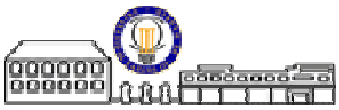

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Subcontracting and Vertical Integration in the Spanish Cotton Industry*

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Abstract

This paper examines changes in the organization of the Spanish cotton industry from 1720 to 1860 in its core region of Catalonia. As the Spanish cotton industry adopted the most modern technology and experienced the transition to the factory system, cotton spinning and weaving mills became increasingly vertically integrated. Asset specificity more than other factors explained this tendency towards vertical integration. The probability for a firm of being vertically integrated was higher among firms located in districts with high concentration ratios and rose with size and the use of modern machinery. Simultaneously, subcontracting predominated in other phases of production and distribution where transaction costs appears to be less important.

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Keywords: transaction cost economics; European industrialization; factory system; organizational change; technological change; international competitiveness.

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Subcontracting and Vertical Integration in the Spanish Cotton Industry

The organizational structure of the cotton industry has attracted much scholarly attention, as it was regarded as one of the key factors explaining the international competitiveness of the industry.[1] On the one hand, Lazonick and others have condemned the reliance of Lancashire on vertically specialised (single-phase) firms, and its adverse consequences for co-ordinated investment in new technologies, transport costs and decision-making.[2] On the other hand, a number of authors have been highly sceptical on this interpretation of the advantages of vertical integration.[3] Particularly, it has been shown that the alleged benefits of vertical integration rarely manifested themselves in terms of superior international competitiveness or profitability.[4]

The differences in business structure of the cotton textile industries across the World emerged relatively earlier. By mid-nineteenth century, English and French cotton firms were mainly vertically specialised whereas in the United States, Germany and Spain cotton firms were mostly vertically structured, combining spinning and weaving.[5] Even within the same country or region, several firms integrated vertically cotton spinning and weaving while others preferred to put their yarn into the market and, hence, were specialized. For example, within Lancashire, vertical integration was more common among cotton mills dedicated to coarse cloth than to those cotton mills devoted to fine goods.[6] Trends across countries were also conflicting: while vertical integration decreased progressively in England and France in the United States and Spain gained momentum over the nineteenth century.

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[1] A review of the literature is available in Jeremy, "Organization".

[2] See Lazonick, "Industrial Organization" and Mass and Lazonick, "British Cotton Industry".

[3] Perry ("Vertical Integration", p. 185) defines vertical integration as the elimination of trade or contractual exchanges within the borders of the firm.

[4] See a review in Leunig, "New Answers".

[5] On England see Taylor, "Concentration and Specialization", Farnie, *English Cotton Industry*, Lyons, "Vertical Integration", Huberman "Vertical Disintegration". On France, see Sicsic, "Firm Size". On the United States, Temin, "Product Quality". On Germany, Brown, "Market Organization".

[6] Huberman, "Vertical Disintegration".

In this international panorama, a very interesting phenomenon is the dramatic transition of the Spanish cotton spinning and weaving industry in practically two decades (from 1840 to 1860) from a market-based system of business relations to a system of vertically integrated firms, where yarn intermediate markets were replaced by internalisation. However, at the same time, other phases of the cotton production and trade remained vertically specialised: Barcelona cotton brokers and merchant-houses organized the supply of raw cotton;[7] cotton-finishing firms were typically vertically specialised; and merchant-houses, agents and independent travellers carried with the marketing of finished cloth.[8]

Precisely, this article investigates the choice of vertical integration of cotton spinning and weaving firms in Spain by mid-nineteenth century. The evidence indicates vertical integration in mid-nineteenth century to be more related to the presence of asset specificity[9] in yarn intermediate markets than other factors. Instead, in other markets like those of raw cotton, semi-finished (grey) and finished cloth, where asset specificity problems appear to be less important, vertically disintegrated firms were more common.

Although this article focuses on the Spanish cotton industry, it may have a much broader significance since several of its arguments can serve to qualify the debate on the role of vertical integration into the development of cotton industry. The evidence collected in this article shows that the structure of intermediate markets could account for vertical integration. Consequently, regions with large markets for intermediate inputs and low concentration ratios, like Lancashire, would not need to develop vertically integrated firms to efficiently develop their cotton industry. Instead, for regions where the extent of intermediate markets was limited and concentration ratios were high vertical integration was the best option. It also shows the weak relation between vertical integration and international competitiveness. Despite the preponderance of vertically integrated firms in cotton

[7] Castañeda and Tafunell, "Mercado mayorista".

[8] Prat and Soler, "Formación de redes comerciales".

[9] The concept of asset specificity refers to the extent to which a particular investment might be used for alternative purposes.

spinning and weaving, Spanish cotton industry had a limited participation in international markets and maintained its domestic market because was heavily protected by tariffs.[10]

HISTORICAL BACKGROUND

Like in many European countries, the development of cotton industry was central to early industrial development of Spain over the nineteenth century. This industry was the first to import power-steam technology and factory-based production from abroad.[11] Cotton textile mills were the single largest employer of manufacturing labour and the major private-owned manufacturing firms.[12] Although during the early industrialization period the cotton industry's rate of growth outstripped all other Spanish industries its impact on overall growth rates was relatively limited. By 1860, cotton textiles' share in Spanish GDP was only between 1 and 2 percent.[13]

The history of Spanish cotton industry is mainly concentrated in Catalonia.[14] Textiles were well established in the region, and Barcelona was an important urban textile centre, since thirteenth century. However, it was during the eighteenth century, and most especially after 1780s, that cotton textiles became an increasingly important dimension of the Catalan economy.[15] The concentration of textile producers in Catalonia magnified the impact on the regional economy. Because the geographic concentration of textile production, Catalonia industrialized more rapidly than did the rest of the country. Moreover, Catalonia was the largest cotton textiles producer in the Mediterranean basin although this industry was minuscule when compared with British or New

[10] On the lower productivity of the Spanish cotton industry see Rosés, "Competitividad internacional" for mid-nineteenth century and Clark, "Why isn't the Whole World" for early twenty century.

[11] Nadal, *Fracaso.*

[12] The data collected in Giménez Guited, *Guia fabril* shows that the cotton industry concentrated more than the 60 per cent of labour in manufacturing establishments of 50 or more workers.

[13] Rosés "Industrialización regional", pp. 64-72.

[14] According to Gimenez Guited (*Guia fabril*), it produced about the 75 percent of the Spanish cotton textiles.

[15] By 1860, cotton textiles employed about one third of Catalan industrial workforce and about one tenth of overall workforce.

England cotton industries. By 1850s, Catalan textile producers wowed about one-seventeenth of the British cloth and one-sixth of the New England's cotton cloth.[16]

The early development of cotton textiles in Catalonia was gradual and was marked as much by continuity as by change. Nevertheless, transformation was not without its discontinuities; so, cotton industry in Catalonia passed through three successive phases (1720s-1780s; 1780s-1833; 1833-1861).

The early period (1720s – 1780s)[17]

Imitating several of the economic policies of the British and French governments, provisions to encourage manufacturing expansion and economic development were introduced in Spain by the new Bourbon dynasty.[18] An initial ban on the import of Asian cotton textiles was implemented in 1717 and was further extended in 1728 on European imitations. However, the legislation allowed the introduction of foreign cotton yarn. These measures provided an initial motivation for the development of cotton textiles in Catalonia; so, a first generation of enterprises devoted to weaving and printing cotton were established in Barcelona in the late 1720s. Nascent manufacturers for the first time sought to influence trade policy. Their lobbying had a long-standing impact on the provisions concerning cotton textiles, and during the most part of the eighteenth and the nineteenth centuries cotton textile producers won strong protection. Nevertheless, this new industry benefited not only from the government initiatives and protection but also from the relative abundance of merchants, artisans and machine-makers in Barcelona, and the ancient tradition of the region in the production of textiles.

