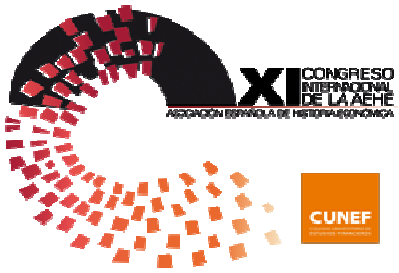


XI Congreso Internacional de la AEHE
4 y 5 de Septiembre 2014
Colegio Universitario de Estudios Financieros (CUNEF)
Madrid

Sesión:

General Purpose Technologies and Economic Growth in Spain

Título de la comunicación:

Wages and prices in early Catalan industrialisation

Autor/es:

Julio Martínez-Galarraga

Marc Prat

Filiación/es académica/s:

Universitat de València

Universitat de Barcelona

Dirección electrónica de contacto:

marc.prat@ub.edu

"The Iberian Peninsula […] had one major industrial region which could stand comparison with the classical regions of Inner Europe: Catalonia. The eighteenth century saw a rapid population increase there accompanied by an agricultural revolution which allowed the Catalans to fill up their empty lands, irrigate hitherto infertile areas, and expand the cultivation of old and new cash crops. Above all, however, the cotton industry developed in what was as early as 1770 called 'a little England in the heart of Spain'".

Sidney Pollard, *Peaceful Conquest*, 1981, 106.

1. Introduction

Catalonia was the only Mediterranean region among the early followers of the British Industrial Revolution in the nineteenth century. The early stages of this industrialisation process were strongly characterised by a specialisation 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 (Nadal 1975). In what was a protected market in Spain, Catalonia concentrated as much as 94 per cent of the cotton industry in 1856 (Nadal 1987). This leading role was complemented by other branches of textiles and, eventually, by other industrial sectors. Indeed, by 1860, Catalonia generated 23.18% of the total gross value added in Spain's industry, and by the end of the century the share had increased to 32.01% (Tirado and Martínez-Galarraga 2008). In Jordi Nadal's words during the nineteenth century Catalonia became 'the factory of Spain'.

Sidney Pollard pointed out that the roots of this economic modernisation can be traced back to, at least, 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 (Vilar 1962; Torras 1988). This had been the result of the successful integration of the Catalan economy into the international trade of the Early Modern period (Valls 2004). Furthermore, since 1736 printed calico manufacturers had begun to establish themselves in Barcelona. In the last two decades of the century the manufacture achieved a significant size and by 1786 Barcelona was the leading printing textile city in Europe (Sánchez 1989; Thomson 2004). 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 in Britain? Why did it not happen 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, as being responsible for economic growth and, eventually, for the Industrial Revolution itself (Marx 1867). 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 (North and Weingast 1989). Other attempts at explanation stress alternatively the Scientific Revolution of the seventeenth century, the Protestant ethic (Weber 1905), the capacity of the British entrepreneurs and the role of technology (Landes 1969), the Industrial Enlightenment (Mokyr 2002 and 2009), or even the spread of middle class values from the elite to other social groups for "biological" reasons (Clark 2007). An alternative explanation, based on economic factors, has recently been proposed by Robert Allen (2009a). In his view, in line with Habakkuk (1962), 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). Moreover, Allen (2009a) not only provides an explanation of why the cradle of the Industrial Revolution was to be found in Britain, but also why British techniques were not adopted on the Continent until the 1830s. In the last decades of the eighteenth century, the steam engine, coke smelting and the new spinning machines were not profitable in Continental Europe because of relative factor prices. Only when British technology had improved sufficiently by the 1830s were the new techniques considered profitable in Western Europe and, hence, adopted.

Allen (2009b) exemplifies the importance of relative prices 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 confirms 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, medium-sized towns and rural areas from the last decade of the eighteenth century onwards. 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 someway to overcoming the technological backwardness experienced in the spread of steam-based industrialisation (Thomson 1992)[1]. In addition to this, the historiography has also highlighted that one of the main handicaps for Catalan industrialisation in the nineteenth century was the lack of cheap coal (Nadal 1975). 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

[1] The adoption of the factory system in the Catalan cotton industry (as far as steam power, throstles, mule jennies and self-acting mules were concerned) accelerated after 1842.

transmission of this technology was much easier. And 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.

The first contribution of this paper is the analysis it undertakes of the evolution of wages and prices in Barcelona, the capital city of Catalonia, during the modern period. Here, we draw on the information gathered by Feliu (1991a, 1991b) whose remarkable work provides a large amount of wage and price data for different occupations and goods, respectively, between 1500 and 1808. This information allows us, 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 (Van Zanden 1999; Pomeranz 2000; Allen 2001; Özmucur and Pamuk 2002; Broadberry and Gupta 2006; Pamuk 2006; Bassino and Ma 2006; Allen *et al*. 2011a; Allen *et al*. 2011b; Allen *et al*. 2012). Based on the nominal wages for construction labourers and a typical subsistence basket (Allen *et al*. 2012), 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).

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 (2009a, 2009b), we measure relative prices as the ratio between the price of labour and the price of capital. We then examine this ratio at an aggregate level for the whole economy and directly for the cotton spinning sector. The micro-level analysis (Allen 2009b) examines whether differences in factor prices made it profitable for domestic producers to purchase a spinning jenny based on the rate of return of such an investment. Our results show that, under alternative scenarios, the potential profitability of the spinning jenny in Catalonia generated strong incentives for adopting new, labour-saving machines in cotton spinning, a booming sector in the general context of the Catalan economy. However, the adoption of the jenny was to face a number of obstacles in these early stages as a consequence of the workers' lack of discipline (Garcia Balañà 2004) and problems of profitability in the 1780s because of difficulties with the preparation of cotton (mainly with the carding process) and the lack of necessary expertise to operate the machines (Thomson 2003a). Once these initial difficulties had been overcome, the spinning jenny began to be adopted across Catalonia in the 1790s, in a process that also involved a technological improvement to the machines (Sánchez 2000b).

The reminder of the paper is organised as follows. The next section summarises 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 3 is devoted to the construction of real wage series for Barcelona between 1500 and 1808. The subsistence basket is defined and the main results presented. In section 4, relative factor prices are analysed and in section 5, we undertake a micro-level analysis of profitability for the first spinning jennies installed in Catalonia.

Interestingly, the exercises conducted allow us to examine our results in comparative perspective with Britain and France. Once our findings are discussed, the final section concludes.

2. The Catalan economy and the development of cotton manufacturing in the 18th century

Economic historians have stressed that Catalonia enjoyed Smithian economic growth from as early as the seventeenth century. According to Torras (1988), a combination of two factors accounts for the changes in the specialisation of the Catalan economy. 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. Feudal structures had been weakened at the end of the fifteenth century and many peasants were able to enjoy the benefits of a labour intensification process thanks to a sharecropping system. As a result, the planting of grapevines expanded substantially, and many areas in Catalonia, especially those located near the coast, became specialised in vineyards. As Valls (2004) explains, the Catalan economy achieved a significant degree of integration with Atlantic Europe during this period. 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 specialisation of grapevines, other areas began to specialise in the production of cereals and manufactures (Torras 1984). As this process evolved, an increasing number of households began to produce in order to sell in the market and, eventually, Catalonia developed into capitalism (Vilar 1962)[2].

Specialisation 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 characterised by the intensive use of the rural labour force for producing new draperies (Torras 1981). 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, organisational capabilities and the availability of capital all contributed to the advent and diffusion of cotton manufacturing in the last quarter of the eighteenth century (Okuno 1999). Indeed, in this respect Catalonia can be considered a successful case in the transition from proto-industry to industrialisation.

This process was further strengthened thanks to 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. 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 (Valls 2004). Thus, Catalonia was to experience a process of agrarian intensification and mercantile and manufacturing growth that

[2] Several authors have stressed that vineyards and proto-industrial specialisation can occur in the same geographical area (Ferrer 1987, Marfany 2010, 2012a). For more on the specialisation in vine growing in the province of Barcelona, see Badia and Tello (2013).

led to a constant rise in population throughout the eighteenth century, as Pierre Vilar (1962) narrates in his classic study. 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 city of Barcelona more than tripled its population, rising from 36,781 to 125,745 inhabitants (Badia and Tello 2013, p. 23). This population growth served to reinforce the specialisation process and by the end of the eighteenth century Catalonia had escaped the Malthusian trap thanks to a sophisticated capitalist economy.

