Catalonia was the only Mediterranean region among the early followers of the British industrial revolution. The roots of this process can be traced back to the seventeenth and eighteenth centuries when the Catalan economy became integrated into international trade, and a successful printed calico industry concentrated in the city of Barcelona. Although the factory system was largely adopted by the cotton industry in the 1840s, the diffusion of the spinning jenny in Catalonia had occurred earlier, in the 1790s. In line with Allen, this article explores whether relative factor prices played a role in the widespread adoption of the spinning jenny in Catalonia. First, series of real wages in Barcelona are supplied for the period 1500–1808. Second, the prices of labour and capital are compared and the potential profitability of the adoption of the spinning jenny is analysed. Findings show that although Catalonia was not a high wage economy in the way that Britain was in the second half of the eighteenth century, evidence from the cotton spinning sector confirms the relevance of relative factor prices in the adoption of new technology. Within the booming cotton sector after the 1780s, high wages created strong incentives for the adoption of the labour-saving spinning jenny.

Catalonia was the only Mediterranean region among the early followers of the British industrial revolution in the nineteenth century. The industrialization process was strongly characterized by its specialization in cotton so that between 1835 and 1861 almost all the cotton spinning and half of the weaving industries in Catalonia adopted the factory system. This leading role was complemented by other branches of textiles and, eventually, by other industrial sectors. In Nadal’s
words, during the nineteenth century Catalonia became ‘the factory of Spain’. As Pollard pointed out, the roots of this economic modernization can be traced back at least as far as the eighteenth century. Catalonia had enjoyed a process of market development since the end of the seventeenth century, which had led to an intensification of its agrarian and proto-industrial sectors and rapid population growth during the eighteenth century. This had been the result of the successful integration of the Catalan economy into the international trade of the early modern period. Furthermore, since 1736 printed calico manufacturers had begun to establish themselves in Barcelona. In the last two decades of the century the industry achieved a significant size and by 1786 Barcelona was the leading printed textile city in Europe. Initially, most of the yarn used as raw material in production was imported from Malta, but during these decades cotton spinning began to expand rapidly and conditions were ripe for the adoption of the spinning jenny. The new machine arrived in Catalonia in the 1780s and was widely adopted in the 1790s. It is in this economic context that Catalonia has come to be known as ‘a little England in the heart of Spain’.

The British industrial revolution remains one of the leading topics of discussion in economic history today. Why did the industrial revolution occur first in Britain? Why did it not begin in the Low Countries, France, or China, for example? Why did it occur at the end of the eighteenth century? These questions have been approached in a variety of ways, giving rise to a rich intellectual debate. Marxists stress the importance of the rise of capitalism, with its free markets and landless proletariat. On the other hand, institutionalists attribute this economic transformation to the English Glorious Revolution of 1688, which limited the king’s despotic behaviour and secured property rights. Other attempts at explanation stress alternatively the scientific revolution, the Protestant ethic, the capacity of the British entrepreneurs and the role of technology, or even the spread of middle-class values from the elite to other social groups for ‘biological’ reasons. An alternative explanation, based on economic factors, has recently been proposed by Allen. In his view, in line with Habakkuk, the key to the industrial revolution lay in the demand for new technologies, which in turn depended on relative factor prices. First, Britain had become a high wage economy during the modern period. Additionally, the stability of its capital markets and the availability of cheap energy favoured the emergence of a price structure in Britain that created a strong incentive to research and develop new technologies to substitute cheap inputs (energy and capital) for the relatively more expensive factor input (labour). Allen exemplifies the importance of relative prices

2 Nadal, Fracaso, pp. 188–225.
3 Pollard, Peaceful conquest, p. 106.
4 Vilar, Catalogne; Torras, ‘L’economia’.
5 Valls, Catalunya.
6 Sánchez, ‘La era’; Thomson, ‘Technological transfer’, p. 255.
7 Marx, Das Kapital.
8 North and Weingast, ‘Constitutions’.
9 Weber, Protestant ethic.
10 Landes, Unbound Prometheus.
11 Mokyr, Enlightened economy.
12 Clark, Farewell.
13 Allen, British industrial revolution.
14 Habakkuk, American and British technology.
by examining the adoption of the first technological innovation in the cotton sector: the spinning jenny invented by Hargreaves in 1764. He conducts a micro-economic analysis, concluding that the ratio between the wages of spinners in English cottages and the price of purchasing a jenny made inventions profitable in England, but not in France or India. The story of the spinning jenny thus supports his endogenous explanation of the British industrial revolution, where the demand for new technologies was a key variable.

In the Catalan case, it is a well-documented fact that the spinning jenny was rapidly adopted in Barcelona, in medium-sized towns, and in rural areas from the mid-1780s, but how does the Catalan experience fit within this ‘demand for technology’-based explanation? Several authors have stressed that, in the second third of the nineteenth century, supply-side arguments might explain the delay in the adoption of new technologies (primarily, the steam engine) in Catalonia. The repeal of the British ban on machinery exports in 1842 would have favoured a process of technology transfer in the cotton industries that, together with a more stable economic and political atmosphere, would have gone some way towards overcoming the technological backwardness experienced in the spread of steam-based industrialization. In addition to this, the historiography has also highlighted that one of the main handicaps for Catalan industrialization in the nineteenth century was the lack of cheap coal. Nonetheless, the adoption in Catalonia of the simplest textile machine, the spinning jenny, at the end of the eighteenth century was not hindered by supply-side factors because the transmission of this technology was much easier. Energy restrictions did not play a decisive role here either, as the spinning jenny was powered by hand, so the only relevant factors were capital and labour.

Given that the evolution of wages plays an essential role in the ‘demand for technology’ explanation, the first contribution of this article is the analysis it undertakes of the evolution of wages and prices in Barcelona, the capital city of Catalonia, during the modern period. Here, the article draws on the information gathered by Feliu, whose remarkable work provides a large amount of wage and price data for different occupations and goods, respectively, between 1500 and 1808. This information makes it possible, on the one hand, to present long-term series of living standards in Barcelona and, on the other, to add the Catalan case to the global picture within the ‘great divergence’ debate. Based on the nominal wages for construction labourers and a typical subsistence basket, real wages are computed by calculating the subsistence ratio. Our results show, in a global comparative perspective, that the evolution of living standards in Barcelona throughout the period fits well with the so-called continental European pattern, somewhat below that of the high wage economies of Atlantic Europe (England and the Low Countries).

15 Allen, ‘Industrial revolution in miniature’.
16 Thomson, Distinctive industrialization.
17 Nadal, Fracaso, pp. 188–225.
18 Feliu, Precios y salarios, vols. I and II.
19 van Zanden, ‘Wages’; Pomeranz, Great divergence; Allen, ‘Great divergence’; Broadberry and Gupta, ‘Early modern great divergence’; Pamuk, ‘Urban real wages’; Bassino and Ma, ‘Japanese unskilled wages’; Allen, Bassino, Ma, Moll-Murata, and van Zanden, ‘Wages’; Allen, Murphy, and Schneider, ‘Colonial origins’.
20 Allen et al., ‘Colonial origins’.

© Economic History Society 2015 Economic History Review, 69, 2 (2016)
In the light of these results, can the early adoption and the successful diffusion of the spinning jenny in the last decade of the eighteenth century in Catalonia be explained in terms of the ‘demand for technology’ argument? What were the relative prices of the two relevant production factors (labour and capital) used in the new machines? Following Allen, relative prices are measured as the ratio between the price of labour and the price of capital.21 This ratio is then examined at an aggregate level for the whole economy and directly for the cotton spinning sector. The micro-level analysis examines whether differences in factor prices made it profitable for cottage domestic producers to purchase a spinning jenny based on the rate of return of such an investment in the late 1780s.22 The results show that, under alternative scenarios, the potential profitability of the spinning jenny in rural Catalonia generated strong incentives for adopting new, labour-saving machines in cotton spinning, a booming sector in the general context of the Catalan economy. In addition, given the availability of data, we also examine and confirm the profitability of the jennies installed in an urban centre (Barcelona) in the late 1790s, in this case under a different organization of production from that employed in the countryside. Indeed, the spinning jenny began to be adopted across Catalonia at the end of the 1780s, in a process that also involved a technological improvement to the machines.23

The remainder of the article is organized as follows. The next section summarizes the main characteristics of the Catalan economy in the eighteenth century, paying special attention to the cotton textile sector and the early adoption and diffusion of spinning machines across Catalonia. Section II is devoted to the construction of real wage series for Barcelona between 1500 and 1808. In section III relative factor prices are analysed, and section IV presents a micro-level analysis of profitability for the first spinning jennies installed in Catalonia. Interestingly, the exercises conducted make it possible to examine the results in comparative perspective with Britain and France. After the findings are discussed, the final section concludes.

I

Economic historians have stressed that Catalonia enjoyed Smithian economic growth from as early as the seventeenth century. According to Torras, a combination of two factors accounts for the changes in the specialization of the Catalan economy.24 First, in the context of French–Dutch rivalry and wars, certain Mediterranean areas were given the opportunity to attain a fuller economic integration with the European markets by exporting wines and liqueurs. Second, the structure of Catalan land and property rights enabled the region’s producers to react positively to this opportunity.25 As a result, the planting of grapevines expanded substantially, and many areas in Catalonia, especially those located near the coast, became specialized in vineyards. As Valls explains, the Catalan economy achieved

---

21 Allen, *British industrial revolution*, pp. 135–55, 182–216; idem, ‘Industrial revolution in miniature’.
22 Allen, *British industrial revolution*, pp. 182–216; idem, ‘Industrial revolution in miniature’.
23 Sánchez, ‘Berguedanes’, pp. 165–70.
24 Torras, ‘L’economia’.
25 Torras also mentions the weakening of guild interests in Barcelona after 1714; Torras, ‘Gremio’; idem, ‘Gremis’; idem, ‘Transformacions’.

