Wages and prices in the early Catalan industrialization

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Abstract
Catalonia was the only Mediterranean region among the first followers of the British Industrial Revolution in the second third of the nineteenth century. The roots of the industrialization process have to be found in the seventeenth and eighteenth centuries when the Catalan economy became successfully integrated in the international trade and enjoyed a process of agrarian and proto-industrial labour intensification. This capitalistic development was reinforced with a successful printed calico manufacture concentrated in the city of Barcelona. Although the factory system in cotton industry was generally adopted in the 1840s, the spinning jenny diffusion occurred in the 1790s. In this paper, in line with Allen (2009a, 2009b), we argue that this wide adoption of the spinning jenny can be explained by relative factor prices. First, we supply series of real wages in Barcelona for the period 1500-1808 following the works conducted within the ‘Great Divergence’ debate. Second, we focus on the cotton spinning sector to analyse the potential profitability of the adoption of spinning jennies in Catalonia. The evidence shows that although Catalonia was not a high-wage economy like Britain in the second half of the eighteenth century, our examination of the cotton spinning sector confirms the relevance of relative prices in the adoption of the new technologies. Within the booming sector of cotton after the 1780s, high wages created strong incentives for adopting the labour saving spinning jenny.

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“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’”.


1. Introduction

Catalonia was the only Mediterranean region among the first followers of the British Industrial Revolution in the nineteenth century. The industrialization of Catalonia was strongly specialized in cotton during its early stages and between 1835 and 1861 almost all cotton spinning and half of the weaving adopted the factory system (Nadal 1975). In a protected Spanish market, Catalonia concentrated in 1856 up to a 94 per cent of the cotton industry (Nadal 1987). This leading role included other branches of textiles and eventually other industrial sectors. In Jordi Nadal’s words Catalonia became during the nineteenth century ‘the factory of Spain’.

As Sidney Pollard points out, this economic modernisation had its roots, at least, in the eighteenth century. Catalonia enjoyed a process of market involvement since the end of seventeenth century that led to an agrarian and proto-industrial intensification and a rapid population growth during the eighteenth century (Vilar 1962; Torras 1988). This was the result of a successful integration of the Catalan economy into the international trade of the Early Modern period (Valls 2004). Furthermore, since 1736 a printed calico manufacture was established in Barcelona. In the last two decades of the century the manufacture achieved a significant size and by 1786 Barcelona was the leading printing city in Europe (Sánchez 1989; Thomson 2004). Most of the yarn used as a raw material in production was initially imported from Malta, but in these decades cotton spinning was rapidly expanding and the conditions were set to adopt 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 was defined as a ‘little England in the heart of Spain’.

The British Industrial Revolution is still today among the main topics in economic history. Why did the Industrial Revolution happen in Britain? Why not in France or China? Why at the end of the eighteenth century? These questions have been answered in different ways producing a very fruitful intellectual debate. Marxists have underlined the rise of capitalism, with its free markets and landless proletariat, as the cause of economic growth and, eventually, of the Industrial Revolution (Marx 1867). On the other hand, liberal institutionalists attribute this economic transformation to the English Glorious Revolution that took place in
1688 limiting the King’s despotic behaviour and securing property rights (North and Weingast 1989). Other explanations have stressed the Scientific Revolution of the seventeenth century, the Protestant ethic (Weber 1904-1905), the Industrial Enlightenment (Mokyr 2002 and 2009), or even the spread down of middle class values from the elite to other social groups for biological reasons (Clark 2007). Robert Allen (2009a) has recently suggested an alternative explanation based on economic factors. In his view, the key aspect of the Industrial Revolution was 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 availability of cheap energy and the stability in capital markets favoured the emergence of a structure of prices in Britain that created a strong incentive to research and develop new technologies to substitute the cheap inputs (energy and capital) for the relatively expansive one (labour). Moreover, Allen does not only explain why the Industrial Revolution was born in Britain but also why the British techniques were not adopted in 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 the British technology had sufficiently improved in the 1830s the new techniques were profitable in Western Europe and thus adopted.

Allen (2009b) exemplifies the relevance of relative prices with the adoption of the first technology in the cotton sector: the spinning jenny. He conducts a microeconomic analysis that shows that the ratio between 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 of new technologies was a key variable. As regards the Catalan case, it is a well-documented fact that the spinning jenny spread rapidly in Barcelona, mid-size towns and other rural areas from the last decade of the eighteenth century onwards. How does the Catalan experience fit within the ‘demand of technology’-based explanation? Some authors have stressed that in the second third of the nineteenth century, supply-side arguments would explain the delay in the adoption of the new technologies (mainly based on the steam engine) in Catalonia. The repeal of the British ban on the export of machineries in 1842 would have favoured a process of technological transfer in cotton industries that, together with a more stable economic and political atmosphere, would have relaxed the technological backwardness experienced in the spread of industrialization (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. Nonetheless, the adoption in Catalonia of the simplest textile machine, the spinning jenny, at the end of the eighteenth century was not blocked at all by supply-side factors because the transmission of this technology was much easier. And energy restrictions were not decisive either. The spinning jenny was moved by human strength so the only relevant factors were capital and labour.

In this general context, the contribution of the paper is twofold. First, we analyse the evolution of wages and prices in Barcelona, the capital city of Catalonia, during the modern

\(^1\) The adoption of the factory system (for steam power, throstles, mule jennies and self-acting mules) in Catalan cotton industry accelerated after 1842.
period. Here, we rely on the information gathered by Feliu (1991a, 1991b) whose remarkable work has provided a large amount of data regarding wages and prices for different occupations and goods 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 debate of the Great Divergence (Van Zanden 1999; Pomeranz 2000; Allen 2001; Özmucur and Pamuk 2002; Broadberry and Gupta; 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 through the subsistence ratio. Our results show that the evolution of living standards in Barcelona throughout the period fits well with the so-called continental European pattern, far below the high-wage economies in Atlantic Europe (England and the Low Countries). In a global comparative perspective, wages in the late 18th c. in Barcelona were close to subsistence levels and thus comparable to those of Central Europe (Vienna) and Northern Italy (Milano and Florence).