It is against this background that the calico-printing sector began to emerge in Barcelona[3]. Manufacturing was initiated, as in other cases in Europe, when a ban was placed on the importation of Asian textiles. During the seventeenth century, the consumption of printed calicoes had enjoyed success throughout Europe thanks to their low price, hygienic qualities and fancy designs, and so these cloths became a key element in the mass consumption revolution that was to characterise those years. The integration of the Catalan economy into the international trade routes favoured the early arrival of these manufactures to Catalonia. In addition, 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. 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 high capital investments were required (Sánchez 1989). During the second half of the eighteenth century, the sector underwent a rapid expansion and by 1784 there were 80 establishments producing printed calicoes, using 2,280 looms, employing 8,638 workers, and with a total production of 435,350 fabrics[4].

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. It was again a protectionist measure implemented by the government - the introduction of a 20 per cent tariff on foreign raw cotton and yarn – that fostered domestic spinning. The main objective of the government was to promote raw cotton imports from its Spanish American colonies. In 1772, the manufacturers of printed calico in Barcelona reacted by founding the Royal Company of American Cotton Yarn (*Real Compañía de Hilados de Algodón de América*)[5].

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. In 1783, the Royal Company was refounded, at a time when, following the conclusion of the first war against Britain, the American raw cotton supply could once more be guaranteed and the production of printed calicoes and the printing of imported linen was booming thanks to

[3] On the rise of printed calico manufactures in eighteenth century Barcelona, see Thomson (2005), Sánchez (2012), Raveux and Sánchez (2010), and the references therein.

[4] Sánchez (2012, p. 39). In Catalonia as a whole, a total of 94 establishments were involved in this activity.

[5] Raveux and Sánchez (2010, p. 69).

exports to Spain's colonial markets (Raveux and Sánchez 2010, p. 69). 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*" (Thomson 2004, p. 255). In 1796, the printed calico factories of Barcelona were employing 12,979 workers (Sánchez 1993, p. 248). 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. By 1792 the cotton weaving sector in Catalonia was equivalent in size to 16 per cent of the British sector (Vilar 1974, 9).

The Royal Company established 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 that controlled the putting-out networks for wool spinning had now moved into cotton spinning and so competed directly with the Royal Company. In short, the Royal Company failed to achieve a cotton spinning monopoly and was unsuccessful in its attempts to colonise areas with no manufacturing tradition. However, it made a decisive contribution to the diffusion of cotton spinning in Catalonia. The Royal Company together with independent businessmen promoted a shift from putting-out networks dedicated to spinning wool to networks spinning cotton and the 'nationalisation' 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[6].

The spinning jenny reached Catalonia in 1784 via France. The first attempt at adoption was made in a mill[7], but subsequently the jennies were mostly used in small domestic workshops. In 1787, the Royal Company established a mill in Barcelona where 14 spinning jennies operated[8]. However, as Garcia Balañà (2004, pp. 166-219) has pointed out, it was quickly realised that this model was not the best way to maximise profits because the women that spun 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. Thus, the Royal Company opted to close down its spinning mill in 1792, while a second attempt, in this case led by Erasme de Gònima, ended in a similar way in 1802. The 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. By as early as 1791, there were at least 108 spinning jennies in Catalonia and throughout that

[6] Raveux and Sánchez (2010), Garcia Balañà (2004) and Okuno (1999).
[7] The term mill refers to centralised manufactures predating the factory system.
[8] Thomson (2003a). In 1790 the factory had 21 jennies and 70 workers (Garcia Balañà 2004, pp. 166-167). For an overview of technological innovations in the Catalan cotton manufacture and cotton industry, see Ferrer (2004), Sánchez (2000b) and Thomson (2003b, table 1, pp. 144-145).

next decade they were widely adopted[9]. Moreover, 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 operational in 1796. This was the origin of what would later become known as the '*berguedanes'*. 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 (Sánchez 2000b, pp. 164-170).

The adoption of new technologies in the cotton sector did not end with the spinning jenny. The water frame arrived in Catalonia in 1793, although its diffusion would have to wait until the first years of the nineteenth century. These machines were ten times more expensive than the biggest jennies and required much more energy to operate. Thus, water frames, which were located in mills near the region's rivers, were more appropriate for 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[10]. In turn, the mule jenny had just been introduced and accounted for a further 2,000 spindles (Sánchez 2000b, pp. 172-175). However, while Catalonia was an early British follower, rapidly adopting the spinning jenny, it was not so successful in its introduction of the water frame or the mule jenny. The lack of coal and the scarcity of waterpower proved a major constraint for the large-scale adoption of these innovations, which did not really take off until the 1840s, when the diffusion adhered much more closely to the Continental pattern. The first cotton factory to employ steam power – 'Bonaplata, Rull, Vilaregut i companyia' – was opened in Barcelona in 1833. By then, in 1830, the number of cotton spindles operating in Catalonia had reached a total of 1,162,237 (of which 89% were jennies). This figure was equivalent to 10 per cent of the British cotton spindles and 28 per cent of those installed in Continental Europe (Farnie 2004, p. 23).

Overall, between 1783 and 1796, thanks to the new peace signed with Britain and the rise in colonial trade, printed calicoes and linen manufactures enjoyed their *belle époque* (Raveux and Sánchez 2010, p. 69)[11]. At the same time, cotton spinning expanded in Catalonia and the spinning jenny was widely adopted. In this context, Vilar (1974) 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 as an indication of growing integration in rural-urban regional labour markets during this period (Mora-Sitjà, 2007). In addition, Mora-Sitjà (2002) 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 (2010, 2012a and 2012b), 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-

[9] Sánchez (2000b, p. 163). See also Solà (1995, p. 2002). In 1790, the carding machine was introduced and this also enjoyed a rapid diffusion (Thomson 2003a, p. 42; Sánchez 2000b, p. 165).

[10] Sánchez (2000b, pp. 170-172); Raveux and Sánchez (2010, pp. 75-77); Thomson (2003b, pp. 24-27); Solà (2002, p. 2004).

[11] A new war with Britain was to affect foreign trade again between 1797 and 1801, and again in the period 1805 to 1807 (Sánchez 1989, 100). The years 1802 to 1804 were to be the last of expansion before the Peninsular War. Indeed, the period 1784 to 1804 has been described as the golden age of Catalan printed calico manufactures (Sánchez 2012, p. 39).

western Europe (De Vries 2008), 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 Catalonia as a high wage economy within western Europe at the end of the eighteenth century. The section that follows seeks to offer quantitative evidence in this regard.