© Economic History Society 2015 Economic History Review, 69, 2 (2016)
a significant degree of integration with Atlantic Europe during this period.\textsuperscript{26} At the same time, the rising population in those areas devoted to vineyards increased the number of potential consumers for other goods such as grain and manufactures. Thus, while some areas advanced in their specialization in grapevines, other areas began to specialize in the production of cereals and manufactures.\textsuperscript{27} As this process evolved, an increasing number of households began to produce in order to sell in the market and, eventually, capitalism developed in Catalonia.\textsuperscript{28}

Specialization and greater market involvement favoured the advance of manufacturing in Catalonia, especially as regards the production of woollen fabrics. Several areas of central Catalonia and the Pyrenean foothills flourished thanks to this activity, following a proto-industrial pattern characterized by the intensive use of the rural labour force for producing new draperies.\textsuperscript{29} This proto-industry in the wool sector was eventually to play a key role in the development of cotton manufacturing. Extensive putting-out networks, skilled labour, organizational capabilities, and the availability of capital all contributed to the advent and diffusion of cotton manufacturing in the last quarter of the eighteenth century.\textsuperscript{30} Indeed, in this respect Catalonia can be considered a successful case in the transition from proto-industry to industrialization. This process was further strengthened thanks to better access to the Spanish market, following the elimination of domestic barriers, and to the progressively improved access to the colonial markets in America during the eighteenth century.\textsuperscript{31} Catalonia played a pivotal role between Atlantic Europe and Spanish America, exporting liqueurs and importing textiles from the former, while re-exporting textiles to the latter.\textsuperscript{32} Thus, Catalonia was to experience a process of agrarian intensification and mercantile and manufacturing growth that led to a constant rise in population throughout the eighteenth century, as Vilar narrates in his classic study.\textsuperscript{33} The population of Catalonia almost doubled between 1718 and 1787, the year in which it reached almost 900,000 inhabitants. Between these same two dates, the population of the city of Barcelona rose from 34,005 to 92,385 inhabitants.\textsuperscript{34}

It is against this background that the calico-printing sector began to emerge in Barcelona.\textsuperscript{35} Manufacturing was set in motion when a ban was placed on the importation of Asian textiles. The prohibitionist measures imposed by the Spanish monarchy during the second and third decades of the eighteenth century promoted import substitution and the development of the domestic manufacture of printed calicoes after 1736 in the city of Barcelona. In this respect the Spanish policy contrasted strongly with the French, which not only prohibited calico-printing imports but also calico manufacturing between 1686 and 1759, with highly negative and persistent repercussions. The Spanish performance was closer

\textsuperscript{26} Valls, \textit{Catalunya}.
\textsuperscript{27} Torras, ‘Especialización’; Badia-Miró and Tello, ‘Vine-growing’.
\textsuperscript{28} Vilar, \textit{Catalogne}.
\textsuperscript{29} Torras, ‘Estructura’.
\textsuperscript{30} Okuno, ‘Entre la llana’.
\textsuperscript{31} Torras also highlights the importance of the Catalan commercial diaspora in the Spanish market; Torras, ‘L’economia’; idem, ‘Old and the new’.
\textsuperscript{32} Valls, \textit{Catalunya}.
\textsuperscript{33} Vilar, \textit{Catalogne}.
\textsuperscript{34} Iglesies, \textit{Cens del comte}; idem, \textit{Estadístiques de població}.
\textsuperscript{35} On the rise of printed calico manufactures in eighteenth-century Barcelona, see Thomson, ‘Explaining’; Sánchez, ‘Orígens’; idem, ‘Indianería’; Raveux and Sánchez, ‘Adaptación’, and the references therein.
to that of the British, although Spanish law supported an import substitution strategy even more explicitly than did the British. This was a new emerging sector, free from any guild regulations, that for technical reasons concentrated a large number of workers in a single space and in which relatively high capital investments were required. During the second half of the eighteenth century, the sector underwent a rapid expansion.

In the printed calico establishments of Barcelona manufactures were woven and printed, but no spinning was undertaken. Indeed, for a long period, cotton spinning was a marginal activity in Catalonia, with most of the yarn being imported from Malta. The Spanish Crown was interested in promoting cotton growing in its American colonies, with the cotton to be spun in Spain. In 1771 therefore it introduced a 20 per cent tariff on foreign raw cotton and yarn. Nevertheless, the printed calico manufacturers in Barcelona still needed foreign yarn, so they reacted by negotiating a three-year tariff moratorium on Maltese yarn. In exchange, they agreed to found the Royal Spinning Company of American Cotton Yarn (Real Compañía de Hilados de Algodón de América) in 1772. The Royal Company was a chartered company that embraced all printed calico manufacturers in Barcelona. Initially, it aimed to promote national spinning by exploiting the existing putting-out networks of wool spinners. However, this venture was to be short-lived.

Thomson stresses that the growth in American cotton spinning in Catalonia depended on demand for high-quality printed calicoes, which needed finer yarns than the Maltese, and the overcoming of certain bottlenecks in the exporting of Spanish American raw cotton. Despite the regulations, Maltese yarn continued to enjoy a dominant market share in Catalonia until the mid-1790s. However, demand for high-quality printed calicoes, known to Spanish consumers thanks to the foreign imports of the relatively liberalized 1760s, continued to rise in the 1770s after the reintroduction of the prohibition on calico imports. This led to an import substitution process, achieved largely thanks to fine-yarn imports from Switzerland and other European countries, but also increasingly by the spinning of American raw cotton in Catalonia. As the technical and transport limitations had been resolved, from the end of the 1770s American raw cotton deliveries became more regular. Even during the war with Britain, between 1775 and 1783, American cotton was spun in Catalonia, although Levantine raw cotton helped to meet the needs of a growing spinning sector.

After the war American cotton exports grew rapidly, in part as a substitution for the Levantine imports, but also because the production of printed calicoes and the printing of imported linen were booming thanks to exports to Spain’s colonial
In fact, in 1786 Barcelona became Europe’s leading textile printing city: ‘The city contained some 113 calico-printing manufactories by 1786, by far the densest concentration in the industry in Europe. By way of comparison, the number of calico printing concerns in Britain and France in 1785 was 111 and 114 respectively, and the number in Switzerland . . . was 59 in the 1790s’. 42

In 1796, the printed calico factories of Barcelona were employing 12,979 workers. 43 Although a major share of output was foreign linen and cotton fabrics printed in Barcelona for export to the Spanish American colonies, cotton weaving and spinning also began to boom during these years. The period 1788–92 has been labelled the final take-off in the spinning sector, and by 1792 the cotton weaving sector in Catalonia was equivalent in size to 16 per cent of the British sector. 44

The rapid increase in spinning was achieved by a region-wide proto-industry, whose main protagonists were small businessmen. However, the Royal Spinning Company, refounded in 1783, also played a role by establishing two systems for yarn provision. On the one hand, it depended on the longstanding tradition of wool spinning in central Catalonia, exploiting the putting-out networks controlled by local weavers and finishers. On the other, the company set up its own workshops in various locations in southern and western Catalonia without any manufacturing tradition or local businessmen, but with cheaper unskilled labour. However, this second system proved unsuccessful and the Company abandoned it in 1787. At the same time, many independent businessmen who controlled the putting-out networks for wool spinning had now moved into cotton spinning and so competed directly with the Royal Spinning Company. In short, the Royal Spinning Company failed to achieve a cotton spinning monopoly and was unsuccessful in its attempts to colonize areas with no manufacturing tradition. However, it made a decisive contribution to the diffusion of cotton spinning in Catalonia. The Royal Spinning Company, together with independent businessmen, promoted a shift from putting-out networks dedicated to spinning wool to networks spinning cotton, and the ‘nationalization’ of this activity was achieved in just a few years. The Catalan case is exceptional in this sense: cotton spinning was introduced late, but once in motion the jenny was quickly and widely adopted. 45

The first spinning jenny, or at least knowledge of it, reached Catalonia in 1784 via two French machine-makers, Pontet and Pradel. The first successful attempt at adoption was made in one of the Royal Spinning Company’s mills, 46 but subsequently the jennies were primarily used in small domestic workshops. As Garcia Balañà has pointed out, it was quickly realized that the mill was not the best place to maximize profits because the women that did the spinning came from household economies and as workers they had few incentives to stay in the mill during long working days or to remain in its employment for a long period of time. 47

41 Raveux and Sánchez, ‘Adaptación’, p. 69.
42 Thomson, ‘Technological transfer’, p. 235.
43 Sánchez, ‘Activitats’, p. 248.
44 On the spinning take-off, see Thomson, ‘Explaining’, p. 725; on the weaving sector, see Vilar, ‘Catalunya industrial’, p. 9.
45 Raveux and Sánchez, ‘Adaptación’, pp. 68–78; Garcia Balañà, Fabricació, pp. 57–145; Okuno, ‘Entre la llana’.
46 Thomson, ‘La introducció’; idem, ‘Transferring’. For an overview of technological innovations in the Catalan cotton manufacture and cotton industry, see Ferrer, ‘Bergadanés’; Sánchez, ‘Berguedanes’; Thomson, ‘Transferencia’. The term ‘mill’ refers to centralized manufactures predating the factory system.
47 Garcia Balañà, Fabricació, pp. 147–246.
most profitable way to exploit the new technology was in the domestic workshops in Barcelona or in the cottages in the traditional textile areas of central Catalonia and the Pyrenean foothills. As Sánchez has shown, by as early as 1791 there were at least 108 spinning jennies in Catalonia, and throughout that next decade they were widely adopted.  

At the same time, the carding machine, a necessary complement, was widely diffused. After 1792, Haley's improved version of the jenny, with 78–80 spindles, was built in central Catalonia, with a total of 250 machines being reported as operational in 1796. Thus, by the beginning of the nineteenth century, Catalonia boasted spinning jennies (each with between 36 to 110 spindles) with a total of 90,000 spindles. It is thought that the most improved local version of the jenny, the ‘berguedana’, with 120 spindles, was invented around 1808. The widely diffused machine-building skills helped the rapid introduction of new technologies and their local improvement.

