CHURCH BUILDING AND THE ECONOMY DURING EUROPE'S 'AGE OF THE CATHEDRALS', 700-1500[1]

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Abstract

This paper presents new data on the construction history of about 1,100 major churches in Western Europe between 700 and 1500 CE. The idea is that church building can be seen as an index of economic activity, reflecting confidence in the future, command of substantial ecclesiastical revenues, mobilisation of large teams of construction workers, and an ability to assemble impressive quantities of building materials at a single site, with the wider economic multiplier effects that this entailed. In a pious age, Church reform, monastic foundation and advancing architectural technology helped kick-start and then lend momentum to the process. Whether so much conspicuous construction activity was beneficial to or a burden upon Christendom's relatively poor and under-developed economy can be debated. What is clear is that churches, like the books and manuscripts produced in the same period, are artefacts that can be quantified. Whereas hard data are lacking for many other aspects of economic activity, at least before 1250, research by generations of architectural historians means that much is known about the construction history of individual churches, commencing with their original foundation. Putting this information together provides estimates of the ecclesiastical building industry for a number of European countries, currently Switzerland, Germany, France, the Low Countries and England but potentially extending to the whole of Latin Christendom. The results shed fresh light on the onset, scale, spatial dimensions and duration of the great economic boom that got under way sometime after 1000 and corresponding features of the long contraction then set in train during the fourteenth century.

[1] Duby, Georges (1976), *Le temps des cathédrales: l'art et la société (980-1420)*, Paris.

I Church building as a proxy index of economic activity

Knowledge of the economic history of Europe in the centuries before the Industrial Revolution has advanced greatly in recent decades thanks to the systematic construction and analysis of time series of prices, wages, state finances and other indices of economic activity.[2] This includes pioneering work on the estimation of national incomes.[3] Progress has nevertheless been greater for the period after than before 1300, for the simple reason that quantifiable data are far more available from that date onwards. Progressively from the thirteenth century rising literacy levels, spread of the use of parchment and paper, and the institutionalisation of states, communes and organisations linked to the Church promoted the creation and preservation of written records.[4] Before these developments, documentary sources remain scarce, thereby hindering quantitative investigation of the European economy as it entered a more dynamic phase sometime between the tenth and the twelfth centuries. Without systematic information on prices and wages, taxes and tolls, tenants and tenancies, harvests and tithes, or the income and expenditure of states or cities, it is difficult to bring greater precision to bear upon essentially qualitative accounts of this formative phase of economic development when Europe's 'commercial revolution' was in full swing.[5]

The relative backwardness and stagnation of Western Europe's economy in the ninth and tenth centuries is conspicuous. Political fragmentation had resulted from collapse of the Carolingian Empire in combination with

[2] John H. Munro (no date), 'The Phelps Brown and Hopkins "basket of consumables" commodity price series and craftsmen's wage series, 1264-1700: revised by John H. Munro', http://www.economics.utoronto.ca/munro5/ResearchData.html; Global Price and Income History Group, http://gpih.ucdavis.edu; European State Finances Database: http://www.esfdb.org; Robert C. Allen (2009), *The British industrial revolution in global perspective*, Cambridge; Jan Luiten van Zanden (2009), *The long road to the industrial revolution: the European economy in a global perspective, 1000-1800*, Leiden and Boston.

[3] Carlos Álvarez-Nogal and Leandro Prados de la Escosura (2013), 'The rise and fall of Spain (1270–1850)', *Economic History Review*, 66 (1), 1-37; Jutta Bolt, and Jan Luiten van Zanden (2014), 'The Maddison Project: collaborative research on historical national accounts', *Economic History Review* 67 (3), 627-51; Stephen N. Broadberry, Bruce M. S. Campbell, Alex Klein, Bas van Leeuwen, and Mark Overton (2015), *British economic growth 1270-1870*, Cambridge; Jan Luiten van Zanden and Bas van Leeuwen (2012), 'Persistent but not consistent: the growth of national income in Holland 1347–1807', *Explorations in Economic History* 49 (2), 119-30.

[4] Michael T. Clanchy (1979), *From memory to written record: England 1066-1307*, London; Richard H. Britnell (1997), *Pragmatic literacy, east and west, 1200-1330*, Woodbridge; Joerg Baten and Jan Luiten Van Zanden (2008), 'Book production and the onset of modern economic growth', *Journal of Economic Growth* 13 (3), 217-35.

[5] Robert S. Lopez (1971), *The commercial revolution of the Middle Ages, 950-1350*, Englewood Cliffs; Bruce M. S. Campbell (2016), *The Great Transition: climate, disease and society in the late-medieval world*, Cambridge, 85-130.

assaults by Vikings in the north and west, Magyars and Slavs in the east and Muslims in the south. With the Holy Roman Empire in disarray, papal authority in abeyance and political and military power increasingly personalised, primary production for mostly direct consumption tended to prevail and Europe was reduced to a peripheral and subordinate role in the world economy as witnessed by the dominance of exports by slaves, many of them destined for the then booming Byzantine and Arab economies.[6] It was from this low point, underpinned by an easing of external pressures, revitalisation of the Latin Church and re-establishment of public authority, that sometime after 1000, and with a quickening tempo from 1100, the economy of Western Europe entered an era of sustained efflorescence and changed fundamentally in almost all dimensions.[7] The most obvious outward sign of these developments was the revival, proliferation and growth of towns, first in southern Europe and in central and northern Italy in particular, then increasingly in regions north of the Alps, France, Southern Germany, England and, above all, Flanders.[8] Instrumental in facilitating these developments were the Church reforms initiated by Gregory VII (r. 1073–85).[9] As Michael Mann observes, by establishing normative patterns of behaviour between fellow Christians and imposing an over-arching religious infrastructure, these reforms 'enabled more produce to be traded over longer distances than could usually occur between the domains of such a large number of small, often highly predatory, states and rulers'.[10] In turn, the fruits of progress were invested, and possibly even over invested, in ever grander and more elaborate church buildings.[11] Tracking church construction can therefore shed further valuable light upon when and where the economic upturn began, the pace and extent of its diffusion, and for how long the momentum of progress was sustained.

The chronology of construction of the greatest churches of them all, cathedrals and other major churches provides an obvious starting point for such an endeavour. Research by generations of architectural historians, archaeologists and others has established the detailed construction histories

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[6] MacCormick, *Origins of the European Economy*, pp. 237ff.

[7] Jack A. Goldstone (2002), 'Efflorescences and economic growth in world history: rethinking the "rise of the West" and the industrial revolution', *Journal World History* 13 (2), 323-89; Campbell (2016), 34-6.

[8] Paul Bairoch, Jean Batou and Pierre Chèvre (1988), *The population of European cities from 800 to 1850: data bank and short summary of results*, Geneva; Campbell (2016), 121-5.

[9] Campbell (2016), 66-76.

[10] Michael Mann (1986), *The sources of social power*, I, *A history of power from the beginning to A.D. 1760*, Cambridge (1986), 383.

[11] Richard Morris (1979), *Cathedrals and abbeys of England and Wales: the building Church, 600-1540*, London; Johnson, H. Thomas (1967), 'Cathedral building and the medieval economy', *Explorations in Economic History* 4 (3), 191-210.

of these often-monumental edifices in impressive detail. These data are among the most detailed, precise and comprehensive available for this period. Here value is added to this high-quality information by converting it into a consistent quantitative format capable of aggregation and analysis at regional, national and pan-national scales.

Construction of each church was, of course, the expression of many impulses: religious, political, artistic, and cultural. Construction work was normally sustained over periods of years and decades and hence was a manifestation of confidence, if not faith, in the future based on an optimistic assessment of the future income streams required to bring such ambitious projects to completion. All required enterprise, planning and organisation of a high order, high inputs of capital and labour (both skilled and unskilled), and assemblage of impressive quantities of resources — stone, brick, lime and sand, timber, iron, lead, copper, glass and much else. Each major project was an intrinsically economic undertaking and could have considerable multiplier effects for the wider economy. Since building booms and economic prosperity tend to march together it is the premise of this paper that cathedral building can be used to gauge the progress and buoyancy, or otherwise, of the medieval economy.[12] Technological advance was a fundamental feature of both. Thus, in the 1140s invention of the Gothic style opened up exciting new architectural possibilities which provided a significant boost to the construction industry by inviting the partial or wholesale replacement of existing structures.[13] By quantifying building and rebuilding projects it is possible to establish the significance of this major innovation relative to other factors driving the extended construction boom.

Systematic data on church building is better for some countries than others. The best and most accessible relates to a core bloc of countries comprising Switzerland, Germany, France, the Low Countries and England, all of which, to varying degrees, were active participants in the Italian-led commercial revolution of the twelfth and thirteenth centuries. As this paper demonstrates, all were also active players (and France a leader) in the concurrent cathedral-building boom that characterised these centuries. Section II explains in detail how the database of cathedrals and other large churches has been assembled to yield regional, national and aggregate indices of church construction. Although data have been collected for the

[12] Broadberry et al. (2015), 152-4.

[13] Otto Georg von Simson and Ernst Levy (1988), *The Gothic cathedral: origins of Gothic architecture and the medieval concept of order*, London; Robert A. Scott (2011), *The gothic enterprise: a guide to understanding the medieval cathedral*, Berkeley and Los Angeles.

eight centuries from 700 to 1500 CE, information for the first four centuries is less robust than for the last four due to the more limited availability of sources and because many churches built in those years were replaced by larger structures after 1100, whose fabrics are therefore far better preserved and understood. Spatial and temporal patterns in construction are discussed in Section III. Attention here focuses upon the timing of the initial take off, the slackening of construction activity evident from the late thirteenth century, and the regional divergences that emerged following the Black Death between countries such as England, where ecclesiastical construction activity switched from major churches to parish churches, and others, most notably the Low Countries, where there was an intensification of major building projects after 1350. These findings bear upon the debate about the severity of the fifteenth-century crisis in Western Europe and lead on to a discussion in Section IV about the factors that may account for these contrasting patterns and the nature of the association between church building and economic activity. Section V concludes.