3. Wages, prices and living standards in Barcelona, 1500-1808

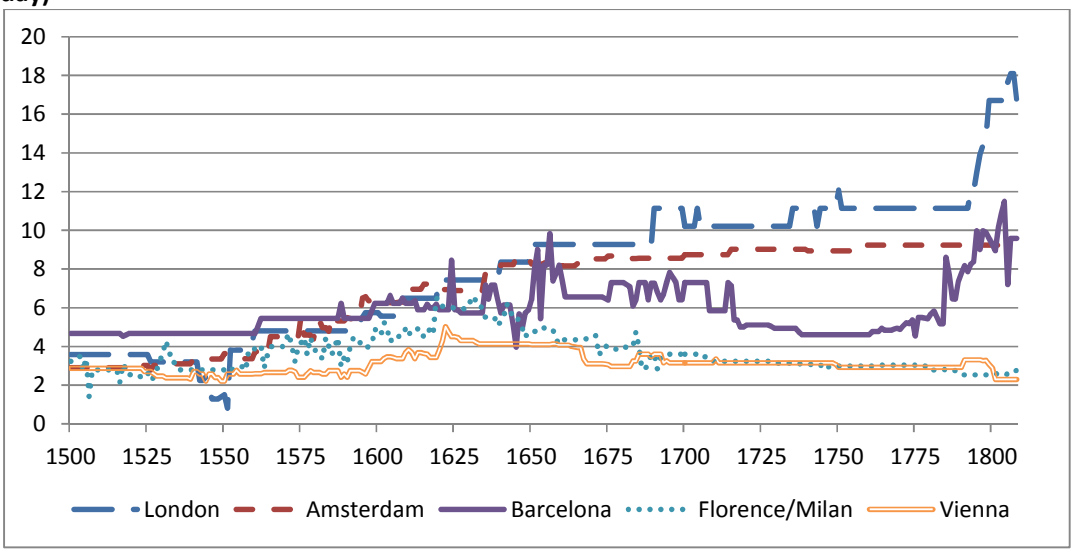
The first step in our research strategy is to compute real wages for Barcelona in the long run from the sixteenth to the beginning of the nineteenth centuries. Our database is built from the wage and price information collected by Feliu (1991a, 1991b). In an exhaustive study, this author reports an enormous 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. Here, we focus solely on those wages and consumer goods included in other international studies so as to ensure the homogeneity of our results and so as to be able to undertake a comparison with existing evidence on real wages in a growing sample of cities around the world. As such, our methodology for constructing real wages for Barcelona follows previous studies in the field (Allen 2001; Allen *et al*. 2011a; Allen *et al*. 2011b, 2012).

First, we compute the daily nominal wages of labourers working in the construction sector (Feliu 1991b, p. 104). The unit of account in the primary sources is *sous catalans* which have to be converted into grams of silver according to the equivalences presented in Feliu (1991a, p. 21) (see Appendix). The data for the sixteenth and seventeenth centuries are taken from the construction work on the cathedral and convents in Barcelona[12], although for certain years for which no data are available, the series are completed with information on the wages paid in the cathedral and in the Monastery of Sant Daniel in Girona, a city lying some 100 km to the north-east of Barcelona. For the eighteenth century the data are taken from Vilar (1950), based on various construction projects recorded in the '*àpoques*' (Feliu 1991b, pp. 76-77).

The results presented in Figure 1 allow us to describe the evolution of nominal wages for construction labourers in Barcelona between 1500 and 1808. The trend shows that nominal wages remained stable in the first half of the sixteenth century. This was then followed by a period of sustained growth up to the mid-seventeenth century, when the tendency was reversed so that by 1750 nominal wages had fallen to the levels recorded at the beginning of the sixteenth century. However, the last decades of the eighteenth century witnessed a substantial rise in wages and by the turn of the century wages had almost doubled.

[12] While building work at the cathedral was not complemented with payments in kind, at the convents food was typically provided (Feliu 1991b, p. 70). Bearing this in mind, we focus, as is the custom in previous research, on cash wages only (Allen 2001).

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



Source: Allen (2001). Florence: 1500-1617; Milan 1618-1808. For Barcelona, see text.

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-west 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, however, wages were still higher in Barcelona than those paid in Northern 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, which shows the fifty-year averages for the same cities.

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

Averages	**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
1800-08	17.1	9.2	9.6	2.6	2.4

Source: Allen (2001). Florence: 1500-1649; Milan 1650-1849. For Barcelona, see text.

Nominal wages hide, nonetheless, differences in the cost of living and in inflation across locations. In order to obtain a clear image of the incomes of 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. This subsistence basket includes a number of goods that are considered to be representative of the consumption of an adult male per year in the period under study (Allen 2009a; Allen *et al*. 2011a; Allen *et al*. 2011b, 2012). The basket thus corresponds to a poverty line and it includes food providing around 1940 calories per day, which is very close to the minimum in-take of calories for survival; in addition, some non-food items, including cloth, soap and fuel are also incorporated (see Table 2)[13].

Table 2. Bare-bones subsistence basket of goods

	Quantity per person per year	Calories/day
Food		
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 (2009a, p. 37); Allen *et al*. (2011a, p. 21); Allen *et al*. (2011b, p. 43).

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, wheat in Southern Europe, sorghum in Beijing, rice in Shanghai, Canton, Japan and Bengal, millet in India, and maize in the Americas). Hence, the calorie in-take also varies slightly across the cities in the sample according to the cereal considered. 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, the latter being more typical in the diet of Northern Europeans; or the use of canvas and linen to represent textiles. Likewise, a fuel consumption of 2 m British Thermal Units (BTUs) per year is used for Barcelona, in line with

[13] See Humphries (2013) for a critical view on Allen's methodology, and his response in Allen (2013a).

other Mediterranean countries and the Americas, that is, places 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 (1991a, 1991b). Detailed information of the price series used to calculate the cost of the subsistence basket defined above, and methodological issues involved in such calculations can be consulted in the Appendix. 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 (Hamilton 1965) and the inflationary effect of the arrival of silver from the Americas, which resulted in a persistent and general increase in prices[14]. 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.

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

averages	**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*. (2011b, p. 44). For Barcelona, see text.

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 and seeks to obtain a more informative and comparable wage index (as in Allen *et al*. 2011b, 2012). The aim of this alternative procedure 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 be made. First, a labourer's daily wages have to be converted into annual earnings. In this case, a total of 250 days of work per year are assumed. Second, the cost of the subsistence basket, which is already expressed in annual terms, is increased by a constant mark-up of 5% to include housing costs, that is, the estimated amount spent on rent. Finally, a representative family consisting of two adults and two children is assumed[15]. 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 3 (Allen, 2001).

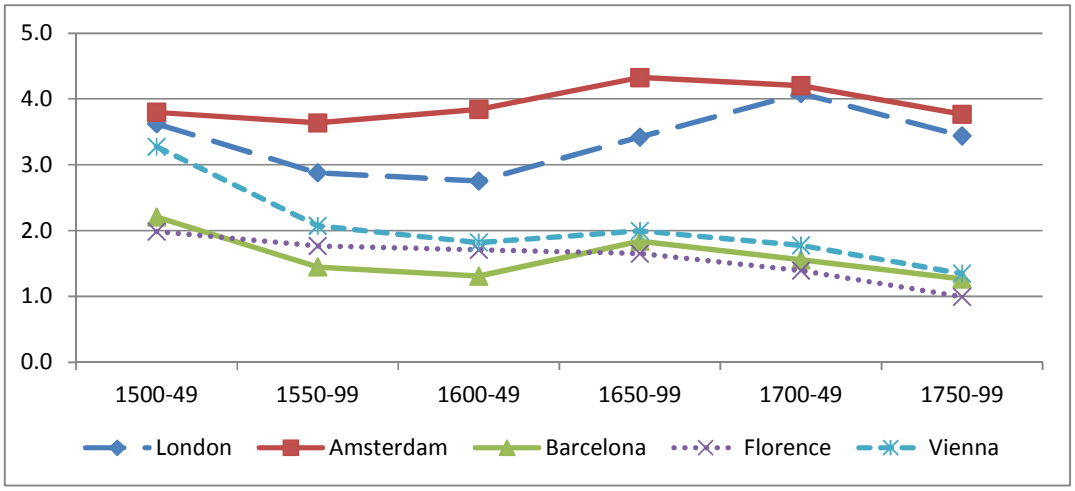
[14] See, for instance, Drelichman (2005), and the works cited therein.

[15] Schneider (2013) has suggested an adjustment of Allen's (2001) real wages to changing demography and variations in household composition in early modern England.

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 in a particular moment of time as a multiple of the poverty line (Allen *et al*. 2011b, p. 9; Allen 2013b).

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 (Allen 2009a, p. 40), a clear divergent pattern within Europe has been found. While cities of north-west 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 was around one, and thus the yearly earnings of construction labourers placed them close to the poverty line. In this case, the evolution 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 in grams of silver, vanishes.

Figure 2. Subsistence ratio for labourers in Europe, 1500-1800 (fifty-year average)



Source: Allen *et al*. (2011b, p. 45). For Barcelona, see text.

