and the 14 percent of steam-power employed in the cotton printing industry. As in the integration of cotton spinning and weaving, the integration into cotton printing progressed during the 1850s although remained relatively scarce in comparison with cotton spinning and weaving. By 1861, 7 of 41 firms integrated all phases and employed about the 24 percent of modern printing cylinders, but a less proportion of the old machinery. Therefore, specialized firms did a large share of cotton printing in Catalonia.

3. The characteristics of specialized and integrated firms

The previous section points that the relative importance of vertically integrated firms progressed from 1850 to 1861 and that they employed a large part of the most modern machinery, namely Self-acting Mules and power-looms, installed in Catalan cotton industry. This section will review other characteristics of vertically integrated firms as size, location and type of production in order to make a preliminary exploration of the determinants of vertical integration.

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with more than 10 workers were considered. This implies 25,366 workers of the 42,631 in Catalonia. Note also that the British sources do not report all labour because, for example, hand-weavers were not included. Gatrell (1977) offers a detailed description of the English sources.

[45] On the printing developments in Catalonia see Nadal (1991), pp. 34-37; and Nadal and Tafunell (1992), pp. 39-50.

According to the table 5, vertically integrated firms predominated among the largest firms in both, cotton spinning and weaving. In cotton spinning in 1850, only the 13 percent of firms with less than 1000 spindles were integrated vertically whereas this proportion grew to the 65 percent in the case of firms with 5000 or more spindles. Similarly, in cotton weaving in 1850, only the 2.5 percent of firms producing less than 100 pieces of cloth per week were vertically integrated whereas their share grew to 85 percent if one considers firms producing more than 500 pieces of cloth per week.

In eleven years, from 1850 to 1861, the average firm size grew considerably in cotton spinning and weaving mainly due to the increasing share of the largest firms in total production. Simultaneously, not only the share of vertically integrated firms into the largest firms grew but also their number. In cotton spinning the number of the largest vertically integrated firms (firms with more than 5000 spindles) doubled from 1850 to 1861 whereas in cotton weaving their number grew from 6 in 1850 to 16 in 1861.

Table 5.
The size distribution of cotton spinning and weaving firms, 1850 and 1861

A. Spinning Firms

Number of spindles		1-999	1000-1999	2000-2999	3000-3999	4000-4999	5000-7499	≥ 7500
1850								
Specialized	Firms	41	59	42	25	7	6	2
	Spindles	27148	85772	103392	85072	31956	38040	26112
Integrated	Firms	6	15	11	6	3	11	4
	Spindles	3960	23580	26360	20930	13588	68752	59412
Total	Firms	47	74	53	31	10	17	6
	Spindles	31108	109352	129752	106002	45544	106792	85524
1861								
Specialized	Firms	50	37	27	22	7	3	3
	Spindles	24208	54937	66172	73690	31180	16670	26231
Integrated	Firms	26	14	17	14	6	15	15
	Spindles	13336	19324	41298	48314	26724	89963	217800
Total	Firms	76	51	44	36	13	18	18
	Spindles	37544	74261	107470	122470	57904	106633	244585

B. Weaving Firms

Production in pieces		0-99	100-199	200-299	300-399	400-499	500-749	≥ 750
1850								
Specialized	Firms	970	18	2	1	0	0	1
	Production	15928	2560	442	320	0	0	800
Integrated	Firms	25	11	8	3	2	2	4
	Production	1042	1605	1958	1032	912	1130	5778
Total	Firms	995	29	10	4	2	2	5
	Production	16970	4165	2408	1352	912	1130	6578
1861								
Specialized	Firms	383	14	5	3	3	2	0
	Production	9385	2006	1388	992	1956	1240	0
Integrated	Firms	58	12	13	5	11	8	8
	Production	1707	1718	3056	1628	4908	4732	11672
Total	Firms	441	26	18	8	14	10	8
	Production	11092	3724	4444	2620	6864	5972	11672

Notes and sources: Spinning: The table only comprises mechanised cotton spinning firms with 10 or more workers. Weaving: Production in pieces is per week. The table only comprises weaving firms with 10 or more workers.