The following decades witnessed a considerable growth in cotton printing production in Barcelona. At the industry heights in 1786, this city was the most important location of cotton

[16] Rosés "Choice of Technology", pp. 136-137.

[17] There is an ample literature on the history of the cotton industry in Catalonia during this period. See recent reviews at Sánchez, "Crisis económica" and Thompson, "Technological Transfer".

[18] In these first developments see Thompson, *Distinctive Industrialisation.*

printing in Europe with 113 calico concerns.[19] Catalan calicoes were sold in the protected domestic markets and the Spanish colonies in America.[20] Simultaneously, there were also important improvements in the rate of technological innovation. By mid-eighteenth century, Catalan manufacturers were pioneers among Continental cotton industries in the adoption of innovations like indigo printing (1746) and engraved copper plates for printing (1770).[21]

The intermediate period (1780s-1833)[22]

The incorporation of the spinning process to the Catalan cotton industry characterized the second period of its development. Because for most of the eighteenth century all cotton yarn was imported (mainly from Malta), cotton spinning was of little importance in Catalonia. For example, the share of cotton yarn produced locally in 1784 was only of 22 percent whereas the remaining 88 percent was imported from Malta (43 per cent) and other Mediterranean Ports. In 1784, two French machine-makers arrived in Barcelona bringing with them the technology of the spinning jenny. The adoption of the spinning jenny by local manufacturers was immediate.[23] Few years later, in 1792, an English engineer introduced an improved Highs jenny of 78 spindles (instead of the common 40 spindles) and a new card machine. Arkwright water frame was to reach Catalonia soon after the Highs jenny.[24] In the next years, local machine-makers not only were able to produce copies of the original spinning jenny but also developed a large jenny with more spindles (sometimes it had up to

[19] Thompson, "Technological Transfer".

[20] 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, "Mercado interno".

[21] Thompson, "Technological Transfer".

[22] See on this period, Sánchez, "Era de la manufactura algodonera", "Indianeria catalana", "Crisis económica" and Thompson, *Distinctive Industrialisation*, "Technological Transfer".

[23] Sánchez, "Crisis económica", pp. 495-496.

[24] Thompson, *Distinctive Industrialisation*, p. 249-254.

120), which received the name of bergadana.[25] By the end of the century (1796), there were reported to be 250 bergadanas in operation.[26]

The successive wars and political disruptions made the progress of the industry during the first quarter of the nineteenth-century difficult. However, a further impulse to the local production of cotton yarn and cloth was given by the ban of foreign imports of cotton yarn in 1802 and the introduction of the mule-jennies from France in 1806. As happened previously with the spinning jenny and the water frame, these wood-made mule-jennies powered by water wheels or horses were rapidly copied by local machine-makers.[27] In the following years, two new major developments affected to the industry. On the one hand, several new cotton mills powered by water wheels or horses and equipped with mule-jennies and water frames were established in Barcelona and other manufacturing towns. The growth in the use of hydraulic power caused a shift in the centre of the gravity of cotton spinning away from downtown Barcelona to the rivers banks in inner Catalonia.[28] On the other hand, another part of the cotton spinning production was located at the remote villages and small towns of the Pre-Pyrenees and other isolated rural zones where they could rely upon a good supply of cheap domestic labour.[29] This was a typical cottage industry. The sub-contractor put out raw materials and semi-finished goods to a producer, who used its own tools, and also played, at least to some extent, a supervisory role of the final product.

Following the diffusion of cotton spinning away from Barcelona, handloom weavers proliferated across Catalonia.[30] Like in cotton spinning, diverse forms of organization prevailed in this industry. Handloom weaving in some districts was model example of independent artisan production whereas in others was the seat of domestic putting-out. In handloom weaving workshops, several

[25] Ferrer Vidal, *Conferencias*, p. 101.

[26] Sánchez, "Crisis económica", p. 494

[27] Sánchez, "Era de la manufactura algodonera", p. 38; Thompson, *Distinctive Industrialisation*, pp. 263-264.

[28] Thompson, *Distinctive Industrialisation*, p. 261.

[29] Gutiérrez, *Impugnación*, Sánchez, "Era de la manufactura algodonera", Thompson, *Distinctive Industrialisation*, and García Balañà, *Fabricació de la fàbrica*.

[30] Sánchez, "Era de la manufactura algodonera".

artisans with a few assistants, who were sometimes young members of his family, ran a small unit-of-production with a limited division of labour. This artisan-organised production was the industrial structure of handloom weaving of the urban villages, suburbs and unincorporated towns in areas such as Reus and Barcelona. Instead, the organization of the domestic putting-out networks was in much the same way as did in cotton spinning. Consequently, although domestic producers used own looms, the sub-contractor put out yarn and played a supervisory role of the final product.

Contrary to cotton spinning and weaving, printing industry remained mainly located in Barcelona.[31] Moreover, this process was scarcely mechanised before the 1830s because few establishments adopted the new British and French machinery.[32] Typically, printing concerns ran like artisan workshops and, hence, the division-of-labour was scarce.

The Revolutionary period (1833-1861)[33]

The first steam-powered mill appeared in 1833 when the company "Bonaplata, Vilaregut, Rull and Cía." began producing cloth made on power looms in Barcelona. In the 1830s, the diffusion of steam-power progressed slowly in Catalan cotton industry. By 1841, the 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.[34] The pace of technological change accelerated in the 1840s with the end of the Civil War in 1840 and the removal of British restrictions to machinery exports. By 1850, the total HP employed in the industry had increased to 3,755 and the proportion attributable had soared to about 60 percent.[35] Eleven years later (1861), 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.[36]

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[31] Thompson, *Distinctive Industrialisation.*

[32] On the mechanisation of calico printing see Nadal and Tafunell, *Sant Martí de Provençals* and Thompson, "Technological Transfer".

[33] See a review of the literature on this period in Carreras, "Cataluña" and Nadal, "Indústria cotonera".

[34] Sayró, *Industria algodonera*, and Madoz, *Diccionario.*

[35] Junta de Fábricas de Cataluña, *Censo de fabricas*.

[36] Comisión especial arancelaria, *Información*.

In Catalonia, technological progress in cotton spinning paralleled the diffusion of steam-power. Thus, from 1841 to 1850, the amount of hand spindles declined dramatically from 725,787 to 180,058 whereas the number of mechanical spindles grew from 316.320 to 524.178.[37] Simultaneously, new iron-made mule-jennies and throstles replaced the old wood-made mule-jennies and water frames. By 1861, the demise of hand spinning was complete since practically all cotton yarn was produced with modern steam or water-powered machinery.[38] Moreover, new self-acting mules displaced mule-jennies from factories.

Technological change was slower in weaving than in spinning. The persistence of handloom weaving can partly be explained by technological reasons. Although the first profitability power looms dated back 1813, they were best suited for weaving coarse cloth. 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 could be produced efficiently with power-looms.[39] This signified the progressive retreat of handloom 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. In Catalonia, the first power-looms were introduced in 1828.[40] By 1841, however, the balance between handlooms and power-looms remained clearly favourable for the hand machinery.[41] In effect, for each power-loom in use, it was more than 100 handlooms. Ten years later (1850), the amount of power-looms had multiplied by twenty-five while the number of handlooms remained roughly the same.[42] The demise of handloom weaving was apparent in 1861 given that the number of handlooms halved with respect to 1850 figures while the

[37] The first figure is from Sayró, *Industria algodonera* and the second from Junta de Fábricas de Cataluña, *Censo de fabricas*.