In the light of these results, we explore whether relative prices may have played a role in the early adoption of the spinning jenny in Catalonia. Can the successful diffusion of the spinning jenny in the last decade of the eighteenth century in Catalonia be explained on the basis of a demand of technology argument? Which were the relative prices of the two relevant production factors used in the new machines (labour and capital)? Relative prices are usually measured in the literature as the price of labour to the price of capital ratio. Allen (2009a, 2009b) examines the ratio at an aggregate level of the economy. Given that such information is not available in our case, we directly focus on the cotton spinning sector and follow Allen’s (2009b) empirical strategy. The analysis at the micro level examines whether differences in factor prices made profitable for domestic producers the purchase of a spinning jenny by computing the rate of return of such investment. Our results show that, under alternative scenarios, the rate of return for Catalan producers was close to that faced in English cottages and, interestingly, noticeably above that recorded in France. Hence, the potential profitability of the spinning jenny in Catalonia generated strong incentives for adopting the labour-saving new machines in cotton spinning, a booming sector in the general context of the Catalan economy. However, the adoption of the jenny confronted in its early stages some difficulties linked to the indiscipline of workers (Garcia Balañà 2004) and the lack of profitability in the 1780s due to the problems in the preparation of cotton (mainly in carding) and the lack of the necessary knowledge to operate the machines (Thomson 2003a). Once these initial difficulties were overcome, the diffusion of the spinning jenny across Catalonia began in the 1790s, in a process that also involved a technological improvement of the machines (Sánchez 2000b).

The reminder of the paper is organised as follows. The next section summarizes some of the main characteristics of the Catalan economy in the eighteenth century, paying special attention to the cotton textiles sector and the early adoption and diffusion of spinning machines across Catalonia. Section 3 is devoted to the construction of real wages series for Barcelona between 1500 and 1808. The subsistence basket is defined and the main results presented. In section 4 a micro-level analysis of profitability for the first spinning jennies installed in Catalonia is undertaken using the framework developed by Allen (2009b).
Interestingly, this type of exercise allows us to examine the 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 the cotton manufacture in the eighteenth century

Economic historians have stressed that Catalonia enjoyed a Smithian economic growth process from the seventeenth century. According to Torras (1988), the combination of two factors would explain the changes in the specialisation of the Catalan economy. Firstly, in the context of the French-Dutch rivalry and wars, some Mediterranean areas faced a new opportunity to achieve a deeper economic integration with the European markets through the exports of wine and liqueurs. Second, the structure of land and property rights enabled Catalan producers to react positively to this opportunity. Feudal structures had been weakened at the end of the fifteenth century and many peasants could enjoy the benefits of a labour intensification process through share-cropping. As a result, farming grapevines experienced a substantial expansion, and many areas in Catalonia, especially those located nearby the coast, became specialised in vineyards. As Valls (2004) has explained, the Catalan economy achieved a significant degree of integration with Atlantic Europe during this period. At the same time, the rising population in the areas devoted to farming grapevines increased the number of potential consumers for other goods like grain and manufactures. Thus, while some areas advanced in their specialisation in vineyards other areas specialised in the production of cereals and manufactures (Torras 1984). As this process took place, an increasing number of households produced to sell in the market and eventually, Catalonia developed into capitalism (Vilar 1962).

Specialisation and market involvement favoured the advance of manufacturing in Catalonia, especially in the production of wool. Several areas in Central Catalonia and the Pyrenean foothills flourished thanks to this activity, following a proto-industry pattern characterised by an intensive use of rural labour force for producing new draperies (Torras 1981). And proto-industry in the wool sector eventually played a key role in the development of cotton manufacturing. Putting-out networks, labour skills, organisational capabilities and capitals contributed to the advent and diffusion of cotton manufacturing in the last quarter of the eighteenth century (Okuno 1999). In fact, Catalonia can be considered as a successful case in the transition from proto-industry to industrialisation.

This process was strengthened with the access to the Spanish market, due to the elimination of inner barriers after 1714, and with the progressively improved access to the colonial markets in America during the eighteenth century. Catalonia played a pivotal role between Atlantic Europe and the Spanish America, exporting liqueurs and importing textiles from the first, while re-exporting textiles to the second (Valls 2004). Thus, Catalonia experienced a process of agrarian intensification and mercantile and manufacturing

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3 Some authors have stressed that vineyards and proto-industry specialisation might happen in the same geographical areas (Ferrer 1987, Marfany 2010, 2012a).
development that led to a continuous increase in population during the eighteenth century, as Pierre Vilar (1962) explained in his classical book. At the same time, this population growth reinforced the specialisation process and by the end of the eighteenth century Catalonia had escaped from the Malthusian trap thanks to a sophisticated and capitalistic economy.

In this context has to be explained the birth of the calico printing manufacturing in Barcelona. The manufacture began, as in other cases in Europe, when the importation of Asian textiles was banned. The consumption of printed calicos had succeeded all over Europe during the seventeenth century on the basis of their low price, hygienic qualities and fancy designs, becoming a key element in the mass consumption revolution that took place in 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 of the Spanish Monarchy during the second and third decades of the eighteenth century promoted import substitution and the development of a domestic printed calicos manufacture after 1736 in the city of Barcelona. This was a new emerging sector, without guild regulations, that for technical reasons concentrated in a single space a large number of workers and in which high capital investments were required (Sánchez 1989). During the second half of the eighteenth century this sector underwent a rapid expansion and by 1784 there were 80 establishments producing printed calicos, using 2.280 looms, employing 8.628 workers, and with a total production of 435.350 fabrics.