II Quantifying the construction of cathedrals and other large churches in Latin Christendom.

The starting point for our database are the churches with a surface area of over 1,000 square meters contained in OpenStreetMap (OSM), a collaborative project to create a free editable map of the world (OpenStreetMap contributors 2016). Besides the many streets, rivers, and roads that make up a useable map, it also contains the outlines of buildings, including churches. Using the Overpass API the maps were queried for all buildings marked as a cathedral, church or chapel, or amenities marked as a place of worship in 10 by 10 km rectangles around city centres.[14] These centres were taken from the Baghdad to London dataset (Bosker et al. 2013), which has been revised and expanded to include settlements with 5.000–10.000 inhabitants at any time between 800 and 1800 or with more than 100,000 inhabitants in the year 2000 (the original dataset contained only settlements with more than 10.000 inhabitants between 800 and 1800). In our research area covering France, Switzerland, Belgium, Luxembourg, the Netherlands, Germany, and Britain, this amounted to 801 settlements out of the database's total of 2,018 settlements. To make sure that the coordinates of the settlements contained in the Baghdad to London dataset were accurately centered on their medieval core, the coordinates were checked

[14] Overpass API: <http://overpass-api.de/api/>. Replication files for the creation of the database at <https://github.com/rijpma/cathedrals>.

using the Google geocoding API.[15] The result of this exercise is a spatial database of polygons representing church building outlines, together with their location and some basic information.[16] The ground surface of all these churches was calculated from the polygons (Hijmans 2015).

This database is still a long way from a database that can reveal developments over the medieval periods. Besides medieval churches, it also includes churches that were built or modified after the Middle Ages. Moreover, it only shows each church as it has survived to today, not its development over time. To address this, building histories of the churches were gathered from a number of sources (see below). Nevertheless, the scale of the task meant it was not feasible to unravel building histories for all European churches obtained from OSM. Data from France suggested this would have involved approximately 22.000 churches for our seven countries. Analysis was therefore limited to churches where the surface area of the place of worship of the ecclesiastical complex in question around the year 2015 exceeded 1,000 m^2. By concentrating our efforts on these places of worship we hope to find that fraction of the ecclesiastical real estate that because of its size and cost will have been more relevant for a medieval town economically than its numerous smaller chapels or lesser parish churches. Another selection criterion was that the church in question had to have been built before 1500. We started the study period with the year 700, because this was the starting point of our population data and stopped just before the arrival of Protestantism began to impact upon the amount of church building and scale of places of worship. Where more detailed information was lacking, we generally worked with time windows of one century because our population data of cities are structured similarly.

The starting point for the building history of each church was the lemma of the church in question in Wikipedia (in the language of the country concerned, as well as in French, English or German when available). For the Belgian, Luxembourg, French and Swiss churches we also consulted the various volumes of the *Dictionnaire des Églises de France, Belgique, Luxembourg, Suisse* (1966–71), which describes the building history of thousands of French, Belgian, Luxembourg and Swiss churches. For Dutch churches this information has been found in *Kunstreisboek voor Nederland* (Don 1985). For Belgian, Dutch and German churches we also relied on the two volumes of Kubach and Verbeek (1976), Oswald et al. (1966, 1968, 1971) and Jacobsen et al. (1991). For French, German and British churches we

[15] <http://maps.googleapis.com/maps/api/geocode/json?address=>
[16] A typical example of the information about a church contained in our data: <http://www.openstreetmap.org/way/28809723>.

found information in Binding (2000). Supplementary information on the building histories of British churches has been found in Morris (1979), and by georeferencing the churches from OSM to the Designation data from the National Heritage List for England.[17]

When precise dates were mentioned for the building history of a church these have of course been used. However, sources were often vague about the dates of a building phase of a church. When it was attributed to a whole century *c* we coded its dates as spanning the whole period, from (*c* – 1)00 to (*c*)00. We coded building at the beginning of a century as (*c* – 1)20 and building at the end of a century as (*c* - *1*)80. The middle of century *c* is (*c* - *1*)50, and so forth.

The (external) horizontal surface areas, in square meters, of the churches were derived from the groundplans of OSM, as described above. These figures were rounded off to 100s of square meters, because the derivation of the historical surface area of a church is necessarily a crude estimate. In the year when the building of a church started from scratch (because either there was no predecessor or it had been totally destroyed), its surface area was classified as zero m^2 in our database. Additional building campaigns adding to an already existing place of worship begin with a year with a blank surface area and end with the final year of that specific building campaign in our database, which also contains the added surface area in m^2 to the church in question.

What we end up with is a database of church construction phases, with the start and end year and how much surface area or height was added to the church. Of course, the surface area of a church preceding the one in OSM is not directly known to us. When a previous version of a church was mentioned in one of the written or electronic sources (with some building date or a date of its destruction) but without specifying the size of the church, we assumed it – as a rule of thumb – to have been 0.53 times the surface area of its successor.[18] This ratio has been estimated from a dataset of 140 churches for which detailed information on the preceding church

[17] Specifically, <https://services.historicengland.org.uk/NMRDataDownload/default.aspx> was used to create links to listed buildings entries at https://historicengland.org.uk/listing/the-list/. The same was done for Scotland using the data provided by the Historic Environment Scotland Portal at <http://portal.historicenvironment.scot/spatialdownloads/listedbuildings> to create links to buildings at <http://portal.historicenvironment.scot/designations>. For Wales no dataset was available for georeferencing, so links to maps have been created from the coordinates in the OpenStreetMaps data to the Historic Wales portal <http://historicwales.gov.uk/#zoom=7>.

[18] Half the surface area may seem a substantial decrease, but one already gets half the surface area with a structure that is only 29% smaller both lengthwise and breadthwise.

buildings is known, based on Wikipedia, Oswald et al. (1966, 1968, 1971), Kubach and Verbeek (1976) and Jacobsen et al. (2001).

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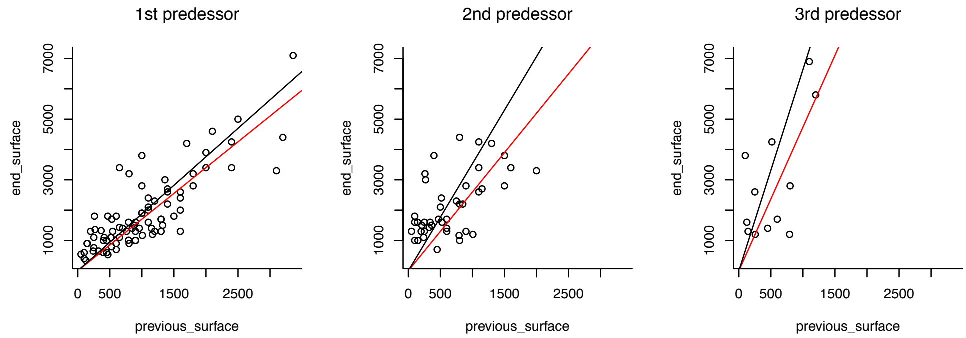

Figure 1. *Relation between ground surface of predecessor and of final churches. Black line (top) gives the overall 0.53 relation, red lines (bottom) the OLS fit*

We stopped applying the rule of thumb that a previous church had approximately half the surface area (× 0.53) of its successor, just before the resulting surface area of the church in question would have become lower than a threshold value estimated from the data contained in *TCCG*. Table 1 provides the average excavated surface area of a regular parish church and that of a typical parish church in a metropole by century for the period 700 to 1200,. Table 1 also gives the surface areas of excavated cathedrals, whether or not within a metropole.

year	700	800	900	1000	1100	1200
Church type:						
Parish churches (within bishoprics)	236	236	322	311	369	482
Parish churches (in metropoles)	1,231	1,172	1,247	1,227	1,227	1,144
Cathedrals (within bishoprics)	583	645	682	682	682	828
Cathedrals (in metropoles)	2,060	2,440	2,550	2,329	2,329	2,514

Table 1. *Average surface area in square meters of an excavated place of worship dating to the year mentioned. (Source: TCCG, N=42).*

At the very least, the cost of constructing a church was not only determined by its surface area, but also by the height of the nave of the church. With this information we can approximate the volume of the church or, alternatively, the surface area of the entire building as a cube (Johnson 1967). If one were to visit each church separately and do all the necessary measurements (James 1972, 1989), the current total volume of the parts (nave, choir, chapels, towers, spire, etc.) together forming a church could be measured with a high level of precision. For our historical estimation of sizes of preceding (and now often largely vanished) churches, such measurements are possible. We therefore have to skip the rest of the building (such as towers, spires, chapels, etc.) and approximate the total volume of a church (as a proxy for its unknown building cost) as the multiplication of its horizontal surface area with its nave height. When this nave height was reported in one of the sources this was the value included in the database. For 151 medieval churches we have data on the actual height (H) of their naves and their surface areas (A). Figure 2 shows these have a reasonable relationship ($R^2 = 0.69$) which translates into $H = 0.45*\sqrt{A}$. When no nave height was reported, its value was approximated by using the above relationship to find H from A.

