

**TECHNOLOGICAL CHANGE, LABOUR COSTS AND PRODUCTIVITY IN
THE CATALAN COTTON INDUSTRY. A STUDY IN BUSINESS
HISTORY: LA ESPAÑA INDUSTRIAL (1855-1930)**

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Introduction

This paper examines one of the factors underlying economic growth and, as such, one of the central issues in economic history: namely, the relationship between technological change and productivity in a labour intensive sector – the cotton industry¹. It seeks to contribute to the ongoing international debate in the field of business history in two respects: first, by examining the links between productivity and technological change and, second, by presenting the case for the measurement of productivity in homogenous physical units.

In this respect, the research is conducted in line with several new approaches that have come to typify the international study of the cotton industry². First, it adopts W. H. Lazonick's historical perspective in the belief that this is fundamental to any demonstration that the establishment of total factor productivity in the cotton industry was a complex process involving economic, social and technological forces³. Yet, unlike other authors⁴, it places the technological factor at the forefront of the analysis. But in common with David and Wright⁵, the article does not seek a purely technological explanation for the increase in productivity, but rather a more complete understanding, which illustrates both the generic and specific features of technological change. From

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¹ VAN ARK, B. & KUIPERS, S. K.(eds.), *Productivity, Technology and Economic Growth*, Kluwer Academic Publishers, Boston, 2000; LINDNER, S.H., "Technology and textiles globalisation", *History and Technology*, 18, 2002, pp. 1-22.

² One of the pioneering studies is Jones's examination of real costs: JONES, G. T., *Increasing return*, CUP., Cambridge, 1933. Among the more recent studies, mention should be made of: BROADBERRY, S. N., *The Productivity Race: British Manufacturing in International Perspective 1850-1990*, CUP., Cambridge, 1997; ROSE, M. B., *Firms, Networks, and Business Values: the British and American Cotton Industries since 1750*, CUP., Cambridge, 2000.

³ LAZONICK, W. H., "Production Relations, Labour Productivity, and Choice of Technique: British and U. S. Cotton Spinning", *The Journal of Economic History*, XLI, 3, September 1981, pp. 496 ff.

⁴According to M. Huberman, the increase in productivity in Lancashire was due essentially to profit-sharing schemes involving the workers: HUBERMAN, M., "When Labor Hires Capital: Evidence from Lancashire, 1870-1914", *Economic History Association Annual Meeting*, September, 2001. Among those who attribute growth in productivity to factors that are not strictly technological, such as the intensification of work: BOWDEN, S. & HIGGINS, D. M., "Productivity on the Cheap. The 'More-Looms' Experiment and the Lancashire Weaving Industry during the Interwar Years", *Business History*, 3, 4, July 1999, pp. 21-41; FOWLER, A., *Lancashire Cotton Operatives and Work, 1900-1950: A Social History of Lancashire Cotton Operatives Lancashire in the Twentieth century*, Aldershot, Ashgate, 2003. Another approach in ATTACK, J.; BATEMAN; F. & MARGO, A., "Productivity in manufacturing and the length of the working day", *Explorations in Economic History*, 40, 2, 2003, pp. 170-194.

⁵ DAVID, P.A. & WRIGHT, G., "General purpose technologies and surges in productivity", *Discussion papers in Economic and Social History*, 31, September 1991, p. 2.

another standpoint, T. Leunig argues for a better measure of productivity, pointing out that earlier estimates have been based on the weight of cotton production regardless of the fineness or thickness of the yarn and, therefore, they overlook the fact that weight is a poor measure of yarn production⁶. Finally, G. Clark develops an approach in which a sectorial study is linked to economic growth or the absence of such growth⁷.

Current Spanish research enters the arena of international debate on the controversial issue of competitiveness, a factor directly linked to productivity. The lack of competitiveness was an argument frequently adopted by industrialists in favour of protectionism or in order to combat government regulations concerning salaries and the length of the working day⁸. In recent studies, various explanations have been forwarded to account for the lack of international competitiveness in the Spanish cotton industry: some hold the industry itself responsible, particularly its production⁹ or marketing¹⁰ phases, while others attribute it to external reasons, such as the limited nature of the domestic market¹¹ and the similar characteristics of international trade¹². Yet, despite the

⁶ LEUNIG, T., "New answers to old questions: explaining the slow adoption of ring spinning in Lancashire, 1880-1913", *The Journal of Economic History*, 61, 2, 2001, pp. 439-465; LEUNIG, T., *Britannia ruled the Waves, Working Papers in Economic History*, 66/01, London School of Economics, October, 2001.

⁷ The argument presented has a strong internal coherence but its initial premises are highly debatable. To begin with, in its adjustment of the production price in accordance with input prices, raw cotton is not taken into consideration, although it would have had an overwhelming weight in the cost structure. Thus, for example, Spanish production costs, adjusted according to price inputs, are lower than those in Britain. In the case of machinery - a predominant factor in the fixed capital of the cotton industry - his initial premises rule out any possible comparative advantages derived from technology on the understanding that the world market had placed the various countries of the world on an even technological footing. This viewpoint ignores the economies of agglomeration enjoyed by the Lancashire industry thanks to the powerful British machine building industry and the Liverpool cotton market, as well as the existence of two major technological areas, typified by the predominant use of intermittent or continuous (ring) spinning: CLARK, G., "Why Isn't the Whole World Developed? Lessons from the Cotton Mills", *The Journal of Economic History*, XLVII, 1, March 1987, pp. 141 ff. Similar arguments are to be found in: CLARK, G. & FEENSTRA, R., *Technology in the Great Divergence*, NBER working paper, 2001.

⁸ FERRER VIDAL, J., *Conferencias sobre el arte de hilar y tejer*, J. Jepús, Barcelona, 1875; INSTITUTO DE REFORMAS SOCIALES, *La jornada de trabajo en la industria textil*, Suc. de Minuesa de los Ríos, Madrid, 1914, p. 48. An analysis of the situation at the end of the XIX century and the beginning of the XX, in CALVO, A., "La industria cotonera catalana a començaments del segle XX", *Recerques*, 44, 2002, pp. 91-110.

⁹J. Maluquer attributes the lack of competitiveness of the Catalan industry abroad to the cost differences arising from the high price of imported combustible fuel, its poor, fragmentary structure, as well as the high wage costs: MALUQUER DE MOTES, J., "La revolución industrial en Cataluña", in SÁNCHEZ ALBORNOZ, N., *La modernización económica de España*, Alianza, Madrid, 1985, p. 218. By contrast, J. R. Rosés blames the high tariffs for the lack of efficiency in the Spanish cotton industry: ROSÉS, J. R., "La competitividad internacional de la industria algodonera española (1830-1860)", *Revista de Historia Económica*, XIX, 2001, pp. 85-110.