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

	London	Amsterdam	Barcelona	Florence	Vienna
1500-49	3.62	3.80	2.21	1.99	3.28
1550-99	2.88	3.64	1.45	1.77	2.07
1600-49	2.75	3.84	1.31	1.71	1.82
1650-99	3.42	4.33	1.84	1.65	1.99
1700-49	4.08	4.20	1.56	1.39	1.77
1750-99	3.44	3.77	1.26	0.99	1.35

Source: Allen *et al*. (2011b, p. 45). For Barcelona, see text.

In a recent paper, López-Losa and Piquero (2013) argue that the differences in real wages between northern and southern Europe obtained in international studies may be overvalued. These authors analyse wages and prices in a sample of Spanish cities during the Modern Period using, among others, Allen et al's. (2012) methodology. They introduce, nonetheless, a variation in the composition of the subsistence basket by including bread instead of grain, given that, in their words, "*... wheat bread was the basic staple for the urban population in Early Modern Spain and its price was a political issue of the first order*". Their results, interestingly, offer a different picture for the late eighteenth century compared to that described in previous studies. By way of example, our data for Barcelona show that between 1750 and 1800, the subsistence ratio in this city stood at around 39% of that obtained for cities in north-west Europe (computed as the average of Amsterdam, Antwerp and London). Yet, according to López-Losa and Piquero's calculations (2013), this percentage figure would rise to 73 points. Hence, they conclude that the difference in the subsistence ratios between northern and southern Europe in the late eighteenth century was not as wide as previous studies suggest. In such a scenario, while Barcelona would still lag far behind the high-wage economies of north-west Europe, the wage gap would be considerably lower.

4.- Factor prices and technology demand during the early phase of Catalan industrialisation.

On the basis of these results, can the early adoption of the spinning jenny in Catalonia be explained in terms of 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 (Allen 2009a), 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 in Europe at that time, in terms of the prices of labour and capital?

Allen (2009b) constructs a ratio between labour and capital prices, taking nominal wages in the construction sector and computing the price of capital based on the following expression:

$$r = P_K(i + d),$$

where r is the cost of capital, 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 (1977, pp. 117, 126 and 157) and correspond to long-term interest rates paid by the British and the French governments[16].

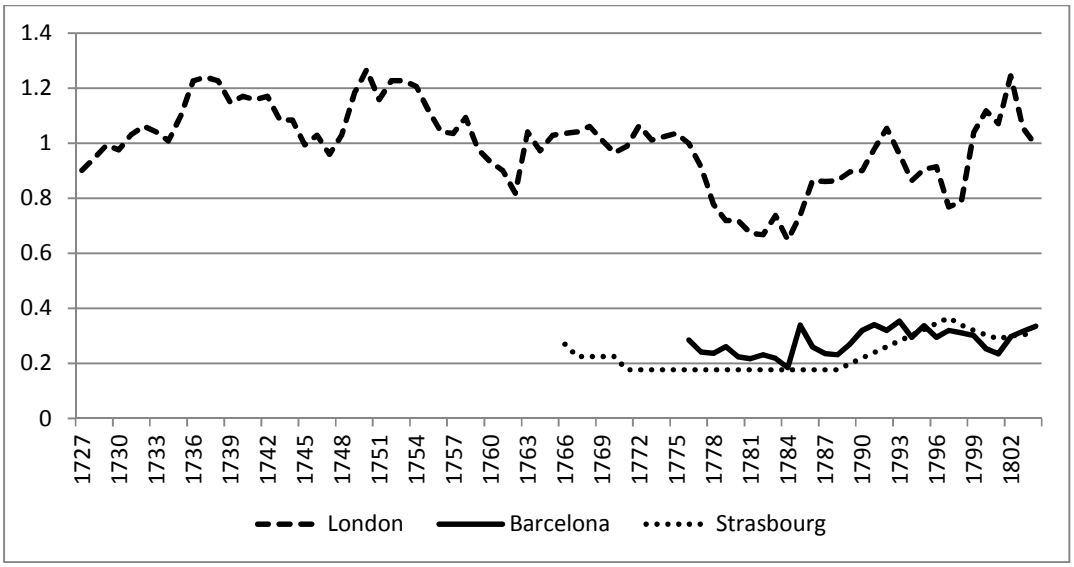
In the spirit of Allen (2009b), we explore the relative prices for labour and capital. However, in gathering the information for Barcelona we run into various problems. First, information for the prices of building materials in Barcelona in that period is incomplete. In order to solve this drawback, 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 (1997)[17]. 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 (2001), while for Barcelona the source used is Feliu (1991a, b) 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 to the interest rates charged to merchants, the results show Barcelona's ratio to be 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.

[16] Homer and Sylla (1963, pp. 157-158, 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 (Homer and Sylla 1963, p. 216).

[17] We wish to thank Joan Carles Maixé-Altés for kindly providing us with the data.

Figure 3. Wage relative to price of capital (London 1776=1)



Sources: see text. Data for London and Strasbourg kindly provided by R. Allen.

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, i.e., the investment cost faced by the producer. The data for England and France are drawn from Allen (2009b, p. 619) and Gragnolati *et al*. (2013, Table 2). Spinners earned 6.25 *d* per day in England and 9 *sous tournois* in France. The price of a 24-spindle jenny for cottage use is estimated at 70 *shillings* 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 (2004) and Okuno (1999). 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 consulted 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 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). It is in this context that "*many projects to mechanize production that were profitable in England proved unprofitable in France*" (Allen

2009b, p. 912). Second, the wage/capital ratio for Barcelona is high, similar in fact to that recorded in England (89.6%). Based on these results it seems that Catalan producers, in common with their English counterparts, may likewise have had an incentive to mechanise production, showing themselves to be more enthusiastic about new cotton spinning technologies than were the French producers.

Table 5. Wage/capital ratio for the textile sector in the late 1780s

	England	France	Catalonia
Daily wage (w)	6.25 d	9 st	6 s
Daily wage in grams of silver (w)	2.90	2.12	3.83
Price of a jenny (J)	840 d	2800 st	900 s
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

Source: Based on Gragnolati *et al*. (2013, Table 2) and Garcia Balañà (2004, pp. 161-2).

Why was the value of the Catalan wage/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[18]. However, it is the relatively high wages earned by spinners that seems to push the Catalan ratio close to British values. Indeed, available evidence for wages supports this finding. Two features nonetheless should be mentioned: a daily wage of 6 *sous* for spinners is actually capturing a lower bound, as we shall see below; and, importantly, a similar wage could be commanded by a spinner working in the rural villages of inner Catalonia as that by a spinner in Barcelona[19].

The best evidence that a spinner earned 6 *sous* per day comes from the Royal Company records, where in 1787 in reference to spinners, it is stated that "36 *sous* per week would seem to be sufficient for a woman (authors' own translation)"[20]. However, this was the wage paid in Barcelona, while a true comparison with spinners' wages in other countries requires wage information about cottage spinners. For wages outside Barcelona, as in the case of Britain and France, the most usual data for spinning are piece rates. Okuno (1999, pp. 61-2)

[18] An illustration of the role played by a skilled carpenter in the construction of the first jennies in Catalonia can be found in Thomson (2003).

[19] This is not surprising, given the integration of the rural-urban labour markets in Catalonia in the last decades of the eighteenth century, as Mora-Sitjà (2007) has explained.

[20] "Teniendo 36 sueldos semanales pareze sería un suficiente jornal para una muger (*sic*)" (Garcia Balañà 2004, 162). They worked six days per week so the daily wage was 6 *sous*.

provides piece rate information for several villages in inland Catalonia. On the basis of this information it is possible to estimate daily wages by assuming an average daily productivity for cottage spinning. If we make the same assumption as Allen (2007, p. 9) of a daily productivity of 1 British pound per day (equivalent to 1.13 Catalan pounds per day)[21], the daily wages would on average be 9.3 *sous* (second column in Table 6). However, information available on wheel spinning productivity in Catalonia gives lower values (Garcia Balañà 2004, p. 162), where the normal full-day production was 0.75 Catalan pounds, corresponding to an average daily wage of 6.2 *sous* (last column in Table 6).

