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## ANALYSIS

# Wood and industrialization Evidence and hypotheses from the case of Spain, 1860–1935

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## ABSTRACT

The aim of this paper is to study wood consumption during the industrial expansion which took place in the western world in the second half of the nineteenth and the first decades of the twentieth century, through the analysis of the case of Spain. For this purpose, we present the series of Spanish wood consumption both as a raw material (WRM) and as firewood (FW) between 1860 and 1935 and we carry out two exercises with these series. The first calculates the intensity of use (IOU), which relates wood consumption in physical terms with the evolution of the GDP. The second, more complex, exercise estimates a standard consumption function that allows us to know the elasticity of WRM with respect to the GDP, the Spanish price of wood and the Spanish price of a substitute material like iron. Based on our results, we discuss the lower dependence of the Spanish industrial economy on wood, the “liberation” of forest areas that may have occurred in Spain as a result of industrialization, and to what extent the trends observed for the Spanish case can be extrapolated internationally. The main conclusion is that industrialization transformed the uses of wood and, though the importance of this resource per unit of GDP decreased, its overall consumption increased, generating greater pressure on forests at an international level.

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## 1. Introduction

The economic uses of wood have always been closely linked with the extension, composition and quality of the world's forests. So, knowing how these uses were affected by the industrial expansion that took place in the western world during the second half of the nineteenth and the first decades of the twentieth century can help us understand some important environmental issues. As industrialization caused deep changes in the social metabolism of the economy

(Krausmann and Haberl, 2002), it must also have altered the importance of a renewable resource like wood. However, the results of this alteration remain, mostly, unstudied.

Before industrialization, wood played a central economic role as an energy source. This was inherent to organic-based energy economies that obtained energy from the solar flow, transformed it with traditional converters and, consequently, depended directly on the quantity of land available (Wrigley, 1988). In this context, wood (and its derivative, charcoal) offered a higher calorific power than any other vegetable fuel, was

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relatively evenly distributed and offered greater security and storage capacity than the energies coming from water or wind (Smill, 1983). Thus, it was essential not only for cooking and heating but also for the development of many industrial processes. At the same time, the properties of wood and the scarcity of alternative materials meant that it was also fundamental as a raw material in the construction of buildings and infrastructures, means of transport and tools. Obviously, the dependence on wood could vary considerably from region to region, but generally speaking, no society could exist without it. Therefore, the growth of organic-based economies was restricted by the difficulties involved in extending the area dedicated to wood production, in increasing its yields and in importing it from distant places at viable prices (Sieferle, 2001a).

The industrial revolution was accompanied by an energetic transition that profoundly altered the situation described above. The growing use of coal (and, later, of oil) through new converters meant that obtaining energy no longer depended directly on the solar flow, but made use of the reserves stored in the earth's crust for millions of years. The result was an exponential growth of the energy available, which, added to new technical and organizational changes, allowed the generation of manufactures and new materials on a much greater scale (Debeir et al., 1991). In this new economic system, it seems obvious that the role of wood had to change. But, what happened to its consumption from then on? Perhaps because it was a traditional raw material, wood has aroused little interest among students of industrialization. Even those historians concerned with the changes in the use of resources are ambiguous about what happened with wood. For example, Wrigley (1988, p. 32) points out that the new system greatly reduced dependence on organic raw materials, and Sieferle (2001b, pp. 48–49) affirms that forested areas could be “liberated” and dedicated to other uses thanks to the use of fossil fuels. But, does this mean that the consumption of wood fell as industrialization expanded? Would it be possible to speak, thus, of a kind of wood “decoupling”, of the type that some authors (Malenbaum, 1978) have suggested in the cases of certain minerals, in recent times?

In contrast to this possibility, some elements allow us to think that the use of wood continued to grow with industrialization. On one hand, if we take into account some of the papers that have analyzed long-run energy consumption, including traditional energies (Kander, 2002; Rubio, 2005; Gales et al., *in press*), it can be argued that, at least until the Second World War, fossil energies did not necessarily substitute traditional energy from wood but were, rather, superimposed on the latter, even though the use of coal and, later, of oil reached much higher levels. On the other hand, although the use of materials like iron, steel and concrete grew considerably with industrialization, this does not necessarily mean that wood ceased to have an important function as a raw material. Indeed, we know that some paradigmatic elements of industrialization, like mining or railroad building, consumed huge quantities of wood. Furthermore, the improvements in the transport systems allowed wood to be transported further and more cheaply and fomented the trade of many other products that required wood in their crating and packaging. Finally, from the end of the nineteenth century, technological change permitted the use of wood as the raw material for the manufacture of wood pulp, textile fibers and chemical products.

As far as we know, no paper has investigated this question systematically by studying the uses that wood gradually lost and those that were maintained or increased. For this reason, in this paper we present a case study based on the Spanish economy that offers some interesting clues. We argue that industrialization transformed the uses of wood and though its importance per unit of GDP decreased, its overall consumption increased, generating greater pressure on forests at an international level. To test this hypothesis, in Section 2 we describe how we have constructed the series of wood consumption in Spain and the exercises we have carried out with them; in Section 3 we present the main results; in Section 4 we discuss the lower dependence of the Spanish economy on wood, we pose some questions about the “liberation” of forest areas that may have occurred in Spain as a result of industrialization and we also discuss the extent to which the results observed in the Spanish case can be extended to the international level; Section 5 presents the main conclusions.

## 2. Measuring wood consumption in Spain

From the nineteenth century, the Spanish economy started a “modern economic growth” in the way described by Kuznets (1973). Both the population and the GDP per habitant grew, and this growth was accompanied by a structural change in which the industrial sector increased its importance. Spanish industry occupied a modest position in the world ranking, but the growth rates of the Spanish industrial production index were similar to those registered by other European countries. Indeed, for the period after the First World War, they were even higher than those obtained by the most industrialized countries of Europe (Carreras and Tafunell, 2005; Prados, 2004; Nadal, 2003). The Spanish economy also started its energetic transition. Between 1830 and 1910 the consumption of coal increased fourfold. From the end of the nineteenth century, hydroelectric power became more and more important and it represented more than one-fifth of the gross energy consumption in 1933. Taken as a whole, the total quantity of modern energies used by the Spanish economy was far from that achieved by the most industrialized countries, but it was in tune with that of other Mediterranean “late comers”, like Italy (Sudria, 1995).

It should be pointed out that just as Spain was not a big consumer of fossil energy, neither was it a great consumer of wood. This fits in with the idea proposed by Malanima (2003) about the lower energy consumption of the Southern European countries, but can be extended to the non-energetical uses of wood. In fact, data available for the first third of the twentieth century place the consumption of wood per inhabitant in Spain among the lowest in the Western world (Lleó, 1929). This situation, shared with other Mediterranean countries, can be explained by two complementary factors. On the one hand, pressure on resources since ancient times had reduced the forested areas in many Mediterranean regions (McNeill, 1992) in a process which could have greater incidence in some regions of Spain due to the agrarian changes of the nineteenth century (Cussó et al., 2006a). On the other, the characteristics of the Mediterranean climate give rise to a particular type of forest in which wood does not

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