¹⁰ PRAT, M. & SOLER, R., "Weaving the Network? The international marketing failure of Catalan cotton textiles (1850-1930)", in BONIN, H. *et al.*, *Transnational Companies (19th-20th Centuries)*, P.L.A.G., Paris, 2002, pp. 219-237.

¹¹ NADAL, J., *El fracaso de la Revolución Industrial en España, 1814-1913*, Ariel, Barcelona, 1975; NADAL, J. & SUDRIÀ, C., "La controversia en torno al atraso económico español en la segunda mitad del siglo XIX(1860-1913)", *Revista de Historia Industrial*, 3, 1993, pp. 208-209; SUDRIÀ, C., "La empresa española y los problemas de competitividad internacional. Una visión desde la industria algodonera", 1999, unpublished.

importance of these contributions, the subject of productivity has still to be tackled in Spanish economic studies¹³.

This paper, therefore, conducted within the traditions of business history, seeks to respond to some of the questions that have arisen in the debate surrounding the cotton industry. The hypothesis it wishes to verify is whether competitiveness in the domestic market was a principal goal of a large sector of the Spanish cotton industry, represented here by *La España Industrial*. The importance of this the firm in Spain's process of industrialisation, linked to the preservation of its company records, has made it the centre of much academic attention, both as a point of reference in the general history of the country and as a specific object of study in its own right¹⁴. Here, this company is used to illustrate a certain attitude which can be extended, if not to the whole, at least to the most dynamic sector of the Catalan cotton industry, which formed the largest part of Spain's cotton production.

The arguments presented here are based on a careful analysis of an enormous amount of data drawn from the company's records that have to-date gone largely ignored. Most notable among these, are the inventory books - *Libros de Inventario* (which record in great detail all the changes in machinery and equipment), the weekly books - *Libros de Semanales*, the monthly statements - *Estados mensuales*, the correspondence - *Correspondencia* - and the manufacturing and trade movement - *Movimiento Fabril y Mercantil*. With the exception of the latter, which dates from a fairly late point in the firm's history, these records cover virtually all the period being studied here. In the first section, this paper outlines the characteristics of *La España Industrial*, its principal objectives and its fight to remain competitive; in the second, it describes the cycles of investment and their link with technological change; in the third and fourth, the paper examines the results in terms of costs and productivity.

¹² Unlike those that focus their analysis on factor costs, Anna Carreras points out that the international market of cotton fabrics was highly influenced by the persistence of the former colonial dominions in the market of the recently independent countries, the highly specific nature of intra-European trade and the weight of product differentiation as a competitive strategy: CARRERAS, Anna, "El mercado internacional de tejidos de algodón en 1913 y la industria española", *Revista de Historia Económica*, XIX, 2001, pp. 111-128 and "La competitividad de las industria algodonera en el período previo a la Primera Guerra Mundial: implicaciones de las estrategias de diferenciación de producto en los mercados internacionales de tejidos acabados", Congreso de la Asociación de Historia Económica, Zaragoza, September 2001, unpublished.

¹³ This is the main conclusion to be drawn from the analysis undertaken by CARRERAS, A., *Estadísticas Históricas de España, siglos XIX y XX*, Fundación Banco Exterior, Madrid, 1989, p. 180.

¹⁴ RIBAS, E., "La España Industrial (1851-1936). Análisis económico-financiero de la Compañía", en CARRERAS, A.; PASCUAL, P.; REHER, D. y SUDRIÀ, C.(eds.), *La industrialització i el desenvolupament econòmic d'Espanya, Homenatge a J. Nadal*, Universitat de Barcelona, Barcelona, 1999, pp. 1,125-1,163; GUTIÉRREZ, M^a LL., *La España Industrial 1847-1853. Un model d'innovació tecnològica*, Enginyers Industrials de Catalunya, Associació-Col·legi, Barcelona, 1997, pp. 193-194.

Survival and competitiveness

Over the first three decades of the XIX century, a modern cotton industry managed to establish itself in Spain with similar characteristics to its continental counterparts¹⁵. Exemplifying the new investment efforts at the end of the civil war, *La España Industrial* was founded in 1847 by a group of industrialists, bankers and politicians centred around the Muntadas family, convinced of the profitability and future of the industry. Undoubtedly, the initial idea came from within the *Instituto Industrial de España*, created seven years earlier out of the merger of two already existing groups. Thus, a vast, ambitious project was formed combining traditional Catalan, industrial know-how in the guise of the Muntadas (formerly from Igualada) and other representatives of the Spanish business and financial worlds.

La España Industrial was remarkable for the size of its share capital, which amounted to 50 million *reales*. Among the shareholders, there were three main groups: manufacturers and traders from Barcelona; investors from Madrid who specialised in such speculative deals and, finally, the firm's employees and collaborators¹⁶. The first success of the company was its capacity to win the confidence of sectors willing to place their savings in the development of modern industry within Spain. This meant breaking with the overwhelming location of the cotton industry in Catalonia¹⁷. In fact, investors from various points throughout Spain¹⁸ showed their interest in forming part of the project but, very shortly afterwards, the economic crisis dealt a severe blow to the group's ambitions. Then the plans to open factories in various zones of Spain had to be postponed and its industrial activity was confined to Barcelona.

¹⁵ For further details, see two classic studies and one which reviews the growth process before the 1830s: NADAL, J., *El fracaso...*; MALUQUER DE MOTES, J., "La estructura del sector algodonero en Cataluña durante la primera etapa de la industrialización (1832-1861)", *Hacienda Pública Española*, 38, 1976, p. 136; SÁNCHEZ, A., "Crisis económica y respuesta empresarial. Los inicios del sistema fabril en la industria algodonera catalana, 1797-1839", *Revista de Historia Económica*, 18, 3, 2000, pp. 485-523.

¹⁶ Of a total of 25,000 shares priced at 2,000 *reales* only 16,000 were bought, so that in 1852 the share capital was reduced to 32 million *reales*. Among the Barcelona shareholders, who accounted for 4,405 shares, were a number of pioneers in the cotton and metal industries, including Rull, Ramis, Tous and Ascacibar. Despite the fact that the Muntadas family, instigators of the project, received 1,632 shares and was the largest group, the nucleus of shareholders was based in Madrid with 10,095 shares: Fondo España Industrial (Fondo E. I.), ANC, Correspondence sent, 12-8-1847, 26-4-1847, 1-5-1847 and 17-5-1847.

¹⁷ The stated aim of these businessmen was "to develop the cotton industry in its various branches" throughout Spain: Letter to the Director of the Banco de Barcelona, 17/2/1847, Fondo E. I., Correspondence received.

¹⁸ Bofill, Batlle y Cía. to the directors La España Industrial, Valencia, 5/3/1847, Fondo E. I., Correspondence received, ANC.