In the printed calicos establishments of Barcelona manufactures were woven and printed, but there was no spinning. In fact, for a long period, cotton spinning was a marginal activity in Catalonia, being most of the yarn imported from Malta. It was again a protectionist measure implemented by the government, the establishment 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 the colonies in Spanish America. Printed calico manufacturers in Barcelona reacted founding in 1772 The Royal Company of American Cotton Yarn (Real Compañía de Hilados de Algodón de América). With the creation of this company, a clear sign of a true willingness in promoting spinning in the country, manufacturers obtained a three-year tariff abolition and, at the same time, a decrease in the price of Maltese yarn. The Royal Company was a chartered company that embraced all printed calico manufacturers in Barcelona. Initially, it aimed to promote national spinning using the putting-out networks of wool spinning. This first attempt was, nonetheless, short-lived. However, the Royal Company was refunded in 1783, just at the moment when, after the end of the first war against Britain, the American raw cotton supply was guaranteed again and the production of printed calicoes and the printing of imported linen boomed because of exports to colonial markets (Raveux and Sánchez 2010, 69). In fact, Barcelona became in 1786 the leading cotton printing city in Europe (Thomson 2004) and by 1792 raw cotton consumption in Catalonia amounted to a 16 per cent of total British consumption (Sánchez 2012). The Royal Company established two systems for

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5 Sánchez (2012, 39). In Catalonia as a whole, a total of 94 establishments were involved in this activity.
6 Raveux and Sánchez (2010, 69).
yarn provision. On the one hand, it used the long lasting tradition of wool spinning in Central Catalonia, through the putting-out networks controlled by local weavers or finishers. On the other hand, the company set up their own workshops in different locations in Southern and Western Catalonia without manufacturing tradition or local businessmen, but with cheap unskilled labour. This second system was not successful and the Company abandoned it in 1787. Moreover, many independent businessmen that controlled putting-out networks for wool spinning were now moving to cotton spinning, directly competing with the Royal Company. In short, the Royal Company did not obtain the cotton spinning monopoly, it failed to colonise areas without a manufacturing tradition and, in fact, this first experience did not last for a long time. However, it contributed decisively to the diffusion of cotton spinning in Catalonia. The Royal Company together with independent businessmen promoted the transfer of spinning putting-out networks from wool to cotton and a ‘nationalisation’ of this activity was accomplished in a few years. The Catalan case is exceptional in this sense: cotton spinning began late but, once it began, the first British technical innovation was widely adopted7.

The spinning jenny arrived to Catalonia in 1784 from France. The first attempt of adoption occurred in a factory although later on the jennies were mostly used in small domestic workshops. The Royal Company established in 1787 a factory in Barcelona that counted with 14 spinning jennies8. However, as Garcia Balañà (2004, 166-219) has pointed out, they realised very soon that this model was not the best option for maximising profits because women that spun belonged to household economies and as workers they did not have incentives to stay in the factory for long working days or to be employed in it for a long period of time. The Royal Company decided to close its spinning factory after 1792, and a second attempt, in this case led by Erasme de Gònima, ended in a similar way in 1802. The most profitable way to implement the new machine was the domestic workshop, either in Barcelona or in the traditional textile areas of Central Catalonia and the Pyrenean foothills. Already in 1791 there were at least 108 spinning jennies in Catalonia and they spread very quickly during the 1790s9. Moreover, after 1792, Haley-type improved versions of the jenny, with 78-80 spindles, were built in Central Catalonia, reaching in 1796 the quantity of 250 machines. These were the origin of the famous later called ‘bergadanas’. At the beginning of the nineteenth century the spinning jennies recorded in Catalonia, from 36 to 110 spindles, amounted for a total of 90.000 spindles (Sánchez 2000b, 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 had to wait to 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 placed near the rivers, were more suitable under the factory system. On the eve of the Spanish

9 Sánchez (2000b, 163). See also Solà (1995, 2002). In 1790, the carding machine was introduced and it also showed a rapid diffusion (Thomson 2003a, 42; Sánchez 2000b, 165).
Independence War (1808), a total of 12,000 water-frame spindles were installed in Catalonia. In turn, the mule jenny had just arrived by then and the mules amounted for only 2,000 spindles (Sánchez 2000b, 172-175).

Overall, between 1783 and 1796, thanks to the new peace with Britain and the rise of colonial trade, the printed calicos and linen manufactures enjoyed their Belle Époque (Raveux and Sánchez 2010, 69). At the same time, cotton spinning expanded in Catalonia and the spinning jenny was widely adopted. In this context, Vilar (1974) argued that high wages in Barcelona attracted workers from the rest of Catalonia. In turn, Mora-Sitjà (2002) underlined that, in spite of the huge population growth recorded during the eighteenth century, wages did not decrease and this evidence would show that Catalonia was escaping from the Malthusian trap. However, Marfany (2010, 2012a and 2012b), analysing one of the most dynamic Catalan industrial cities of that century – Igualada –, argues that the market oriented activity of many Catalans was not for the desire of higher consumption levels, as it was the case in North-Western Europe (De Vries 2009), but for surviving, for nurturing an increasing population with scarce land. Thus, the labour intensification process in vineyard and manufactures did not go along with high income and consumption levels, but only with population growth. Taking this together, historiography is not unanimous in describing Catalonia at the end of the eighteenth century as a high wage economy in the context of Western Europe. The next section seeks to offer quantitative evidence in this respect.

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

A first step in our research strategy is the computation of real wages for Barcelona in the long run going from the sixteenth century to the beginning of the nineteenth century. Our data base relies on the information on wages and prices gathered by Feliu (1991a, 1991b). This author collected, in an extensive work, an enormous amount of information regarding both wages for different occupations and the prices of consumer goods in the city of Barcelona between 1500 and 1808. Here, we focus exclusively on those particular wages and consumer goods included in other international studies in order to make our results homogeneous and therefore comparable with the existing evidence on real wages in an increasing sample of cities around the world. Thus, our methodology to construct real wages for Barcelona follows previous work on 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, 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, 21) (see Appendix). The data for the 16th and 17th c. comes from the construction

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11 A new war with Britain affected foreign trade between 1797 and 1801, and again in 1805-7 (Sánchez 1989, 100). The years 1802-4 were the last of expansion before the Spanish Independence War. In fact, the period 1784-1804 is described as the golden age of Catalan printed calico manufactures (Sánchez 2012, 39).
works in the cathedral and convents in Barcelona, although in some particular years in which data is missing, the series are completed with the information on the wages paid in the cathedral and in the Monastery of Sant Daniel in Girona, a nearby city 100 km north of Barcelona. For the 18th c. the data is taken from Vilar (1950), based on different construction works recorded in the ‘àpoques’ (Feliu 1991b, 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 throughout this period shows that nominal wages remained stable in the first half of the 16th c. Then, a period of sustained increase followed up to the mid-17th c. This tendency was nonetheless reversed and by 1750 the nominal wage had decreased to the levels recorded at the beginning of the 16th c. However, the last decades of the 18th c. witnessed a substantial rise in wages and by the turn of the century wages have almost doubled.