[38] Giménez Guited, *Guia Fabril.*

[39] See Von Tunzelmann, *Steam Power*, chapter 7. Instead, Farnie, *English Cotton Industry* and Lyons, "Powerloom Profitability" gave importance to the development of the Blackburn plain loom in 1841.

[40] Ferrer Vidal, *Conferencias*.

[41] Sayró, *Industria algodonera* and Madoz, *Diccionario.*

[42] Junta de Fábricas de Cataluña, *Censo de fabricas*.

number of power-looms multiplied by 1.7.[43] Of the total cotton cloth wowed in that year in Catalonia only about one-fifth was made by hand-weavers.[44]

Technological advance also modified drastically cotton-finishing processes. 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. In Catalonia, the technological progress was exceptionally rapid in cotton printing during the 1840s and the 1850s. In 1835, only four cylinder printing machines had been installed in Catalonia but by 1850 the number of active machines had soared to 41, arriving to 65 in 1861. The diffusion of the perrotine was even more impressive. The machine arrived from France only six years after its invention in 1840 and by 1861 there were 43 in use.[45]

CHANGES IN BUSINESS ORGANIZATIONS

The eighteenth-century calico printing industry was based on medium-large and centralised units-of-production although having several managerial structures, from capitalistic firms to artisans' co-operatives. The typical unit of production was formed by several work-teams, which were composed of several masters, artisans and apprentices, and labourers.[46] It was also integrated backward into cotton weaving and forward into marketing. The forward integration into marketing of calico producers was facilitated by the fact that many partners of the calico printing concerns were merchants. To distribute their products outside Catalonia, manufacturers organized a network of agents that were on charge of looking for buyers and received the fabrics on credit. For this reason, a considerable part of the capital of the calico concerns was commonly devoted to finance these marketing networks.

[43] Giménez Guited, *Guía Fabril.*

[44] See appendix.

[45] Nadal, "Indústria cotonera", pp. 34-37; and Nadal and Tafunell, *Sant Martí de Provençals*, pp. 39-50.

[46] Thompson , *Distinctive Industrialisation* and Sánchez, "Era de la manufactura algodonera".

However, cotton concerns employed sometimes, particularly in overseas trade, alternative channels of distribution like cloth wholesalers, independent travellers and specialized merchant houses.[47]

A movement towards specialization began in the early 1790s, with the spread of cotton spinning and weaving away from Barcelona.[48] So, the new cotton spinning mills were specialised and did not integrated forward into cotton weaving. Similarly, printing concerns abandoned backward integration into cotton weaving and, hence, employed the cloth made by independent handloom weavers. Therefore, it was common that spinning millowners and printing concerns relied on external contracts with the independent handloom weavers.

How these different types of specialized firms structured their business relations during the first four decades of the nineteenth century?[49] The precise relation between the interrelated sources of entrepreneurship and capital and the product strategies and the scale of firms during this period is difficult to determine. It was clear, however, that a complex interaction between different cotton textile producers and merchants was replicated throughout Catalonia. Arrangements varied between typical business-relations, intermarriage and associated based kinship-based networks of partnerships, through to the more formal internalisation of activity. Although business organization was very far from impersonal atomistic competition, there could be no question of a single producer, or group, exerting overwhelming dominance. In any case, the cotton industry was organized hierarchically. On the top, an elite of businessmen with interests in several firms controlled large putting-out and subcontracting webs of small firms by offering to them credit, intermediate goods and marketing services. At the middle, a large number of small-medium textile producers were able to operate on the combination of credit from merchants and advances from other producers. The medium textile producers frequently rented space, and sometimes power, to the largest producers. Self-employed and domestic workers,

[47] Thompson, *Distinctive Industrialisation*, pp. 87-88.

[48] Sánchez, "Era de la manufactura algodonera", pp. 93-99.

[49] This structure of the cotton industry was first described by Maluquer de Motes, "Estructura". Recent detailed accounts are available in Solà Parera, *Aigua* and Garcia Balañá, *Fabricació de la fàbrica*. It is interesting to note the close parallelisms with Lancashire during the period. See, on Lancashire, Rose, *Firms*.

who operated within the putting-out webs, occupied the lower ranks of the industry. This hierarchical structure served to the interests of the large businessmen and was adapted to the fluctuations in the demand for cotton goods, which were common in Spain due to the scarcity of the domestic market.[50] Thus, at the peak of the business cycle capitalists increased the number of sub-contractors, whereas the contrary held in the trough years.

TABLE 1
THE DIFFUSION OF VERTICAL INTEGRATION IN COTTON SPINNING AND WEAVING, 1850 AND 1861

	1850				1861			
	Firms	%	Production	%	Firms	%	Production	%
				A: Spinning				
Specialized	229	72.93	7,654	63.99	149	58.20	6,740	39.06
Integrated	85	27.07	4,308	36.01	107	41.80	10,518	60.94
Total	314	100.00	11,962	100.00	256	100.00	17,258	100.00
				B: Weaving				
Specialized	891	91.29	5,779	55.69	411	79.34	5,039	33.01
Integrated	85	8.71	4,598	44.31	107	20.66	10,225	66.99
Total	976	100.00	10,377	100.00	518	100.00	15,264	100.00

Notes: Some rounding. From the table it had been excluded firms with less than 10 workers. The production is expressed in Tons of yarn and cloth, respectively.

Sources: The sources are Junta de Fabricas de Cataluña, *Censo de fabricas* for 1850 and Giménez Guited, *Guia fabril* for 1861. For the estimation of production and coverage of the sample see appendix.

Vertical integration of cotton spinning and weaving was scarce to the 1840s[51] but progressed dramatically in the following years (see table 1). According to the industrial survey for 1850,[52] vertical integration was rather common among cotton spinning: 229 firms with 9,389 spinners were devoted exclusively to cotton spinning, and 85 firms with 4,235 spinners had integrated vertically into cotton spinning and weaving. 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

[50] On the domestic market for cotton goods see Prados, "Producción".

[51] The first cotton spinning and weaving vertically integrated firms had appeared in the last years of the eighteenth century. See Sánchez, "Era de la manufactura algodonera".

[52] See appendix for sources.

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.

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.[53] By 1861, vertically integrated firms employed more than the 60 percent of spindles, more than the 80 percent of power-looms and produced the 67 percent of cotton cloth.[54] Moreover, in eleven years the number of vertically integrated firms had increased by 25 percent while the number of specialized firms decreased by about 35 percent in cotton spinning and more than halved in weaving.

In comparison with England and France vertical integration was much more important in Catalonia.[55] English vertically integrated cotton 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.[56] French vertically integrated cotton mills employed only the 3 percent of the cotton textiles workforce.[57] In a sharp contrast, in Catalonia the vertically integrated mills employed the 65.8 percent of workers, the 80.2 percent of power-looms and the 55.2 percent of spindles.

The integration of cotton spinning and weaving with cotton printing was a comparative rarity. In 1850, only 4 of 57 firms devoted to printing also integrated vertically cotton weaving. These

[53] Comisión especial arancelaria, *Información*.

[54] Gimenez Guited, *Guia fabril*. For the estimation of production see appendix.