La España Industrial managed to forge a modern reputation for itself both in terms of its organisational and technical capabilities. It established itself as a joint-stock company and set up a number of bodies that were able to see the project through successfully. Thus the management, entrusted to the Muntadas family, was given considerable freedom in which to operate, and a Governing Board was set up comprising the ten founding members. This would later be converted into an Inspection Board. From the technical angle, it broke with the dispersed and inefficient industrial infrastructure that it had inherited¹⁹. In its place, it created a business powered by a more efficient energy source, equipped in the main with the most advanced machinery of the day²⁰, i.e. mule spinning frames and mechanical looms. Above all the machinery was of English design, but adapted to the conditions of Catalonia²¹. It is worth stressing, for example, that it installed mule spinning frames six years before the *Fábrica de la Rambla* in the Southern coast of Barcelona - Vilanova i la Geltrú- followed suit. After a short time, the productive capacity was expanded again, making it the largest factory in Spain²². Despite projects to find a rural location to make use of hydraulic power, the economies of agglomeration offered by the city of Barcelona meant it made better sense to locate production in the immediate vicinity of the city, with the option of using coal as its energy source.

The founders of *La España Industrial* tried to enter the domestic market by offering a competitive product, but without renouncing quality, which they prized even above

¹⁹ This had been provided by one of the founding companies, Muntadas Hermanos: Fondo E. I., Museu d'Estampació de Premià de Mar (MEPM), Copiador de Cartas, 28 August and 4 September 1848; 3 April 1849 and 22 April 1850.

²⁰ *Revista Industrial*, March 1858, p.116. The initial machinery comprised 18,000 Sharp selfacting mule spindles; 3,000 H. Platt throstle spindles and 500 looms.

²¹ To give just one example, the layout of the loom factory was the result of the joint work of the machine maker, Hibbert Platt, and the engineer, Angel Martorell, who was sent by *La España Industrial* to Manchester: Fondo E. I., Correspondence sent: 7-10-1847. The network of *La España Industrial* was formed by engineers such as M. de Bergue and J. Barrau, who acted as consultants and intermediaries. A. Martorell followed closely the building of the Platt looms, sent reports to *La España Industrial* about manufacturing processes and possible innovations in the company's machinery: Fondo E. I., Correspondence sent, 30-11-1847. An example of adaptation to the climatic conditions of Catalonia, a much warmer country than England, was the use of a wire device rather than one made of rubber in the roving frames: id., 2-9-1847.

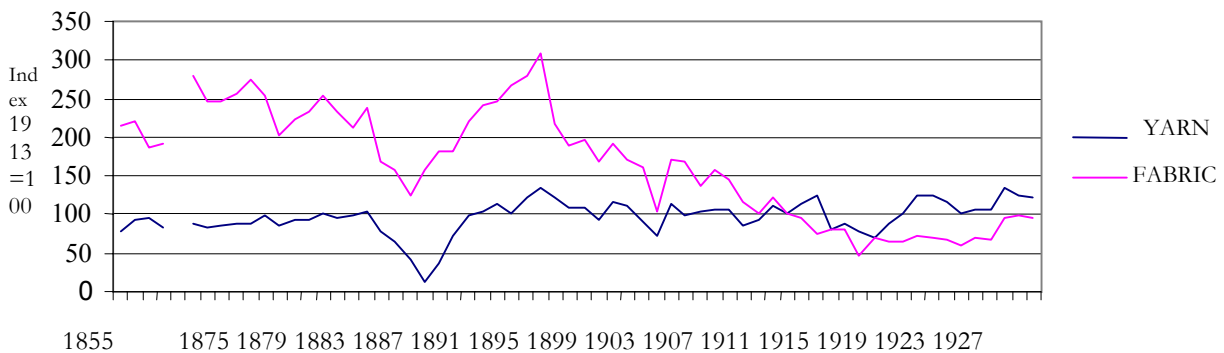
²² Differences in opinion on this matter are caused by the date of observation. There were 300 looms in *La España Industrial*, according to a letter to Mr. Heath of London, 13 March 1852; the machinery bill in England records the purchase of 18,036 Sharp mule frames while some scholars report 2,240 continuous and 18,336 mule frame spindles in the spinning section and 500 looms in that of fabrics: GUTIÉRREZ, M^a LL., *La España Industrial 1847-1853. Un model d'innovació tecnològica*, Enginyers Industrials de Catalunya, Associació-Col·legi, Barcelona, 1997, pp. 193-194. Between 1852 and 1853, 34 selfacting mule, 423 mechanical looms, 463 combs, 1 roving frame, 1 warping machine, 90 folding machines, 2 spooling machines, 1 twisting machine and 1,100 mechanical shuttles were installed: Fondo E. I., Inventories. In 1865, there were 114 mule frames with 37,778 spindles, 22 flyer throstle with 3,520 spindles and 7 mule jennies with 840 spindles: *Información sobre el derecho diferencial de bandera*, t. 4, p. 11.

productivity. Success depended above all on the economies of scale, both in terms of production and in terms of purchasing raw materials, and on good organisation²³.

In response to this first challenge, they built the factory in Sants²⁴, which in addition to its great size was a fully integrated plant - one in which the complete production cycle could be carried out. The modern manufacturing system required regular production behaviour in order to make the investment profitable. However, in an industry centred largely on the domestic market of what was essentially an agrarian economy, subject therefore to the success and rhythm of the harvests, an unstable demand was only logical, and this translated into uncertainty, oscillations in production and changes in product type. In fact, the oscillations in production were a constant feature in *La España Industrial*, as can be seen in Figure 1.

The emergence of organisations defending the worker's interests was a further element of instability in the production process. The major conflicts of the 1880s, at the beginning of the century, and then in the years following the Great War had a major effect on the evolution in production of *La España Industrial*. The third element of instability in the production was caused by technological innovations, limiting themselves to certain moments and overlapping at times with conflictive situations.

Figure 1. Production of yarn and fabric in España Industrial 1855-1930(1913=100)



Source: Own from Fondo E. I., ANC.

²³ Martorell was asked, for example, to reduce the speed of the looms to avoid defects in the product: Fondo E. I., Correspondence sent, 30-11-1847. The larger factories had greater negotiating powers and so were able to obtain raw cotton at lower prices: TAFUNELL, X. & CASTAÑEDA, LL., "El mercado mayorista del algodón en Barcelona en el siglo XIX", in CARRERAS, A.; PASCUAL, P.; REHER, D. and SUDRIÀ, C. (eds.), *La industrialització i el desenvolupament econòmic...*, p. 993.