More interestingly, the significant progress 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 in the gradually more and more complete international picture. For simplicity, we focus our comparison on some representative European cities (London, Amsterdam, Florence/Milan and Vienna). Firstly, Barcelona stands out in the beginning of the 16th c. for having higher nominal wages. Between 1550 and 1650, a period of wage dispersion across European cities, Barcelona was still in a good position, although wages in North-Western

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12 While the works at the cathedral were not complemented with other payments in kind, in convents the provision of food was a usual practice (Feliu 1991b, 70). Bearing this in mind, we focus, as customary in previous research, on cash wages (Allen 2001).
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, nonetheless, wages were still higher in Barcelona than in Northern Italy and Vienna and from that moment onwards an exceptional increase in nominal wages took place. In this case, nothing like that is observable for the continental counterparts. Table 1, where 50 year averages are presented for the same cities supplements the previous findings.

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<tbody>
<tr>
<td>London</td>
<td>Amsterdam</td>
<td>Barcelona</td>
<td>Florence/Milan</td>
<td>Vienna</td>
<td>1800-08*</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>3.1</td>
<td>4.7</td>
<td>2.9</td>
<td>2.7</td>
<td>17.1</td>
<td></td>
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<tr>
<td>4.6</td>
<td>4.7</td>
<td>5.3</td>
<td>3.8</td>
<td>2.6</td>
<td>17.1</td>
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</tr>
<tr>
<td>7.1</td>
<td>7.2</td>
<td>6.1</td>
<td>4.7</td>
<td>4.4</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>9.7</td>
<td>8.5</td>
<td>7.1</td>
<td>4.1</td>
<td>3.5</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>8.9</td>
<td>5.5</td>
<td>3.2</td>
<td>3.2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>11.5</td>
<td>9.2</td>
<td>6.0</td>
<td>2.9</td>
<td>3.0</td>
<td>3.1</td>
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</tr>
<tr>
<td>17.7</td>
<td>9.2</td>
<td>9.6</td>
<td>2.6</td>
<td>2.4</td>
<td>3.1</td>
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</tbody>
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Nominal wages hide, nonetheless, differences in the cost of living and inflation across locations. In order to obtain a clear image of the incomes of workers and therefore in the standard of living in comparative perspective, 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 it is common in the related literature, this consumer price index is estimated calculating a consumption basket that represents the minimum for subsistence. This subsistence basket includes a number of goods which 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). This 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, like cloth, soap or fuel are also incorporated (see table 2)\(^3\).

There are, of course, differences in the consumption patterns across countries. As in pre-industrial societies cereals represented a large share of the budget expenditure, the basket is geographically adapted to consider different grains available depending on the area studied based on the 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, or maize in the Americas). Hence, the in-take of calories also varies slightly across the cities in the sample according to the cereal considered. In our calculations for Barcelona, an

\(^3\) See Humphries (2012) for a critical view on Allen’s methodology.
An equivalent quantity of the cheapest and most common grain, wheat, has been taken. Another example in this sense would be the inclusion in the basket for Southern European countries of olive oil instead of butter, being the latter more present in the diet of Northern Europeans; or the use of canvas and linen as representative for textiles. Likewise, a fuel consumption of 2 m BTUs per year is adopted for Barcelona as in Mediterranean countries or in the Americas, that is, in places where more temperate climates reduced the necessary quantity of fuel for heat.

Table 2. Bare bones subsistence basket of goods

<table>
<thead>
<tr>
<th></th>
<th>Quantity per person per year</th>
<th>Calories/day</th>
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<tbody>
<tr>
<td><strong>Food</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>215 kg</td>
<td>1,657</td>
</tr>
<tr>
<td>Beans</td>
<td>20 kg</td>
<td>187</td>
</tr>
<tr>
<td>Meat (beef)</td>
<td>5 kg</td>
<td>34</td>
</tr>
<tr>
<td>Olive Oil</td>
<td>3 lt</td>
<td>60</td>
</tr>
<tr>
<td><strong>Non-Food</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soap</td>
<td>1.3 kg</td>
<td></td>
</tr>
<tr>
<td>Linen / Canvas</td>
<td>3 m</td>
<td></td>
</tr>
<tr>
<td>Candles</td>
<td>1.3 kg</td>
<td></td>
</tr>
<tr>
<td>Lamp Oil</td>
<td>1.3 lt</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>2 m BTUs</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>1,938</td>
</tr>
</tbody>
</table>

Sources: Allen (2009a, 37); Allen et al. (2011a, 21); Allen et al. (2011b, 43).

The time series of prices between 1500 and 1808 are obtained again 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) were higher than in the rest of Europe. This would be the outcome of the Price Revolution in Spain and the inflationary effect of the arrival of silver from the Americas, which translated into a persistent and general increase in prices (see, for instance, Drelichman 2005, and the works cited therein). The inclusion of Valencia/Madrid in the last column of the table illustrates that a similar evolution (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 (grams of silver per year)