The adoption of new technologies in the cotton sector did not end with the spinning jenny. A new war with Britain in 1797 interrupted what were still fairly important imports of Maltese yarn. Moreover, in 1802 a ban on yarn imports was introduced. Both these circumstances increased the pressure for expansion of the spinning of cotton. Against this backdrop, Arkwright’s water frame was rapidly adopted during the early years of the nineteenth century. These machines were more expensive than the biggest jennies and required much more energy to operate, although small 48-spindle units were successful in Catalonia. In Manresa alone, a city in central Catalonia on the Cardener River, six factories with water frames were founded between 1801 and 1808 to take advantage of the water power.

Arkwright’s machines, which were located in mills on the region’s riverbanks, were more suited to use in a factory system. On the eve of the Peninsular War (1808), a total of 12,000 water frame spindles had been installed in Catalonia. In turn, the mule jenny had just been introduced and accounted for a further 2,000 spindles.

During the Peninsular War (1808–14) industrial activity was severely interrupted, but much of the infrastructure remained unharmed. The postwar crisis was to have a negative impact on the cotton industry, especially between 1822 and 1825. While weaving and spinning resisted quite well, calico printing was badly affected. As the American markets were lost with the demise of the Spanish Empire, manufacturers turned to the home market, strengthening the process of mechanization and concentration. During the period 1815–25 almost 60 per cent of the investment in the cotton industry was devoted to spinning. ‘Berguedanes’ substituted old spinning jennies, and water frames and mule jennies diffused. After 1826 there was an acceleration in investment and mechanization. In Barcelona in 1829 the mule jenny was already dominant, with 410 units in operation, although many were driven by animal power and the firms were not large. The largest firms

48 Sánchez, ‘Berguedanes’, p. 163. See also Solà, ‘Indústria tèxtil’.
49 Sánchez, ‘Berguedanes’, p. 165; Thomson, ‘Transferring’, p. 42; Solà, ‘Filar’, p. 155.
50 Sánchez, ‘Berguedanes’, pp. 164–70.
51 Solà, ‘Filar’, pp. 154–5.
52 Thomson, ‘Olot’, p. 330.
53 The first water frame arrived in Catalonia in 1793; ibid.
54 Solà, Aigua, pp. 63–107.
55 Sánchez, ‘Berguedanes’, pp. 170–2; Raveux and Sánchez, ‘Adaptación’, pp. 75–7; Thomson, ‘Transferencia’, pp. 24–27; Solà, ‘Filar’.
56 Sánchez, ‘Berguedanes’, pp. 172–5.
57 For this period, see Thomson, Distinctive industrialization; Sánchez, ‘La empresa’; Rosés, ‘Subcontracting’.

© Economic History Society 2015 Economic History Review, 69, 2 (2016)
were still the spinning factories near the rivers, outside the capital. The next step came with the use of steam power. The first cotton factory to introduce steam—‘Bonaplata, Rull, Vilaregut i companyia’—was opened in Barcelona in 1833 and was destroyed in the turmoil of the summer of 1835. By then, in 1830, the number of cotton spindles operating in Catalonia had reached a total of 1,162,237 (of which 89 per cent were jennies and ‘berguedanes’). This figure was equivalent to 10 per cent of the British cotton spindles and 28 per cent of those installed in continental Europe.

Overall, the adoption of the spinning jenny took place in the late 1780s and early 1790s. Indeed, between 1783 and 1796, thanks to the new peace established with Britain and the rise in colonial trade, printed calicoes and linen manufactures enjoyed their belle époque. At the same time, cotton spinning expanded in Catalonia and the spinning jenny was widely adopted. In this context, Vilar argues that high wages in Barcelona attracted workers from the rest of Catalonia, creating a labour shortage in the countryside. The consequent rise in rural wages, and the lower wage gap between the city and the countryside, is seen by Mora-Sitjà as an indication of growing integration in rural–urban regional labour markets during this period. In addition, she stresses that, in spite of the large population growth recorded during the eighteenth century, wages did not fall, indicating that Catalonia was escaping the Malthusian trap. However, Marfany, analysing one of Catalonia’s most dynamic industrial towns of that century—Igualada—argues that the industriousness and the market oriented activity of many Catalans was not to satisfy a desire for higher consumption levels, as was the case in north-western Europe, but rather to survive and to nurture a growing population on scarce land. Thus, the labour intensification process in the region’s vineyards and manufacturing sector was not accompanied by rising income and consumption levels, but only by population growth. Based on this situation, the historiography is not unanimous in describing the wage levels achieved in Catalonia at the end of the eighteenth century. The section that follows seeks to offer quantitative evidence in this regard from a European comparative perspective.

II

The first step in our research strategy is to compute real wages for Barcelona in the long run from the sixteenth to the beginning of the nineteenth century. Our database is built from the wage and price information collected by Feliu. In an...
exhaustive study, this author reports an enormous amount of information regarding both the wages for a range of occupations and the prices of consumer goods in the city of Barcelona between 1500 and 1808. Our methodology for constructing real wages for Barcelona follows previous studies in the field so as to be able to undertake a comparison with existing evidence on real wages in a growing sample of cities around the world.67

First, we compute the daily nominal wages of labourers working in the construction sector.68 The unit of account in the primary sources is sous catalans which have to be converted into grams of silver. The results presented in figure 1 allow us to describe the evolution of nominal wages for construction labourers in Barcelona between 1500 and 1808. Interestingly, the significant progress that has been made in the production of comparable long-term series of wages in the context of the ‘great divergence’ debate allows us to place the Catalan experience within the increasingly complete international picture. For the sake of simplicity, we confine our comparison to just a few leading European cities (London, Amsterdam, Florence/Milan, and Vienna). First of all, Barcelona stands out at the beginning of the sixteenth century for having higher nominal wages. Between 1550 and 1650, a period of wage dispersion across Europe’s cities, Barcelona retained this position, although wages in north-western Europe were already higher. In the next century, while wages continued to increase in London and remained stable in the Low Countries, in Barcelona the decrease in wages followed the tendency observed for other cities in continental Europe. By 1750, nominal wages in Barcelona had fallen to the levels recorded at the beginning of the sixteenth century; however, wages were still higher in Barcelona than those paid in northern

67 Allen, ‘Great divergence’; Allen et al., ‘Wages’; Allen et al., ‘Colonial origins’. Detailed information on the wages and prices series used to calculate real wages and the methodological issues involved in such calculations can be consulted in Martínez-Galarra and Prat, ‘Wages and prices’.
68 Feliu, Precios y salarios, vol. II.

Figure 1. Nominal wages for construction labourers, Europe, 1500–1808 (grams of silver per day)
Source: Allen, ‘Great divergence’, p. 416. Florence, 1500–1617; Milan, 1618–1808. For Barcelona, see section II.
Italy and Vienna. From that moment on an exceptional increase was recorded in nominal wages, a rise that was not observed in the wages of its continental counterparts. These findings are supplemented by table 1.

Nonetheless, nominal wages hide differences in the cost of living and in inflation across locations. In order to obtain a clear image of the incomes of construction workers and, as such, of their comparative standards of living, the usual problems raised with nominal variables have to be overcome. Real wages are usually obtained by comparing nominal wages to a consumer price index. Here, as is common in the related literature, this consumer price index is estimated by calculating a consumption basket that represents the minimum for subsistence, including a number of goods that are considered to be representative of the consumption of an adult male per year in the period under study. The basket includes food providing around 1,940 calories per day, which is very close to the minimum intake of calories for survival; in addition, some non-food items, including cloth, soap, and fuel, are also incorporated (table 2).

Table 1. Nominal wages for construction labourers, Europe, 1500–1808 (grams of silver per day)

| Average | London | Amsterdam | Barcelona | Florence/Milan | Vienna |
|---------|--------|-----------|-----------|---------------|--------|
| 1500–49 | 3.2    | 3.1       | 4.7       | 2.9           | 2.7    |
| 1550–99 | 4.6    | 4.7       | 5.3       | 3.8           | 2.6    |
| 1600–49 | 7.1    | 7.2       | 6.1       | 4.7           | 4.4    |
| 1650–99 | 9.7    | 8.5       | 7.1       | 4.1           | 3.5    |
| 1700–49 | 10.5   | 8.9       | 5.5       | 3.2           | 3.2    |
| 1750–99 | 11.5   | 9.2       | 6.0       | 2.9           | 3.0    |
| 1800–8  | 17.1   | 9.2       | 9.6       | 2.6           | 2.4    |

Sources: Allen, ‘Great divergence’, p. 416. Florence, 1500–1649; Milan, 1650–1849. For Barcelona, see section II.

Table 2. Bare-bones subsistence basket of goods

| Food          | Quantity per person per year | Calories per day |
|---------------|------------------------------|------------------|
| Wheat         | 215 kg                       | 1,657            |
| Beans         | 20 kg                        | 187              |
| Meat (beef)   | 5 kg                         | 34               |
| Olive oil     | 3 l                          | 60               |
| Non-food      |                              |                  |
| Soap          | 1.3 kg                       |                  |
| Linen/canvas  | 3 m                          |                  |
| Candles       | 1.3 kg                       |                  |
| Lamp oil      | 1.3 l                        |                  |
| Fuel          | 2 million BTUs               |                  |
| Total         |                              | 1,938            |

Sources: Allen, British industrial revolution, p. 37; Allen et al., ‘Wages’, p. 21; Allen et al., ‘Colonial origins’ (conference paper), p. 43.