[55] 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 with more than 10 workers were considered. Note also that the British sources do not report all labour because, for example, handloom weavers were not included. Gatrell, "Labour" offers a detailed description of British sources.

[56] Farnie, *English Cotton Industry*, p. 317.

[57] Sicsic, "Firm-size", p. 459.

vertically integrated firms had the 9 percent of workers and the 14 percent of steam-power employed in the cotton printing industry.[58] 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 the two consecutive phases and employed about the 24 percent of modern printing cylinders, but a less proportion of the old machinery.[59]

CHARACTERISTICS OF VERTICALLY INTEGRATED FIRMS

This section examines several major characteristics of vertically integrated firms in cotton spinning and weaving. First, it shows that vertically integrated firms predominated among the largest firms in cotton spinning and weaving. Second, it documents that this type of cotton firms tended to produce medium-coarse quality cloth. Third, it also establishes that vertically integrated cotton mills produced more products than specialized firms but in longer series. Finally, it points that the distribution of vertically integrated firms was not equal across all Catalan cotton textiles districts.

Vertically integrated firms predominated among the largest firms in both, cotton spinning and weaving (see the further table 2). In cotton spinning in 1850, only one-third of smallest firms (producing less of 50 Tons of yarn per year) were integrated vertically whereas this proportion grew to the 62 percent in the case of largest firms (producing more than 100 Tons of yarn per year). Similarly, in cotton weaving in 1850, only the 6 percent of firms producing less than 50 tons of cloth per year were vertically integrated whereas the share of this type of firms grew to 86 percent if one considers firms producing more than 100 tons of cloth per year.

[58] Junta de Fábricas de Cataluña, *Censo de fabricas*.

[59] Giménez Guited, *Guia Fabril.*

TABLE 2
THE SIZE DISTRIBUTION OF COTTON SPINNING AND WEAVING FIRMS, 1850 AND 1861

		Spinning			Weaving		
	Firm Size (Tm. year)	Small <50	Medium 50-100	Large >100	Small <50	Medium 50-100	Large >100
				A: 1850			
Specialized	Firms	173	48	8	882	7	2
	Production	3,399	3,155	1,100	4,943	444	392
Integrated	Firms	56	16	13	59	14	12
	Production	876	1,140	2,292	493	1,041	3,064
Total	Firms	229	64	21	912	21	14
	Production	4,274	4,295	3,392	5,436	1,485	3,456
				B:1861			
Specialized	Firms	103	40	6	393	8	10
	Production	2,640	3,113	987	3,028	582	1,429
Integrated	Firms	50	28	29	56	18	33
	Production	1,266	2,276	6,976	803	1,302	8,120
Total	Firms	153	68	35	449	26	43
	Production	3,907	5,389	7,963	3,831	1,884	9,550

Notes and Sources: see table 1.

In eleven years, from 1850 to 1861, the average firm size grew considerably in cotton spinning and weaving. In cotton spinning, the average production per firm grew from 38 tons of yarn per year in 1850 to 67 tons of yarn per year in 1861. Similarly, in cotton weaving, the average production per firm grew from 10.6 tons of cloth per year in 1850 to 29 tons of cloth per year in 1861. This growth of the average production was mainly due to the increasing share of the largest firms in total production. Simultaneously, the number of the largest vertically integrated firms grew considerably. In cotton spinning the number of the largest vertically integrated firms more than doubled from 1850 to 1861 whereas in cotton weaving their number practically tripled between these same years.

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 cloth, and hence coarser yarn, than specialized firms.[60] 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.

[60] Temin, "Product Quality".

Instead, English integrated firms producing for the domestic market tended to produce a wide variety of products.[61]

TABLE 3
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)
Weaving	2	2	14
Printing	2	12	6
Spinning and weaving	4	10	0
Spinning, weaving and printing	2	9	1

Notes: 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, Castores, Chalecos, Florentinas, Guatas, Indianas finas, Pañuelos, and Piqués.

Sources: The source of data on production is Orellana, *Exposición*,[62] the classification of the quality of products is based on Ronquillo, *Diccionario* and the classification of firms is based on Gimenez Guited, *Guia fabril*.

As table 3 shows vertically integrated firms in Catalonia, regardless of they integrated vertically spinning and weaving or all three phases (spinning, weaving and printing), tended to produce medium-coarse cloth. Instead, specialized weaving firms tended to produce fine and fancy cloth. Finally, cotton-finishing firms produced all type of cotton goods since cloth quality depended on weaving firms. Commonly, these cotton-printing firms elaborated a reduced range of products and sometimes were sub-contracted by cotton weaving firms.

Like in Britain, vertically integrated cotton firms in Catalonia tended to elaborate a wider 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 fabrics (standard deviation of 2.44). However, vertically integrated firms (larger than specialized firms) produced on

[61] Brown, "Market Organization".

[62] This book collects data on cotton firms that showed their products in an exposition on homage to the Queen during her visit to Barcelona. The sample of firms was of 54 (17 weaving firms, 14 printing firms and 23 vertically integrated firms).

average more quantity of each type of cloth than specialized firms.[63] In effect, the series of cloth produced by specialized firms were on average of 24 Tons (standard deviation of 19) whereas these series in integrated firms were on average of 109.5 tons (standard deviation of 40). Consequently, vertically integrated firms produced their standardized products (coarser cloth) on a larger scale than the specialized firms that produced finer and fancy cloths. Fine and fancy clothes were produced in small batches (to order), and require a shorter series than the coarser fabrics.

FIGURE 1
CATALONIA'S COTTON TEXTILE DISTRICTS

Figure 1 shows that Cotton production was relatively dispersed across Catalonia. To put an example, the distance between Barcelona and the capital of the second most important cotton district Igualada (Anoia) was about 40 miles by road. Power-based production was mainly based on the coastal districts whereas water-based production was located in the banks of the rivers in the districts of Anoia, Bages, Girona and North. Furthermore, there were remarkable differences in the distribution of the

[63] The average amount of tons of cloth of each different series is obtained by dividing the total amount of cloth produced for firm in 1861 by the number of different cloths showed in the exposition.

vertically integrated firms across cotton districts in Catalonia (see table 4) although this business organization progressed markedly from 1850 to 1861 in all districts (the only exception to this general rule was cotton spinning at the North district).

TABLE 4
THE SHARE (%) OF VERTICALLY INTEGRATED FIRMS IN THE DIFFERENT DISTRICTS 1850 AND 1861

	Spinning		Weaving	
Districts	1850	1861	1850	1861
Anoia	11.23	56.09	28.70	67.01
Bages	47.34	56.55	69.93	76.09
Barcelona	31.81	66.40	40.84	62.56
Garraf	100.00	100.00	100.00	99.78
Girona	38.97	48.71	59.93	71.51
Maresme	20.76	76.59	13.79	41.03
North	35.67	26.49	13.77	57.80
South	52.76	60.20	35.45	71.69
Vallès	16.16	27.86	2.21	27.76

Notes: The share of vertically integrated firms is computed as the ratio between the estimated production in Tons of yarn or cloth per year of vertically integrated firms and the estimated production in Tons of yarn or cloth per year of a given district. The actual countries (comarques) of Alt Penedés, Anoia, Baix Llobregat and Conca de Barberà formed the cotton district of Anoia; the county of Bages formed the cotton district of Bages; the county of Barcelonés formed the cotton district of Barcelona; the county of Garraf formed the cotton district of Garraf; the counties of Gironés, la Selva, Garrotxa and Pla de l'Estany formed the cotton district of Girona; the countiy of Maresme formed the district of Maresme; the counties of Cerdanya, Solsonés, Berguedà and Osona formed the North cotton district; the counties of Alt Camp, Baix Camp and Tarragones formed the South cotton district and, finally the counties of Vallès Occidental and Vallès Oriental formed the cotton district of Vallès.