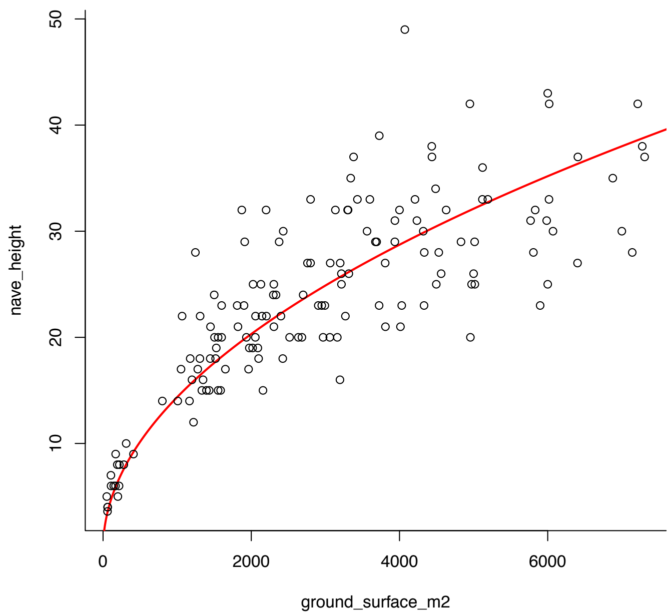

Figure 2. *Nave height (H) and ground surface (A) of 151 churches in our database with fitted regression line ($H = 0.45*\sqrt{A}$).*

The database contains 2,107 observations of construction phases that are estimated directly using a still-visible ground plan and 2,528 that are estimated using the rule of thumb, while their corresponding building dates were found in electronic or written sources concerning the church in question.

Country	Cities	Cities w. church	Total churches	Phases all	Phases pre-1000	Phases pre-1200
Be	58	45	98	380	48	158
Ch	15	12	24	104	25	55
De	226	162	359	1474	230	609
Fr	308	239	448	2105	549	1183
Nl	47	32	55	200	11	35
UK	147	68	88	372	64	190
Total	801	558	1072	4635	927	2230

Table 2. Overview of the dataset by present-day country: number of cities in expanded Baghdad-to-London data, cities which have at least one church, total number of churches, and total number of building phases (all, pre-1000, pre-1200) in our database.

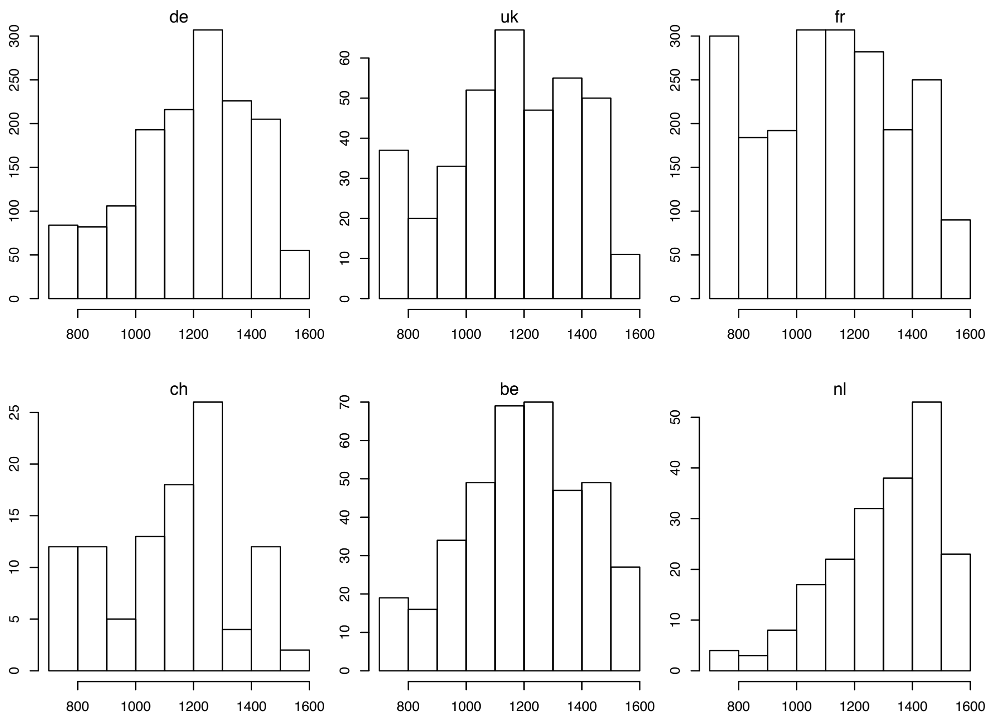

Figure 3. Distribution of building phases over time, by country.

One possible concern about our data is that it has a bias towards today's Catholic regions because conventual churches destroyed at the Reformation do not show up in our OSM starting point. This is more likely to understate the scale of pre-Reformation church building in England than in the Netherlands, where the wave of pre-1300 monastic foundation was less pronounced. Some Dutch monastic churches did indeed end up at the disposal of the cities and were demolished. Many, however, remained intact and were converted to Protestant worship (Van Beeck Calkoen 1910). A few also survived and were adapted to other uses. Unlike England, post-Reformation losses in the Netherlands were therefore relatively small.

To check the quality of our data we compare it to the data gathered by John James (1972, 1989).[19] He has surveyed Gothic churches built between 1060 and 1250 in the Paris Basin and made estimates of the costs of more than 1,500 churches constructed in this period. This dataset is comprehensive, covering all surviving churches built at that time in this region, which allows us to find out the effects of our urban focus on the representativeness of our sample. We make three comparisons. First, we have directly matched some of the churches in James' dataset against churches in our OSM-dataset based on a distance criterion (figure 4). Because many of the churches James surveyed were rural and were not restricted to churches larger than 1.000 m^2, this comparison is based on a limited number of churches. To alleviate this, our second comparison looks the total costs per decade implied by James' measurements with a series of total construction from our database in the Paris Basin in the same period (figure 5). Finally, we also split James' data in two depending on whether we were able to match the church to our data to see whether our sample of churches is different from the broader sample collected by James regardless of measurement method or differences in time window.

[19] James' database can be consulted at <http://creationofgothic.org>.

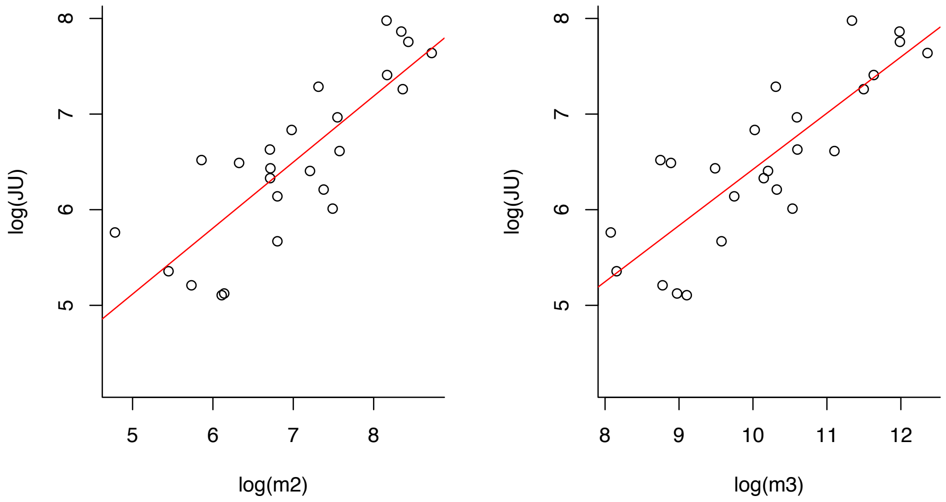

Figure 4. *Cost estimates compared with squared (left panel) and cubic (right panel) metres of churches built between 1060 and 1250 in the Basin de Paris.*

James created his own measure for the costs involved in constructing the churches he included in his dataset, whereas our measures for estimating output are the built area and volume measured in square and cubic metres. Nonetheless, in all comparisons, there is a clear positive relation between James's estimates and ours. However, there is a lot of noise as well, especially in the direct comparison with OSM. There are a number of explanations for this. For one, there are cases where only Gothic parts of an otherwise non-Gothic church were included by James (e.g. St Basile in Étampes). Finally, the matching was done automatically based on a distance criterion, which means some of the matches might be spurious while other true matches are missed. Clearly, James's approach of surveying each building in detail will lead to very accurate results. Our method, however, provides a good approximation and has the great merit that it can be scaled up to larger geographical areas.

Comparing James's data with our results also makes it possible to find out how representative the large churches included in our dataset are for the total construction activity of all churches as measured by James. As Figure 5 indeed shows, both series (our sample of large churches and all churches included in James's work) behave very similarly. The correlation between the two series is also very high: 0.94 (and 0.71 when looking at first differences). This is an important result: while our sample is based on urban churches, it nonetheless seems representative of developments in a wider area.