---

69 Allen, British industrial revolution; Allen et al., ‘Wages’; Allen et al., ‘Colonial origins’.
70 See Humphries, ‘Lure of aggregates’, for a critical view on Allen’s methodology, and his response in Allen, ‘High wage economy’.
There are, of course, differences in the consumption patterns across countries. As in pre-industrial societies cereals represented a large share of budget expenditure, the basket is geographically adapted to consider the different grains available depending on the area studied and based on the regional diet (for instance, oats in northern Europe, polenta in northern Italy, and wheat in southern Europe). In our calculations for Barcelona, an equivalent quantity of the cheapest and most common grain, wheat, has been taken. Another example in this sense would be the inclusion of olive oil in the basket for southern European countries instead of butter, or the use of canvas and linen to represent textiles. Likewise, a fuel consumption of two million British thermal units (BTUs) per year is used for Barcelona, in line with other Mediterranean countries where more temperate climates reduce the amount of heating fuel required. The time series of prices between 1500 and 1808 are likewise obtained from Feliu.71

The results in table 3 show that the cost of acquiring the goods in the subsistence basket in Barcelona (expressed in grams of silver) was higher than in the rest of Europe. This reflects the outcome of the price revolution in Spain and the inflationary effect of the arrival of silver from the Americas, which resulted in a persistent and general increase in prices.72 The inclusion of Valencia/Madrid in the last column of the table illustrates that a similar evolution (and one that was even more extreme) in the cost of living took place in other cities in Spain.

Finally, real wages can be conventionally obtained by calculating the ratio between nominal wages and a standard consumer price index. As mentioned above, the strategy adopted here is in line with previous research in the field.73 The aim is to examine the purchasing power of the wages earned by a labourer on a yearly basis in relation to the annual cost of subsistence of a representative family. The construction of this subsistence ratio requires a number of assumptions to be made. First, a labourer’s daily wages have to be converted into annual earnings, assuming a total of 250 days of work per year. Second, the cost of the subsistence basket, which is already expressed in annual terms, is increased by a constant mark-up of 5 per cent to include housing costs, that is, the estimated amount spent on rent. Finally, a representative family consisting of two adults and two children

71 Feliu, *Precios y salarios*, vols. I and II.
72 Hamilton, *American treasure*; idem, *War and prices*; Drelichman, ‘Curse of Moctezuma’, and the works cited therein.
73 Allen et al., ‘Colonial origins’.

---

**Table 3. Cost of the equivalent bare-bones subsistence baskets, 1500–1800 (grams of silver per year)**

|          | London | Amsterdam | Barcelona | Florence | Vienna | Valencia/Madrid |
|----------|--------|-----------|-----------|----------|--------|-----------------|
| 1500–49  | 67     | 66        | 176       | 99       | 59     | 144             |
| 1550–99  | 128    | 104       | 306       | 156      | 96     | 324             |
| 1600–49  | 201    | 152       | 374       | 177      | 180    | 439             |
| 1650–99  | 220    | 158       | 319       | 129      | 127    | 383             |
| 1700–49  | 201    | 172       | 282       | 177      | 130    | 328             |
| 1750–99  | 264    | 202       | 382       | 240      | 165    | 392             |

Source: Allen et al., ‘Colonial origins’ (conference paper), p. 44. For Barcelona, see section II.
The cost of keeping this family at subsistence levels is considered to be equivalent to an annual payment of three baskets such as the one described in table 2. The interpretation of this subsistence ratio has certain advantages over more conventional wage indexes. First, it provides a useful answer to the question: can a man working full time for a year support a family at the minimum subsistence level? A ratio below one indicates that families face economic hardships, as the yearly income is not sufficient to keep the family at the subsistence level. If the ratio is above one, then families enjoy a surplus and can expand their consumption, while their earnings allow them to move above the subsistence level. Second, the cost of subsistence for a family, when transformed to current dollars, is very similar to the present-day poverty line as defined by the World Bank at $1.25 per day. Hence, a subsistence ratio equal to one implies that a family is living on the edge of the poverty line. As such, the ratio measures the standard of living at a particular moment in time as a multiple of the poverty line.

The computation of the subsistence ratio for Barcelona allows us to analyse the evolution of living standards in the period under study in a European comparative perspective (figure 2 and table 4). In previous studies a clear divergent pattern within Europe has been found. While cities in north-western Europe, such as London and Amsterdam, enjoyed a high standard of living (around three to four times above the subsistence level), the cities of continental Europe experienced a continuous decline over time. By the end of the eighteenth century, the subsistence ratio in these latter cities was around one, and so the yearly earnings of construction labourers placed them very close to the poverty line. In this case, the evolution

---

74 Schneider, ‘Real wages’, has suggested an adjustment of Allen’s real wages (Allen, ‘Great divergence’) to changing demography and variations in household composition in early modern England.

75 Allen, ‘Great divergence’.

76 Allen et al., ‘Colonial origins’; Allen, ‘Poverty lines’.

77 Allen, British industrial revolution.
of Barcelona follows that of the continental cities. Thus, when the cost of living is considered in relation to the computation of the subsistence basket, the relatively favourable position found for Barcelona, in terms of nominal wages, vanishes.

III

On the basis of these results, can the early adoption of the spinning jenny in Catalonia be explained by relative factor prices? A recently expressed view in the debate as to why the industrial revolution began in Britain claims that the profitability of new technologies was a key variable. According to this line of argument, inventions affect the input requirements of production, and technologies generate a bias in the use of factors. Specifically, in comparison with the spinning wheel, the spinning jenny increased capital requirements while reducing labour needs. Thus, not only do we need to examine the average wage levels of a particular economy, we also need to study the structure of relative prices, including those of both labour and capital. How did Barcelona perform in comparison with England and France, Europe’s two main cotton producers at that time, in terms of the prices of labour and capital?

Allen constructs a ratio between labour and capital prices, taking nominal wages in the construction sector and computing the price of capital \( (r) \) based on the following expression:

\[
r = P_K (i + d)
\]

where \( i \) is the interest rate, \( d \) is the depreciation rate, and \( P_K \) denotes the price of capital goods as a geometric average of the prices of labour and building materials (iron, bricks, and soft wood). The interest rates included in the exercise were obtained from Homer and correspond to long-term interest rates paid by the British and the French governments.

Table 4. Subsistence ratio for labourers in Europe, 1500–1800

|        | London | Amsterdam | Barcelona | Florence | Vienna |
|--------|--------|-----------|-----------|----------|--------|
| 1500–49 | 3.73   | 3.80      | 2.21      | 1.99     | 3.28   |
| 1550–99 | 2.96   | 3.64      | 1.45      | 1.77     | 2.07   |
| 1600–49 | 2.83   | 3.84      | 1.31      | 1.71     | 1.82   |
| 1650–99 | 3.49   | 4.33      | 1.84      | 1.65     | 1.99   |
| 1700–49 | 4.16   | 4.20      | 1.56      | 1.39     | 1.77   |
| 1750–99 | 3.51   | 3.77      | 1.26      | 0.99     | 1.35   |

Source: Allen et al., ‘Colonial origins’ (conference paper), p. 45. For Barcelona, see section II.

78 Ibid. From an economic theory point of view, see Acemoglu, ‘Directed technical change’; idem, ‘Labor scarcity’.

79 Allen, ‘Industrial revolution in miniature’.

80 Homer, History, pp. 117, 126, 157; Homer and Sylla, History, pp. 157–8, 170, 192, 217. British interest rates correspond to the annual average of the yields of long-term British government securities (3% annuities and Consols). In turn, French data refer to long-term interest on government credit (rentes), beginning in 1756. It is argued that the French rentes were similar in structure to the British Consols; ibid., p. 216.
In the spirit of Allen, we explore the relative prices for labour and capital. However, in gathering the information for Barcelona we run into various problems. First, information on the prices of building materials in Barcelona in that period is incomplete. In order to solve this drawback, as a first approximation, we compute a raw ratio between nominal wages and nominal interest rates. Second, to the best of our knowledge, data on the interest rates paid by government bonds in Spain in the late eighteenth century are not available. We use, by way of alternative, the short-term commercial interest rates or *descuentos* provided by Maixé-Altés. Arguably, these interest rates are, in fact, more appropriate for the calculations undertaken in this exercise given that they are the rates that merchants and manufacturers would have had to pay in Catalonia to obtain credit, and thus they reflect more accurately the cost of capital for those involved in manufacturing activities. Unfortunately, while these interest rates are particularly suitable, they hinder the comparison of ratios between Barcelona and the other cities considered. The results are presented for London (England), Strasbourg (France), and Barcelona (Catalonia). The data for nominal wages in the first two cities are drawn from Allen, while for Barcelona the source used is Feliu, as detailed in the previous section. Figure 3 depicts the ratio for the aforementioned cities, with London in 1776 being set equal to 1.

Bearing in mind then that the interest rates for Barcelona do not correspond to public debt but rather to the interest rates charged to merchants, the results

---

81 Allen, ‘Industrial revolution in miniature’.
82 Maixé-Altés, ‘Coyuntura’, p. 195. We thank Joan Carles Maixé-Altés for kindly providing us with the data.
83 Allen, ‘Great divergence’.
84 Feliu, *Precios y salarios*, vols. I and II.
show Barcelona’s ratio to be slightly increasing, although still well below the levels reached in London. Therefore, at an aggregate level, no incentive appears to have been present in Catalonia for labour substitution. However, given that the price of capital in London (and Strasbourg) is captured by the long-term interest rates in government bonds, this could be considered as overestimating the ratio. Even so, the ratio for Barcelona is comparable to the values obtained for Strasbourg.

Given the limitations of the previous exercise, in order to gain further insights into the role played by the relative prices of production factors in the adoption of technology, an alternative approximation is suggested. Instead of focusing on the general prices for labour and capital at the aggregate macro-level for different economies, we rely on information from the cotton textile sector in the late 1780s for England, France, and Catalonia. Once again we compute a raw ratio between the price of labour and the price of capital for the specific task of cotton spinning. In so doing, we take the daily wage paid to a spinner as the price of labour; for the price of capital we use the purchase price of a spinning jenny, that is, the investment cost faced by the producer. The data for England and France are drawn from Allen and Gragnolati et al.