²⁴NADAL, J., *El fracaso...*; NADAL, J., "La indústria cotonera", *Història Econòmica de la Catalunya Contemporània. Indústria, transports i finances*, Enciclopèdia Catalana, Barcelona, 1991; ENRECH, C., *La España Industrial, obrers i patrons*, unpublished undergraduate dissertation, UAB, 1990, pp. 8 ff. The factory only came into operation gradually: in April 1849 there were 14 flyer throstle, 36 mule frames and 160 looms, among others, working; at the end of May, the spinning section was working at full capacity: between 23 and 28 May, printing began; between 7-12 November, bleaching and between 13-18 February 1854, dyeing: Fondo E. I., Premià de Mar, Copiador de Cartas, 2 April and 21 May 1849; Fondo E. I., ANC, *Comunicats*

The instability in demand and the variability in the product were corrected by regulating mechanisms. *La España Industrial*, which had opted for a production concentrated on fully integrated process, manufactured the vast majority of the yarn that it wove and the fabrics that it sent to the market. The production completed outside the factory accounted for a very small proportion and served the dual purpose of being a complement in times of normality and of substitution in times of emergency. Yarn sales accounted for around 20% of total production at virtually all times. In other words, production was adjusted to match the orders, but any alterations in this behaviour were exceptional (1880s, the period following the independence of the colonies and the First World War). The very nature of the integrated factory made it possible to adapt rapidly to changes in the type of product imposed by the market.

Risk taking: investment and technological change

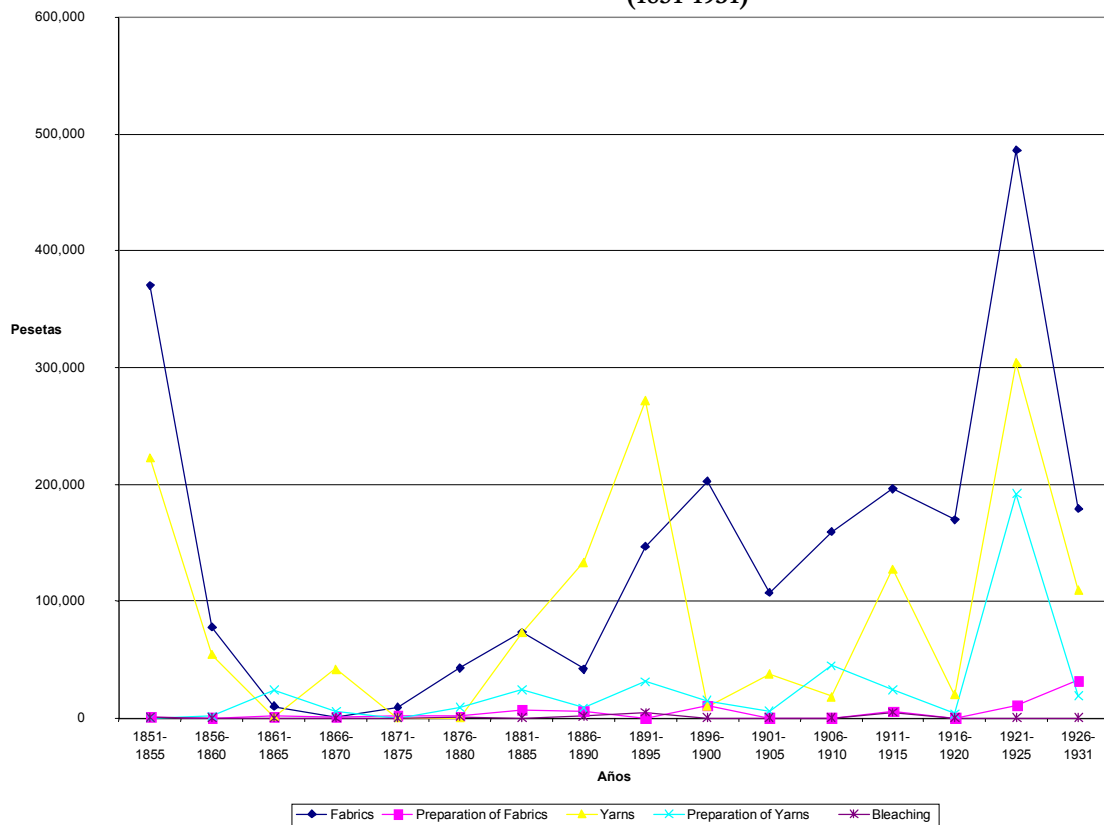
Due to the need to account for its actions before the shareholders, the subject of profit levels was of particular concern to *La España Industrial*. Already in 1860, one of the shareholders was echoing a widely held belief among the firm's other members and the public, that the capital employed by *La España Industrial* was less profitable than that invested in other firms, in clear contradiction with the increased production economic theory conceded to the increase in size. In order to settle the matter, the same shareholder called for a careful study aimed at “producing as cheaply as the cheapest producer and matching the others in the securing of the company's interests”. At the same time, in order to remedy possible shortcomings, he proposed concentrating all activities in the Sants factory, following the abandonment of the small factories in the important textile city of Sabadell and in the surroundings of Barcelona, Sarrià²⁵.

Setmanals.

²⁵ Documents of the General Board of Shareholders of *La España Industrial*, 5 February 1860, MEPM.

Figure 2, based on data contained in the *Libros de Inventario*²⁶, reveals three investment cycles. The first is the prolongation and termination of the company's foundation; the other two extended for about thirty years and were of varying intensity, characterised by marked fluctuations. They show, therefore, the first great expansion, the major transformation of the factory at the end of the XIX century and the redevelopment programme of the 1920s.

Figure 2.-Evolution in Investments by Section in La España Industrial (1851-1931)



Source: Own from Fondo E. I., ANC.

The enormous investment effort made as a result of its initial foundation²⁷ enabled *La España Industrial* to face up to any difficulties during a long period with certain advantages, and to establish itself firmly in the market. Nevertheless, the conditions under which the firm was used to operating began to undergo a major change in the final decades of the

²⁶ Fondo E. I., ANC.

²⁷ The company valued the spinning factories at 1,440,000 *reales de vellón*; the transmissions at 374.200 *reales de vellón* and the machinery at 1,982,300 *reales de vellón*. Fondo E. I., ANC, Correspondence sent, 4 and 10-

XIX century. The great challenge for the cotton industry in Barcelona and its hinterland (el Llano) was being able to compete with the river-based factories, which enjoyed comparative advantages in the costs of labour and energy and the tax burden. *La España Industrial*'s response to this challenge was to make technological changes aimed at lowering production costs, without having to change location. It is worth highlighting that the decision to make this technological change was met out of its own resources, which guaranteed the firm an enviable financial independence and reduced financial costs²⁸.

Forty years of production had meant that the machinery had aged inexorably²⁹ and *La España Industrial* now faced the dilemma: modernise or die. Thus, began a period of great transformations, driven in turn by a general crisis.

First, we shall examine the general responses to the difficulties, when at the end of the euphoria ushered in with the *gold fever* and with the persistence of market insecurity³⁰, there was a contraction and division of demand. The first measure to be taken by the firm was to reduce costs by making technological changes and to lower prices to overcome the added difficulties of increased competition³¹. The second set of measures involved product innovation to increase their market penetration with popular articles (light-weight cottons - gingham - and handkerchiefs), dedicating resources to the study of the characteristics of these products and the machinery needed to produce them³². Thirdly, economies of scale were sought through increases in production, even by producing more goods for the colonial markets, which, without generating great profits, meant unit costs could be kept low. Finally, in the final weeks of 1884 the partial work reduction meant the difficulties could be alleviated somewhat.