Sources: See table 1.

EXPLAINING VERTICAL INTEGRATION IN COTTON SPINNING AND WEAVING

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 ("Vertical Integration") has recently noted "there is not and will never be one unified theory of vertical integration". However, the transaction cost theory of the firm is the most widely employed framework for the study of these institutional arrangements.[64]

[64] 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 different

Ronald Coase ("Nature") was the first to argue that the firm integrates to avoid the costs of market exchange. Modern transaction cost-theory holds that these costs will be higher, the fewer the number of parties in the market and the more specialized the assets involved in the transaction, known as asset specificity. 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.[65] Rents can be protected by means of vertical integration, where a merger eliminates any adversary interests, or by the use of contractual safeguards such as formalized long-term contracts and reputation.[66] As a rule non-specific investment will result in market governance (subcontracting) while specific or idiosyncratic investment and recurrent transacting will result in firm governance (vertical integration). 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. Oliver E. Williamson (*Mechanisms of Governance*) identifies up to five different situations in which asset specificity is thought to arise: physical asset specificity, dedicated assets, site specificity, human asset specificity and intangible assets. The first three are the most pertinent in order to explain the vertical integration of cotton spinning and weaving.

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approaches is Joskow "Vertical Integration". See, also, Shelanski and Klein, "Empirical Research" and Klein "Make-or-buy Decision" for the empirical literature.

[65] Williamson, *Markets, Economic Institutions, Mechanisms of Governance*, Klein, Crawford and Alchian, "Vertical Integration" and Grossman and Hart, "Costs".

[66] In the case of the Spanish early cotton industry reputation matters little since firms were commonly new and the survival rate was very low. Similarly, contracts were difficult to enforce because the performance of Spanish trials and the changing political situation.

To analyse the issue of the determinants of the decision of vertically integrate cotton spinning and weaving, this section follows the standard empirical strategy of the transaction cost literature.[67] Vertical integration is seen as a function of a certain asset specificity properties of the underlying transaction. Given that asset specificities (or transaction costs) are not directly observable (and difficult to measure), several of the typical proxies for asset specificity like market concentration, production capacity, and type of technology are used.

Two alternative definitions of the dependent variable, vertical integration of cotton spinning and weaving production, are employed in this article although the same set of independent variables is considered to explain them. The first treats vertical integration as a dummy variable, where a cotton firm is vertically integrated if it is in possession of machinery of the two production phases. The second approach treats vertical integration as a limited dependent variable, measured by the ratio of cloth production capacity to yarn production capacity in the case of cotton spinning, and the inverse in the case of cotton weaving. A ratio of one is assumed to indicate self-sufficiency. In the case of cotton spinning, a ratio of less than one suggests market transaction to sell excess yarn (for example, if the value is zero this indicates that the firm put all its yarn into market transactions). Similarly, in the case of cotton weaving, a ratio of less than one suggests market transactions to supplement the production of cloth.

Market concentration serves as a proxy for the potential for a small-numbers bargaining problem since suggests the amount of alternative suppliers (or buyers) that firms may turn to in the event of the opportunistic behaviour by another party.[68] Then, high concentration could be associated

[67] See Klein, "Make-or-buy Decision" for a detailed analysis of the strategies for empirical research in transaction-cost economics.

[68] Ohanian ("Vertical Integration") suggest this test for transaction cost theory. It should be noted, however, that the high market concentration indicator is also consistent with monopoly (monopsody) power explanations for vertical integration. Moreover, transaction-cost and market-power based theories of vertical integration are difficult to distinguish, empirically, since each makes similar predictions (see, MacDonald, "market Exchange"). However, the objective of this paper is not to test the superiority of one over the other but to present an explanation for vertical integration in cotton industry. And what it is clear from the results

with situations where there is greater possibility for "hold-up" problems and a greater incentive to vertically integrate. In the case of high concentration ratios dedicated assets and site specificity problems may appear. On the one hand, 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.[69] 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. Consequently, to set a cotton-spinning firm in a certain location would be very risky if the firm had not found enough demand, and different demanders, for the quantity of yarn of a certain count (quality) that it was capable to put into the market. Due to this, it could be interesting for firms entering into certain locations with few buyers of their yarn integrate into the next phase instead to grow horizontally by acquiring more firms in the same phase. An analogous problem, but on the buyer side, arise with cotton weaving firms. Therefore, if a cotton-weaving firm enter in a particular market with a small number of yarn producers, it could suffer "hold-up" problems from their suppliers. On the other hand, 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 (see graph 1 and table 4). 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 districts where the number of alternative supplier and/or buyers was relatively small. Consequently, given that reallocation costs were high it is likely that mills in districts with high concentration ratios tend to integrate vertically cotton spinning and weaving.

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is that high buyer and seller concentration ratios were closely related with vertical integration. Therefore, I do not reject an alternative interpretation based on market power although it seems less plausible within the Spanish historical context given the behaviour of prices in cotton yarn, grey cloth and printed cloth.

[69] Joskow, "Contract Duration".

The decision to integrate and the extent of vertical integration are hypothesized to be a positive function of firm size, because the transaction-cost-savings would be greater in larger firms compared to smaller firms (all else equal). There are several reasons for this. First, larger firms suffered more dedicated asset problems than smaller firms because the costs of a supply (demand) disruption would be greater than for a smaller firms.[70] Second, if the frequency of transaction rises with firm size, a greater frequency of transactions will increase the gains arising from integration and may justify the costs of internal organization. [71] Third, the presence of imperfections in capital markets can give an incentive to vertical integration of larger firms. Vertical integration works as an internal capital market and, therefore, it represents the elimination of financial intermediaries.[72] In other words, the absence of external financing can give an incentive to firms to buy the next phase and to employ their money invested in circulating capital (i.e., the money used for credit to customers) within the firm. In Spain, the small size of the market and its unstable character caused difficulties for financial institutions trying to develop an impersonal system of money lending. [73] Thus, the Catalan cotton firms used an important part of their resources financing their own customers since credits from banks and other financial intermediaries were scarce. It was rare that wholesalers or shops paid in advance or amortised their debts over short periods. Similarly, small firms could not easily borrow money or discount bills-of-exchange in banks. For this reason, it was common for larger firms to finance smaller industrial firms. Consequently, for large cotton firms it could be very convenient to integrate backward (or forward) because they already indirectly financed this phase and convert the circulating capital lent to other companies into fixed capital, which was directly owned by the company.

Finally, I hypothesize a positive relation between modern machinery and vertical integration. Physical assets and dedicated assets specificity can account for this situation. Physical asset specificity

[70] Temin ("Product Quality", p, 902) raised a similar point.

[71] Instead, other authors hypothesised a negative relation between firm size and the probability of integration due to managerial diseconomies of scale. For a full discussion of the managerial problems and advantages of vertical integration see Williamson, *Economic Institutions*, chapter 6.

[72] Williamson , *Markets* and Mowery, "Finance".

