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On the use of palynological data in economic history: New methods and an application to agricultural output in Central Europe, 0–2000 AD

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Abstract

In this paper we introduce a new source of data to economic history: palynological data or, in other words, information about pollen grains which are preserved in the bottom sediments of various water basins. We discuss how this data is collected and how it should be interpreted; develop new methods for aggregating this information into regional trends in agricultural output; construct an extensive dataset with a large number of pollen sites from Central Europe; and use our methods to study the economic history of Greater Poland, Lesser Poland, Bohemia, Brandenburg, and Lower Saxony since the first century AD.

Keywords: Agricultural production; Biological measures of economic history; Central Europe; Palynological data; Vegetation history
JEL classification: C82; N50; N53; N93; Q19

Economic historians are often interested in studying the dynamics of human activity over the very long term.[1] However, data about the past is inherently scarce and many interesting questions, especially about the pre-modern era, cannot be answered. As noted by Steckel (2013), "economic historians are left with surviving scraps of evidence, often collected for other purposes". As a consequence, various researchers aim to collect and analyze data from non-standard sources which could serve as a proxy for human activity. For example, skeletal remains are now routinely used as a source of data about the evolution of human health (Steckel, 2003, 2008, 2013; Koepke and Baten, 2005, 2008). Other "biological measures of economic history", namely mortality rates, stature, and body mass index, are also used to study shorter time periods.[2]

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[1] Similar questions are also of interest to growth theorists. For example, Galor and Weil (2000) and Galor and Moav (2002) develop a unified growth theory which is intended to capture varying patterns of stagnation and growth over the entire course of human history. Related contributions include Goodfriend and McDermott (1995), Acemoglu and Zilibotti (1997), Kelly (2001), Kögel and Prskawetz (2001), Hansen and Prescott (2002), and Lagerlöf (2003).

[2] See, for example, Voth and Leunig (1996), Baten and Murray (2000), Komlos et al. (2003), Komlos (2007), Baten et al. (2010), Brainerd (2010), and Austin et al. (2012) for recent applications.

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In this paper we introduce palynological data as an alternative "biological measure" which can also serve as a useful proxy for human activity. Various plants produce pollen grains and spores which then accumulate in the bottom sediments of lakes and other water basins. Palynologists extract sediment cores from the floors of lakes, establish a chronology of layers of sediments, and count pollen grains of various plant taxa within each layer. Selected taxa – especially *Cerealia* (cereals) – are generally regarded as anthropogenic indicators, and variations in their relative presence can be interpreted as variations in human activity (Behre, 1981; Feeser and Furholt, 2014; Lechterbeck et al., 2014; Woodbridge et al., 2014). However, most of the palynological literature focuses on local phenomena (a single site or several sites in close proximity to one another) which are arguably of limited interest to economic historians.[3] Therefore, we develop new methods of aggregating palynological data into regional trends. Our methods take into account both the geographical distribution of pollen sites and the chronological distributions of core samples which can (and do) differ between these sites. Moreover, we use cross validation to determine the optimal structure of penalties for spatial distance and time distance. We then use our methods to study long-term variation in agricultural output in Central Europe during the last two millennia.

Our paper is thereby related to an important field of research in economic history which studies trends in agricultural production and productivity. Notable contributions to this field include Clark (1991), O'Brien and Prados de la Escosura (1992), Allen (2000), Olmstead and Rhode (2002), Federico and Malanima (2004), Allen (2009), Campbell and Ó Gráda (2011), Kelly and Ó Gráda (2013), and many others. The advantage of our approach is that it significantly extends the timespan of analysis. While most of these previous studies are restricted to several centuries or less, our paper investigates regional trends in agricultural output in Greater Poland, Lesser Poland, Bohemia, Brandenburg, and Lower Saxony since the first century AD. The disadvantage of our results, however, is that they cannot be transformed into common measures of amount of land under cultivation and output per unit of land. On the contrary, these results are inherently relative, and are only suggestive of the relative importance of various plant taxa in the vegetation of a given region. Clearly, each source of data has its own limitations; our intention is therefore to increase the number of alternative sources available to economic historians.

Background

Nature has its own archive, where information from its past is stored in the form of sediment which accumulates over millennia. Among these archives, lakes and marshes preserve material from the most recent periods. In particular, lakebed and peat sediments, accumulated every year, contain pollen grains produced by the surrounding vegetation. This pollen signal reflects the spatial structure of vegetation around a lake or marsh in a given period, and the radius which delineates the relevant area can vary from less than one kilometer to dozens of kilometers, depending on the plant in question (Sugita, 1993; Gaillard et al., 2008; Hellman et al., 2009). The task of palynology is to retrieve and analyze this material, so that one can reconstruct the past environment around a given site.[4]

The first step is to extract a core sample from a lakebed or peat accumulation. Sediment cores of an appropriate length (often several meters) are brought to laboratories, where pollen samples for microscope analyses, and organic material for radiocarbon dating, are collected at regular intervals (usually a few centimeters). Then, pollen grains from each sample are identified and counted, and this procedure results in the creation of a dataset with counts of pollen grains from different plants or plant groups. Each of these plants or plant groups is typically referred to as a *taxon* (pl. *taxa*), since for some plants it is possible to identify the exact species while, in other cases, only a genus or family can be identified. Palynologists never count all the pollen grains in a sample, and usually restrict their attention to a subsample of 500–1500 grains which is believed to provide representative information on the proportions of pollen grains in a sample.

Such a dataset has only an ordinal chronology which is based on the actual core depths of subsequent samples. However, there are several methods of constructing an absolute chronology for this data. Typically, radiocarbon dating is applied to organic material from a selection of core depths. Once these dates are known, it is possible

[3] To the best of our knowledge, there exists only one paper in the economic literature which analyzes palynological data. Namely, Hanley et al. (2009) study economic determinants of long-run biodiversity change, and they use pollen data to construct their measure of diversity. Therefore, they do not use pollen data to approximate actual human activity, while this is the approach which we take in this paper. On the other hand, there exists an established tradition in landscape archeology to use palynological data in studies of human impact on the environment. See, for example, Williamson (2004), Bakker et al. (2012), Kadrow and Włodarczak (2013), and Kaptijn et al. (2013).

[4] A good introduction to palynology for historians is provided by Eastwood (2005). See also methodological discussions in Vermoere (2004) and Izdebski (2013).