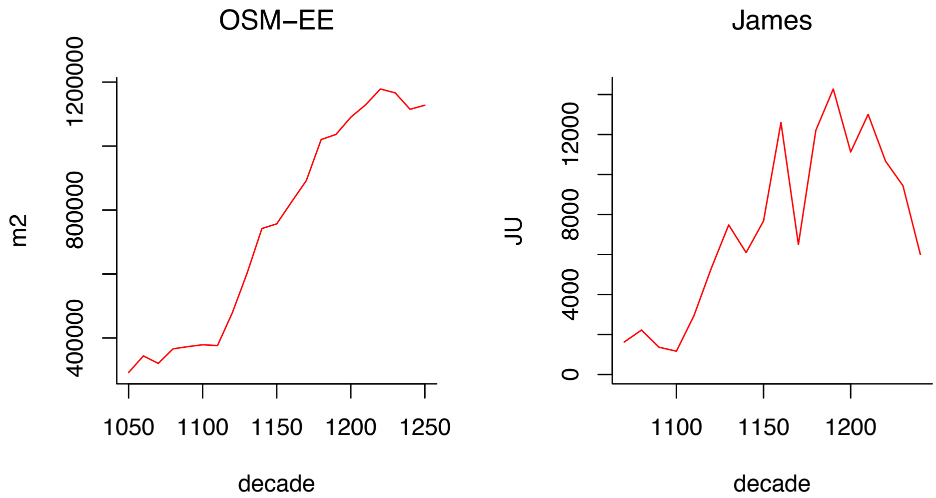

Figure 5. *Comparison of square meters of church building in our data (left panel) with James' estimates of construction costs (right panel), 1050–1250.*

Figure 6 presents the comparison of James' estimates of the construction costs of churches that are in our database to all the churches surveyed by him. The overall trends in total construction costs are very similar and show that our sample of churches is representative of overall developments in the Paris Basin (correlation 0.91; correlation of first difference 0.71). Moreover, this comparison also shows that the large number of rural churches means we could only match three per cent of James's churches, our focus on large urban churches does capture 23 per cent of the total building activity in the area between 1050–1250.

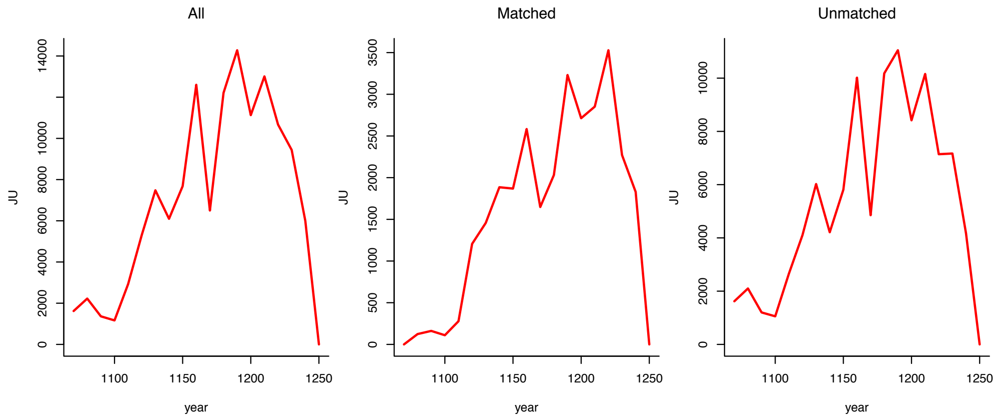

Figure 6. *Comparison of James' estimates of total construction costs of all, matched, and unmatched churches in the Paris Basin, 1050–1250.*

III Chronological and spatial patterns of church construction

Let us start with the 'big picture', the development of church building in Western Europe (the sum of BE, CH, DE, FR, NL, and UK) between 700 and 1500 (Figure 7).

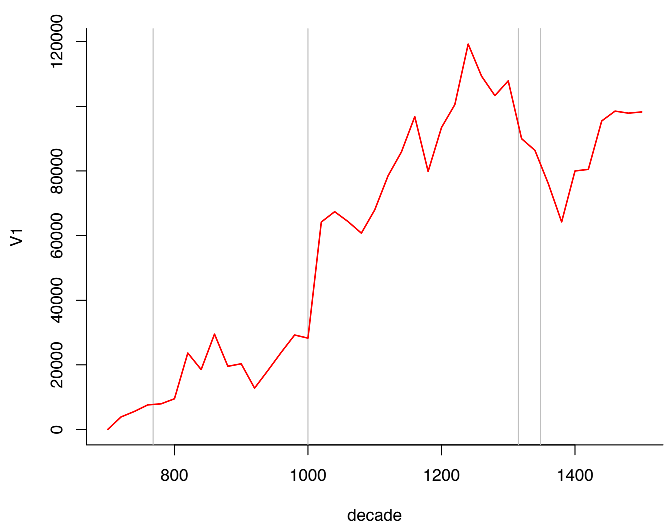

Figure 7. *Church building in Western Europe, in m² per period of 20 years. Reference lines at 768, 1000, 1315 and, 1348.*

The first impression conveyed by Figure 7 is that there was indeed a big boom in church construction in the High Middle Ages – between 1000 and 1300 building activity grew spectacularly from low levels (about 20,000 m² per period of twenty years) to six times that level at the peak of the 1220s/30s. The Carolingian Renaissance clearly shows up in the estimates: between the 780s and 860s the level of activity is higher than before and there is a real decline of construction until the first decades of the tenth century. The Ottonian Renaissance (c 950-1000) can also be identified as a period of – still modest – growth. However, the real break occurs around the year 1000, when church building suddenly surged. This growth spurt is well-known from the literature. At the time, the monk Glaber, working in Dijon and Cluny, commented that 'on the threshold of the aforesaid thousandth year' every nation of Christendom was rivalling with other nations in building new churches, cladding itself everywhere in a white mantle of churches' (see Hiscock 2003; Landes 2003). With the boom around the year 1000 the 'big wave' of the High Middle Ages starts, which continues, with some ups and downs, until the 1220s (when the absolute peak in construction activity occurs), or until the 1280s, as until the end of the thirteenth century activity levels remained very high. But from the 1280/90s – half a century before Black Death - a strong decline sets in, consistent with Campbell's (2016) findings for Britain (and the international economy), which lasts until the 1360s. After the shock of the Black Death has been 'digested', a strong recovery began, which brought output levels back to almost those of the best years of the thirteenth century. However, as we will see below, this recovery after the 1360s was very unequally spread over the study area.

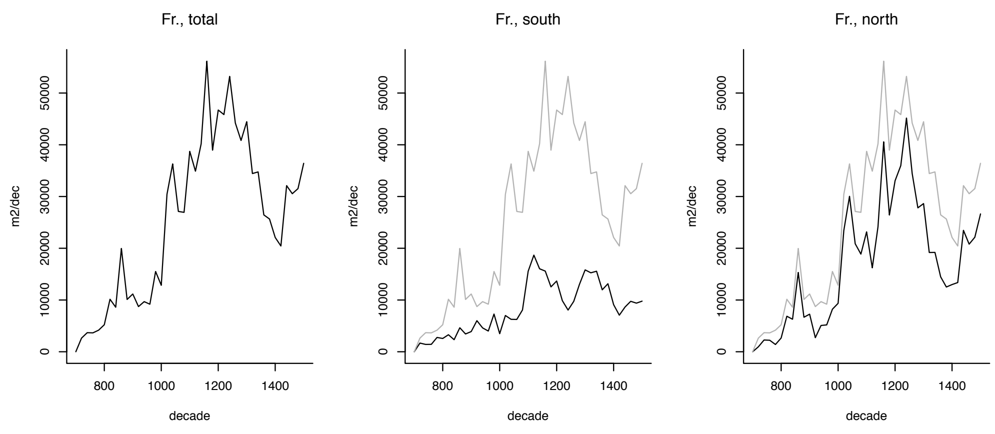

Figure 8. *Church construction in square metres by 20-year period in France. Additional superimposed line for France total in gray.*

We will now review trends in the various countries (using contemporary boundaries). The larger countries France, Germany and the United

Kingdom, are split in two, to expose any differences in pattern between their southern and northern parts (they are split, rather arbitrarily, at a latitude which divides the country into two more or less equal parts: FR at 46, DE at 50.5 and the UK at 53 degrees).

It is probably no surprise that of all regions in Western Europe, northern France shows a pattern of growth and contraction that is closest to that of Western Europe as a whole. In particular, all four cycles of growth can be identified in the north: the Carolingian cycle, the eleventh century 'Romanesque' cycle, the twelfth/early thirteenth century 'Gothic' cycle, and a fourth cycle in the fifteenth century. Also evident is the recovery after the sharp decline during the bleak years of the 1320s to 1380s. What strikes perhaps most in figure 8 is that whereas the north of France follows this Western European growth pattern closely, the south appears to have been affected by very different influences. The Carolingian peak is clearly stronger in the north than in the south, where it is hardly visible. The sudden building frenzy in the north at about 1000 has no counterpart in the south, where expansion only began after about 1060. In the north renewed growth started in the 1120s, giving birth to the Gothic style in the 1140s, which, in turn, helped sustain expansion into the next century. But in the south construction activity declined until the 1240s, after which a recovery set in which lasted until the 1320s. Yet in the north construction activity was declining from the mid-thirteenth century and this trend was not reversed until the mid-fifteenth century, when ending of the Hundred Years War triggered a belated building boom. That boom was more muted in the south, which had been spared the worst of these hostilities.