Spinners earned 6.25d. per day in England and 9 sous tournois in France. The price of a 24-spindle jenny for cottage use is estimated at 70s. in England and 140 livres tournois in France. For Catalonia, the spinners’ wage and the price of a jenny (in sous) are obtained from Garcia Balañà and Okuno. A 36-spindle jenny, the most common machine used in Catalonia at that time, would have cost around 900 sous. As the number of spindles is greater than that on the machines in England or France, our calculations tend to push the ratio between wages and the price of capital downwards for Catalonia.

The results of this exercise can be seen in table 5. First, the relative prices of labour and capital show that there were significant differences between England and France, as established in previous research. The wages relative to the cost of capital in France were less than half those recorded in England. It is these significant differences that are at the heart of the explanation as to why the industrial revolution occurred in Britain. The high price of labour in England

| Table 5. | Wage/price of capital ratio for the textile sector in the late 1780s |
|---|---|---|
|     | England | France | Catalonia |
| Daily wage (w) | 6.25d. | 9st. | 6s. |
| Daily wage in grams of silver (w) | 2.90 | 2.12 | 3.83 |
| Price of a jenny (J) | 840d. | 2,800st. | 900s. |
| Price of a jenny in grams of silver (J) | 389.75 | 658.14 | 575.01 |
| (w) / (J) | 0.00744 | 0.00321 | 0.00667 |
| England = 100 | 100 | 43.2 | 89.6 |

Note: d. = shillings; s. = sous; st. = sous tournois.
Sources: Based on Gragnolati, Moschella, and Pugliese, ‘Spinning jenny and the guillotine’, tab. 2, p. 14; Garcia Balañà, Fabricació, pp. 161–2.
relative to that of capital seems to explain why English producers adopted the new machines that allowed them to substitute the more expensive factor of production (labour) and to use the cheaper one (capital). Second, the wage/price of capital ratio for Barcelona is high, similar in fact to that recorded in England (89.6 per cent). On the basis of these results it seems that Catalan producers, in common with their English counterparts, may likewise have had an incentive to mechanize production, showing themselves to be more enthusiastic about new cotton spinning technologies than were the French producers.

Why was the value of the Catalan wage/price of capital ratio for cotton spinning more than twice as high as that of the French ratio? The figures in grams of silver (table 5) show that the jenny was only slightly cheaper in Catalonia than in France, so that the difference in the ratio is attributable to the higher Catalan wages. Since spinning jennies were constructed by local carpenters, the relatively low price of the spinning machines can be explained as a result of a 'Marshallian' concentration of skilled carpenters around the high number of cotton manufacturers and calico printers in Barcelona. However, it is the relatively high wages earned by spinners that seem to push the Catalan ratio close to British values.

Indeed, the limited available evidence for wages seems to support this finding. Contemporary testimonies referring to the Royal Spinning Company report that a spinner would receive a weekly wage of 36 sous: 'in the belief that 36 sous a week would seem to be a sufficient daily wage for a woman'. They worked six days a week so the daily wage was six sous. This was the wage proposed for the first spinners using spinning jennies in a mill in Barcelona, based on the experience of the Royal Spinning Company as a cotton yarn putting-out在外 in the Catalan countryside.

Further evidence on the wages paid once again comes from the Royal Spinning Company’s putting-out activity. In a contemporary statement referring to the rural village of Prats del Rei in 1790, one of the company’s middlemen complains of ‘the lack of finding anyone because everybody is otherwise occupied and the women earn eight or nine diners the hour for cotton’. Assuming 10 hours in a full working day, this would give a daily wage of between 6.6 and 7.5 sous (1 sou = 12 diners). This wage is quite high, and, as the quotation suggests, it was offered in a situation that might be considered exceptional, in the sense that it seems to be a time of labour scarcity during the summer months. Thus, we use the more cautious value of six sous as the wage paid in Catalan cottages. In addition, most of the evidence for the spinners’ earnings refers to piece rates. The piece rates paid in several villages in the 1780s, following conversion to daily wages based on production level, tend to confirm that six sous is a reasonable assumption.

---

87 An illustration of the role played by a skilled carpenter in the construction of the first jennies in Catalonia can be found in Thomson, ‘Transferring’, p. 27. The Marshallian argument could be extended to the enormous range of artisanal skills in Barcelona.
88 Garcia Balañà, Fabricació, p. 162 (quotation); Thomson, ‘Transferring’, p. 37.
89 Okuno, ‘Entre la llana’, p. 62.
90 Thomson, ‘Transferring’, p. 39.
91 Okuno, ‘Entre la llana’, p. 62.
92 This evidence indicates that the wages paid to cotton spinners in Barcelona and in the countryside were similar. This is coherent with the argument that there was a high degree of labour market integration (rural and urban) during this period, as claimed by a number of authors; for example, Mora-Sitjà, ‘Labour market’. As for integration between Barcelona and its hinterland, it has been argued that “The Catalan region was not “invertebrate” but rather exceptionally well-articulated, interaction between its “comarcas” (counties), and the capital being facilitated by the lie of its valleys and river, road, and sea transport. The existence of such an “urban
Thus, Catalan spinning in the 1780s had high nominal wages and relative factor prices similar to those recorded in Britain. Although Catalonia was not a high wage economy, cotton spinners could have achieved a better standing in terms of wages. Spinners were mainly women who earned half the wage of a construction labourer, while their English counterparts received just a quarter of the British construction labourer’s wage (2.9 vs. 11.9 in grams of silver). Thus, if a comparison is drawn with England, at first sight it might seem that Catalan spinners were relatively well paid. Yet the best way to compare earnings is to rely once again on real wages. The determination of the subsistence ratio as in section II gives a wage for English and Catalan spinners of 0.87 and 0.80, respectively (figure 4). While the real wage of an English spinner was only 8.75 per cent higher than that of a Catalan spinner, the wage of an English construction labourer in the second half of the eighteenth century more than doubled the Catalan wage. Hence, in the context of the Catalan economy, spinners were very well paid.

In our view, this difference reflects the expansion in cotton spinning during these years. As mentioned in section I, printed calico exports boomed after 1783 and this coincided with a process of import substitution of cotton yarn. The increase in raw cotton imports entering the port of Barcelona is evidence of this increase in cotton spinning. In 1783, raw cotton imports totalled 223,900 pounds. Ten years later, in 1793, the total had risen almost five-fold (to 1,098,433 pounds). All this raw cotton had to be spun in Catalonia, which resulted in a high demand for spinners as well as high wages for spinners, and hence there was a strong incentive to substitute labour by adopting the spinning jenny.

Figure 4. Labourers’ and spinners’ real wages (subsistence ratio) in England and Catalonia

Note: The figure is constructed computing the spinners’ wages full-time and annually, as with the construction labourers.

Source: See fig. 2 and sections II and III.

Thus, Catalan spinning in the 1780s had high nominal wages and relative factor prices similar to those recorded in Britain. Although Catalonia was not a high wage economy, cotton spinners could have achieved a better standing in terms of wages. Spinners were mainly women who earned half the wage of a construction labourer, while their English counterparts received just a quarter of the British construction labourer’s wage (2.9 vs. 11.9 in grams of silver). Thus, if a comparison is drawn with England, at first sight it might seem that Catalan spinners were relatively well paid. Yet the best way to compare earnings is to rely once again on real wages. The determination of the subsistence ratio as in section II gives a wage for English and Catalan spinners of 0.87 and 0.80, respectively (figure 4). While the real wage of an English spinner was only 8.75 per cent higher than that of a Catalan spinner, the wage of an English construction labourer in the second half of the eighteenth century more than doubled the Catalan wage. Hence, in the context of the Catalan economy, spinners were very well paid.

In our view, this difference reflects the expansion in cotton spinning during these years. As mentioned in section I, printed calico exports boomed after 1783 and this coincided with a process of import substitution of cotton yarn. The increase in raw cotton imports entering the port of Barcelona is evidence of this increase in cotton spinning. In 1783, raw cotton imports totalled 223,900 pounds. Ten years later, in 1793, the total had risen almost five-fold (to 1,098,433 pounds). All this raw cotton had to be spun in Catalonia, which resulted in a high demand for spinners as well as high wages for spinners, and hence there was a strong incentive to substitute labour by adopting the spinning jenny.
In the light of these results, can we conclude that the relative prices of production factors played a role in the early adoption of the spinning jenny across Catalonia? Here, the issue at stake is just how profitable it would have been for Catalan producers to adopt the spinning jenny in the early stages of industrialization. The detailed information available for the Catalan case allows us to conduct a precise micro-economic analysis to examine the profitability of the first jennies installed in Catalonia. The spinning jenny was first introduced in 1784 and was widely adopted through the 1790s, which suggests that the spinning jenny was profitable in Catalonia during this period. Allen has shown that jennies were profitable for people living in contemporary English cottages but not for their French counterparts. Below, we seek to apply the same analysis to the Catalan case in order to test whether or not his interpretation of the industrial revolution allows us to explain what happened south of the Pyrenees.