[73] Graell, *Informació pública*.

problems arise when firms make investments in equipment and machinery with design characteristics specific to the transaction and, hence, lower values in alternative uses. Several technical characteristics of the machinery available in the cotton industry during the second third of the nineteenth century could generate this kind of problems. First, the self-acting mule in cotton spinning and the power-loom in cotton weaving were only suitable for the medium and coarse qualities. Second, as it has been shown previously, they produced longer series than other types of machinery; consequently, they also incur in dedicated assets problems. The old technologies, mule-jennies and handlooms, were more efficient in the elaboration of fine cloth and mixed-fabrics and could produce in small batches (to order).[74] Third, power-looms 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.[75] Power-loom weaving firms could not know *ex-ante* this quality 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. Moreover, the marginal value of this high-strength yarn was nothing for handloom weavers since they could employ all types of yarn without additional costs.[76] Consequently, theory predicts that firms employing self-acting mules or/and power-looms (modern machinery) tend to integrate vertically cotton spinning and weaving more frequently than firms employing mule-jennies or handlooms.

[74] 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, *Tratado completo*. However, the self-acting mule was more flexible than the throstle as the latter efficiently produced only a very limited range of counts in larger series. See, also, Von Tunzelmann, *Steam Power* and Lyons, "Powerloom Profitability".

[75] Von Tunzelmann, *Steam Power* and Lyons, "Powerloom Profitability".

[76] This problem could be solved if Catalan weaving firms established long-term contracts with their yarn suppliers or a system of reputation based on trademarks. However, during this period, the firms lasted short periods (typically five years or less) and contracts were hard to enforce given the well-known inefficiency of the Spanish legal system. Moreover, Spanish patent law did not protect trademarks and quality improvements from imitations.

These arguments can be formalized into the following pair of equations:

(1) Vertical Integration (PROB=1) = F (Concentration, Size, Modern Machinery),

(2) Cloth (yarn) production / Yarn (cloth) production = F (Concentration, Size, Modern Machinery).

The equation (1) can be estimated by a logit regression (the dependent variable takes the value 1 if vertical integration is positive). In the equation (2), because the dependent variable is limited between zero (market transaction) and one (self-sufficiency), this model should be estimated by a Tobit regression.

However, with these two different methods of regression, one cannot control for the unobservable heterogeneity. For example, some firms would like to integrate vertically upward (or downward) but had not access to necessary funds or their managers were unable to manage an upward (downward) phase. If one assumes that this unobservable heterogeneity is a firm-specific component, this can be addressed by using panel data techniques given that we had observations for two different periods (1850 and 1861).[77] In this case, one has two alternative models: fixed and random effects. If individual effects and regressors are correlated, the choice should be a fixed-effects model. Instead, if regressors and individual effects are orthogonal, one should employ the random-effects model.[78] The Hausman ("Specification Tests") test shows that the random-effect model is more efficient than the fixed-effects model but both models do not differ systematically. In this case, the standard solution is to investigate directly the correlation between individual effects and regressors. The results obtained in these tests lead us to accept the null hypothesis of non-correlation in all the models estimated, at any significance level. Hence, the choice has been to estimate a random-effects logit model for equation 1 and the random-effects Tobit model for equation 2.

[77] Panel data methods were employed for first time to analyse vertical integration in González-Díaz, Arruñada and Fernández, "Causes of Subcontracting". Basically, this article applies their methodology.

[78] To analyse this issue this article follows the standard procedure described in Greene, *Econometric Analysis*, pp. 479-480.

TABLE 5
DETERMINANTS OF VERTICAL INTEGRATION IN COTTON SPINNING AND WEAVING

Dependent Variable	Vertical integration = 1; 0 otherwise		Cloth (yarn) production / Yarn (cloth) production	
Method	Logit	Random-effects Logit	Tobit	Random-effects Tobit
		A: Only spinning		
Constant	-1.6683[a]	-2.8520[a]	-2.9480[a]	-2.8878[a]
	(0.2830)	(0.8752)	(0.4157)	(0.4532)
Concentration	0.0299[a]	0.0512[a]	0.0255[a]	0.0294[a]
	(0.0074)	(0.0179)	(0.0067)	(0.0065)
Size	0.0126[a]	0.0195[a]	0.0077[a]	0.0096[a]
	(0.0025)	(0.0060)	(0.0015)	(0.0017)
Modern Machinery	0.0076[a]	0.0123[b]	0.0087[a]	0.0093[a]
	(0.0024)	(0.0049)	(0.0027)	(0.0019)
Log likelihood	-358.8458	-355.7697	-422.6898	-467.3471
Chi^2	60.85	12.41	94.40	54.67
Pseudo R^2	0.0782	n.a.	0.1005	n.a.
Observations	608	608	608	608
		B : Only weaving		
Constant	-3.7067[a]	-3.8446[a]	-4.7907[a]	-4.7845[a]
	(0.3070)	(0.3135)	(0.6034)	(0.6030)
Concentration	0.0225[a]	0.0232[a]	0.0299[a]	0.0298[a]
	(0.0078)	(0.0080)	(0.0076)	(0.0076)
Size	0.0063[b]	0.0064[b]	-0.0004[d]	-0.0004[d]
	(0.0028)	(0.0029)	(0.0012)	(0.0013)
Modern Machinery	0.0328[a]	0.0342[a]	0.0420[a]	0.0419[a]
	(0.0030)	(0.0031)	(0.0051)	(0.0051)
Log likelihood	-350.7424	-349.5236	-468.7724	-468.7241
Chi^2	391.01	287.70	337.81	79.90
Pseudo R^2	0.3579	n.a.	0.2639	n.a.
Observations	1472	1472	1472	1472

Notes: Standard errors are in brackets. Yearly dummies are included in all regressions. The concentration variable is a geometric average of the concentration ratios in cotton spinning sector and cotton weaving in a given district. This follows Caves and Bradburd ("Empirical Determinants") that recommended estimating joint seller and buyer market concentration in each market. These concentration ratios are obtained as the ratio between the (estimated) production capacity of the largest four firms of that district and the total (estimated) production capacity of that district.[79] Size is measured as the production capacity in tons (of yarn or cloth) per year. Modern machinery is measured as the ratio of the estimated production made by steam and water-powered machinery to the total estimated production of the firm. [a] indicates significant at 0.01 level; [b] indicates significant at 0.05 level; [c] indicates significant at 0.1 level; [d] indicates no significant.

[79] I also tested alternative measures of concentration like the total amount of production capacity of the district, the total production capacity of yarn or cloth, and the concentration ratio of the upward (backward) sector without significantly different results in the regressions. All these alternative estimations are available under request from the author.

Sources: See table 1.

The table 5 presents a variety of estimation results. They are broadly consistent each other, suggesting that the results are robust to regression specification. The explanatory variables worked reasonably well doing their work explaining vertical integration. More prominently, all the coefficients are of the expected sign and, practically in all occasions significant. However, some differences among the different estimations are remarkable. Particularly, the different specifications explain better vertical integration in cotton weaving than spinning. This is mainly due to the high significance of the variable "machinery" in cotton weaving indicating that physical asset specificity was very important in the case of the adoption of power-looms. Therefore, it is likely that vertical integration advanced as a backward integration of power-loom weaving into mechanical spinning.