As the table 6 shows there were remarkable differences in the distribution of the vertically integrated firms across cotton districts in Catalonia. Larger shares of vertically integrated firms were common in districts with difficult road communications and, hence, relatively isolated like Garraf,[46] Gironés and Bages. Instead, the districts well connected with ports, like those of Barcelona and Tarragona, were relatively abundant in specialized firms.

Table 6.
The share (percent) of vertically integrated firms into the cotton production of the main districts

	1850		1861	
Districts	**Spinning**	**Weaving**	**Spinning**	**Weaving**
Alt Camp	26.89	29.27	1.52	9.21
Anoia	26.87	25.56	83.83	64.64
Bages	48.91	66.05	56.55	75.09
Baix Camp	73.42	32.40	91.19	90.29
Baix Llobregat	16.97	38.96	45.34	64.86
Barcelonés	32.11	36.66	66.29	59.00
Garraf	87.86	98.16	100.00	99.73
Gironés	50.21	82.03	58.30	99.69
Maresme	18.98	11.58	76.59	38.39
Osona	34.50	14.63	25.22	62.16
Vallès Occidental	16.43	4.17	27.50	32.26

Notes and sources: See text.

Previous accounts of the cotton industries tend to stress that specialized and integrated firms differed in both, type of products and the degree of specialization. Vertically integrated firms in England and the United States tend to produce coarser yarn, and hence coarser cloth, than

[46] The district of Garraf is relatively close to Barcelona but it suffered many problems of transport during this period. See the claims of the local firms in Comisión Especial Arancelaria (1867).

specialized firms.[47] On the other hand, specialised English spinners typically focused their production on a narrow range of counts while specialised weavers also concentrated in a relatively narrow range of cloths. Instead, English integrated firms producing for the domestic market tended to produce a wide variety of products.[48]

Table 6.
The relation between type of firm and cloth quality, 1860

Type of firm	Coarse cloth (counts below 20)	Medium cloth (counts 20-60)	Fine and Fancy cloth (counts 60 or more)
Hand Weaving	1	2	14
Power weaving	1	0	0
Printing	2	12	6
Spinning and Weaving	4	10	0
All phases	2	9	1

Notes and Sources: Some firms produced more than one quality of cloth. Coarse cloth: Curados, Cutíes, Driles, Empesas and Percalinas bastas. Medium cloth: Brillantinas, Elefantes, Empesas finas, Guineas, Hamburgos, Indianas normales, Madepolan, Muselinas, Panas, Percalinas, Retores, Ruanesas and Semi-retores. Fine cotton cloth and mixed fabrics: Batistas, Cashmires, Castores, Chalecos, Florentinas, Guatas, Indianas finas, Mantones, Pañuelos, and Piqués. The source of data is Orellana (1860), the classification of the quality of products is based on Ronquillo (1851-1857) and the classification of firms is based on Gimenez Guited (1862).

As table 6 shows vertically integrated firms in Catalonia, regardless of they integrated vertically spinning and weaving or all three phases, tended to produce medium-coarse cloth. Instead, specialized hand-weaving firms tended to produce fine and fancy cloth. Finally, cotton-finishing firms produced all type of cotton goods since cloth quality depended on the yarn employed. Commonly, these firms elaborated a reduced range of products

[47] Temin (1988).
[48] Brown (1992).

and were sub-contracted by cotton weaving firms. They therefore did not participate in the distribution of finished cotton cloth. In effect, the wholesale market of finished cloth was in hands of vertically integrated firms, weaving firms and some major wholesalers in Barcelona.[49]

Like in Britain, vertically integrated cotton firms in Catalonia tended to elaborate a more wide variety of products than specialised firms. Thus, weaving firms elaborated on average 1.4 different cloths (standard deviation of 0.79), printing firms elaborated on average 1.8 different fabrics (standard deviation of 1.05) and vertically integrated firms elaborated on average 3.5 different cloths (standard deviation of 2.44).[50] More prominently, the largest Catalan cotton firm (the España Industrial SA), which integrated vertically cotton spinning, weaving, finishing, machinery repairs and wholesale distribution, produced thirty-eight different fabrics in 1858. The price of the final products was disparate since the cheapest was sold at one third of the price of the most expensive.[51]