The depression at the end of the century caused a deterioration in the normal conditions in which the Catalan cotton industry had to operate. Indeed, the permanent limitations of the domestic market were accentuated by the reduction in the purchasing capacity of customers

11-1848. The *real de vellón* was equivalent to 0,25 pesetas.

²⁸ La España Industrial, *Memorias de la Junta de Accionistas*; RIBAS, E., "La España Industrial (1851-1936). Análisis Económico-financiero de la Compañía", in *La industrialització i el desenvolupament...*, pp. 1.125-1.163. According to Y. Blasco, La España Industrial appeared towards the bottom of the list of those obtaining credit loans from the Banco de Barcelona.

²⁹ The firm recognised that its machinery had not, for some years, been "in step with industrial advances": La España Industrial, *Memorias...*

³⁰ The management identified the main causes as the fall in orders, above all in Andalusia, which paralysed sales and left the warehouses in Catalonia overflowing; to this was added the commercial agreements with England. But some markets, such as that in Valencia, were severely hit by the epidemic, which caused great panic among its population: E. I., ANC., Correspondence received.

³¹ The company modernised its chemical laboratory, introduced the first ring spinning machines and made a number of other minor changes: Board 1884, MEPM and *Libros de Inventario*, Fondo E. I., ANC.

³² CALVO, A., "Estrategias de competitividad: la diferenciación del producto en la industria algodonera catalana. una aproximación desde la España Industrial", *Homenatge a E. Giralt* (forthcoming).

in the country's wheat belts due to competition from foreign cereals, and the increase in imported fabrics. In 1886, a number of factories were closed and the amount of work was reduced in others, which led to dismissals and emigration. The negative effects were felt most markedly in Barcelona, where the number of strikes called became frequent, and even the preparations for the Universal Exhibition were not enough to stem unemployment.

The crisis exacerbated the problems of the cotton industry, which was suffering high raw material and wage costs³³. The overriding need to lower costs in order to face increasing domestic competition led a growing sector of Catalan industrialists down the road of technological innovation. The most visible expression of this was the development of ring spinning, the continuous process until this time not particularly competitive but which was becoming more and more productive and easier to handle³⁴. However, the great variety in the business and productive structure meant that the adoption of this machine was rapid in some instances but only gradual in others. Thus, the ring frames were introduced in factories with a range of sizes and labour force structures and in a number of different locations throughout Spain. Initially, and at quite an early date, they were adopted in new investments, but it was not until the early years of the XX century that they became the most frequent choice. Thus, the technical structure of the sector was altered in favour of ring spinning and, just before the First World War, about two thirds of the sector was using ring spinning frames³⁵. A comparison with the continental Europe in terms of technological uptake placed Catalonia between Italy, on the one hand, and France and Germany, on the other.

During this process of change instigated by the crisis, not all the firms enjoyed the same fortunes. Some of the pioneers in the introduction of ring spinning were forced to close down, as was the case of Batlló y Batlló, a large integrated firm in Barcelona³⁶. A second group, among them the Güell factory, which decided to maintain their technological *statu quo*, albeit expressing concern for the so-called 'work reform', came up against a strong workers' movement³⁷, and were forced to abandon their urban location and seek a less

³³ The latter were due, in part, to the large number of workers on each machine: 3.29 workers per 1,000 spindles in Great Britain; 8.94 in France and 11.93 in Spain: CALVO, A., *La transformación de la estructura industrial en Cataluña, 1898-1920*, unpublished doctoral thesis, Universidad de Barcelona, 1986, pp. 41 ff.

³⁴ CALVO, A., "La cara conocida. Cambio tecnológico y adaptación al mercado en la industria algodonera catalana (fines del siglo XIX-comienzos del siglo XX)", in CARRERAS, A.; PASCUAL, P.; REHER, D. & SUDRIÀ, C.(eds.), *La industrialització i el desenvolupament econòmic*, pp. 1164-1174.

³⁵ NADAL, J.(1991); SAXONHOUSE & WRIGHT (2000).

³⁶ CALVO, A., "La cara conocida. Cambio tecnológico y adaptación al mercado en la industria algodonera catalana (fines del siglo XIX-comienzos del siglo XX)", in CARRERAS, A.; PASCUAL, P.; REHER, D. & SUDRIÀ, C.(eds.), *La industrialització i el desenvolupament econòmic*, pp. 1164-1174.

³⁷ CALVO, A., "Clientes, amigos y buenos parroquianos", in DELGADO, J. M. *et al.*, *Las relaciones económicas entre Aragón y Cataluña(siglos XVIII-XX)*, Instituto de Estudios Altoaragoneses, Huesca, 1990, p.

militant work force in the rural areas outside Barcelona. Finally, a third group chose to modernise and maintain their urban location.

Aligning themselves with this last group, *La España Industrial*, without being a pioneer in the introduction of ring spinning, did adopt the innovation several years before other competitors. By breaking with the relative technological stability that had been maintained for a long time in the spinning section, the company was seeking to achieve two goals: make savings in the work force and in its fuel bills. Its concern was mainly with the domestic market but it was not altogether without interests in the colonial market and a number of neighbouring markets, such as the Portuguese.

This obsession with cutting labour costs clashed with the workers' interests, who responded by taking strike action against the management's wish to take away their pay for holidays falling on a weekday³⁸. The company sought to offset the impact of the strike by transferring obsolete printing machines to the plants in Barcelona. But the persistence of the drop in the market forced it to adjust the work to consumer demand by reducing the product range and the production of printed clothes.

This combination of the persistence of the crisis and the listlessness of the market, on the one hand, and the conflict with the workers, on the other, brought about the virtual wholesale modernisation of the machinery in *La España Industrial*. However, this could only be carried out after first overcoming fierce opposition from a sector of the shareholders.

In response to the new demands, the firm's management presented a carefully reasoned plan for the partial renewal of the machinery³⁹, which affected in the first instance only the yarns section, and their preparation. But the plan ran into opposition within the board of shareholders, originating from the Inspection Board⁴⁰, who wished to see a gradual and partial reform which would avoid a sudden abrupt outlay of capital. Furthermore, this group of doubters considered the reform to be insufficient as it failed to attack the firm's main problem, that is, the lack of competitiveness of its products in relation to those of the factories located on the rivers.

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³⁸ In some sections, the strike led to factories being shut down and production was paralysed for a long period. After fifteen weeks, the conflict was ended with an agreement whereby the company had to pay the holidays on condition that the workers worked these extra hours during the year: Correspondence sent, letter to the Civil Governor of Barcelona, 5 February 1887, ANC; Documentos de las Juntas generales de accionistas de la E. I., MEPM.