TABLE 6
DETERMINANTS OF VERTICAL INTEGRATION IN COTTON SPINNING AND WEAVING: ENTRANTS VERSUS ESTABLISHED FIRMS

Sample	Entrants		Established	
Method	Logit	Tobit	Logit	Tobit
Constant	-3.7842[a]	-4.4843[a]	-5.1539[a]	-2.8647[a]
	(0.3966)	(0.6129)	(1.3308)	(0.9772)
Concentration	0.0290[a]	0.0269[a]	0.0328[c]	0.0097[d]
	(0.0077)	(0.0072)	(0.0174)	(0.0132)
Size	0.0099[a]	0.0023[c]	0.0178[b]	0.0024[d]
	(0.0024)	(0.0014)	(0.0074)	(0.0022)
Modern Machinery	0.0193[a]	0.0269[a]	0.0288[a]	0.0239[a]
	(0.0027)	(0 .0039)	(0.0099)	(0.0072)
Log likelihood	-277.2565	-389.8194	-60.7414	-91.4793
Chi^2	193.07	161.66	57.20	47.30
Pseudo R^2	0.2612	0.1717	0.3201	0.2054
Observations	637	637	140	140

Notes: Standard errors are in brackets. All estimations comprise observations in cotton spinning and weaving (sector dummies are included in the regressions). The dependent variable in logit estimations is Vertical integration = 1, 0 otherwise. The dependent variable in Tobit regressions is Cloth (yarn) production /Yarn (cloth) production. [a] indicates significant at 0.01 level; [b] indicates significant at 0.05 level; [c] indicates significant at 0.1 level; [d] indicates no significant. See table 5.

Sources: See table 1.

It is also interesting to explore whether integration behaviour of entering cotton firms differed from established firms. The period of entry was eleven years (from 1850 to 1861). Table 6 presents

the results of an analysis of the probability to integrate and the extent of internal markets separately for firms that were new in the sample year of 1861 and for established firms that had been operating in the previous sample year.[80] The models are the same than those estimated in table 5, and were estimated only for firms operating in 1861.

It is remarkable that the regression coefficients in both logit and Tobit estimations suggest that established cotton firms were less reactive to the transaction-cost variable, the concentration ratio, comparing to entering firms. This implies that once a firm was established as integrated or specialized, few firms changed of business structure. Over the period 1850-1861, only 15 of 118 firms chose to switch, most by eliminating or purchasing a mill. As a result, most established firms did not adapt to changes in the determinants of vertical integration over time. In other words, the rapid increase in the share of vertically integrated firms occurred through the large amount of entry and exit of firms during the period. Given that the concentration ratios in each district grew over the period[81] as a consequence of the increase in the average firm size, entrants to each district were more likely to be integrated over time. The large coefficient for the concentration for entrants compared to established firms is consistent with their response to the increase in district concentration, and the results for the entry variable also point a stronger role for transaction-cost factors among entrants than established firms.

EXPLAINING VERTICAL SPECIALIZATION IN COTTON PRINTING AND MARKETING

The objective of this section is to apply the intuitions behind the model outline above to other phases in the production and distribution of cotton textiles. More specifically, it will speculate about

[80] Ohanian ("Vertical Integration") suggested this test.

[81] More specifically, in 1850 the concentration ratios (measured as the average of the ratios of the four largest firms in cotton spinning and weaving) were the following: Anoia (26.30 percent), Bages (32.99 percent), Barcelonès (23.80 percent), Garraf (89.61 percent), Gironés (71.46 percent), Maresme (23.35 percent), Osona 21.56 (percent), Tarragona (53.28 percent) and Vallès (34.54 percent). Instead, in 1861, they were: Anoia (37.37 percent), Bages (32.65 percent), Barcelonès (37.48 percent), Garraf (81.80 percent), Gironés (81.72 percent), Maresme (43.14 percent), Osona (43.65 percent), Tarragona (56.89 percent) and Vallès (36.97 percent).

the relevance of the dependent variables (concentration, size and modern machinery) in explaining the limited scope of vertical integration in cotton-printing, raw cotton markets, and finished cloth markets.

Why vertical integration was so limited in cotton printing? Interestingly, the cotton printing firms in Catalonia shared several of the characteristics of vertically integrated firms in cotton spinning and weaving but also differed in others prominently.

Size and the production of longer series were characteristics shared by printing and vertically integrated cotton and weaving firms. The average production capacity of cotton-printing firms was of 131 Tons in 1850 and of 223 Tons in 1861; that is, several times the average capacity of cotton spinning and weaving firms. Moreover, the ten largest firms in cotton printing had more production capacity (measured in Tons) than the ten largest firms in cotton spinning or weaving. Consequently, at first sight, their size may justify the costs of internal organization and made desirable backward vertical integration of cotton-printing firms into cotton weaving. However, the extent of vertical integration among these largest cotton-printing firms was limited; so, in 1861, only 3 of 10 integrated vertically cotton printing with cotton weaving.[82] Moreover, like in cotton spinning and weaving, modern printing firms produced long series of each type of cloth than traditional firms; therefore, apparently, they could incur in dedicated assets problems.

However, printing firms also differed prominently in other characteristics. First, they did not suffer the physical asset problems of power-loom weaving firms since modern printing machinery could use any kind of cotton cloth regardless their quality, which was easiest measured for any expert.[83] Second, in spite that the overall (region-wide) concentration of the cotton-printing phase was the highest,[84] the concentration level of the firms by district was relatively low. Catalan cotton-printing firms were concentrated in only two locations: the majority of firms were located in Barcelona (particularly, at the borough of Sant Martí de Provençals) and the remaining at the Anoia cotton district

[82] Similarly, of the ten largest cotton-weaving firms only three integrated forward into cotton printing.

[83] Comisión especial arancelaria, *Información*.

[84] This was mainly due to the fact that the number of firms was much less than in the other phases.

(mainly in the town of Igualada).[85] In other words, weaving firms did not experienced small-numbers bargaining problems when sold their grey cloth to printing firms or when subcontracted printing processes. Moreover, given the structure of the distribution of cloth in Catalonia, printing firms also not suffer that kind of problems. Cotton cloth was produced elsewhere in Catalonia but was habitually transported to Barcelona for their distribution; so the majority of cotton-weaving firms had a storehouse in the city. In other words, the supply of grey cloth in Barcelona was continuous exceeding by large the production capacity of the city and its surroundings. In sum, the preponderance of specialized firms in cotton printing can be explained by appealing to the little importance of asset specificity in printing production.[86]

It is remarkable to note that similar arguments can be used to explain the low levels of backward integration of cotton firms into the supply of raw cotton and forward integration into the distribution of finished cloth. In the first case, the quality of raw cotton was easy to recognize for any expert since depend on the physical, and observable, characteristics of the fibre. Moreover, in Barcelona were located a sizeable amount of wholesale merchants that were capable of maintain a continuous flow of raw cotton at competitive prices. For example, the largest individual consumer of raw cotton in Catalonia, the "España Industrial SA", chartered ships with raw cotton from New Orleans in the late 1850s but decided to abandon this type of business rapidly because did not obtain any savings at all.[87]

In the case of finished fabrics marketing, a large number of wholesalers, merchants and agents devoted to trade with cotton goods were also located in Barcelona. Commonly, these merchants carried with all the distribution of Catalan cloth through Spain although they sometimes received credit from cotton industry firms. Therefore, for any cotton firm was relatively easy to change of merchant; in

[85] For example, by 1850, 49 of 57 printing firms were located at the District of Barcelona and in 1861 this proportion grew since 37 of 42 were located there.

[86] It should be noted that had been estimated regressions similar to those of table 5 employing cotton-finishing data without any significant result.