4. Explaining Vertical Integration

As a large literature emphasizes, vertical integration is a complex phenomenon that is the result of many causes, which can act alone or interact. Moreover, as Paul L. Joskow (2003) has recently noted "there is not and will never be one unified theory of vertical integration". However,

[49] For example, the finishing firm Abelló, Santos and Cia of Grácia (Barcelona) advertised itself as the producer of cheap printed cloth for other companies. Jaumeandreu and Cía, of Sant Martí de Provençals (Barcelona) advertised itself as a printer and as sub-contracted by four important weaving firms (Ferrer and Cía, Santacana, Sadurní and Cía, Rafecas, Marqués and Cía, and Gallifá and Argemí). Similarly, in the industrial exposition of 1860, many vertically integrated producers of cotton cloth exposed printed goods even though they did not have printing machinery in their factories. See , Orellana (1860).
[50] The source is Orellana (1860).
[51] España Industrial (1858).

the transaction cost theory of the firm is the standard framework for the study of these institutional arrangements.[52]

According to the transaction cost theory,[53] vertical integration is more related the presence of a relationship specific investment (asset specificity)[54] than other factors. When exchange implies sizeable investments in relationship-specific capital, an exchange relationship that depends on repeat bargaining is unattractive. Investment in such assets exposes agents to a potential hazard since the lack of alternative uses raises the scope for opportunistic behaviour amongst contracting parties. If conditions vary, trading partners may try to expropriate the rents accruing to the specific assets. This is the so-called the "hold-up" problem.[55] Rents can be protected by means of vertical integration, where a merger eliminates any adversary interests. As a rule non-specific investment will result in market governance (sub-contracting) while specific or idiosyncratic investment and recurrent transacting will result in firm governance. All in all, when a firm invests in assets that have a high degree of asset specificity it tend to integrate into the next phase in order to avoid opportunism in their transactions with other firms.

Williamson (1996) identifies up to five different situations in which asset specificity that is directly relevant to vertical integration is thought to arise: physical asset specificity, dedicated assets, site specificity, human

[52] Alternative frameworks to transaction cost theory for the analysis of vertical integration comprise the neoclassical theories of vertical integration and the property rights approach, which had many similarities, but also some relevant differences, with the transaction cost approach. A good review of the first approach is in Joskow (2003). For the second approach see the same Joskow (2003) and Whinston (2003).
[53] There are many notable surveys of the transaction cost approach see, among others, Williamson (2000), Joskow (2003) for the theoretical underpinnings and Shelanski and Klein (1995), Boerner and Macher (2002) and Klein (2004) for the empirical literature (which already comprises more than 600 articles).
[54] The concept of asset specificity refers to the extent to which a particular investment might be used for alternative purposes.
[55] Williamson (1975)(1985)(1996), Klein, Crawford and Alchian (1978) and Grossman and Hart (1986).

asset specificity and intangible assets. The first three are the most pertinent in order to explain the vertical integration of cotton spinning and weaving.

Physical asset specificity arises when firms make investments in equipment and machinery with design characteristics specific to the transaction and, hence, lower values in alternative uses. In the case of cotton industry in the second third of the nineteenth century, the Self-acting Mule in cotton spinning and the Power-loom in cotton weaving were only suitable for the medium and coarse qualities. In other words, they had few alternative uses because they could not produce all the different types of cotton goods.[56] The old technologies, Mule-Jennies and handlooms, were more efficient in the production of fine cloth and mixed-fabrics but could produce all qualities.[57] Another important physical assets specificity problem arise with power-looms, it required very homogeneous high-strength yarn to avoid recurrent breakouts during the weaving process. Only Self-acting Mules and Throstles were capable to produce the required amount of homogeneous high-strength yarn since Mule-Jennies and hand-spindles were unable to do so.[58] However, the marginal value of this high-strength yarn was nothing for handloom weavers since they could employ all types of yarn without additional costs. It is also important to note that weaving firms faced another asset specificity problem associated with yarn quality since they could not know *ex-ante* the strength of the yarn. In effect, when yarn was placed in power-looms one could discover by the frequency of breakouts if conforms the strength requirements. Consequently, theory

[56] Note that, until now, economic theory has not developed an independent measure of asset specificity. Consequently, asset specificity is a relative argument. Thus, one can argue that self-actor mules contained more asset specificity than mule-jennies. Since the latter were able to efficiently produce more counts (qualities) of yarn than the former and, also, could change count easier.