In Allen’s model the decision makers are domestic producers who live in cottages and spend some of their time spinning cotton for weavers or merchants. The question is whether or not these domestic producers deemed it profitable to buy a 24-spindle jenny because of an increase in labour productivity; that is, whether the reduction in labour costs offset the sum of the price of a jenny plus a normal profit rate. The rate of return of the investment is obtained by solving the following equation:

$$J = \sum (w\Delta L - m)(1 + r)^t$$

(2)

with $t = 1, 2, \ldots, n$ where $J$ is the price of a jenny, $w$ the daily wage of a spinner, $\Delta L$ the number of days of labour saved per year, $m$ the cost of maintenance of the jenny, and $r$ is the internal rate of return to be calculated. The labour saved is computed as:

$$\Delta L = YD(1 - 1/P)$$

(3)

where $Y$ is the number of working days in a year, $D$ the part of a working day devoted to spinning, and $P$ the relative productivity of the new technology compared to the former (that is, the spinning wheel). To solve this equation, several assumptions must be made. First, the time span $t$ is set at 10 years, representing the life expectancy of a jenny. The cost of maintenance $m$ is assumed to be 10 per cent of the purchase price of the jenny and the number of working days per year ($Y$) to be 250. As for $D$ and $P$, several scenarios are examined. It is believed that cottage spinners devoted between 30 and 50 per cent of their working time to spinning, with $D$ being equal to 0.3, 0.4, or 0.5 in alternative calculations. For example, if we assume that spinners devoted 40 per cent of their working time to spinning, then the 250 working days are computed as 100 full time equivalent days. On the other hand, contemporary testimonies indicate that the labour productivity of the 24-spindle jenny was between two and four times that of the

---

94 Allen, ‘Industrial revolution in miniature’.
95 In the specific case of Catalonia, Ildefons Cerdà (quoted in Mora-Sitjà, ‘Labour market’, p. 165) estimated that in 1856 labourers in calico-printing factories worked 249 days a year.
96 Allen, ‘Industrial revolution in miniature’ (working paper), pp. 9–10.
spinning wheel. In this case, with a typical $P$ equal to 3, up to 66.6 per cent of the labour would be saved. A key assumption in the model is that the gains in labour productivity are analysed as a cost reduction, not as an output increase. This has been criticized by Gragnolati et al. (‘Spinning jenny and the industrial revolution’; eisdem, ‘Spinning jenny and the guillotine’). They argue that it is not economical to make an investment in a technology with increasing returns to scale and at the same time to reduce the quantity of labour applied. They develop a model in which factor prices and the size of demand are combined to predict precisely the timing of the adoption of the jenny both in Britain and France. Allen’s answer to this critique is to stand by his assumption that spinners had a target level of consumption, in the same way that farm labourers did in earlier centuries under the putting-out system; Allen, ‘Spinning jenny: a fresh look’.

Once all these parameters have been fixed, the two variables that make the spinning jenny profitable or unprofitable in each country are those included in table 5, that is, the purchase price of a jenny ($J$) and the daily wage of a spinner ($w$). Since Allen’s interpretation is concerned with relative factor prices, the higher the ‘wage/jenny price’ ratio, the greater the probability of it being profitable to adopt the spinning jenny. Our results in the previous section show that the Catalan ratio is much closer to the British than to the French ratio, being only 10 per cent lower than the former. Indeed, the Catalan internal rates of return under different scenarios are quite similar to those found in Britain, as can be seen in table 6. If we consider, as Allen does, a 15 per cent profitability threshold, only in the worst case scenario was buying a jenny not a profitable investment in Catalonia in the late 1780s (as it was also in Britain). By contrast, as Allen has shown, only in the best case scenario was the jenny profitable in France in these same years.

There is evidence that as early as 1791 there were at least 108 jennies in Catalonia and that they then spread very quickly throughout the 1790s in Barcelona, as well as in the region’s manufacturing towns and villages, and in the countryside. The boom in demand for printed calicoes and the need to provide an increasing share of the yarn from home led to the rapid expansion of cotton spinning and the adoption of new machines in Catalonia. Yet the jennies did not

---

### Table 6. Rates of return to buying a spinning jenny in Britain, France, and Catalonia

| Relative productivity | % full-time | Britain (%) | Catalonia (%) | France (%) |
|------------------------|-------------|-------------|---------------|------------|
| 2                      | 0.5         | 34.6        | 29.9          | 0.2        |
| 2                      | 0.4         | 24.0        | 20.3          | -8.2       |
| 2                      | 0.3         | 12.3        | 9.4           | -21.7      |
| 3                      | 0.5         | 51.2        | 44.8          | 10.7       |
| 3                      | 0.4         | 38.0        | 32.9          | 2.5        |
| 3                      | 0.3         | 24.0        | 20.3          | -8.2       |
| 4                      | 0.5         | 59.2        | 52.0          | 15.3       |
| 4                      | 0.4         | 44.7        | 38.9          | 6.8        |
| 4                      | 0.3         | 29.4        | 25.2          | -3.7       |

Sources: Allen, ‘Industrial revolution in miniature’, tab. 1, p. 916; Garcia Balañá, Fabricació, pp. 161–2.
change the scale or the geographical location of spinning because they were powered by hand.\textsuperscript{101} In fact, most of them were installed in homes or in small workshops.

By replicating Allen’s analysis, we have already shown that the spinning jenny was profitable for Catalan cottage producers at the end of the 1780s; however, the abundance of available data allows us to conduct a slightly different test for domestic producers in Barcelona during the second half of the 1790s. The aim of this exercise is to provide a robustness check of the profitability of the spinning jenny in Catalonia, to examine a different context in which this technological innovation was adopted (urban households and workshops), and to contribute to the debate on the success of the factory system in the early stages of the industrial revolution. To do this, we need to return once more to the Royal Spinning Company.

Garcia Balañà undertook a detailed study of the Company’s records in the years following the adoption of the spinning jenny.\textsuperscript{102} While cottage and urban domestic spinners were adopting the jenny in Catalonia, the Royal Spinning Company failed to centralize yarn production with jennies in a mill. In 1791, working six days a week, the average weekly production of one spinner was 5.4 lbs, that is, 0.9 lb per day, well below the target of 1.5 lbs set by the company in 1788. Garcia Balañà attributes this failure to the fact that the spinners were young girls, most of whom formed part of urban households in which their labour was required on an intermittent, irregular basis. The flexibility they had previously enjoyed as they moved between the house, the workshop, and the mill was essential for the urban households of which they were members.\textsuperscript{103} However, the mill’s profitability depended on an increase in throughput and on the lengthening of the time the spinners spent working, in short, on making sure that a full-time working day was achieved. The Royal Spinning Company mill was unable to break the economic logic of the urban households, whether by imposing disciplinary codes or by offering incentives; the fathers of the young spinners retained greater power over the girls than the mill foremen. The time of the factory system for cotton spinning had not yet arrived. In fact, the Royal Spinning Company decided to close its mill soon afterwards, probably not much later than the end of 1792, and to buy the yarn in the market.\textsuperscript{104}

Following the closure of its mill, the Royal Spinning Company stocked up on yarn from domestic producers in Barcelona and its hinterland. This time, they tried not to have to depend on the middlemen of the old putting-out system and so they established direct links with their suppliers. Garcia Balañà reports that in 1797 the Company decided to lease jennies to various domestic producers and small workshops in Barcelona.\textsuperscript{105} The terms of the agreement were as follows: the Company remained the owner of the jenny, but the spinning was to be done at the spinner’s home or domestic workshop. In exchange for the use of the Company’s jenny, the piece rate fell from 12 to 7.5 sous per lb.\textsuperscript{106} However, given the increase

\begin{footnotesize}
\textsuperscript{101} Sánchez, ‘Orígens’, p. 40.
\textsuperscript{102} Garcia Balañà, \textit{Fabricació}, pp. 166–219.
\textsuperscript{103} Carbonell, \textit{Sobreviure}, pp. 121–4, quoted in Garcia Balañà, \textit{Fabricació}, p. 187.
\textsuperscript{104} Garcia Balañà, \textit{Fabricació}, pp. 166–246.
\textsuperscript{105} Ibid.
\textsuperscript{106} Ibid., p. 193.
\end{footnotesize}
in labour productivity, the spinner could afford a piece rate reduction of that amount. In contrast with Allen’s model for the cottage jenny, here the investor was the Company, not the spinner, and the productivity increase was for the benefit of the investor obtained in return for a reduction in the piece rate. In this context, we can calculate the internal rate of return of this investment using the following expression:

$$J = \sum Q (p^w - p^j) - m/(1 + r)^t$$  \hspace{1cm} (4)

where the summation is over $t = 1, 2, \ldots n$, $Q$ is the annual production of yarn, $p^w$ is the piece rate with the wheel, $p^j$ the piece rate with the jenny, and $m$ the additional maintenance costs associated with the jenny. Fortunately, actual data are available for the annual production ($Q$) of several spinners that worked for the Company in 1798,\textsuperscript{107} so no assumptions about the number of days worked and the labour intensity have to be made in this case. It is our contention that this is an interesting contribution given that Crafts questioned the robustness of Allen’s analysis on the basis of the change in results when the assumptions for the parameters in the previous equation are modified.\textsuperscript{108} In 1797, 36-spindle jennies were cheaper than they were by the end of the 1780s, costing just 450 sous. However, the Company files do not specify which kind of jennies were leased out.\textsuperscript{109} Therefore we make a conservative assumption of 60-spindle jennies with a price in 1797 of 1,200 sous.\textsuperscript{110} Thus, we assume $J = 1,200$, $m = 120$, $p^w = 12$, and $p^j = 7.5$. In table 7 the internal rates of return for three urban domestic spinners are presented.