Information is also available for an hourly wage for spinners (not a piece rate) in Prats de Rei, a small rural town 90 km to the north west of Barcelona, of 8-9 *diners* in 1790 (Okuno 1999, p. 62). If we consider a full working day to be ten hours long (Thomson 2003, p. 39), then the daily wage earned by a spinner would range between 6.6 and 7.5 *sous*[22]. Overall, the evidence available indicates that spinners' wages in the 1780s were very similar in Barcelona and in the countryside and that taking 6 *sous* as a daily wage for cottage spinning is a cautious decision.

Table 6. Piece rates and wages in Catalan cotton spinning (in *sous*)

Year	Village	piece rate	daily wage	
			1.13 cp/day	0.75 cp/day
1783	Cardedeu	7.5	8.5	5.6
1783	Cardedeu	8	9	6
1783	Cardedeu	10	11.3	7.5
1783	Several villages	8.5	9.6	6.4
1788	Prats de Rei	7	7.9	5.3
1790	Castellfollit	7.5	8.5	5.6
1790	Cervera	9	10.2	6.8
Average		8.2	9.3	6.2

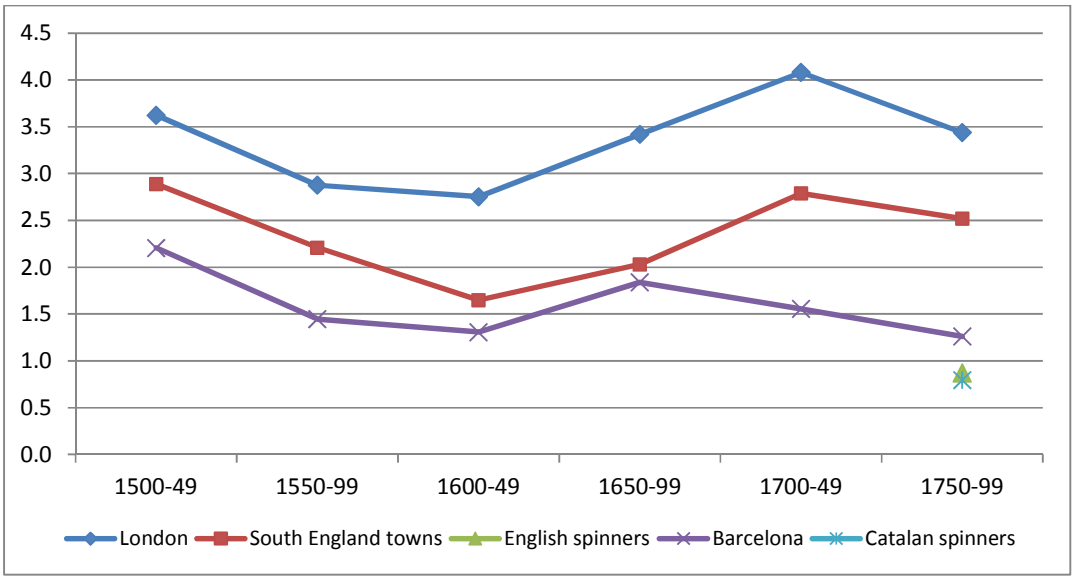
Source: Okuno (1999, 61-62). Note: The notation *cp* stands for Catalan pounds.

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 3 gives a wage for English and Catalan spinners of 0.87 and 0.80, respectively (Figure 4). While the real wage of

[21] A Catalan pound is equivalent to 400 grams.
[22] 1 *sou* = 12 *diners*.

an English spinner was only 8.75% higher than a Catalan spinner's wage, 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.

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



Source: For London and South England towns, Allen (2001); for the rest, see text. Note: the figure is constructed computing the spinners' wages full-time and annually as with the construction labourers.

In our view, this difference does not reflect a smaller gender wage gap in the Catalan economy but rather it highlights the bottleneck in cotton spinning during these years. As mentioned in section 2, 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 (Thomson 2005, p. 714). Ten years later, in 1793, the total had risen almost five-fold (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. The wages in other textile occupations were not especially high (see Table 7). For example, unskilled male workers in the calico manufacturing sector earned almost the same as unskilled construction workers, and skilled male earnings were also similar between these two sectors. It was spinning that was particularly well paid.

Table 7. Daily wages for different occupations in Barcelona, late 1780s

Occupation	Gender	qualification	Sector	sous
Engraver*	Male	skilled	Calicoes	26
Bricklayer/Carpenter	Male	skilled	Construction	21.3
Meadow foreman	Male	skilled	Calicoes	15
Labourer	Male	unskilled	Construction	12.2
Meadow labourer	Male	unskilled	Calicoes	12
Spinner	Female	skilled	Cotton	6
Winder/washer	Female	unskilled	Calicoes	3

Source: Feliu (1991b), Mora-sitjà (2011), Garcia Balañà (2004) and Okuno (1999). *Engravers' wages range from 18.75 to 33.75 *sous* based on their experience (Mora-Sitjà 2011, 246). Here we take the average: 26 *sous*.

5. The profitability of the spinning jenny in Catalonia at the end of the eighteenth century: a micro-economic analysis

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 industrialisation. 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 1786 and was widely adopted through the 1790s, which suggests that the spinning jenny was profitable in Catalonia during this period. Allen (2009b) has shown that jennies were profitable for 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 Allen's 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:

$$J = \sum(w\Delta L - m)\,/(1 + r)^t, \text{ with } t = 1,2, \ldots\ n$$

where J is the price of a jenny, w the daily wage of a spinner, ΔL 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:

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

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 (i.e., the spinning wheel). To solve this equation, several assumptions must be made. First, the time span t is set at ten 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[23]. 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[24]. 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 spinning wheel. In this case, with a typical P equal to 3, up to 66.6 per cent of the labour would be saved.

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 ratios, 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 8. 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.

[23] In the specific case of Catalonia, Ildefons Cerdà estimated that in 1856 labourers in calico-printing factories worked 249 days a year. Quoted in Mora-Sitjà (2007, 165).
[24] For a critical assessment of this methodology, see Crafts (2011).

Table 8. Rates of return to buying a spinning jenny in Britain, France and Catalonia

Relative Productivity	Per cent Full-Time	Britain (per cent)	Catalonia (per cent)	France (per cent)
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

Source: Allen (2009b), Table 1, and Garcia Balañà (2004, pp.161-162).

A key assumption in Allen's model is that the gains in labour productivity are analysed as a cost reduction, not as an output increase. Hence, when a spinner bought a jenny with which she could produce three times as much yarn per hour as with a wheel, the spinner did not triple her production but rather produced the same amount and saved the two thirds of her time previously devoted to spinning. This assumption has been criticised by Gragnolati *et al*. (2011, 2013). 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. If a cottager made an effort to buy a jenny, she would try to make it profitable by using it intensively, increasing her working time rather than reducing it. In fact, they demonstrate that by maintaining the quantity of labour and, thus, increasing production, the jenny would have been profitable in France in all but the worst case scenario. Thus, they conclude that Allen's model is incomplete and factor prices alone cannot explain the delay in the adoption of the spinning jenny in France (Gragnolati *et al*. 2011). In fact, in a subsequent study 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 (Gragnolati *et al*. 2013).

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: when the daily wage rose, they worked less; when their wages fell, they worked more. Thus, it is plausible that spinners would have reduced their working time when they reached a similar level of production and income by employing less time (Allen 2011). It is our belief that Allen is right in making this assumption, although we understand the Italian scholars' concern for the labour intensification issue, because it too may have played a key role in the adoption of the spinning jenny in Catalonia and it links up with the fundamental debate about the emergence of the factory system in the Industrial Revolution.