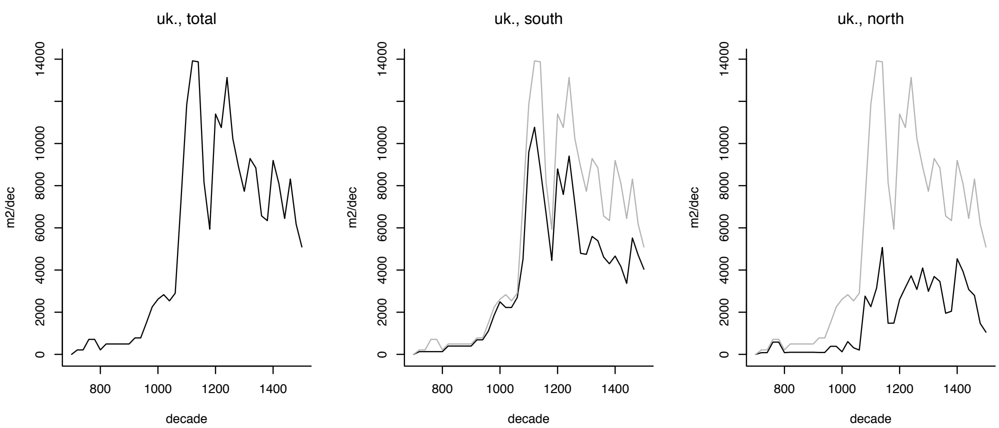

Figure 9. *Church construction in square metres by 20-year period in Britain. Additional superimposed line for Britain-total in gray.*

The UK shows a different pattern (figure 9). As it did not belong to the Holy Roman Empire there was no Carolingian Renaissance. Southern Britain showed a modest growth in construction activity during the second half of the 10th century, but there was no 'year 1000' boom. Instead. the big jump in church building happened between the 1060s and 1100s, directly following the Norman Conquest of 1066. This growth spurt affected the whole of England but was most dramatic in the south. Here, the first phase of growth (1060-1100) was followed in the early decades of the 12th century by another. Nevertheless, the peak in activity at about 1100 was so extreme that it was never surpassed. Building activity abated in the 1160s but then picked up following introduction of the Gothic style in the closing decades of the twelfth century without recovering to the levels of the post-1066 peak. In the south high levels of activity ended in the 1220s, when a downturn set in that lasted until the middle decades of the fifteenth century. Activity in the north was less variable. The downturn of the mid-fourteenth century associated with the Black Death and Scottish wars was followed by a modest recovery but construction activity then contracted during most of the fifteenth century.

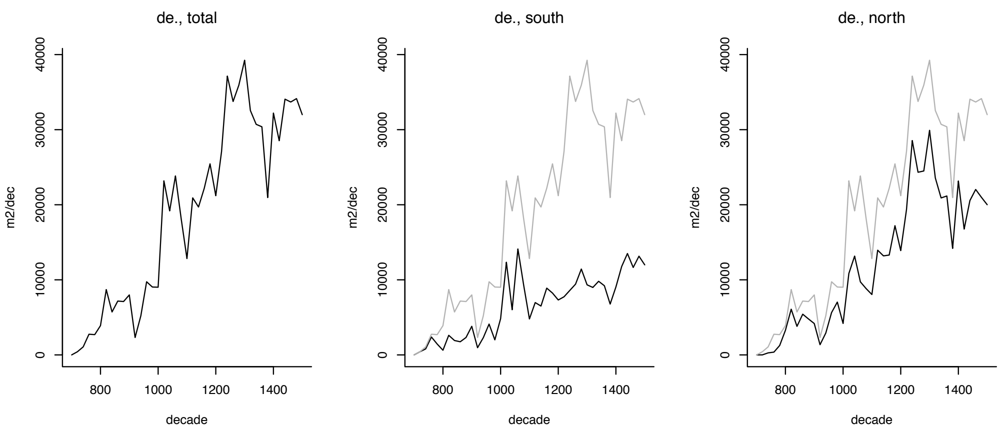

Figure 10. *Church construction in square metres by 20-year period in Germany. Superimposed line for Germany-total in gray.*

Germany – and in particular the northern part of it – experienced a clear Carolingian building boom, followed by decline around 900, and recovery after 950 (Figure 10). Here too, the '1000 boom' was marked in both parts of the empire but was not sustained after c 1080. Construction activity picked up after 1100 (again before the spread of the Gothic style) and this new phase of growth was particularly strong in the north. The climax in the 1280s occurred later than elsewhere in Western Europe, and the decline which followed was smaller. Recovery from the 1360s was also stronger than in France or England.

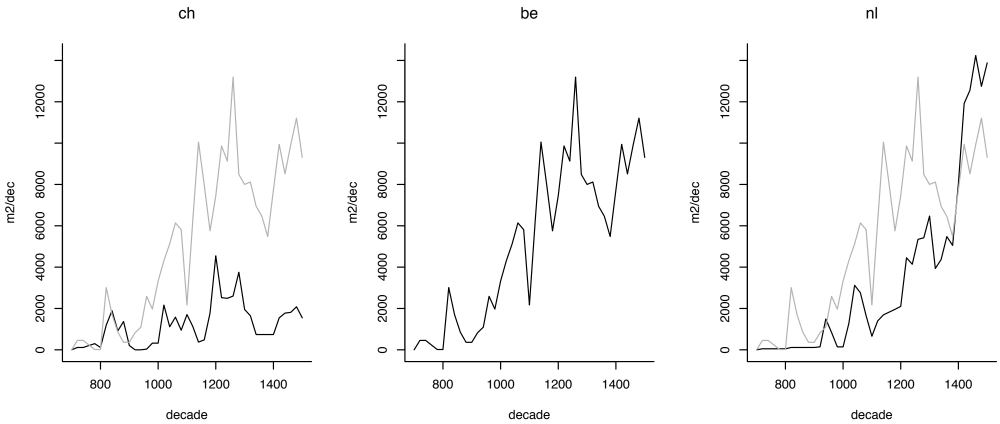

Figure 11. *Church construction in square metres by 20-year period in Switzerland, Belgium and the Netherlands. Superimposed reference for Belgium in gray.*

Finally, each of the three small countries had their own growth paths (figure 11). Switzerland and Belgium, but not the Netherlands, participated in the boom around 800. The Southern Low Countries followed the general European growth pattern quite closely, experiencing an impressive boom in church construction which began in the mid-tenth century and lasted until the mid-thirteenth century. Activity then declined until the 1360s, after which an impressive recovery set in. In contrast, the Northern Low Countries only started to build large churches for the first time around 1000. Here there was little interruption to the building boom in the first half of the fourteenth century, and the decade of the Black Death marks the starting point of a spectacular growth phase that continued until the end of the period under study (see Van Bavel and Van Zanden 2004). The booms and busts of these two economies are clearly related to the processes of commercialization and urbanization that started in the Southern Low Countries around 1000 and continued strongly in Brabant and Holland after 1350. No such dramatic change occurred in the third country, Switzerland, where church construction broadly tracked the general Western European trend.

These chronologies of church construction echo wider economic trends and both were powerfully influenced by changing population levels. It therefore makes sense to estimate per capita levels of church construction. Such a measure allows better comparison both between countries and with the European average. The pitfalls of attempting such estimates are obvious. With the possible exception of England after 1086 (Broadberry et al., 2015), available population estimates are subject to large margins of error. Reliance has to be placed on the estimates published by MacEvedy & Jones (1978). These probably underestimate the effect of the Black Death and the other demographic shocks of the first half of the 14th century), but for all their deficiencies, they are the best currently available and are those used in Bosker et al. (2013).

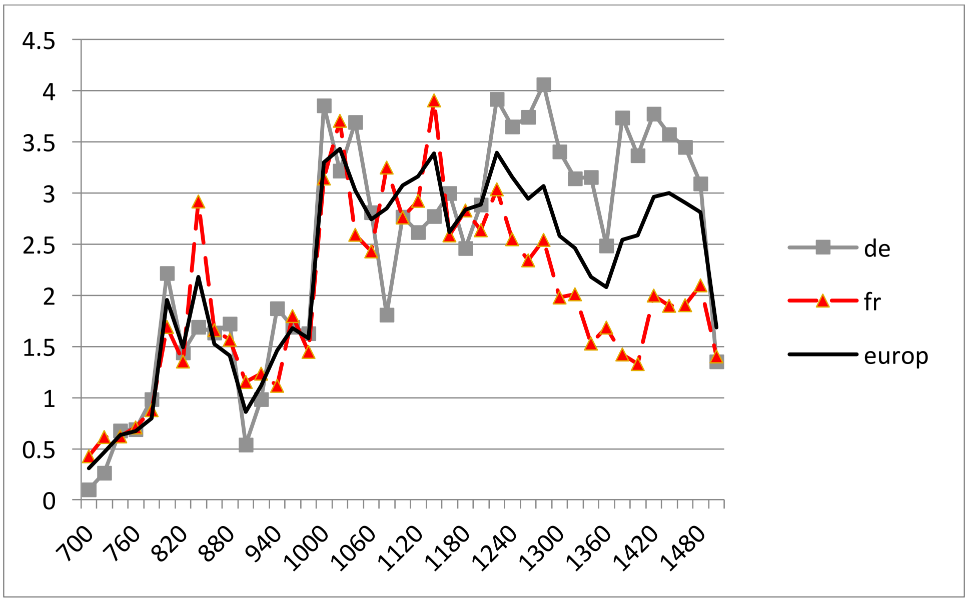

Figure 12. Per capita church construction: Western Europe, France and Germany.

Figure 12 presents the estimates of the per capita values for Western Europe as a whole, compared with France and Germany. There really seems to have been a Western European 'business cycle' in this period, because it is striking how much similarity there is between these three series. Already during the Carolingian era France and Germany appear to have moved in tandem: the '1000 boom' was very similar in both countries, and between 1000 and 1200 both reached a plateau of high levels of per capita construction. After that date, the two countries diverged: output levels began to fall in France, but in Germany there was another rise and decline only set in from the 1280s. For obvious reasons, the two large countries France and Germany largely drove the Western European average, which from the 1220s tracked a mid-course between the rather dramatic decline of France and the more stable pattern found in Germany.