Thus, it seems clear that this kind of investment was highly profitable for the Company. Garcia Balañà stresses that some of the suppliers were not single spinners but small family workshops overseen by a man.\textsuperscript{111} In fact, the same households that thwarted the efforts of the Company’s mill by interfering in the regular supply of young female labour now leased the jennies and produced yarn at home. These workshops became specialized in cotton spinning and were more efficient in terms of labour intensification than had previously been possible under the mill’s regulations. In short, family hierarchies and gender roles were still more powerful than the factory system at the time of the jenny. In addition, this success of the small units may also be attributed to the development of the cotton and yarn

\hspace{1cm} \textsuperscript{107} Ibid., tab. 3.3, pp. 197–8.
\hspace{1cm} \textsuperscript{108} Crafts, ‘Explaining’; Allen, ‘Spinning jenny: a fresh look’.
\hspace{1cm} \textsuperscript{109} Biblioteca de Catalunya, Barcelona, Fons Erasme de Gònim/Erasme de Janer.
\hspace{1cm} \textsuperscript{110} Conservative in the sense that we assume a high price for the jennies. This price comes from Garcia Balañà, \textit{Fabricació}, p. 202.
\hspace{1cm} \textsuperscript{111} Garcia Balañà, \textit{Fabricació}, pp. 202–19.
market, the spread of carding mills, and the availability of hand-operated or horse-driven carding machines. These Marshallian external economies of scale contributed to make small spinning firms competitive. In the light of these results, the success of the adoption and the rapid diffusion of the spinning jenny can be explained. The new technology was successfully adopted by Catalan cottage spinners and urban domestic producers, but not by the mills or factories of Catalonia, although some cases are recorded.\footnote{For example, Josep Rovira’s mill in l’Espluga de Francolí or Joan Vilaregut’s in Barcelona; Garcia Balañà, \textit{Fabricació}, pp. 227–46; Solà, \textit{Aigua}, pp. 67–70.}

V

The roots of the exceptional experience that represents Catalan industrialization in the late eighteenth and nineteenth centuries lay in the early integration of its economy in international trade during the seventeenth and eighteenth centuries and the development of an increasingly capitalist economy. Moreover, a highly distinctive cotton manufacturing sector developed in the region after 1736 and the spinning jenny was widely adopted in the 1790s. In common with other historical developments, spinning machines were introduced by the calico manufacturers, who saw an opportunity to increase their profit margins by vertically integrating their activities and producing the cotton yarn themselves. Against this backdrop, our study focuses on this case of early industrialization as we analyse the price structure of the factors of production associated with technology adoption and diffusion, taking as our framework of reference Allen’s studies of the British industrial revolution.\footnote{Allen, \textit{British industrial revolution}; idem, ‘Industrial revolution in miniature’.
}

The first contribution of this article is the construction it undertakes of long-term annual real wage series for Barcelona between 1500 and 1808, based on the subsistence ratio. In this way, the Catalan experience can now be incorporated within the global history of wages and prices that in recent years, within the broader context of the ‘great divergence’ debate, has provided information for a growing pool of cities around the world in the early modern period. Our results show that living standards in Barcelona adhered to the typical continental pattern. Furthermore, in the second half of the eighteenth century Catalonia was not a high wage economy, in the way that Britain and the Low Countries were, although it did occupy a respectable position behind this front line. In addition, the structure and evolution of the relative prices of the production factors at the aggregate level of the Catalan economy were comparable to those in other areas of western Europe (such as France) but were less favourable in terms of labour substitution when compared with Britain.

However, when the focus is shifted to the cotton spinning sector, where technological changes were taking place, our results point to different conclusions. At the end of the 1780s, the ratio between the spinners’ wages and the price of purchasing a jenny in Catalonia was below but close to that in Britain, and well above the French ratio. Thus, relative prices in Catalonia at that time favoured the demand for new technologies to substitute labour, a more expensive production factor than capital. Further, a micro-level analysis confirms the acceptable
rate of return of investing in the purchase of spinning jennies. The machines were commercially profitable. Catalan producers had incentives to mechanize production, as was the case for British producers, and this led to the adoption and diffusion of this early technology of the industrial revolution across Catalonia. Hence, a British macro-invention that changed factor proportions by saving labour was widely adopted in the Catalan textile sector.

This result can be explained by the expansion of the calico-printing sector in Barcelona in the last decades of the eighteenth century. Production and exports boomed after 1783 and, at the same time, an accelerated process of yarn import substitution was taking place. Cotton spinning was displacing wool in many peasant homes in central Catalonia and the Pyrenean foothills, and new initiatives were being taken in the city of Barcelona, but there was still a major bottleneck that left the sector in great need of large amounts of cotton yarn. This high demand translated into high wages for cotton spinners, and hence created a strong incentive to incorporate labour-saving technology in the form of the spinning jenny. Although at the macro level real wages were not especially high in Catalonia, at the micro level, the key sector, cotton spinning, was booming. This interpretation fits well with Crafts’s view of the British industrial revolution, according to which technological changes were concentrated in a number of dynamic sectors and it took a long time before the effects were perceived at the macro level, thanks to an increase in productivity.114

This case study of Catalonia also shows that in the late eighteenth century cotton producers were sensitive to factor prices within an institutional framework of lower quality than that which had developed in north-western Europe. The explanation based on the demand for technology can nonetheless be complemented with technology-supply or market size arguments to provide a more complete view of the socio-economic transformations that led Catalonia to an early industrialization—albeit one that was not exempt from difficulties—and to become the main industrial centre in the Mediterranean throughout the nineteenth century.

Date submitted 5 March 2014
Revised version submitted 24 March 2015
Accepted 8 April 2015

DOI: 10.1111/ehr.12127

114 Crafts, British economic growth; idem, ‘Forging ahead’.

Footnote references
Acemoglu, D., ‘Directed technical change’, Review of Economic Studies, 69 (2002), pp. 781–809.
Acemoglu, D., ‘When does labor scarcity encourage innovation?’, Journal of Political Economy, 118 (2010), pp. 1037–78.
Allen, R. C., ‘The great divergence in European wages and prices from the middle ages to the First World War’, Explorations in Economic History, 38 (2001), pp. 411–77.
Allen, R. C., The British industrial revolution in global perspective (Cambridge, 2009).
Allen, R. C., ‘The industrial revolution in miniature: the spinning jenny in Britain, France, and India’, Oxford University, Department of Economics, working paper 375 (2007).
Allen, R. C., ‘The industrial revolution in miniature: the spinning jenny in Britain, France and India’, Journal of Economic History, 69 (2009), pp. 901–27.
Allen, R. C., ‘The spinning jenny: a fresh look’, Journal of Economic History, 71 (2011), pp. 461–4.

© Economic History Society 2015

Economic History Review, 69, 2 (2016)
Allen, R. C., ‘The high wage economy and the industrial revolution: a restatement’, Economic History Review, 68 (2015), pp. 1–22.

Allen, R. C., ‘Poverty lines in history, theory, and current international practice’, Univ. of Oxford Dept. of Economics discussion papers, 685 (2013).

Allen, R. C., Bassino, J.-P., Ma, D., Moll-Murata, C., and van Zanden, J. L., ‘Wages, prices, and living standards in China, 1738–1925: in comparison with Europe, Japan, and India’, Economic History Review, 64, S1 (2011), pp. 8–38.

Allen, R. C., Murphy, T. E., and Schneider, E. B., ‘The colonial origins of the divergence in the Americas: a labor market approach’, paper presented at the 9th European Historical Economics Society conference, Dublin (2–3 Sept. 2011).

Allen, R. C., Murphy, T. E., and Schneider, E. B., ‘The colonial origins of the divergence in the Americas: a labor market approach’, Journal of Economic History, 72 (2012), pp. 863–94.

Badia-Miró, M. and Tello, E., ‘Vine-growing in Catalonia: the main agricultural change underlying the earliest industrialization in Mediterranean Europe (1720–1939)’, European Review of Economic History, 18 (2014), pp. 203–26.

Bassino, J.-P. and Ma, D., ‘Japanese unskilled wages in international perspective, 1741–1913’, Research in Economic History, 23 (2006), pp. 229–48.

Broadberry, S. and Gupta, B., ‘The early modern great divergence: wages, prices, and economic development in Europe and Asia, 1500–1800’, Economic History Review, LIX (2006), pp. 2–31.

Camps, E., La formación del mercado de trabajo industrial en la Cataluña del siglo XIX (Madrid, 1995).

Carbonell, M., Sobreviure a Barcelona: dones, pobresa i assistència al segle XVIII (Vic, 1997).

Clark, G., A farewell to alms: a brief economic history of the world (Princeton, NJ, 2007).

Crafts, N. F. R., British economic growth during the industrial revolution (Oxford, 1985).

Crafts, N. F. R., ‘Forging ahead and falling behind: the rise and relative decline of the first industrial nation’, Journal of Economic Perspectives, 12 (1998), pp. 193–210.

Crafts, N. F. R., ‘Explaining the first industrial revolution: two views’, European Review of Economic History, 15 (2011), pp. 153–68.

Delgado, J. M., ‘De la filatura manual a la mecànica. Un capítol del desenvolupament de la indústria cotonera a Catalunya (1749–1814)’, Recerques, 23 (1990), pp. 161–79.

Drelichman, M., ‘The curse of Moctezuma: American silver and the Dutch disease’, Explorations in Economic History, 42 (2005), pp. 349–80.

Farnie, D. A., ‘The role of merchants as prime movers in the expansion of the cotton industry, 1760–1900’, in D. A. Farnie and D. J. Jeremy, eds., The fibre that changed the world: the cotton industry in international perspective, 1600–1990s (Oxford, 2004), pp. 15–55.

Feliu, G., Precios y salarios en la Cataluña moderna (Barcelona, 1974).

Feliu, G., Precios y salarios en la Cataluña moderna, II:Combustibles, productos manufacturados y salarios (Madrid, 1991).

Ferrer, L., ‘Bergadanas, continuas y mules. Tres geografías de la hilatura del algodón en Cataluña, 1790–1830’, Revista de Historia Económica, 22 (2004), pp. 337–86.

Garcia Balaná, A., La fabricació de la fàbrica: treball i política a la Catalunya cotonera, 1784–1874 (Barcelona, 2004).

Gragnolati, U., Moschella, D., and Pugliese, E., ‘The spinning jenny and the industrial revolution: a reappraisal’, Journal of Economic History, 71 (2011), pp. 455–60.

Gragnolati, U., Moschella, D., and Pugliese, E., ‘The spinning jenny and the guillotine: technology diffusion at the time of revolutions’, Cliometrica, 8 (2014), pp. 5–26.

Habakkuk, H. J., American and British technology in the nineteenth century: the search for labour-saving inventions (Cambridge, 1962).

Hamilton, E. I., War and prices in Spain: 1651–1800 (Cambridge, 1947).

Hamilton, E. I., American treasure and the price of revolution in Spain, 1501–1650 (New York, 2nd edn. 1965).

Homer, S., A history of interest rates (New Brunswick, NJ, 2nd edn. 1977).

Homer, S. and Sylla, R., A history of interest rates (New Brunswick, NJ, 1963).

Humphries, J., ‘The lure of aggregates and the pitfalls of the patriarchal perspective: a critique of the high wage economy interpretation of the British industrial revolution’, Economic History Review, 66 (2013), pp. 693–714.

Iglesies, J., El censo del comerç de la floridablanca, 1787: (part de Catalunya) (Barcelona, 1970).