Although historians have traditionally argued that the spinning jenny first arrived in Catalonia in 1780 in the towns of Puigcerdà and Olot, near the French border, there is no

conclusive evidence to confirm this claim[25]. Indeed, it seems more than probable that the first spinning jenny, or at least knowledge of it, reached Barcelona in 1784 via to two French machine-makers, Pontet and Pradel. With the financial backing of a French citizen resident in Barcelona, the Marquis de Gaubert, they built fourteen 36-spindle jennies. However, producing yarn with these new machines proved to be a far from easy task and so Gaubert was obliged to travel to France to learn more about the preparation of cotton before it could be spun. Gaubert came to realise that this process of technological transfer was too demanding and he opted to sell the jennies to the Royal Company of American Cotton Yarn in 1786[26]. As mentioned in section 2, this was a chartered company owned by the printed calico manufacturers of Barcelona and established with the aim of promoting cotton spinning in Catalonia in substitution of Maltese yarn imports. The Royal Company decided to establish a mill in Barcelona with the 14 jennies. Thomson (2003a) has explained in great detail the process by which the company adopted this new technology and how they were able to make it economically profitable in the period 1786-88. The improvements were achieved primarily by buying better quality raw cotton and by introducing stricter disciplinary rules for workers to ensure they produced more and better yarn. Carders, rovers and spinners were employed to work in the mill for ten hours each day and they were obliged to meet certain production objectives: for each spinner this was set at 1.5 lb of yarn per day. By the end of 1788, the firm was turning a profit (Thompson, 2003a).

However, Garcia Balañà (2004, pp. 166-219) undertook a detailed study of the Company's records over the following years. He analysed the production of 19 spinners working on spinning jennies for a 27-week period during the first six months of 1791. Working six days per week, the average weekly production of one spinner was 5.4 lb, that is, 0.9 lb per day, well below the target set in 1788. In fact, Garcia Balañà detects a marked inter-week variability for each spinner and concludes that the main problem facing the firm was guaranteeing that the spinners turned up to work at the mill regularly. In short, the strict regulations introduced in 1788, aimed at achieving labour intensification in the mill, seemed to have little effect. 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. As Carbonell (1997) has shown, these young girls undertook a large number of tasks: they were required to sell, spin, wash clothes, help in the workshop, transport water, wait upon, wet nurse, and a long *et cetera*. 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[27]. 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. With labour intensification and the growth in production, the profitability of the capital investment was guaranteed, precisely the outcome that Gragnolati *et al*. (2012) expect from a person who bought a jenny. Cottage spinners might have had their target level of consumption, but the Royal Company owners certainly sought to maximise their profits. The Royal Company mill, however, was unable to break the economic logic of the urban households, be it by imposing disciplinary codes or by offering incentives;

[25] Sánchez (2000b, p. 162).
[26] Thomson (2003a, pp. 21-26); Sánchez (2010b, p. 162) and Garcia Balañà (2004, pp. 147-148).
[27] Carbonell (1997, pp. 121-4), quoted in Garcia Balañà (2004, p. 187).

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 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[28].

Yet, this episode did not mark the end of the spinning jenny in Catalonia; it was no more than the beginning. 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 (Sánchez, 2000b). The booming demand for printed calicoes and the need to provide all 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 change the scale or the geographical location of spinning because they were powered by hand[29]. In fact, most of them were installed in homes or in small workshops. We have already shown that the spinning jenny was profitable for Catalan domestic producers at the end of the 1780s by replicating Allen's analysis; however, the abundance of available data allows us to conduct a slightly different test for the second half of the 1790s. But to do so we need to return once more to the Royal Company.

Following the closure of its mill, the Royal 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 (2004, pp. 189-202) reports that in 1797 the Company decided to lease jennies to various domestic producers and small workshops in Barcelona. The terms of the agreement were as follows: the owner of the jenny remained the Company, 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. But given the increase 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:

$$\mathrm{J} = \sum \mathrm{Q}\left(\mathrm{p^w} - \mathrm{p^j}\right) - \mathrm{m}/(1+\mathrm{r})^{\mathrm{t}}\,,$$

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, 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 (2011) questioned the robustness of Allen's (2011) analysis on the basis of the change in results when the assumptions for the parameters in the previous equation are modified. In 1797, 36-spindle

[28] Garcia Balañà (2004, pp. 166 and 188-189).
[29] Sánchez (2012, p. 40).

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. We make, therefore, a conservative assumption of 60-spindle jennies with a price in 1797 of 1,200 *sous*[30]. Thus, we take $J = 1.200$, $m = 120$, $p^w = 12$, and $p^j = 7.5$. In Table 9 the internal rates of return for three domestic spinners or small workshops are presented.

Table 9. Rates of return to leasing a spinning jenny in Catalonia in 1798

Spinner's name	Nº. Jennies	Q per jenny	TIR
		(in lb)	(in %)
Francesca Costa	1	142.2	42.0
Francesca Pasqual	1	154.2	46.8
Josepa Serra/Paula Arnau	2	220.6	72.4

Source: Garcia Balañà (2004, Table 3.3 and pp. 197-8).

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. In fact, he explains that 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 specialised 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. However, in the case of the water frame and the mule jenny, technology that required the use of water or steam energy and where economies of scale acquired greater significance, the factory system finally succeeded.

6. Conclusions

Catalonia was the only region of Southern Europe to be among the followers of the British Industrial Revolution in the second third of the nineteenth century. The roots of this exceptional experience lay in the early integration of the Catalan 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 historical experiences elsewhere, 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 industrialisation 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 (2009a, 2009b) studies of the British Industrial Revolution.

[30] Conservative in the sense that we assume a high price for the jennies.

The first contribution of the paper 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 or 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 (e.g., 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 similar 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 mechanise 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 exceptional conjuncture of circumstances enjoyed by 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, 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' (1985, 1998) view of the British Industrial Revolution where 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.

In the first decades of the nineteenth century the cotton sector in Catalonia had to overcome a number of difficulties in order to advance after what had been a promising start. The new macro-inventions emanating from the British Industrial Revolution in the cotton sector used natural resources that were both scarce and expensive in Catalonia, namely, water

and coal. The price structure in Catalonia favoured the adoption of the spinning jenny. The new technologies, including Arkwright's water frame and Crompton's mule, being energy-based, created a price structure for the production factors that in this case might not have been so favourable for Catalan producers. Thus, the process of technology transfer slowed down. The high price of energy could be blamed for this outcome. Other authors stress that the British ban on machine exports was also responsible, and only after it had been lifted in 1842 could the Catalan textile industry adopt the technology under the factory system. In any case, the adequacy of the first textile technology and the delay in the adoption of the subsequent technologies would explain why the spinning jenny and its local improvement, the *berguedana*, had a long life in Catalonia.

This case study of Catalonia also shows that, thanks to the exceptional conjuncture of circumstances 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-west 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 – albeit one that was not exempt of difficulties – industrialisation and to become the main industrial centre in the Mediterranean throughout the nineteenth century.

Appendix

Nominal wages for labourers

Daily wages (*sous per jornal*) for unskilled workers in the construction sector come from Feliu (1991a, pp. 104-106). The data are converted from *sous* into grams of silver using the information provided by Feliu (1991a, p. 21).

Subsistence basket

The basket for Barcelona (Table 2) replicates that adopted in previous studies (Allen *et al*. 2011a; Allen *et al*. 2011b, 43; Allen *et al*. 2012). The quantities of goods per year included in the basket are the same with just one exception. Allen *et al*. (2011a) consider a consumption basket that includes alternative cereals on the basis of consumption patterns. Hence, the equivalent quantity of wheat needs to be calculated by taking into account that the staple food in Barcelona during the period of study was bread made with wheat flour. The question that needs to be asked is what quantity of wheat was required to obtain a total of 1,657 calories per day. According to Allen *et al*. (2011a, p. 38), the caloric power of wheat was 3,390 calories per kg. Assuming a flour extraction rate of 83% (Allen 2001, p. 419), an equivalent quantity of wheat of 215 kg per year is obtained.