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Amsterdam</th>
<th>Barcelona</th>
<th>Florence</th>
<th>Vienna</th>
<th>Valencia/Madrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500-49</td>
<td>67</td>
<td>66</td>
<td>175.6</td>
<td>99</td>
<td>59</td>
<td>144</td>
</tr>
<tr>
<td>1550-99</td>
<td>128</td>
<td>104</td>
<td>305.7</td>
<td>156</td>
<td>96</td>
<td>324</td>
</tr>
<tr>
<td>1600-49</td>
<td>201</td>
<td>152</td>
<td>374.2</td>
<td>177</td>
<td>180</td>
<td>439</td>
</tr>
<tr>
<td>1650-99</td>
<td>220</td>
<td>158</td>
<td>318.5</td>
<td>129</td>
<td>127</td>
<td>383</td>
</tr>
<tr>
<td>1700-49</td>
<td>201</td>
<td>172</td>
<td>282.0</td>
<td>177</td>
<td>130</td>
<td>328</td>
</tr>
<tr>
<td>1750-99</td>
<td>264</td>
<td>202</td>
<td>382.3</td>
<td>240</td>
<td>165</td>
<td>392</td>
</tr>
<tr>
<td>1800-49</td>
<td>383</td>
<td>266</td>
<td>-</td>
<td>352</td>
<td>233</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Allen et al. (2011b, 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 at this point follows 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 incomes earned by a labourer on a yearly basis in relation with the annual cost of subsistence of a representative family. The construction of the so-called subsistence ratio implies thus some assumptions. Firstly, the daily wages have to be converted into annual earnings of labourers. In this case, a total of 250 days of work per year are taken. Secondly, 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 spending required to pay the rent. Finally, a representative family consisting of two adults and two children is assumed. The cost of keeping this family at subsistence levels is considered to be equivalent to an annual payment of three baskets like the one described in Table 3 (Allen, 2001).

The interpretation of this subsistence ratio presents some advantages when compared to more conventional wage indexes. On the one hand, it provides useful information: can a man working full time during a year support a family at the minimum levels for subsistence? A ratio below one indicates that families face a difficult economic condition as the yearly income earned is not even sufficient to keep the family at the subsistence level. If the ratio is above one, then families have a surplus to expand consumption and the income earned allows them to move away above the subsistence level. On the other hand, the cost of subsistence for a family, when transformed to current dollars, is very close to the present poverty line defined by the World Bank at $1.25. Hence, a subsistence ratio equal to one implies that a family is living on the edge of the poverty line. This ratio thus measures the standard of living in a particular moment of time as a multiple of the poverty line (Allen et al. 2011b, 9).

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 works (Allen 2009a, 40), a clear divergent pattern within Europe is found. While cities of North-Western Europe like London and Amsterdam enjoyed a high standard of living (around three to four times above the subsistence level), cities of continental Europe experienced a continued decline over time. By the end of the 18th c., the subsistence ratio was around one, and thus the yearly earnings of the construction labourers set 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 with the construction of the subsistence basket, the relative good position found for Barcelona in terms of nominal wages in grams of silver, vanishes.

Figure 2. Subsistence ratio for labourers in Europe (fifty years average)

Table 4. Subsistence ratio for labourers in Europe

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Amsterdam</th>
<th>Barcelona</th>
<th>Florence</th>
<th>Vienna</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500-49</td>
<td>3.62</td>
<td>3.80</td>
<td>2.21</td>
<td>1.99</td>
<td>3.28</td>
</tr>
<tr>
<td>1550-99</td>
<td>2.88</td>
<td>3.64</td>
<td>1.45</td>
<td>1.77</td>
<td>2.07</td>
</tr>
<tr>
<td>1600-49</td>
<td>2.75</td>
<td>3.84</td>
<td>1.31</td>
<td>1.71</td>
<td>1.82</td>
</tr>
<tr>
<td>1650-99</td>
<td>3.42</td>
<td>4.33</td>
<td>1.84</td>
<td>1.65</td>
<td>1.99</td>
</tr>
<tr>
<td>1700-49</td>
<td>4.08</td>
<td>4.20</td>
<td>1.56</td>
<td>1.39</td>
<td>1.77</td>
</tr>
<tr>
<td>1750-99</td>
<td>3.44</td>
<td>3.77</td>
<td>1.26</td>
<td>0.99</td>
<td>1.35</td>
</tr>
<tr>
<td>1800-49</td>
<td>3.65</td>
<td>2.89</td>
<td>-</td>
<td>0.73</td>
<td>-</td>
</tr>
</tbody>
</table>

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

4.- Factor prices and profitability of the spinning jenny in Catalonia at the end of the 18th c.

On the basis of these results, is it possible to explain the early adoption of the spinning jenny in Catalonia in terms of factors’ relative prices? A recent view in the analysis of why the Industrial Revolution was British argues that the profitability of the new technologies was a key variable in explaining it. According to this interpretation (Allen 2009a), inventions do affect the input requirements in production, and technologies generate a bias in the use of factors. In particular, when compared to the spinning wheels, the spinning jenny increased capital requirements while reducing labour requirements. Thus, it is important not only to examine the average wage levels of a particular economy but also the structure of relative prices including both labour and capital. How did Barcelona perform compared with England and France, the main two cotton producers in Europe at that time, in terms of the prices of labour and capital?
Unfortunately, the calculations made by Allen (2009b) cannot be reproduced in the case of Barcelona due to the lack of information. In his comparison of the ratio between labour and capital prices, he takes nominal wages in the construction sector (Allen, 2001) and computes the price of capital on the basis of 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 are obtained from Homer (1977, 117, 126 and 157) and correspond to long term interest rates paid by the British and the French governments for bonds (annuities and consols in the case of the former and rentes in the case of the latter).

Although it is not possible to replicate Allen’s equation, here an alternative tentative 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 in the cotton textile sector in the late 1780s for England, France and Catalonia. In this case, we compute a raw ratio between the price of labour and the price of capital in the works of cotton spinning. In so doing, we take the daily wage earned by a spinner and for the price of capital we use the purchase price of a spinning jenny, which is the cost of the investment faced by the producer. The data for England and France come from Allen (2009b, 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 jenny of 24 spindles for cottage use is estimated to be 70 shillings in England and 140 livres tournois in France. For Catalonia, the wage of spinners and the price of a jenny (in sous) are obtained from Garcia Balañà (2004). A jenny had a cost of around 900 sous and it corresponds to a representative jenny of 36 spindles, the most common size used in Catalonia at that time. As the number of spindles is higher than that of the machines in England or France our calculations are thus pushing downwards the wage relative to price of capital ratio for Catalonia.

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

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>France</th>
<th>Catalonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily wage (w)</td>
<td>6.25 d</td>
<td>9 st</td>
<td>6 s</td>
</tr>
<tr>
<td>Price of a jenny (J)</td>
<td>840 d</td>
<td>2800 st</td>
<td>900 s</td>
</tr>
<tr>
<td>(w) / (J)</td>
<td>0.00744</td>
<td>0.00321</td>
<td>0.00667</td>
</tr>
<tr>
<td>England=100</td>
<td>100</td>
<td>43.2</td>
<td>89.6</td>
</tr>
</tbody>
</table>

Source: Gragnolati et al. (2013, Table 2); Garcia Balañà (2004, 161-2).