[57] The Spanish contemporary technical handbooks refer to these problems with the Self-acting Mule and the advantages of maintaining the use of Mule-Jennies. See, for example, Arau (1855). However, the Self-acting Mule was more flexible than the Throstle as the latter efficiently produced only a very limited range of counts. See, also, Von Tunzelmann (1978) and Lyons (1987).

[58] Von Tunzelmann (1978) and Lyons (1987).

predicts that firms employing Self-acting Mules or/and Power-looms tend to integrate vertically cotton spinning and weaving more frequently than firms employing Mule-Jennies or handlooms.

Dedicated assets problems arises when a supplier make an investment that would not otherwise be made but for the expectation of selling a substantial amount to a particular buyer/s. If that relationship terminated suddenly, it would leave the supplier with significant excess of capacity. There is a "buyer" side analogy to the supplier dedicated asset history as well.[59] A buyer that relies in a single (or few) supplier(s) for a large volume of an input may find it difficult and costly to replace immediately these supplies if they are terminated prematurely. The initial investment in plant and motive power for Self-actings Mules and Throstles was relatively important because minimum efficient size was larger than in the case of Mule-Jennies and hand machinery. Consequently, to invest in this new technology would be very risky if the firms had not found enough demand for the relatively large quantity of yarn that this spinning machine was capable to put into the market. Moreover, the presence of many cotton mills with Self-acting Mules in the market should push down the price of yarn in the market. Due to this, it was interesting for firms with Self-acting Mules to vertically integrate into the next phase instead to grow horizontally by acquiring more Self-acting Mules. For this reason, the largest spinning firms were vertically integrated in Catalonia. An analogous problem, but on the buyer side, arise with power-looms. Like in the case of Self-acting Mules, power-looms required an initial large inversion. To produce efficiently, power-weaving firms required a continuous and large flow of high-strength yarn of homogeneous quality but this was not easy to assure since the market for yarn was not enough large in Catalonia. For this reason, large weavers tend to integrate backward the production of yarn.

[59] Joskow (1987).

Finally, site specificity arises when successive stages are located in close proximity to one another, reflecting previous decisions to minimize inventory and transport expenses. Once sited the assets in question, the set-up and/or reallocation costs are high. Catalan cotton industry was relatively dispersed in many districts. More prominently, many mills were water-powered and were located in the countryside relatively isolated from suppliers and/or buyers. Even many steam-powered mills were located in towns where the number of alternative supplier and/or buyers was relatively small. Consequently, given that reallocation costs were high it is likely that relatively isolated mills tend to integrate vertically cotton spinning and weaving.

To sum up, there were many incentives to vertically integrate the production of cotton goods in the 1840s and the 1850s. The characteristics of the machinery, the small size of the markets and the location specificities all gave incentives to vertically integrate the production of the cotton yarn and cloth. These hypotheses can be formalised in the next model:

(1) Vertical Integration (PROB=1) = F (Machinery, Size, Location)

Where I assume that the probability of a cotton firm being vertically integrated is function of the type machinery, the size of the firm, and location. I will consider all Catalan cotton spinning and weaving firms with 10 or more workers in 1850 and 1861.[60] The dependent variable is binary: the variable takes the value 1 when the firm is vertically integrated and 0 when not.