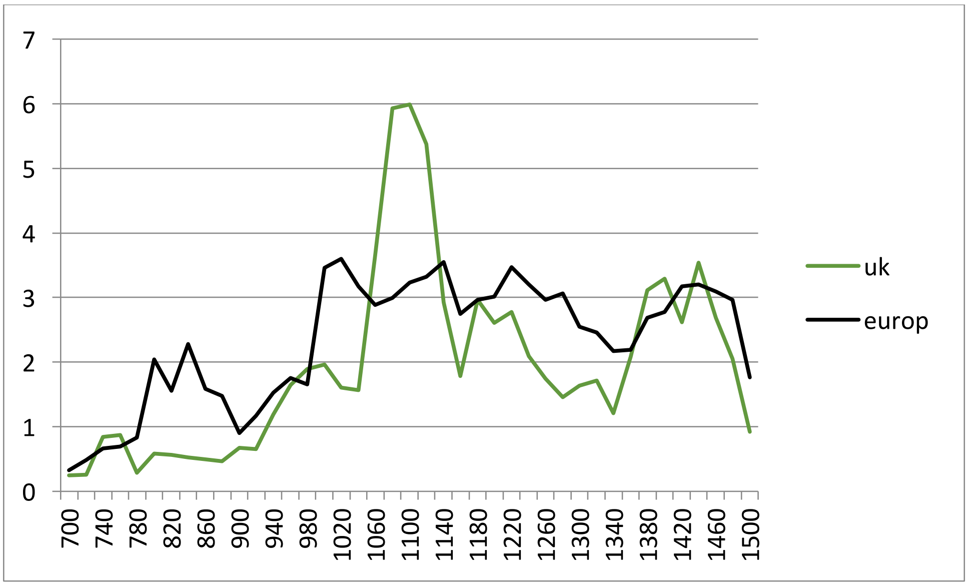

Figure 13 Per capita Church construction: Europe and the United Kingdom

What is most striking about the comparable UK series is that when corrected for the growth of the population, the post-1066 peak in construction activity emerges as even more pronounced. The decades around 1100 show the highest per capita production levels of the entire period, strongly surpassing the European average at that point. Also the recovery after the 1340s/50s, when GDP per head started to make significant gains (Broadberry et al., 2015), shows up as quite pronounced once the post Black Death decline of the population is taken into account.

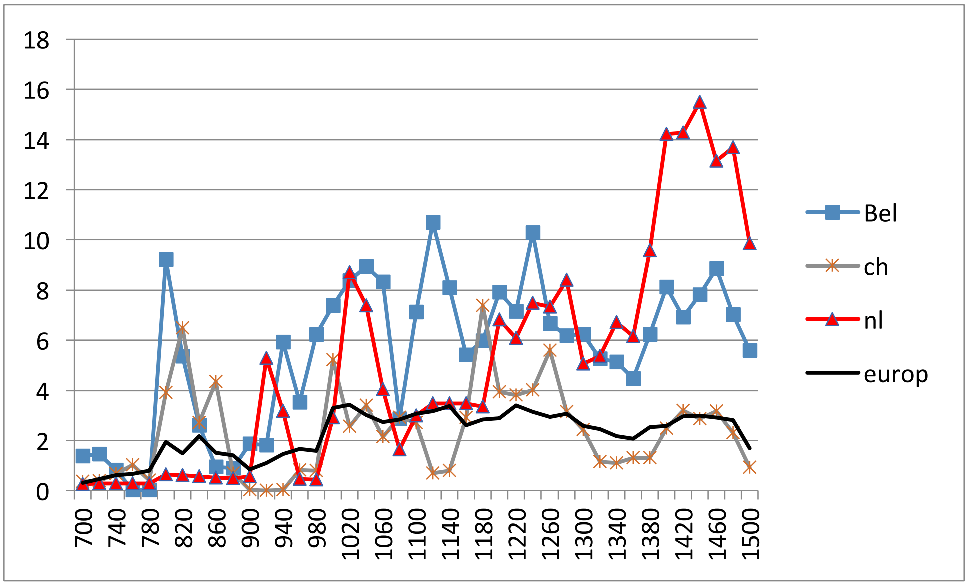

Figure 14. Per capita Church construction: Europe, Switzerland, Belgium and the Netherlands

In the small countries, Belgium and the Netherlands in particular, output levels were much higher than in Western Europe as a whole, probably due to the exceptionally high levels of urbanization present there and correspondingly higher levels of GDP.

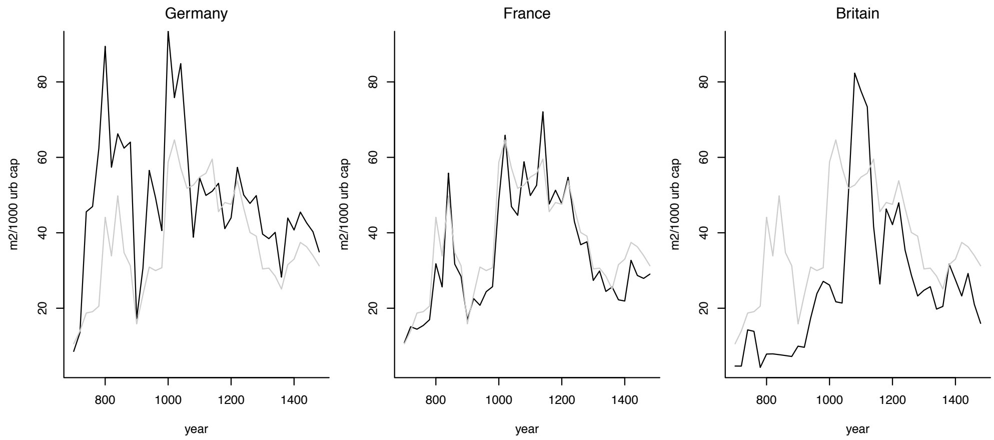

Figure 15. *Church construction in m² per 1,000 urban inhabitants in Germany, France, and Britain (gray reference line: European per urban capita church construction).*

Our choice to focus on churches located in cities and their immediate surroundings means part of the trends we see, may reflect changes in urbanization. As cities grew, so we may simply observe a larger share of church construction activity. To explore this, we also express church construction per 1,000 urban inhabitants, using urban inhabitants data from the extended Baghdad-to-London dataset (figures 15 and 16; Bosker et al. 2013). In France, Germany, and Britain the differences this makes are limited. Levels of construction activity in pre-millennial Germany are higher, reflecting the low urban population combined with sizeable building projects during the Carolingian period. Trends in France and England are very similar to those seen earlier.

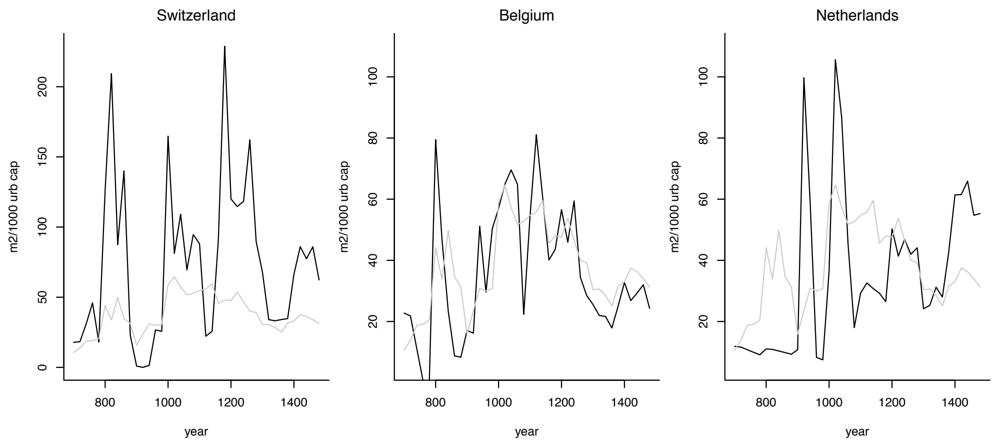

Figure 16. *Church construction in m² per 1,000 urban inhabitants in Switzerland, Belgium, and the Netherlands (gray reference line: European per urban capita church construction). Note: Switzerland not on the same scale as Belgium and the Netherlands.*

Expressing per capita church construction in this way makes a greater difference to the estimates for Switzerland and the Southern and Northern Low Countries. The very low urban population in Switzerland means that church periods of active church construction show up as peaks. More importantly, the high urbanization rates in the Low Countries in the fourteenth and fifteenth century deflate the volume of building activity towards the end of our period. Nevertheless, building activity per urban capita in the Netherlands in the fifteenth century remains high relative to the European average.