³⁹ MUNTADAS, M., *Reforma total de la maquinaria en las secciones de preparación de hilados e hilados. Su costo y economía anual*, October 1887, Fondo de la España Industrial, ANC.

⁴⁰ General Board of Shareholders, 1888, ANC.

Therefore, the Inspection Board established its main goal as the search for competitiveness, and recognised that a possible remedy lay in the partial reform of the machinery and considered the transfer of production to a mountain area feasible in order to benefit from the better energy supply, lower taxes and lower labour costs. The shareholders were split in to those who supported the management plan and those that were opposed to it, and voices were raised questioning the authority of Matías Muntadas, while others even called for the immediate liquidation of the company. Finally, the management plan was agreed to and the Inspection Board was forced to resign. The concluding words of M. Muntadas in his speech before the shareholders, at the end of August 1888, stressed the principles underlying his actions: prudence, loyalty and constancy.

The restructuring, which affected the preparation, spinning, weaving and finishing sections, meant either the modification of part of the equipment, its amplification or the making of new investments so as to replace the existing machinery. In the preparation section the carding machines were modified, a large number of the roving frames were renewed and five drawing frames and two fulling machines with automatic apparatus for the cloths were installed. The yarns section was fitted out with 21,288 new ring spindles. In the fabrics section, 400 new and 500 refitted looms replaced the 1,000 old looms. Similarly, in the finishing sections, the firm installed boilers and various systems to save water and steam, as well as the varied and expensive chemical products then being used. Other changes were introduced in the handling of the products, the rationalisation of the production space and the energy systems. These involved the installation of a goods lift in the yarns section; the concentration of the fabrics section in one area; the use of gas lighting produced externally (*Compañía Lebón*) and the centralisation of the production of motive force in a large 750 horsepower steam engine, as well as the optimisation of its use thanks to a cable transmission system. The total cost of the reform, which rose to a sum of 1,092,000 pesetas, was paid out of the company's own financial resources⁴¹, although the need to increase the working capital became more evident. Meanwhile, the activity became more strongly centred at the factory in Sants, with the transfer of the sizings subsection from the workshops in Barcelona⁴².

The technological changes ushered in a period of transition in which a number of readjustments had to be made. With a large part of the factory at a standstill, the

⁴¹ Management Report, 1 February 1891, ANC. Plots of land were sold in Sants while others were taxed: 26 August 1888; a loan granted by the *Banco Hipotecario de España* was not used: Report 30 August 1891.

⁴² Report 24 February 1889.

production was weakened and factory purchases had to be increased, but sales rose⁴³. Immediately, the reform strengthened the weight of the spinning and weaving sections in the make-up of the factory's capital. The positive effects were not long in coming and were made manifest in a 25% reduction in production costs and in the making of profits. At the same time, the stock market responded favourably and the shares of *La España Industrial* rose.

Such a major transformation was accompanied by a drastic reorganisation of the workforce. In real terms, the 42 per cent reduction in the 1,531 employees meant a saving of 51,000 pesetas each month, while in qualitative terms, the introduction of ring spinning paved the way for a re-grading of the workforce and a modification to the payment system, substituting young workers paid by the day for adult female pieceworkers. To this should be added the saving in fuel and repairs, as well as the greater perfection achieved in manufacturing⁴⁴.

The final phase in the reform, carried out in 1900, sought to reduce labour and energy costs in the water branch, while at the same time introducing further innovations in production. All this was achieved by closing down the nightshift, installing electric lighting that was produced by the company, making colour production automatic, adjusting the colour blots to avoid losses in the washing process and mechanising the mercerisation process which was a way of achieving a silk-like finish using chemicals. The company also mechanised, at least in part, the oxidation and drying of special cloths and the wringing of washed pieces to facilitate drying, with the consequent saving in coal⁴⁵. Other changes affected the initial phases of the cotton production process⁴⁶.

The First World War led to a new cycle of investment ending in the twenties. The efforts centred above all on the expansion and perfecting of the fabrics section with new looms for velveteen, most of which were fitted with special mechanisms (tap machines), cutting tools that mechanised one of the most expensive operations, and humidifiers for the cloths.

One of the most spectacular changes was the introduction of electricity as the motive power throughout the factory in substitution of steam power. This meant the installation

⁴³ Due, according to the management, to the “quality of the printing, the permanent brilliance of the colouring, exquisite taste and perfect finishing”: Management Report, 26 August 1888.

⁴⁴ In the fabrics section (not the main focus of this study), M. Muntadas aimed at doubling the production of each weaver in exchange for a 20% increase in wages: Management Report, 30 August 1891; *Datos...*, p. 146.

⁴⁵ Management Report, 10 February 1901.

⁴⁶ In 1912-13, the 85 old carding machines were replaced by 14 new ones: Reports 16 February 1913 and 15 February 1914.

of 60 electric motors generating a total of 1,700 horsepower and the contracting of energy from an electricity company⁴⁷. Although no particular attention is paid to this change in the annual report, years later, M. Muntadas would stress the transcendental significance of this technological change, calling it “a transformation that was even more important than earlier changes, and of course just as opportune and as fortunate”⁴⁸. A similar energy saving was achieved, in the middle of the Great War, with the installation of an automatic loader for the steam boilers, which reduced the coal consumption by a fifth⁴⁹. Shortly after this, in 1923, the structure of energy costs, dominated by coal, changed substantially as 86 percent of the energy absorbed by the cotton spinning and weaving operations was produced by electricity, a percentage that was reduced greatly in the water branch⁵⁰.

Productivity

Productivity, one of the most transparent indicators of efficiency and economic growth, measures the relationship between a unit of production and the amount of input needed to produce this unit⁵¹. The components of this indicator include technology and economies of scale, as well as the changes in the skills of the workforce and the organisation of production⁵².

In the case we are examining here, technological change led to a significant increase in the productivity of the workforce and a reduction in wage costs - two factors that are highly influential in a firm's competitiveness. Specifically, wages are a fundamental element in cost structures (accounting for around a quarter or a fifth of the total costs for the most commonly produced yarns). Below, these two factors are examined from a variety of angles.

We shall begin by making a general calculation of the evolution in the profitability of labour and capital in the period before the great technological change. The data provided by the

⁴⁷ CALVO, A., *La transformación de la estructura industrial en Cataluña, 1898-1920*, unpublished doctoral thesis, University of Barcelona, 1986, pp. 41 ff. Earlier, in 1895, Muntadas Hnos. had been contracted to install electric lighting in various sections and workshops of the factory.

⁴⁸ Reports 16 February 1913 and 1922. In the second of these, M. Muntadas reviews the great moments in his management of the firm. In the spinning section, for example, the introduction of electricity made a variable speed in the continuous spinning process possible, which, in turn, reduced the number of breaks in the yarn: HALL, H., “The Driving of Textile Mills”, *The Electrician*, February, 29, 1924, p. 253.