Prices, measures and conversions

Wheat and beans: Expressed in *sous per quartera*, prices come from Feliu (1991a, pp. 42-44 and 157-158, respectively). Wheat prices in Barcelona are obtained by combining the information in Giralt (1958) for the cathedral of Barcelona between 1500 and 1599; the data in Serra (1988) for the period from 1600 to 1714 from the Augustinian convent in Barcelona; while from 1715 to 1808 the primary source is the 'mercurial' of Barcelona. Beans refer to '*faves*'. In both cases, for the conversion of the series to litres we take the equivalence: 1 '*quartera*' = 12 '*quartanes*' = 69.528 l (Feliu 1991a, 18). This is transformed into kilograms taking the following value: 1 l of wheat = 0.772 kg. The missing years for bean prices are obtained applying the same evolution as that recorded for wheat prices. Meat: Data from Feliu (1991a, p. 75) is expressed in *sous per lliura carnissera*. We take 1 *lliura carnissera* to be equal to 1.2 kg (Feliu 1991a, p. 18). Olive oil: Prices, in *sous per càrrega*, are obtained from Feliu (1991, p. 106) and converted to litres using the equivalence 1 *càrrega d'oli* = 124.5 l (Feliu (1991a, 18). Soap: The series of soap prices in Barcelona start in 1574 (Feliu 1991b, p. 57) and are completed on the basis of the evolution of olive oil prices. Expressed in *sous per arrova*, the data is converted to kilograms as follows: 1 *arrova* = 26 *lliures catalanes* and 1 *lliura catalana* = 400 grs. Thus, 1 *arrova* = 10.4 kg (Feliu 1991a, 18). Canvas/linen: Given the absence of sufficiently complete information for the price of textiles in Barcelona we take a combination of the price of linen (Hamilton, 1965) from a neighbouring Mediterranean city, to the south of Barcelona (Valencia), and the price of canvas in Barcelona. The linen series are incomplete and we use the price of canvas to give dynamics to the series especially before 1550 and after 1650. The core of the series is nonetheless constituted by linen prices expressed in *alnas per diners*, which need to be transformed into metres and converted to grams of silver. The transformation is based on information in Hamilton (1965, p. 181): 1 *alna valenciana* = 0.91 cm. The conversion from *diners* to grams of silver is somewhat problematic. From 1501 to 1609, data come from Hamilton (1965, p. 318). From 1610 to 1650, the data in Hamilton (1965, p. 131, Table 10) are used. Actually, after 1612 *diners* were not issued any more and they were suppressed after the War of the Spanish Succession (1707), although the currency remained as an accounting monetary unit with the equivalence: 1 *sou* = 12 *diners*. Candles: Recorded in *sous per lliura* (Feliu 1991b, p. 52), candles are transformed into kilograms taking 1 *lliura* = 400 g (Feliu 1991a, 18). Lamp oil: In this case, we employ the prices used previously for olive oil. Fuel: the prices of firewood (*llenya*) are expressed in *sous per quintal* and need to be transformed into million BTUs in silver grams. First, the conversion from *quintals* to kilograms is made using the equivalence: 1 *quintal* = 4 *arroves*; 1 *arrova* = 26 *lliures*; 1 *quintal* = 104 *lliures*; 1 *lliura* = 400 g; 1 *quintal* = 41.6 kg (Feliu 1991a, 18). In order to transform this measure into million BTUs we follow Malanima (2006) and his analysis of Italy considering that this country is quite similar to Catalonia. Given that 1 kg of 'Mediterranean' firewood produces 3000 Kcal, and that 1 BTU is equal to 0.252164401 Kcal, it can be established that 2 m. BTUS = 168.12 kg of firewood, and thus 1 kg of firewood = 11896.26 BTUs.

References

Allen, R.C. 2001. The Great Divergence in European wages and prices from the middle ages to the First World War, *Explorations in Economic History* 38, 411-477.

Allen, R.C. 2007. The Industrial Revolution in miniature: the spinning jenny in Britain, France, and India, *Department of Economics Working Paper No. 375*, University of Oxford.

Allen, R.C. 2009a. *The British Industrial Revolution in global perspective*, Cambridge University Press, Cambridge.

Allen, R.C. 2009b. The Industrial Revolution in miniature: the spinning jenny in Britain, France and India, *Journal of Economic History* 69, 901-927.

Allen, R.C. 2011. The spinning jenny: a fresh look, *Journal of Economic History* 71, 461-464.

Allen, R.C. 2013a. The high wage economy and the Industrial Revolution: a restatement, *Discussion Papers in Economic and Social History* 115, University of Oxford.

Allen, R.C. 2013b. Poverty lines in history, theory, and current international practice, *Department of Economics Discussion Papers* 685, University of Oxford.

Allen, R.C., Bassino, J.P., Ma, D., Moll-Murata, C., Van Zanden, J.L. 2011. Wages, prices and living standards in China, 1738-1925: in comparison with Europe, Japan, and India, *Economic History Review* 64, 8-38.

Allen, R.C., Murphy, T.E., Schneider, E.B. 2011. The colonial origins of the divergence in the Americas: a labour market approach, *Paper presented at the 9th EHES Conference in Dublin*.

Allen, R.C., Murphy, T.E., Schneider, E.B. 2012. The colonial origins of the divergence in the Americas: a labour market approach, *Journal of Economic History* 72, 863-894.

Badia, M., Tello, E. 2013. An inner-frontier model to explain vine-growing specialization in the province of Barcelona in the mid-nineteenth century, *mimeo*.

Bassino, J.P., Ma, D. 2006. Japanese unskilled wages in international perspective, 1741–1913, *Research in Economic History* 23, 229-248.

Broadberry, S., Gupta, B. 2006. The early modern great divergence: wages, prices and economic development in Europe and Asia, 1500-1800, *Economic History Review* 59, 2-31.

Carbonell, M. 1997. *Sobreviure a Barcelona: dones, pobresa i assistència al segle XVIII,* Eumo Editorial, Vic.

Clark, G. 2007. *A farewell to alms: a brief economic history of the world*, Princeton University Press, Princeton.

Crafts, N.F.R. 1985. *British economic growth during the Industrial Revolution*, Clarendon Press, Oxford.

Crafts, N.F.R. 1998. Forging ahead and falling behind: the rise and relative decline of the first industrial nation, *Journal of Economic Perspectives* 12(2), 193-210.

Crafts, N.F.R. 2011. Explaining the first Industrial Revolution: two views, *European Review of Economic History* 15(1), 153-168.

De Vries, J. 2008. *The Industrious Revolution. Consumer behavior and the household economy, 1650 to the present*, Cambridge University Press, New York.

Drelichman, M. 2005. The curse of Moctezuma: American silver and the Dutch disease, *Explorations in Economic History* 42, 349-380.

Farnie, D.A. 2004. The role of merchants as prime movers in the expansion of cotton industry, 1769-1990. In Farnie, D.A., Jeremy, D.J (eds.), *The fibre that changed the world: the cotton industry in international perspective, 1600-1990s*, Oxford University Press, Oxford, 15-55.

Feliu, G. 1991a. *Precios y salarios en la Cataluña moderna. Volumen I: Alimentos*, Banco de España, Madrid.

Feliu, G. 1991b. *Precios y salarios en la Cataluña moderna. Volumen II: Combustibles, productos manufacturados y salarios*, Banco de España, Madrid.

Ferrer, L. 1987. *Pagesos, rabassaires i industrials a la Catalunya central (segles XVIII-XIX)*, Abadia de Montserrat, Barcelona.

Ferrer, L. 2004. Bergadanas, continuas y mules. Tres geografías de la hilatura del algodón en Cataluña (1790-1830), *Revista de Historia Económica* 22, 337-386.

Garcia Balañà, A. 2004. *La fabricació de la fàbrica. Treball i política a la Catalunya cotonera (1784-1874)*, Publicacions de l'Abadia de Montserrat, Barcelona.

Giralt Raventòs, E. 1958. En torno al precio del trigo en Barcelona durante el siglo XVI, *Hispania: Revista Española de Historia*, 38-61.

Gragnolati, U., Moschella, D., Pugliese, E. 2011. The spinning jenny and the Industrial Revolution: a reappraisal, *Journal of Economic History* 71, 455-460.

Gragnolati, U., Moschella, D., Pugliese, E. 2013. The spinning jenny and the guillotine: technology diffusion at the time of revolutions, *Cliometrica* (*first on line article*).