Iglesies, J., El censo general del estado de Catalunya en el primer censense del segle XVII (Barcelona, 1974).

Landes, D. S., The unbound Prometheus: technological change and industrial development in western Europe from 1750 to present (Cambridge, 1969).

Lévy-Leboyer, M., Les banques européens et l’industrialisation internationale dans la première moitié du XIXe siècle (Paris, 1964).

Lévy-Leboyer, M., ‘Les processus d’industrialisation: le cas de l’Angleterre et de la France’, Revue Historique, 239 (1968), pp. 281–98.

Mayné-Altes, J. C., ‘De la dependencia maltesa al triunfo de la hilatura catalana. El comercio catalano-maltés 1780–1800’, in Ministerio de Asuntos Exteriores, ed., Actas primer coloquio internacional hispano maltes de historia (Madrid, 1991), pp. 177–226.
WAGES, PRICES, AND TECHNOLOGY

Maixé-Altés, J. C., ‘La coyuntura financiera en Barcelona a finales del Antiguo Régimen: el mercado de efectos, 1776–1808’, Revista de Historia Industrial, 12 (1997), pp. 181–203.

Marfany, J., ‘Is it still helpful to talk about proto-industrialization? Some suggestions from a Catalan case study’, Economic History Review, 63 (2010), pp. 942–73.

Marfany, J., ‘Land, proto-industry and population in Catalonia, c. 1680–1820: an alternative transition to capitalism?’, paper presented at the Economic History Seminar, University of Barcelona (March 2012).

Marfany, J., Land, proto-industry and population in Catalonia, c. 1680–1829: an alternative transition to capitalism? (Farnham, 2012).

Martínez-Galarraga, J. and Prat, M., ‘Wages and prices in early Catalan industrialisation’, University of Barcelona economics working papers, E14, 305 (2014).

Mors, K., Das Kapital. Kritik der politischen oekonomie (Hamburg, 1867).

Mokyr, J., The enlightened economy: the economic history of Britain, 1700–1850 (2009).

Mora-Sitjà, N., ‘Labour and wages in pre-industrial Catalonia’, Univ. of Oxford discussion papers in economic and social history, 45 (2002).

Mora-Sitjà, N., ‘Labour market integration in a pre-industrial economy: Catalonia, 1772–1816’, Oxford Economic Papers, 59 (2007), pp. i56–77.

Nadal, J., El fracaso de la revolución industrial en España, 1814–1913 (Barcelona, 1975).

North, D. C. and Weingast, B. R., ‘Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England’, Journal of Economic History, XLIX (1989), pp. 803–32.

Okuno, Y., ‘Entre la llana i el cotó. Una nota sobre l’extensió de la indústria del cotó als pobles de Catalunya el darrer quart del segle XVIII’, Recerques, 38 (1999), pp. 47–76.

Oliva Melgar, J. M., ‘El cotó americà en la primera fase de la indústria moderna de Catalunya’, in Segones Tornades d’estudis catalano-americans (Barcelona, 1987), pp. 165–72.

Oliva Melgar, J. M., Catalunya i el comerç privilegiat amb América (Barcelona, 1988).

Pamuk, Ş., ‘Urban real wages around the eastern Mediterranean in comparative perspective, 1100–2000’, Research in Economic History, 23 (2006), pp. 209–28.

Pollard, S., The peaceful conquest: the industrialization of Europe, 1760–1970 (Oxford, 1981).

Pomerantz, K., The great divergence: China, Europe, and the making of the modern world economy (Princeton, NJ, 2000).

Raveux, O. and Sánchez, A., ‘La adaptación tecnológica como factor de localización industrial. Una revisión de las investigaciones sobre la industria de hilados de algodón en Cataluña, 1772–1885’, Investigaciones de Historia Económica, 6 (2010), pp. 65–94.

Rosés, J. R., ‘Subcontracting and vertical integration in the Spanish cotton industry’, Economic History Review, 62 (2009), pp. 45–72.

Sánchez, A., ‘La era de la manufactura algodonera en Barcelona, 1736–1839’, Estudios de Historia Social, 48–9 (1989), pp. 65–113.

Sánchez, A., ‘La indianeria catalana: ¿mito o realidad?’, Revista de Historia Industrial, 1 (1992), pp. 213–28.

Sánchez, A., ‘Les activitats econòmiques a Barcelona, 1717–1833’, in J. Sobrequer, ed., Història de Barcelona. El desplegament de la ciutat manufacturer. vol. 5 (Barcelona, 1993), pp. 215–72.

Sánchez, A., ‘La empresa algodonera en Cataluña antes de la aplicación del vapor, 1783–1832’, in F. Comín and P. Martín Aceña, eds., La empresa en la historia de España. La empresa en la historia de España (Madrid, 1996), pp. 155–70.

Sánchez, A., ‘Crisis económica y respuesta empresarial. Los inicios del sistema fabril en la industria algodonera catalana, 1797–1839’, Revista de Historia Económica, XVIII (2000), pp. 485–523.

Sánchez, A., ‘Les berguedanes i les primeres màquines de filar’, in J. Maluquer de Motes, ed., Tècnics i tecnologia en el desenvolupament de la Catalunya contemporània (Barcelona, 2000), pp. 161–75.

Sánchez, A., ‘El origen de la industrialización, 1759–1832’, in J. Nadal, J. M. Benaul, and C. Sudrià, eds., Atlas de la industrialització de Catalunya, 1750–2010 (Barcelona, 2012), pp. 1–9.

Schneider, E. B., ‘Real wages and the family: adjusting real wages to changing demography in pre-modern England’, Explorations in Economic History, 50 (2013), pp. 99–115.

Solà, À., ‘Indústria tèxtil, màquines i fàbriques a Berga’, l’Erol, 47 (1995), pp. 12–15.

Solá, À., ‘Filar amb bergadanès. Mite i realitat d’una màquina de filar cotó’, in La indústria tèxtil. Actes de les V Jornades d’Arqueologia Industrial de Catalunya (Barcelona, 2002), pp. 143–68.

Solá, À., Aigua, indústria i fabricants a Manresa, 1759–1860 (Manresa, 2004).

Thomson, J. K. J., ‘State intervention in the Catalan calico-printing industry in the eighteenth century’, in M. Berg, ed., Markets and manufacture in early industrial Europe (1991), pp. 57–89.

Thomson, J. K. J., A distinctive industrialization: cotton in Barcelona, 1728–1832 (Cambridge, 1992).

Thomson, J. K. J., ‘La introducció de les màquines jenny a Barcelona (1784–1789): les primeres etapes en la creació d’una tradició de construcció de maquinària’, Recerques, 42 (2001), pp. 125–46.

Thomson, J. K. J., ‘Transfering the spinning jenny to Barcelona: an apprenticeship in the technology of the industrial revolution’, Textile History, 34 (2003), pp. 21–46.

Thomson, J. K. J., ‘Transferencia tecnológica en la industria algodonera catalana: de la indiana a la selfactina’, Revista de Historia Industrial, 24 (2003), pp. 13–50.

Thomson, J. K. J., ‘Olot, Barcelona and Avila and the introduction of the Arkwright technology to Catalonia’, Revista de Historia Económica, 21 (2003), pp. 297–334.
Thomson, J. K. J., ‘Technological transfer to the Catalan cotton industry: from calico-printing to the self-acting mule’, in D. Farnie and D. Jeremy, eds., *The fibre that changed the world: the cotton industry in international perspectives, 1600–1990* (Oxford, 2004), pp. 249–82.

Thomson, J. K. J., ‘Explaining the “take-off” of the Catalan cotton industry’, *Economic History Review*, LVIII (2005), pp. 701–35.

Thomson, J. K. J., ‘The Spanish trade in American cotton: Atlantic synergies in the age of enlightenment’, *Revista de Historia Económica*, 26 (2008), pp. 277–313.

Torras, J., ‘Estructura de la industria pre-capitalista. La draperia’, *Recerques*, 11 (1981), pp. 7-28.

Torras, J., ‘Especialización agrícola e industria rural en Cataluña en el siglo XVIII’, *Revista de Historia Económica*, 2 (1984), pp. 113–27.

Torras, J., ‘L’economia catalana abans del 1800. Un esquema’, in J. Nadal, ed., *Història econòmica de la Catalunya contemporània*, vol. 1 (Barcelona, 1988), pp. 14–38.

Torras, J., ‘The old and the new. Marketing networks and textile growth in eighteenth-century Spain’, in M. Berg, ed., *Markets and manufacture in early industrial Europe* (1991), pp. 93–113.

Torras, J., ‘Gremio, familia y cambio económico. Pelaires y tejedores en Igualada, 1695–1765’, *Revista de Historia Industrial*, 2 (1992), pp. 11–30.

Torras, J., ‘Gremis i indústria rural a la Catalunya moderna’, in A. Carreras, P. Pascual, D. Reher, and C. Sudrià, eds., *Doctor Jordi Nadal: la industrialització i el desenvolupament econòmic d’Espanya* (Barcelona, 1999), pp. 925–35.

Torras, J., ‘Transformacions agràries i indústria rural. Qüestions obertes’, *Estudis d’Història Agrària*, 20 (2007), pp. 155–63.

Valls, F., *La Catalunya atlàntica: aiguardent i teixits a l’arrencada industrial catalana* (Vic, 2004).

Vilar, P., *La Catalane dans l’Espagne moderne: recherches sur les fondements économiques des structures nationales* (Paris, 1962).

Vilar, P., ‘La Catalunya industrial: reflexions sobre una arrencada i sobre un destí’, *Recerques*, 3 (1974), pp. 7–22.

Vries, J., *The industrious revolution: consumer behavior and the household economy, 1650 to the present* (New York, 2008).

Weber, M., *The Protestant ethic and the spirit of capitalism* (1930).

van Zanden, J. L., ‘Wages and standards of living in Europe, 1500–1800’, *European Review of Economic History*, 3 (1999), pp. 175–98.