⁴⁹ Report 16 February 1919.

⁵⁰ Untitled manuscript, Fondo E. I., MEPM,

⁵¹ DEAN, E. R. & SHERWOOD, M. K., “Manufacturing costs, productivity, and competitiveness, 1979-1993”, *Monthly Labor Review*, October 1994, p. 4.

⁵² JABLONSKY, M., “Multifactor productivity: cotton and synthetic broadwoven fabrics”, *Monthly Labor Review*, July 1995, p. 29.

management of *La España Industrial*⁵³ indicate that the technological change in spinning led to an increase in the profitability of labour (measured by the relationship between weekly profits and costs). This upward trend in profitability was most marked following the events of the *Semana Trágica* (the Tragic Week) and during the period of expansion of the First World War, coinciding with the introduction of electric power in the factory. However, these levels of profitability were not maintained, and the two variables fell in the 1920s back to the levels recorded at the beginning of the century. This means that the major investment efforts of the 1920s, above all in the sections of yarn preparation, yarns and fabric preparation, did not have the expected repercussions in labour and capital returns. The reasons for this lie in the reduction of the working time and in the radical changes in working relations, as the paternalistic nature of relations that had characterised the nineteenth century came to an abrupt end. Unfortunately, we do not have space to examine this change in any detail here.

A second approach, restricted this time to spinning, is based on data drawn from the *Estados mensuales* and the *Libros de Semanales*. Figure 3, Annual Production per Worker, shows that the major investment efforts at the outset led to a comparatively high rate of productivity but with clear signs of stagnation. If we ignore the work being carried out on the few obsolete flyer throstle, the productivity of the employees working the mule spinning frames - by far the most numerous in the factory - became relatively stagnant after 1882. However, the technological shift brought an end to this as the use of the ring spinning frames meant the productivity of a female worker in the Sants' factory could be doubled. An identical conclusion can be drawn from the factory's *Semanales*. Furthermore, this higher productivity was maintained, although not without marked fluctuations. With the exception of those years that might be classified as forming part of the initial trial period, productivity per female worker in the spinning section (using ring spinning frames) of *La España Industrial* tended to improve in the period between 1890 and 1925, though in 1930 a shift occurred in this trend. Of even greater significance is the fact that a similar behaviour can be seen if we examine productivity per woman/hour. This is considered a more accurate measure of productivity, since it takes into consideration the variations in the working day. Moreover, the productivity of the other sections also improved thanks to the change in technology, with the consequent reduction in the costs of the finished product, the fabric.

⁵³ *Movimiento fabril y mercantil 1890-1931*, Fondo E. I., ANC.

Given that the firm was fully integrated, the increase in the output of the intermediate product - the yarn, had favourable repercussions on the cost of the finished product, the fabric. Nadal and Sudrià have shown that, after the spectacular leap caused by the episode known as “cotton hunger”, the prices of the fabrics manufactured by *La España Industrial* fell almost constantly until the end of the XIX century⁵⁴. This means that the reform in the spinning section strengthened this downward trend that dated back a number of years.

Insert Figure 3 here

It would be right to argue that here we are falling into the same error committed by part of the previously underlined international debate, overlooking the fact that the product (both the yarn and fabric) is not homogenous. We should therefore seek to offer a more accurate explanation of the productivity per woman worker and, to do that, we must take into consideration the fact that the composition of the product has a marked influence on the quantity of output⁵⁵.

If we compare the average indices of yarn count produced and the productivity per woman worker, it can be seen that there exists a non-constant, inverse relationship between the two variables. This means that the count of the yarn is a significant element, though not the only one, in determining the rate of productivity. Thus, any explanation of the variations in productivity must include other factors. In addition to the strategy of product differentiation, three components that have a marked influence on productivity have been detected: the technical division of labour, experience and technological change. Given the restrictions of space, we shall only examine the third of these here by adopting a different approach to that outlined above, that is incorporating the product type into the expression of measurement of productivity. We shall therefore analyse labour productivity according to the machine type, differentiating between the production of weft and warp and their established groups of yarn count.

In *La España Industrial* significant differences were to be found in the composition of their yarns and fabrics. The highly versatile mule spinning frames produced a wider range of yarns, on the whole of an intermediate thickness and with a tendency to become increasingly thicker. The ring spinning process was less versatile and the range of yarns produced was not as great.

⁵⁴ NADAL, J. y SUDRIÀ, C., “La controversia en torno al atraso económico español en la segunda mitad del siglo XIX(1860-1913)”, *Revista de Historia Industrial*, 3, 1993, pp. 208-209.

⁵⁵ CALVO, A., “Estrategias de competitividad: la diferenciación del producto en la industria algodonera

To produce finer yarns, and hence fabrics of greater quality, required more time and, therefore, the wage rates per unit product were also higher. According to the management's calculations, in the yarn preparation section, the production of the medium-quality machines fell by up to 36 percent for each additional number of fineness of the yarn. To warp a count 30 yarn on a ring spinning frame cost 70 percent more than for a count 12. The production of quality fabrics per loom did not reach 20 percent of the output of a loom used for a coarse fabric⁵⁶. Clearly, the cost structure had to reflect the differences in the characteristics of the products. Thus, the costs for general expenses and colour in the manufacture of a smooth percaline fabric and moleskin might have varied up to 70 percent, and even more in the sizing of a smooth percaline and wide damask⁵⁷.

In the production of weft numbers 0-14.5, during the brief period in which they overlapped, the productivity of the ring spinning frame was initially not as great as that of the mule frame but this situation was to be reversed with time. In the production of weft numbers 15-32, the ring frame was generally more productive than its predecessor, but at numbers below 32, the loss in productivity of the mule frames due to the increase in the fineness of the yarn was greatly reduced. Moreover, the ring spinning frames were able to resolve satisfactorily the problems that the mule frames had experienced in the production of warps since the 1870s. For weft numbers 15-32, it reached a productivity that was greater than that attained by the mule frame in the earlier period.

Insert Figures 4 and 5 here

Unit Labour Costs

Unit labour costs are used here to describe the relationship between the total wages paid to workers and the output obtained. Above, we described the technological option, which involved the careful planning and consideration of every last detail, reflecting a complete understanding of the conditions of production. Among its primary objectives, *La España Industrial* highlighted the reduction in costs, as is illustrated by various examples. One such example was the request to attach friction wheels to the carding machines so as to be able to set them in motion or stop them simultaneously as well as setting them off gradually,

catalana. una aproximación desde la España Industrial”, *Homenatge a E. Giralt* (forthcoming).