Habbakuk, H.J. 1962. *American and British technology in the nineteenth century: the search for labour-saving inventions*, Cambridge University Press, Cambridge.

Hamilton, E.J. 1947. *War and prices in Spain: 1651-1800*, Harvard University Press, Cambridge.

Hamilton, E.J. 1965. *American treasure and the price of revolution in Spain, 1501-1650*, Octagon Books, New York (first edition 1934).

Homer, S. 1977. *A history of interest rates*, Rutgers University Press, New Brunswick (NJ) (second edition).

Homer, S., Sylla. 1963. *A history of interest rates*, Rutgers University Press, New Brunswick (NJ).

Humphries, J. 2012. 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* 6(3), 693-714.

Landes, D.S. 1969. *The unbound Prometheus: technological change and industrial development in Western Europe from 1750 to present*, Cambridge University Press, Cambridge.

López-Losa, E., Piquero, S. 2013. Was the little divergence so big ? Spanish real wages in the North-Western European mirror, 1500-1800, *Paper presented at the IV Encuentro de la AEHE*.

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

Malanima, P. 2006. *Energy Consumption in Italy in the 19th and 20th Centuries*, Consiglio Nazionale delle Richerche, Napoli.

Marfany, J. 2010. Is it still helpful to talk about proto-industrialization? Some suggestions from a Catalan case study, *Economic History Review* 63, 942-973.

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

Marfany, J. 2012b. Terra, proto-indústria i població a Catalunya: una altra transició al capitalisme?, *mimeo*.

Marx, K. 1867. *Das Kapital. Kritik der politischen oekonomie*, Hamburg.

Mokyr, J. 2002. *The gifts of Athena: historical origins of the knowledge economy*, Princeton University Press, Princeton.

Mokyr, J. 2009. *The enlightened economy: the economic history of Britain, 1700-1850*, Penguin Books, London.

Mora-Sitjà, N. 2002. Labour and wages in pre-industrial Catalonia, *Discussion Papers in Economic and Social History* 45, University of Oxford.

Mora-Sitjà, N. 2007. Labour market integration in a pre-industrial economy: Catalonia, 1772-1816, *Oxford Economic Papers* 59, 156-177.

Mora- Sitjà, N. 2011. El primer proletariat català. Mà d'obra i relacions laborals a les fabriques d'indianes de Barcelona, *Barcelona Quaderns d'Història* 17, 237-252.

Nadal, J. 1975. *El fracaso de la Revolución Industrial en España, 1814-1913, Ariel, Barcelona.*

Nadal, J. 1987. La industria fabril española en 1900. Una aproximación. In Nadal, J., Carreras, A., Sudrià, C. (eds.), *La economía española en el siglo XX. Una perspectiva histórica*, Ariel, Barcelona, 23-61.

North, D.C., Weingast, B.R. 1989. Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England, *Journal of Economic History* 49, 803-832.

Okuno, Y. 1999. Entre la llana i el cotó. Una nota sobre l'extensió de la indústria del cotó als pobles de Catalunya al darrer quart del segle XVIIII, *Recerques* 38, 47-76.

Özmucur, S., Pamuk, S. 2002. Real wages and standards of living in the Ottoman Empire, 1489-1914, *Journal of Economic History* 62, 293-321.

Pamuk, S. 2006. Urban real wages around the Eastern Mediterranean in comparative perspective, 1100–2000, *Research in Economic History* 23, 209-228.

Pollard, S. 1981. *The peaceful conquest. The industrialization of Europe 1760-1970*, Oxford University Press, Oxford.

Pomeranz, K. 2000. *The great divergence: China, Europe, and the making of the modern world economy*, Princeton University Press, Princeton.

Raveux, O., Sánchez, A. 2010. 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* 17, 65-94.

Sánchez, A. 1989. La era de la manufactura algodonera en Barcelona, 1736-1839, *Estudis d'Historia Social* 48-49, 65-113.

Sánchez, A. 1993. Les activitats econòmiques a Barcelona (1717-1833). In Sobrequés, J. (ed.), *Història de Barcelona. El desplegament de la ciutat manufacturera*, Barcelona, vol 5.

Sánchez, A. 2000a. Crisis económica y respuesta empresarial. Los inicios del sistema fabril en la industria algodonera catalana, 1797-1839, *Revista de Historia Económica* 18, 485-523.

Sánchez, A. 2000b. Les berguedanes i les primeres màquines de filar. In Maluquer de Motes, J. (dir.), *Tècnics i tecnologia en el desenvolupament de la Catalunya contemporània*, Enciclopèdia Catalana, Barcelona, 161-175.

Sánchez, A. 2012. Els orígens de la industrialització, 1750-1832. In Nadal, J., Benaul, J.M., Sudrià, C. (dirs.), *Atles de la industrialització de Catalunya, 1750-2010*, Edicions Vicens Vives, Barcelona, 1-9.

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

Serra, E. 1988. *Pagesos i senyors a la Catalunya del segle XVII. Baronia de Sentmenat, 1590-1729*, Barcelona.

Solà, A. 1995. Indústria tèxtil, màquines i fàbriques a Berga, *l'Erol 47,* 12-15.

Solà, A. 2002. Filar amb 'bergadanes'. Mite i realitat d'una màquina de filar cotó. In *La indústria tèxtil. Actes de les V Jornades d'Arqueologia Industrial de Catalunya*, Enginyers Industrials de Catalunya, Barcelona, 143-168.

Solà, A. 2004. *Aigua, indústria i fabricants a Manresa (1759-1860)*, Centre d'Estudis del Bages, Manresa.

Thomson, J.K.J. 1992. *A distinctive industrialization. Cotton in Barcelona, 1728-1832*, Cambridge University Press, Cambridge.

Thomson, J.K.J. 2003a. Transferring the spinning jenny to Barcelona: an apprenticeship in the technology of the Industrial Revolution, *Textile History* 34, 21-46.

Thomson, J.K.J. 2003b. Transferencia tecnológica en la industria algodonera catalana: de las indianas a la selfactina, *Revista de Historia Industrial* 24, 13-50.

Thomson, J.K.J. 2004. Technological transfer to the Catalan cotton industry: from calico-printing to the self-acting mule. In Farnie, D., Jeremy, D. (eds.), *The fibre that changed the world*, Oxford University Press, Oxford, 249-282.

Thomson, J.K.J. 2005. Explaining the 'take-off' of the Catalan cotton industry, *Economic History Review* 58, 701-735.

Tirado, D.A., Martínez-Galarraga, J. 2008. Una nova estimació retrospectiva del VAB regional industrial. Espanya (1860-1930), *Working Paper E08/192, Facultat d'Economia i Empresa, Universitat de Barcelona*.

Torras, J. 1981. Estructura de la indústria pre-capitalista. La draperia, *Recerques* 11, 7-28.

Torras, J. 1984. Especialización agrícola e industria rural en Cataluña en el siglo XVIII, *Revista de Historia Económica* 2, 113-127.

Torras, J. 1988. L'economia catalana abans del 1800. Un esquema. In Nadal, J. (ed.), *Història econòmica de la Catalunya contemporània*, v. 1, Enciclopèdia Catalana, Barcelona, 14-38.

Van Zanden, J.L. 1999. Wages and standards of living in Europe, 1500-1800, *European Review of Economic History* 3, 175-198.

Valls, F. 2004. *La Catalunya atlàntica. Aiguardent i teixits a l'arrencada industrial catalana*, Eumo Editorial, Vic.

Vilar, P. 1950. Elan urbain et mouvement des salaires dans le bâtiment. Le cas de Barcelone au XVIIIè siècle, *Revue d'Histoire économique et sociale*.

Vilar, P. 1962. *La Catalogne dans l'Espagne moderne. Recherches sur les fondements économiques des structures nationales*, SEVPEN, Paris.

Vilar, P. 1974. La Catalunya industrial: reflexions sobre una arrencada i un destí, *Recerques* 3, 7-22.

Weber, M. 1905. *The protestant ethic and the spirit of capitalism*, Allen & Unwin, London (English version 1930).