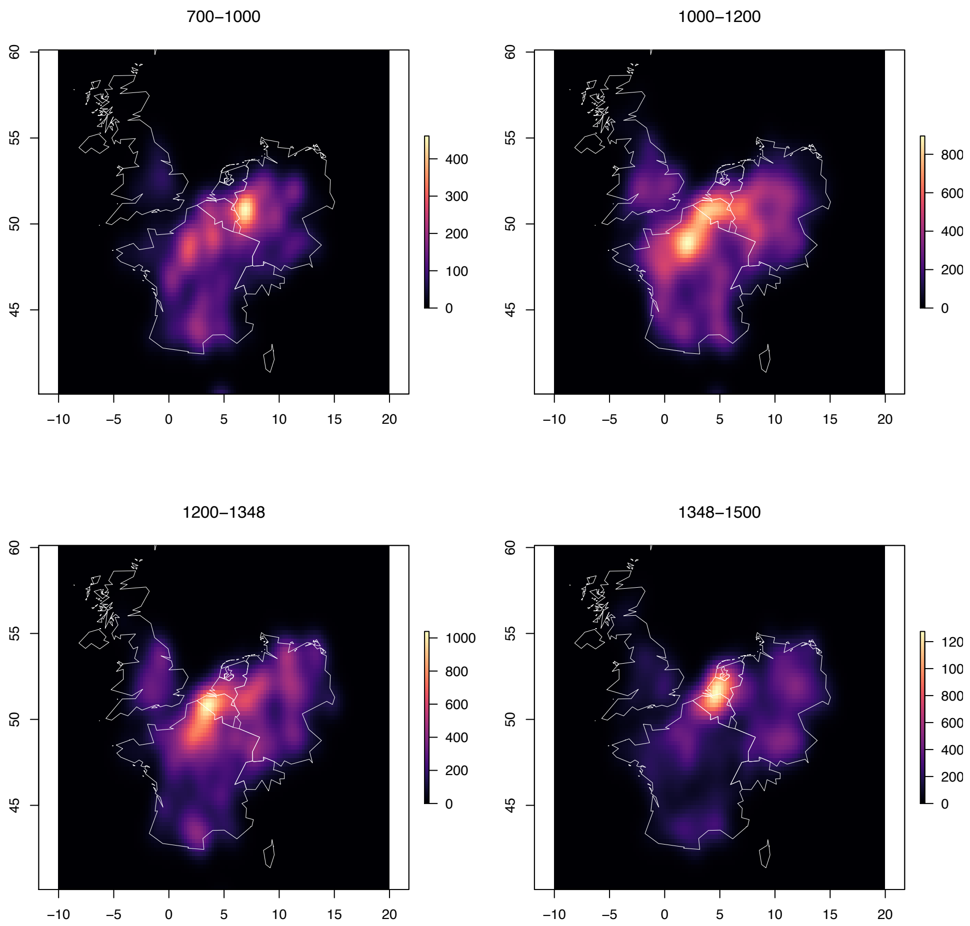

Figure 17. *Heat map of church building activity in Europe, 700–1500. Maps smoothed using a Gaussian filter (Hijmans 2016). Note: the maps are not on the same scale, meaning we are looking at the relative distribution of building activity in each period.*

Another way to present these data is to project them on maps. Figure 17 presents four maps of per capita building activity in the 700-1500 period. Between 700 and 1000 the center of gravity was in Western Germany – close to the 'capital' of the Carolingian Empire in Aachen – but also in northern France there was already significant activity. In the next period, these two regions became connected to each other by including the core parts of present day Belgium. This region of high building activity stretching from West-Germany to Northern France – between the rivers Rhine and Seine – almost perfectly coincided with the classic region of the feudal society as defined by Marc Bloch. In the period 1200-1340 the German part of this arc appeared to be weakening, and the Northern Netherlands started to come to the fore. Finally, during the post-1350 period, building activity concentrated in the Low Countries. By this time, very little building activity could be found in southern France relative to the northern regions of our research area.

IV Explanations

Various explanations are offered for these spatial patterns. Political structures – stable state structures such as the Carolingian Empire, the Ottonian stage of the Holy Roman Empire – clearly played a role. The coincidence with classic feudalism has already been noted; apparently this new set of institutions made it possible to mobilize large amounts of resources for the spectacular church construction that occurred there. There is perhaps also a correlation with the development of the heavy plough, occurring in the 9th–10th century and spreading in the period thereafter (see Andersen and Jensen, forthcoming). This innovation made it possible to exploit much more successfully the loess and clay soils of Northern France, Belgium and Western Germany. There is a striking resemblance between the map shown in figure 17 above and the map of loess soils in western Europe. As already mentioned, a third driving factor was commercialization and urbanization, which underpinned the construction of (large) churches in Northern France, Belgium (Flanders in particular) and the Northern Netherlands.

Without doubt, much of the impetus for church building came from the Church itself and the religious fervour which it promoted. Energetic church building, in turn, begot architectural innovation which then encouraged further church building and rebuilding. The most striking discontinuity in the series is probably the big boom at about 1000, after which European output levels more than doubled. Intrinsic to this was emergence of the mature Romanesque style. The historian of architecture, Hiscock, summarizes this transition as follows: 'After the eclectic efflorescence of the first Carolingian architecture, there are few standing remains of importance before the middle years of the tenth century and few which display much architectural consistency until the 980s. By contrast, from the 1020s buildings not only begin to survive in significant numbers, they are recognizably Romanesque, albeit in various regional guises' (Hiscock 2003: xiv). But the fact that this building boom coincided with the emergence of the Romanesque style, does not necessarily mean that the architectural innovations stimulated the growth of church building. Whereas the Gothic style developed in the middle decades of the 12th century was really 'revolutionary' – for example in the way in which space was created at much lower costs than in the Romanesque style and light was allowed into the church – the Romanesque style that emerged at about 1000 was in many ways a continuation of stylistic traditions which went back to Roman times. But once the templates of the 'new' style had been set in stone, it must have sustained and facilitated – even encouraged – building activity; the famous Cluny churches (II and III) were, for example, a source of inspiration all over Europe, as the centralized and hierarchical Cluniac Order was part of the Papal Reform movement of the late eleventh century and the various new monastic orders spawned at that time, all of which needed new buildings for worship.

The Gothic style was really different from its predecessor (although, as always there were borderline cases here as well). There are many stories of cities and bishops wishing to build a church in the new style, or adapt an existing building plan accordingly. But the new style only came into being when church building was already booming – the 1140/50s were peak years, with new Gothic churches, almost exclusively around Paris, accounting for only a fraction of that peak. Again, the new style sustained and greatly stimulated building activity after the 1140s when it began to spread to surrounding cities, and clearly intensified building activity in (firstly) Northern France, and then in the rest of Western Europe after about 1180. But a clear break cannot be identified that is linked to this innovation. Rather, this is a case of Church reform, piety and economic prosperity stimulating church building from which breakthrough solutions to age old structural problems emerged.

What is perhaps equally striking is that after the development of these two more or less pan-European architectural styles at about 1000 and 1150, there were no more radical changes in style. The large churches constructed in Brabant and Holland in the 15th century (at that time the centre of gravity of the Western European church building industry), for example, are easily recognizable as fitting neatly into the Gothic style – with some variations, of course (e.g. Brabantine Gothic). Gothic architecture continued to develop; in England, for example, even more refined styles emerged (decorated style in c. 1250) and perpendicular style in c. 1350), but these were basically variations on the same underlying Gothic structure. After the outbursts of creativity in the 11th and 12th century, the Gothic approach settled as the dominant style, and continued as such (north of the Alps) until the spread of renaissance concepts in the 16th. The absence of radical innovation after the 12th century perhaps helps to explain why there was no new big wave of building activity in the late Middle Ages.

The building boom of the end of the first millennium has been the subject of recent research, which starts with the famous quote by Glaber about the 'white mantle of churches', the most impressive testimony of that building boom. Glaber was a key figure in the reform movement concentrated in Cluny, and his quote reflects the successes of that movement in the years around 1000. To reform is to build, and to build is to reform, is a way to summarize the link, and Cluny itself, where three increasingly impressive churches followed each other in rapid succession, culminating in Cluny III which was the largest church in Latin Christendom, is the best example. The movement spread rapidly, stimulated by the growing territorial power of the Ottonian state (in Germany and parts of Italy). Outside the German Empire the movement was also an almost 'immediate' success, however. It also spread to the Norman kingdom that emerged in the west, from where it crossed the Channel in 1066 (Hiscock 2003: 13). But the reform movement of monks who allied themselves with kings and princes, also had a 'bottom up' dimension: 'Building churches not only emanated from orders, funds, and symbolic programmes generated from high in the hierarchy', Landes (2003: 258) concludes, 'but also… from forces working their way up from below, from the desires and demands of a religiously aroused populace'. The link between the Cluniacs and the Peace of God movement, is given as an example of such a 'bottom up' influence.

Did monastic reform continue to have an impact on the building cycle of the big churches? We were able to compare the fluctuations in the foundation of new monasteries in England between 1000 and 1350 with the building cycle reconstructed here.

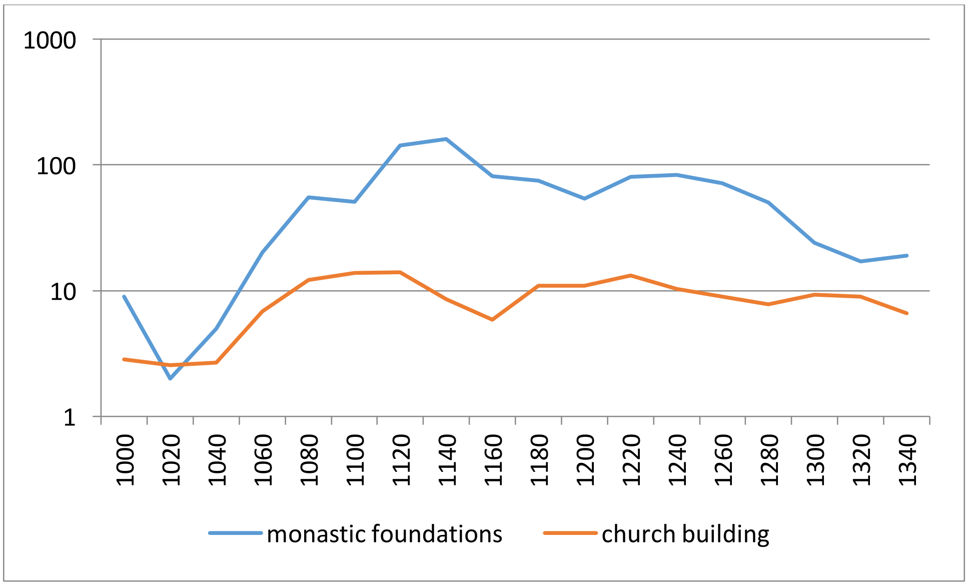

Figure 18. *Monastic Foundations and Church Building in England.*

There is, in the long term, a certain connection – a strong increase during the 11th century, decline in the 13th and early 14th century – but the link is not very strong. Church building declined in the middle decades of the 12th century, when the number of foundations was peaking, and also in other periods, the correlation is not very strong. Perhaps this is due to the limitations of our dataset – with its focus on urban churches, whereas many monasteries (before the rise of the mendicants in the 13th century) were located in the countryside and a higher proportion of their churches did not survive the Reformation.