The results of the exercise can be consulted in Table 5. First, the relative price of labour and capital shows that there were significant differences between England and France as previous research has established. These differences, in fact, are at the root of the explanation of why the Industrial Revolution was British. The high relative price of labour in
England in relation with capital would explain why English producers adopted the new machines that allowed them to substitute the expensive factor of production (labour) and use the cheaper one (capital). Second, the wages relative to the cost of capital in France were less than half of those recorded in England. In this context, as Allen argues, in the light of such a significant difference, “many projects to mechanize production that were profitable in England proved unprofitable in France” (Allen 2009b, 912). Finally, the data for Barcelona shows high values for the ratio, close to that recorded in England (89.6%). According to these results it seems that Catalan producers may also have had an incentive to mechanize production as English had, being more enthusiastic than French producers about the new technologies in cotton spinning.

Did relative prices in production factors play a role in the early adoption of the jenny across the Catalan territory as surveyed in section 2? Here, the key issue is the profitability of adopting the spinning jennies by Catalan producers in the early stages of industrialization. The detailed information available for the Catalan case allows us to conduct a more precise microeconomic analysis to examine the profitability of the first jennies installed in Catalonia. The spinning jenny was introduced in 1786 and was widely adopted in the 1790s, so historical facts lead to believe 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 the French ones. In what follows, we attempt 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 and, at the same time, explore if the Catalan case can qualify his model in the light of recent critiques (Gragnolati et al. 2013).

In Allen’s model the decision makers are domestic producers who live in cottages and spend a share of their time spinning cotton for weavers or merchants. The question is whether or not these domestic producers found profitable to buy a 24 spindle jenny due to the increase in labour productivity, namely, if the decrease in labour costs covered the sum of the price of a jenny and offered 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, \( \Delta L \) the number of days of labour saved per year, \( m \) the cost of maintenance of the jenny and \( r \) is the internal rate of return to be calculated. The labour saved is computed as:

\[ \Delta L = YD(1 - 1/P) \]

being \( Y \) the number of working days in a year, \( D \) the share of a working day devoted to spin and \( P \) the relative productivity of the new technology in relation to the old one (the spinning
wheel). For solving this equation, several assumptions are needed. Firstly, the time span \( t \) is supposed to be 10 years, the life expectancy of a jenny. The cost of maintenance \( m \) is assumed to be a 10 per cent of the purchase price of the jenny and the number of working days per year (\( Y \)) to be 250. In relation to \( D \) and \( P \) several scenarios are examined. It is believed that cottage spinners devoted between 30 and 50 per cent of their working time to spin, being \( D \) equal to 0.3, 0.4 or 0.5 in alternative calculations. For example, if we assume that spinners devoted 40 per cent of their working time to spin, 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 2 and 4 times that of the spinning wheel. In this case, with a typical \( P \) equal to 3, up to a 66.6 per cent of the labour would be saved.

Once all these parameters are chosen, the two variables that make the spinning jenny profitable or not 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 about relative factor prices, the higher the ‘wage/jenny price’ ratio, the higher will be the probability of being profitable to adopt the spinning jenny. Our results show that the Catalan ratio is much closer to the British than to the French one, being only a 10 per cent lower than the former. Indeed, the Catalan internal rates of return under different scenarios are quite similar to the British as can be seen in Table 6. If we consider, as Allen does, a 15 per cent profitability threshold, only in the worst possible scenario buying a jenny was not a profitable investment in Catalonia in the late 1780s, just like in Britain. On the contrary, as Allen has shown, only in the best scenario was the jenny profitable in France in the same years.

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

<table>
<thead>
<tr>
<th>Relative Productivity</th>
<th>Per cent Full-Time</th>
<th>Britain (per cent)</th>
<th>Catalonia (per cent)</th>
<th>France (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.5</td>
<td>34.6</td>
<td>29.9</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>24.0</td>
<td>20.3</td>
<td>-8.2</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
<td>12.3</td>
<td>9.4</td>
<td>-21.7</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>51.2</td>
<td>44.8</td>
<td>10.7</td>
</tr>
<tr>
<td>3</td>
<td>0.4</td>
<td>38.0</td>
<td>32.9</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>0.3</td>
<td>24.0</td>
<td>20.3</td>
<td>-8.2</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>59.2</td>
<td>52.0</td>
<td>15.3</td>
</tr>
<tr>
<td>4</td>
<td>0.4</td>
<td>44.7</td>
<td>38.9</td>
<td>6.8</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
<td>29.4</td>
<td>25.2</td>
<td>-3.7</td>
</tr>
</tbody>
</table>

Source: Allen (2009b), Table 1, and Garcia Balañà (2004, 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, this author is assuming that when a spinner bought a jenny that produced three times per hour than a wheel, she did not produce the triple but the same amount and spared two thirds of her time devoted to spin. This assumption has been criticised by Gragnolati et al. (2011, 2013). They argue that it is uneconomical to undertake an investment in a technology with increasing returns of scale and
to decrease the quantity of labour applied. If a cottager made an effort to buy a jenny, she would try to get it profitable by using it intensively, increasing working time instead of reducing it. In fact, they demonstrate that maintaining the quantity of labour and, therefore, increasing production, the jenny would have been profitable in France in all but the worst 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 following work they develop a model in which factor prices and demand size are combined for predicting precisely the timing of the adoption of the jenny either in Britain and France (Gragnolati et al. 2013).

Allen’s answer to this critique is that he stands for the assumption that spinners had a target level of consumption, in the same way as farm labourers had it in the previous centuries under the putting-out system: when the daily wage increased, they worked less; when the opposite happened, they worked more. Thus, it is plausible that spinners reduced their working time when they reached a similar production and income level with less time (Allen 2011). In our view Allen is right in his assumption, although we understand the concern of the Italian scholars on the labour intensification issue because it played an important role in the adoption of the spinning jenny in Catalonia and links with a fundamental debate around the rise of the factory system in the Industrial Revolution.