⁵⁶ Quality fabrics refer specifically to moleskin and articles inferior to a second drill. *Datos de la producción de la España Industrial*, p. 21.

with the aim of saving time and cutting down on the use of raw materials⁵⁸. Another example, and perhaps one that is more highly illustrative, is to be found in the choice of machines with fewer spindles so that the firm was able to employ more women and, thereby, reduce the wage bill, a feature that *La España Industrial* converted into one of its main differentiating characteristics⁵⁹.

Similarly, it has been pointed out that the introduction of the first ring spinning frames in *La España Industrial* was due to the need to cut wage costs in order to face the strong competition in the domestic market. An analysis of the *Libros de Semanales* provides responses to a series of questions concerning the eventual reasons for technological change.

The introduction of ring spinning frames was, of course, a response to the technical obsolescence of the flyer throstles, but in particular it was a response to the growing costs of one of the varieties of yarn produced by the mule frames: namely, the warp yarns. Thus, the ring spinning frames led to the dismantling of the wage system based on piecemeal rates, while drastically reducing the wage costs for the production of yarns and virtually evening out the production costs of weft and warp yarns.

Figure 6.- Wage costs for a kilogram of yarn at *La España Industrial*

This change is more clearly illustrated by studying the Graphs illustrating wage costs according to yarn type and number in ring spinning frames. LEI, 1887-1930.

The major restructuring undergone by the factory in the 1890s, led to even greater wage cuts. The unit wage cost (total wage paid /total amount of yarn produced) fell by 22.7 percent between 1877 and 1882 as opposed to 40 percent between 1882 and 1890. But the differences were not only quantitative: the fall in wages that took place between 1881 and 1890 was caused by other factors. The fall in wages between 1877 and 1882⁶⁰ might hypothetically be explained by a general wage fall, but at this time the average wage in the yarn section did not fall, in fact, it actually rose. This could have been due to changes in

⁵⁷ *Production data...*, pp. 56 and 138.

⁵⁸ Fondo España Industrial, Correspondence sent, letter to Schlumberger, 18-8-1847.

⁵⁹ The size of the mule frames was smaller in *La España Industrial* than those in the Rambla de Vilanova, for example (320-348 spindles in the former as opposed to 412-452 in the latter). In 1853, the Fàbrica de la Rambla had 8 Higgins continuous machines with 253 spindles, 5 mule frames with 412 spindles and 6 with 452 spindles: oral communication from R. Soler and SOLER, R., “‘Dios quiera que salgamos de una vez de tan desgraciado negocio’. L’adquisició de maquinària de la fàbrica de La Rambla: un episodi de difusió de tecnologia tèxtil (1833-1840)”, in *La industrialització i el desenvolupament econòmic d’Espanya, Homenatge a J. Nadal*, University of Barcelona, Barcelona, 1999, pp. 1,101-1,124. Ninety-two percent of the workforce in the spinning section was made up of women and girls: *Información sobre derecho diferencial...*, p. 14.

⁶⁰ Considering the earlier mechanisation of cotton spinning, the manual spindles were now totally residual (5,215 manual as opposed to 686,131 mechanical spindles). But now, over 50 per cent of the fabric, historically

the organisation of the work, but in *La España Industrial* the make-up of the teams and the piecemeal system remained stable. Alternatively, it could be attributed to the adoption of new spinning technology. However, in the 1860s and 1870s, no major technological changes were made at the factory and investment levels were low. In 1877, following the purchase of 21 automatic looms for the production of corduroy, the average count (thickness) of the yarns produced by *La España Industrial* dropped significantly: the average fell from 28.27 to 24.28. In other words, it fell below yarn 25, the point at which wage costs shot up⁶¹.

It comes as no surprise to learn that wages shot up between 1915 and 1920, with rates reaching 187.5 percent, due in large part to the rise in the average wages of the spinners. Yet, the improvements in productivity per worker-hour between 1915 and 1920 (17.5 percent), and the possible effects of such significant technological changes as the introduction of electricity in 1914, did nothing to stem the rise in wages.

Conclusion

In short, the previous pages have explored long-term links between productivity and technological change, analysed from the perspective provided by business history. Here, a cotton manufacturer, modern in its organisational and technological characteristics and operating a complete production cycle like most other firms in its sector, has served, to a certain extent, to depict the behaviour of the cotton industry. The study has been based, empirically, on the construction of long time series of production, investment, productivity and unit labour costs data, while, methodologically, these data reflect the latest tendencies within this research field, with their emphasis on product uniformity. As a measure of productivity, we adopted the productivity of labour. Technological change has been analysed quantitatively, by examining investment, and qualitatively, by describing its technical components.

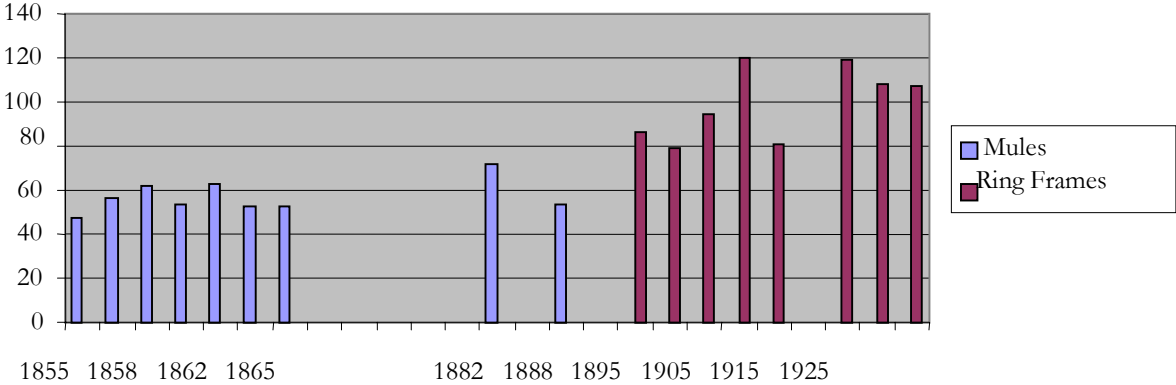
The approach adopted contributes important elements to our understanding of the cotton sector over a long time period. We have seen the type of adjustments imposed by the uncertainties of demand and other changes in the sector as a result of perfect competition.

out of step, was mechanised (6,469 manual looms and 7,273 mechanical looms).

⁶¹ CALVO, A., "Estrategias de competitividad: la diferenciación del producto en la industria algodonera

The evidence presented shows the complex nature of the strategies employed by the firms, which, although sheltered by the regulations of protectionism, had to face conditions of strong domestic competition, in which their survival was far from guaranteed. It also shows that only a part of the improvements in productivity can be explained by changes in the product make-up. Technological change appears as a key element in a complex strategy to reduce costs, whereby firms might then face the intense domestic competition from a position of advantage.

Figure 4.- Work productivity in *La España Industrial*: Warp count 25-31 (kg/woman worker per week)



catalana. Una aproximación desde la España Industrial”, *Homenatge a E. Giralt* (forthcoming).