I consider different measures of MACHINERY reflecting the relation between certain types of machinery in both, cotton spinning and power weaving. For cotton spinning in 1850, I use as measure of machinery

[60] The data for 1850 is drawn from Junta de Fabricas (1850) whereas the data for 1861 is drawn from Gimenez Guited (1862).

specificity a dummy variable that takes the value 1 if the firm had installed water wheels or steam engines with 20 HP or more since this amount of power was necessary to spin high-strength yarn. Instead for cotton spinning in 1861, I take capital intensity (fixed capital divided by the amount of labour) as proxy for power installed since these figures are not directly available from the sources. For cotton weaving in 1850 and 1861, I simply take the share of power-looms into the total amount of looms of the firm. MACHINERY variable is expected to be positively associated with vertical integration due to the presence of physical asset specificity.

I introduce the variable SIZE in the regressions. This variable is the amount of estimated product (yarn or cloth) derived from the type and amount of machinery installed because data such as firm sales is not available for the full sample. The transaction-cost saving were likely to be greater in large firms compared to a smaller firms (all else equal). Moreover, given that the frequency of transactions rises with firm size, a greater frequency of transaction will raise the benefits to integration and may justify the cost of internal organization. [61] Thus, firm size is expected to be positively related to vertical integration.[62]

Finally, it would be interesting to consider the presence of dedicated assets and site specificity. The absolute size of district markets, the variable LOCATION, serves as proxy as a proxy for the small-number bargaining problem, which is behind dedicated assets and site specificity. Generally, a limited extent of market for yarn or cloth indicates the number of alternative suppliers (or buyers) firms may turn to in the event of opportunistic

[61] Williamson (1985), p. 60.
[62] Others, instead, have suggested a negative association between firm size and vertical integration due to managerial diseconomies of scale. See, for example, Levy (1985) and Huberman (1990).

behaviour by another party.[63] Consequently, I expect that LOCATION variable is inversely related to vertical integration.

Table 7.
Determinants of vertical integration in cotton spinning and weaving

	1850		1861	
	Spinning	**Weaving**	**Spinning**	**Weaving**
Constant	-0.8756[a]	-3.6769 [a]	0.0496[d]	-1.7518 [a]
	(0.1918)	(0.2845)	(0.3186)	(0.2035)
MACHINERY	0.7232[c]	3.9632[a]	0.2878[a]	2.7427[a]
	(0.4254)	(0.6507)	(0.0642)	(0.3651)
SIZE (x 10^3)	0.0683[c]	4.2053[b]	0.0431[a]	2.1178[b]
	(0.0387)	(2.1003)	(0.0081)	(1.0696)
LOCATION (x 10^3)	-0.098[a]	-0.0299[d]	-0.0640[d]	-0.0264[a]
	(0.026)	(0.085)	(0.1810)	(0.0067)
Log likelihood	-178.93	-116.17	-147.43	-185.33
Chi^2	60.40[a]	169.55 [a]	53.10[a]	181.80 [a]
Pseudo R^2	0.14	0.42	0.15	0.33
Observations	352	848	256	526

Notes and Sources: The method of estimation is LOGIT. Standard errors are in brackets. SIZE is measured in Kg of cotton yarn in spinning and in pieces of cotton cloth per week in weaving. LOCATION is measured in pieces of cotton cloth per week in Spinning and in Kg. of cotton yarn in weaving. See text for the definition of the variables. [a] indicates significant at 0.01 level; [b] indicates significant at 0.05 level; [c] indicates significant at 0.10 level; [d] indicates no significant.

All the coefficients are of the expected sign and the model works quite well in all estimations although some differences among the different estimations are remarkable. In both dates, 1850 and 1861, the model explains better weaving than spinning. This is mainly due to the high significance of the variable MACHINERY in cotton weaving indicating that

[63] In all regressions, I tried with alternative measures of market size. For example, in cotton spinning I employed both cotton yarn production and cotton cloth production in the district without significant different results. However, given that it is likely to be more exogenous to dependent variable, I present in the table the result with cotton cloth in the case of spinning and with cotton yarn in the case of weaving.

physical asset specificity was very important in the case of the adoption of power-looms. Therefore, the progression of vertical integration in Spanish cotton industry could be linked to the diffusion of power weaving and the demise of hand-weavers.

5. Summary and conclusions (TO BE WRITTEN)

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