Although traditionally historians have argued that the spinning jenny arrived to Catalonia in 1780 in the towns of Puigcerdà and Olot, close to the French border, there is no concluding evidence to support this view. Most probably the first spinning jenny, or the knowledge about it, arrived in Barcelona in 1784 through two French machine-makers, Pontet and Pradel. Supported financially by a French citizen living in Barcelona, the Marquis de Gaubert, they built 14 jennies of 36 spindles. However, producing yarn with these new machines did not prove to be easy and it forced Gaubert to travel to France in order to learn about the preparation of cotton before being spun. Finally, Gaubert realised that this process of technological transfer was too harsh and decided to sell the jennies to the Royal Company of American Cotton Yarn in 1786. As mentioned in section 2, this was a chartered company owned by the printed calicos manufacturers of Barcelona set with the aim of promoting cotton spinning in Catalonia for substituting Maltese yarn imports. The Royal Company decided to establish a factory in Barcelona with the 14 jennies. Thomson (2003a) has explained in much detail the process of adopting this new technology and making it economically profitable by the Royal Company in the period 1786-88. The improvement was attained mainly by buying higher quality raw cotton and setting disciplinary rules for workers in order to produce more yarn and of better quality. Carders, rovers and spinners had to work in the factory for 10 hours per day and accomplish production objectives: for each spinner it was 1.5 lb of yarn per day. By the end of 1788, the firm was able to produce cotton yarn with profits (Thompson, 2003a).

However, García Balañà (2004, 166-219) also studied very carefully the records of the Company for the following years. He analysed the production of 19 spinners with her jennies for 27 weeks during the first six months of 1791. Working six days per week, the weekly average production per spinner was 5.4 lb, this is to say, 0.9 lb per day, far below the objective

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15 Sánchez (2000b, 162).
of 1788. In fact, Garcia Balañà detects a huge inter-week variability for each spinner and he concludes that the main problem of the firm was to ensure the regular attendance of the spinners to the factory. Thus, the strict norms established in 1788, trying to ensure labour intensification in the factory system, did not succeed. Garcia Balañà explains this failure as being the result of spinners being young girls, most of them integrated in urban households in which their labour was required in an intermittent and irregular basis. As Carbonell (1997) has shown these young girls performed a large number of activities, they could sell, spin, wash clothes, help in a workshop, transport water, wait upon, wet nurse,... The flexibility they had among the house, the workshop and the factory was essential for the urban households they belonged\(^{17}\). The factory’s profitability depended on the increase of the throughput and the lengthening of working time, on making sure that the full-time working day was achieved. With labour intensification and production growth, the profitability of the capital investment was guaranteed, just what Gragnolati et al. (2012) expected from a person who bought a jenny. Cottage spinners might have a target level of consumption, but the Royal Company owners certainly maximised profits. The factory of the Royal Company was unable to break the economic logic of the urban households with disciplinary codes and incentives; the fathers were still more powerful than the factory foremen. The time of the factory system for cotton spinning had not come yet. In fact, the Royal Company decided to close its factory soon afterwards, probably not much later than the end of 1792, and to buy the yarn in the market\(^{18}\).

However, this was not the end but only the beginning of the jennies in Catalonia. There is evidence that just in 1791 there were at least 108 jennies in Catalonia and they spread very quickly throughout the 1790s in Barcelona, in manufacturing towns and villages, and in the countryside (Sánchez, 2000b). The booming of the printed calicos demand and the need to provide all the yarn from home rapidly expanded cotton spinning and the new machines in Catalonia. The jennies, nonetheless, did not change the scale and the geographical localisation of spinning because they were moved by hand\(^{19}\). In fact, most of them were located at home or at small workshops. We have already shown that spinning jenny was profitable for Catalan domestic producers at the end of the 1780s by replicating Allen’s model. However the abundance of available data allows us to apply a slightly different test for the second half of the 1790s. For doing so, we need to come again to the Royal Company.

After the closure of the factory, the Royal Company stocked up on yarn from domestic producers in Barcelona and its hinterland. This time, they tried not to rely on the middlemen of the old putting-out system so they established direct links with its suppliers. Garcia Balañà (2004, 189-202) has shown that in 1797 the Company decided to let its jennies to some domestic producers and small workshops in Barcelona. The agreement was as follows: the owner of the jenny was the Company, but the spinning was done at home or at the workshop of the spinner. In exchange of using the Company’s jenny, the piece rate decreased from 12 to 7.5 sous per lb. Given the increase in labour productivity, the spinner could afford a piece rate reduction of that amount. In contrast with Allen’s model on the cottage jenny, here the investor was the Company, not the spinner, and the productivity increase was taken by the


\(^{18}\) Garcia Balañà (2004, 166 and 188-189).

\(^{19}\) Sánchez (2012), p. 40.
investor in a decrease in the piece rate. In this context, we calculate the internal rate of return of this investment according to the following expression:

\[ J = \sum Q(p^w - p^j) - m/(1 + r)^t, \]

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. Luckily, real data are available for the annual production \( (Q) \) of several spinners that worked for the Company in 1798, so no assumptions on working days and labour intensity have to be done in this case. We take \( J = 900, m = 90, p^w = 12, \) and \( p^j = 7.5. \) In Table 7 the internal rate of return for three domestic spinners or small workshops is presented.

<table>
<thead>
<tr>
<th>spinner's name</th>
<th>n. Jennies</th>
<th>Q per jenny (in lb)</th>
<th>TIR (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Francesca Costa</td>
<td>1</td>
<td>142.2</td>
<td>60.6</td>
</tr>
<tr>
<td>Francesca Pasqual</td>
<td>1</td>
<td>154.2</td>
<td>66.7</td>
</tr>
<tr>
<td>Josepa Serra/Paula Arnau</td>
<td>2</td>
<td>220.6</td>
<td>100.2</td>
</tr>
</tbody>
</table>

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

Thus, it seems clear that this kind of investment was very profitable for the Company. Garcia Balañà underlines that some of the suppliers were not single spinners but small family workshops ruled by a man. In fact, he explains that the same households that blocked the Company’s factory by interfering in the regular supply of girls’ labour, now they succeeded in organising spinning with the jenny at home. These workshops became specialised in cotton spinning, thus being more efficient in labour intensification than the factory regulations. Family hierarchies and gender roles were still more powerful than the factory system at the time of the jenny. However, with the water-frame and the mule-jenny, which implied the use of water or steam energy and where economies of scale tended to be more relevant, the factory system finally succeeded.