[87] See on this market, Castañeda and Tafunell, "Mercado mayorista".

other words, the small-number bargaining problem was of little importance in the distribution of finished cloth. More prominently, it was common for the largest cotton industry firms to maintain commercial relations with a large number of merchant-houses (sometimes more than fifty).[88]

SUMMARY AND IMPLICATIONS

This article offers new insights into the causes of vertical integration, and subcontracting, in Spanish cotton industry by applying some of the arguments of the transaction cost theory. The use of vertical integration was more widespread in yarn markets characterized by relatively high buyer and seller concentration. New entrants especially shown to be sensitive to the transaction-cost factors, measured by district concentration, compared to the established firms. Larger cotton spinning and weaving firms and those employing the most recent technology (self-acting mules and power-looms) were also more likely to vertically integrate due to physical and dedicated assets problems. Instead, subcontracting predominated in those phases, like cotton printing and the marketing of raw cotton and finished cotton goods, where small-numbers bargaining problems were minor and where asset specificity problems were less important. Consequently, vertical integration was not caused by any broad characteristic of the Spanish market for cotton goods but for some particular characteristics of the intermediate markets for yarn.[89]

These results suggest the appeal of some sort of evolutionary interpretation of the changes in the market structure of the cotton industry in Catalonia over the eighteenth and the nineteenth centuries in the line of the life-cycle theory advanced by George J. Stigler ("Division of Labor"). At the beginnings, the predominance of vertical integration into weaving and marketing among calico printing concerns was probably caused by the small-numbers bargaining problem. Therefore, there were not

[88] See Prat and Soler, "Formación de redes comerciales".

[89] Note that this result contradicts previous research (Maluquer, "Estructura") that stressed that, given the characteristics of the Spanish home market (small and unstable), the only choice for Catalan cotton firms was subcontracting.

enough independent handloom weavers[90] and merchants to satisfy the buyer and seller necessities of the relatively large printing concerns. The reliance of cotton firms in vertical integration decreased since the 1790s onwards. It is likely that the industry grew enough to maintain specialized firms in both, cotton weaving and printing. Simultaneously, the new cotton spinning industry was vertically specialized because was formed by relative small units of production. Moreover, cotton industry machinery allowed producing in small batches (to order). In other words, asset specificity problems (particularly physical assets and dedicated assets) appear to be minor during this period. Moreover, given the high levels of uncertainty and the low levels of asset specificity, vertical specialization was efficient to cope with the unstable demand given the low contracting costs.[91] The situation changed dramatically with the arrival of the factory system and the new self-acting mules, throstles and power-looms. These new technologies were less flexible than the older machinery and produced longer series of each type of yarn and cloth; then, cotton mills grew on size and put pressure on local markets for yarn. For this reason, dedicated, physical and site specificity problems arise and new entrants in cotton spinning and weaving decided to integrate vertically these two consecutive phases. It is likely that this situation was maintained over the rest of the century given that the average mean size grew, the industry remained dispersed in many locations due to the increase in the number of watermills, and the high survival rates of established cotton firms, which were reluctant to change of business organization.

How these results for Spain compare with previous studies for other countries? It is clear that Spanish experience has some important resemblances with the experience of other countries and this

[90] Thompson (*Distinctive Industrialisation*) underlines that the absolute preponderance of the guild system in Barcelona, which limited the extent of the market, had made the organization of the weaving industry in a putting-out basis virtually impossible.

[91] The literature on transaction costs argue that uncertainty is relevant for vertical integration if a certain degree of asset specificity exists. If a transaction does not require specific investments, contracting costs are small and a new agreement could be easily reached in any new situation. Instead, when asset specificity exists, uncertainty increases the cost of establishing how the participants should act in each possible contingency and makes possible the existence of unforeseen hold-up problems. See on this point, for example, Williamson, *Economic Institutions*.

research may serve to throw light in some obscure issues. Previous studies on the cotton industries in Lancashire, the United States and Germany have found that size, product type (coarse goods) and localization were major determinants of vertical integration of cotton spinning and weaving.[92] It appears that a universal pattern is that bigger spinning and weaving firms had a major tendency to vertically integrate than smaller firms. Product type is directly related to the choice of technology given that some technologies (like the self-acting mule and the power-looms) were more adapted to the production of coarser than finer goods. Consequently, the variable machinery of this study can be considered practically equivalent to the variable quality of these studies. In other words, it also seems that certain technologies, which were employed to produce coarse goods, had more predisposition to vertical integration given their asset specificity problems. In spite of all these studies have considered the relative importance of the location variables, they have rarely linked this relevance to the presence of small-number bargaining problems.[93] This study offers a straightforward explanation for the relevance of location in the choice between vertical integration and market governance. Districts with high concentration ratios suffered from small-numbers bargaining problems and, hence, had a large share of vertically integrated firms. This argument could be employed to explain why English cotton industry was vertically specialized and the U.S. and the German cotton industries were vertically integrated. In Lancashire, the concentration of cotton firms of different phases in a short distance was extraordinary. Instead, cotton firms in Spain, the United States and Germany were sometimes dispersed or even isolated from other firms. Consequently, it is not strange that they suffered from small-numbers bargaining problems and face large transaction and transport cost when change of supplier or buyer.

Finally, I would like to highlight three broad suggestions for further research. First, the evidence in this paper points to the importance of high concentration ratios and the subsequent small-

[92] Huberman "Vertical Disintegration", Temin, "Product Quality" and Brown, "Market Organization".

[93] A notable exception to this rule is the article of Leunig ("New Answers") on Lancashire cotton industry during the early twenty century. He argues that spinning firms did not suffered hold-ups because, given the high spatial concentration of the industry, it was enough downstream competition.

numbers bargaining problems in the firms' choice of vertical integration. Consequently, it would be desirable to extent the evidence on market concentration to cotton industries in other countries. Second, the article's findings suggest the need for rethinking the relationship between vertical integration and international competitiveness. In the line of the previous study of John C. Brown ("Market Organization") on Germany, the results obtained here supports the view that there was not close connexion between vertical integration and a successful position in international markets for cotton goods. Third, from the point of view of the economic theory, this article has shown the explanatory power of the transaction cost theory in economic and business history.

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Appendix: Estimating production capacity of cotton firms

The sources of this study are the two major surveys conducted during the period on the Catalan cotton industry. The survey of 1850 (Junta de Fabricas de Cataluña, *Censo de fabricas*) 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 firm, 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. The industrial guide for 1861 (Gimenez Guited, *Guia fabril*) collected data on all cotton firms located in Catalonia. It seems that the original data was drawn from the records of the industrial tax. The data was similar to those collected in the previous survey. However, unlike the census for 1850, it did not separate workers across the different phase since aggregate them by establishment and firm.

These two surveys did not recorded data on the actual production of each firm. But given that different types of spindles and looms produced different amounts of product per year, one can derive from the machinery figures the amount of production capacity in Tons per year of each firm. According to the sources, the average production capacity of the different type of spindles were of: 3 Kg. per year in hand-spindles; 11Kg. per year in mule-jennies powered by horses; 15 Kg. per year in throstles; 20 Kg. per year for mule-jennies steam or water powered; and 23 Kg. per year for self-acting mules. Similarly, the average production capacity of the hand-looms was of 280 Kg. per year and those of power-looms was of 1400 Kg. per year. The sources of these figures are Sayró, *Industria algodonera*, Figuerola, *Estadística* and Comisión especial arancelaria, *Información.*

Employing the figures of estimated production, one may compute the coverage of the sample by dividing the corresponding values (collected in table 1) by the amount of yarn and cloth production furnished in Rosés (“Industrialización regional”, p. 74-75). Thus, in 1850 the coverage of cotton spinning is 99.77 percent and 93.89 percent in cotton weaving; in 1861 this coverage is of 94.75 percent in cotton spinning and is 95.74 percent in cotton weaving.