5. Conclusions

Catalonia was the only region of Southern Europe that was among the followers of the British Industrial Revolution in the second third of the nineteenth century. This exceptional position had its roots on the early integration of the Catalan economy in international trade during the seventeenth and eighteenth centuries and the development of an increasingly capitalistic
Moreover, a distinctive cotton manufacture developed after 1736 and the spinning jenny was widely adopted in the 1790s. In this context, we focus on the analysis of this relevant case of early industrialization analysing the structure of prices of production factors taking as a framework Allen’s (2009a, 2009b) model of technological adoption and diffusion.

A first contribution of the paper is the construction of long term real wage series for Barcelona. Thus, the Catalan experience can be included in the global history of wages and prices that in the last years, within the 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 real wages based on the subsistence ratio in Barcelona followed a continental pattern, similar to that of Northern Italy or Vienna. In the second half of the eighteenth century Catalonia was not a high wage economy like Britain or the Low Countries, although it occupied a respectable position in a second line. This is not an unexpected result and it is coherent with the picture of the Catalan economy given by the historiography, but it does not explain by itself the wide diffusion of the spinning jenny, a key technology during the very early stages of the Industrial Revolution at the end of the eighteenth century. In fact, in Allen’s view, the key element in the explanation is relative factor prices.

Given the absence of information, we have not been able to replicate the price of labour to the cost of capital ratio at an aggregate level for the Catalan economy. Instead, we have turned to the cotton spinning sector, where technological changes were taking place. Relative prices in this sector show that at the end of the 1780s the ratio between the spinners’ wage and the price of purchasing a jenny in Catalonia was much closer to that in Britain than the French one. Consequently, when Allen’s micro-level analysis is applied to examine the early adoption of the spinning jenny in Catalonia, we find that Catalan producers had incentives to mechanise production, as it was the case for British producers. This is our second contribution: for Catalan domestic spinners, it was profitable to buy a jenny already at the end of the 1780s. In addition to this, we have reached a similar conclusion with a slightly different analysis, that is, when the investment decision was not taken by the spinner but by the yarn buyer. Hence, the wide adoption of the spinning jenny in Catalonia since the late 1780s can be described on the basis of Allen’s model of technological diffusion.

Then, how is it possible to explain that in a non-high-wage economy the factor prices’ ratio in cotton spinning was favourable to the substitution of capital for labour? We believe that the answer lies in the exceptional conjuncture of printed calicos manufacturing 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 set in the city of Barcelona, but still a strong bottleneck existed. This translated into high wages for cotton spinners and thus, into a strong incentive to buy a labour-saving technology, the spinning jenny. Although at a macro level real wages were not exceptionally high in Catalonia, at a micro level the relevant sector, cotton spinning, was booming. This interpretation fits well with Crafts’ view of the British Industrial Revolution where technological changes were concentrated in some particular dynamic sectors and it took a long time before the effects at a macro level were perceived. Nevertheless, the process of economic development and the capitalistic and market-oriented
nature of the Catalan economy enabled the Catalans of the second half of the eighteenth century to escape the Malthusian trap and to develop a large cotton manufacturing sector in which the first British technological innovation in textiles, the spinning jenny, was early adopted.

Appendix

Nominal wages for labourers

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

Subsistence basket

The basket for Barcelona (table 2) replicates that of previous studies (Allen et al. 2011a; Allen et al. 2011b, 43; Allen et al. 2012). The quantities per year in the goods included in the basket are the same with only one exception. Allen et al. (2011a) offer a consumption basket that considers alternative cereals on the basis of consumption patterns. Hence, the equivalent quantity of wheat needs to be calculated taking into account that the staple food in Barcelona during the period of study was bread made with wheat flour. What quantity of wheat was required to obtain a total of 1657 calories per day? According to Allen et al. (2011a, 38) the caloric power of wheat was 3,390 calories per kg. Assuming a flour extraction rate of 83% (Allen 2001, 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, 42-44 and 157-158, respectively). Wheat prices in Barcelona are obtained linking the information in Giralt (1958) for the cathedral of Barcelona between 1500 and 1599; the data in Serra (1988) in the period going from 1600 to 1714 coming from the Augustinian convent in Barcelona; and, 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 liters we take the equivalence: 1 ‘quartera’ = 12 ‘quartanes’ = 69.528 lt (Feliu 1991a, 18). This is transformed into kilograms taking the following value: 1 lt 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, 75) is expressed in ‘sous per lliura carnissera’. We take 1 ‘lliura carnissera’ equal to 1.2 kg (Feliu 1991a, 18). Olive oil: Prices, in ‘sous per càrrega’, are obtained from Feliu (1991, 106) and converted to liters using the equivalence 1 ‘càrrega d’oli’ = 124,5 lt (Feliu 1991a, 18). Soap: The series of soap prices in Barcelona start in 1574 (Feliu 1991b, 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) in a close Mediterranean city 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 are nonetheless linen prices expressed in ‘alnas per diners’ and need to be transformed into meters and converted to grams of silver. The transformation is based on the information in Hamilton (1965, 181): 1 ‘alna valenciana’ = 0.91 cm. The conversion from ‘diners’ to grams of silver is somehow problematic. From 1501 to 1609, data comes from Hamilton (1965, 318). From 1610 to 1650, the data in Hamilton (1965, 131, table 10) is used. Actually, after 1612 the ‘diners’ were not issued any more and they were suppressed after the Succession War (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, 52), candles are transformed to kilograms taking 1 ‘lliura’ = 400 gr (Feliu 1991a, 18). Lamp oil: In this case, we use the same 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 grs; 1 ‘quintal’ = 41.6 kg (Feliu 1991a, 18). In order to transform this measure in 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 1BTU 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.

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