A large share of church building was in the form of cathedrals. Bishops and cathedral chapters were responsible for some of the most impressive churches in Europe. Two things stand out in figure 20 comparing total church building activity with cathedral building. First, cathedral construction declined sharply from c. 1350 onwards while church building activity in general remained high. Second, cathedral construction was indeed a large share of total church construction. Not only is the trend very similar up until the middle of the fourteenth century but, at 25% of the total, cathedral building was also a very substantial share of the total. What this may mean is that there was a role in Europe's building boom for the funds bishops and their chapters had at their disposal, such as tithe receipts from appropriated benefices and rising revenues from episcopal estates. Most important to the financing of cathedrals were the voluntary contributions of the faithful, often enticed by indulgences and relics (Vroom 1982; Vroom 2010).

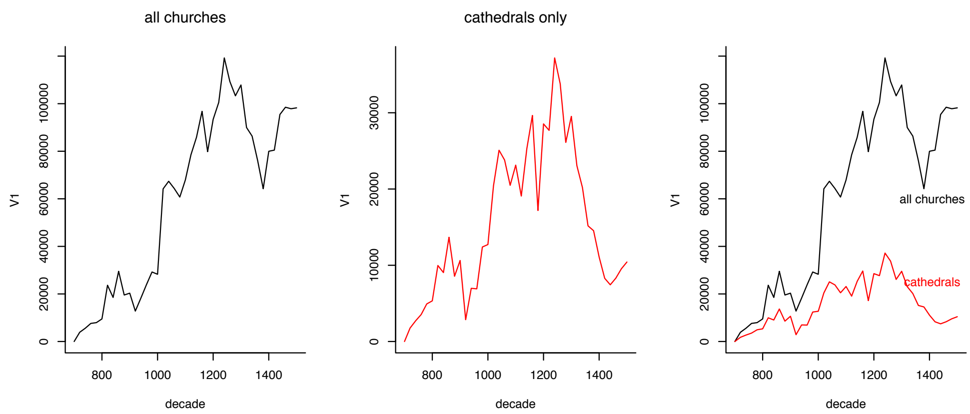

Figure 19. *All church construction activity and cathedral construction activity.*

Finally, what do these estimates tell us if we see them as powerfully influenced by economic forces? The Carolingian Renaissance is from that perspective not a surprise, but the new data allow us to put this into perspective – and perhaps learn that both the Northern Netherlands and England were outside the scope of that building cycle. The sudden acceleration at about 1000 (or after 1066 in the case of England) probably owed more linked to religions, institutional and political forces, as argued already, than to a sudden dramatic expansion of the economies involved. Indeed, England's new Norman masters used church building to demonstrate their power and seal their takeover of both Church and state. On the other hand, the large-scale building projects starting at about 1000 must have been financed from growing surpluses, and have had their impact on the real economy. The correlation with the classical feudal system – between Seine and Rhine – also points in this direction. Explaining both the genesis and the long term consequences of the great Romanesque boom should be one of the priorities of future research where we hope to focus on interactions between the growth of cities and the great building projects in the new dataset.

The factors behind the start of the next, 'Gothic', building cycle are less clear-cut. The growth of international trade probably accelerated after the First Crusade (1095-1099), which established commercial footholds for the great Italian trading cities in the Levant, and opened up new trade routes as a result. As Campbell (2016) has demonstrated, the long medieval boom in international trade continued until the 1250s, then slowly lost momentum until, from the 1290s, a long decline set in. The economic slowdown was clearly reflected in the decline in building of great churches and only in Germany did construction activity remain high until the 1280s. Thereafter, the 'Crisis of the late Middle Ages' is clearly visible in our series, with the exception of the Northern Low Countries, which appeared to continue to grow and urbanize. However, the crisis was certainly less severe on a per capita basis than often has been suggested. Recovery already started in the 1360s-1380s, and during the middle decades of the 15^{th} century building activity returned – in Germany and England, but not in France – to levels comparable to those of the pre-1348 period.

Another way to get an impression of the economic determinants of the process is to discriminate between the various 'first nature' locations of cities. Their accessibility to water and with it their potential for trade, is an important first-nature characteristic. All cities have been classified as 'sea', 'river' or 'land' cities. The 'sea'-cities are at the sea coast or on the tidal stretches of rivers. The 'river'-cities are located on navigable non-tidal rivers or inland waterways. Finally, the 'land'-cities are landlocked and were accessible by land transport only. Were agricultural innovation (the heavy plough) and/or institutional innovation in agriculture (the spread of feudalism) the driving factors of the big boom, we would expect landlocked cities to have performed as well as cities close to the sea. If trade and commerce were more important, cities on rivers and at the coast should have enjoyed an advantage.

Figure 20 presents the average of each century's built volume of churches (in 1000s m^3) per city for the whole of the study area, plotted by the end year of each century. It shows that before 1000 cities close to the sea did not develop more favourably than others – perhaps the Vikings contributed to the poor performance of such cities, or agricultural changes were driving the process. This changed after 1000: the boom in church building in the eleventh century was mainly to be found in the river and sea cities in our sample, and not to that same extent in the landlocked cities. After 1300, as maritime technology advanced, cities close to the sea also began to out-perform those on rivers, whereas landlocked cities appear to have stagnated from the 13th century onwards. The strong link with river and sea trade which is implied by this comparison, suggests that commercial opportunities were a prominent component of Western Europe's great church building boom.

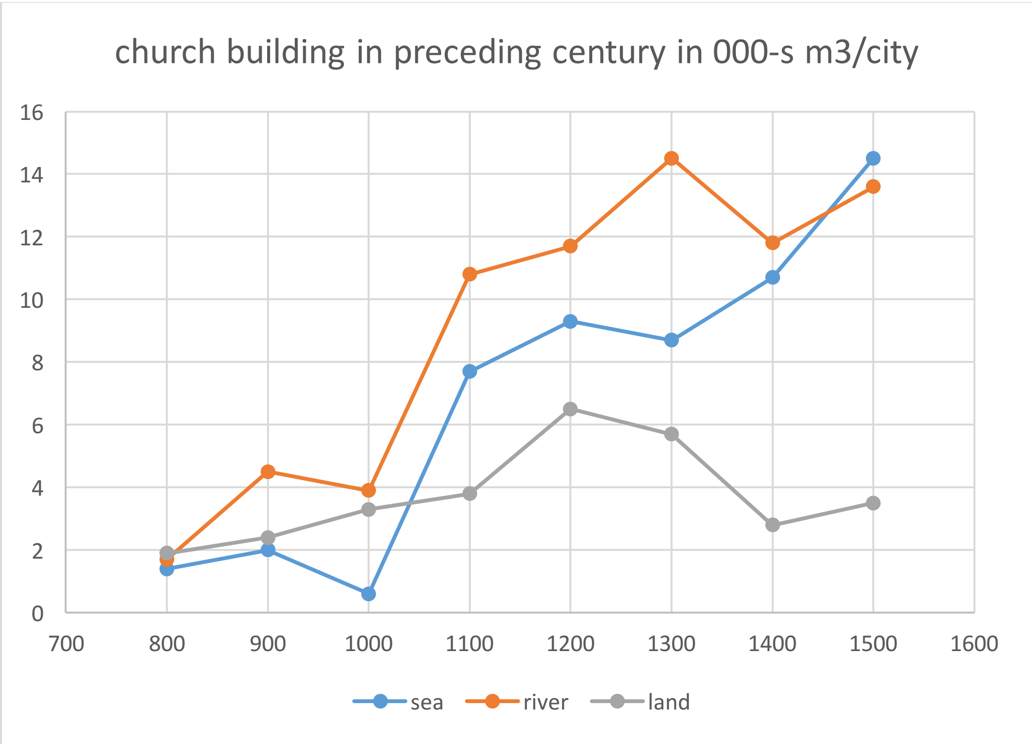

Figure 20. Average volume of churches (in 000-s m^3) per city built in the preceding century

Conclusion

This is an exploration of the first results of a project to reconstruct church building in Medieval Western Europe. We think the data on the construction history of large churches has a large potential for informing us about wider trends in the medieval economy, and can shed new light on the debate about the causes of the big boom that transformed European society between c. 950 and 1300. While focusing on of large urban churches may introduce biases, comparisons with more comprehensive datasets on church construction have shown that the results are probably quite representative of the evolution of the sector as a whole. Moreover, the patterns that we find are in accordance with what is known about the spatial and chronological evolution of the European economy at the time.

Key findings from this investigation are as follows. First, spatially, the initial big boom appears to have been concentrated in the area between Rhine and Seine which is usually linked to classic feudalism, suggesting a connection with this new system of exploitation of agricultural (and human) resources. Second, at the same time, after 1000, the cities bordering the sea and rivers, experienced much more growth in church building than landlocked cities, suggesting that commercial factors were becoming increasingly important. Third, after 1350, the center of gravity of church building moved to the Low Countries, the only region that seems not to have been affected too much by the Black Death of 1348. Fourth, this perhaps suggests a periodization of growth, in the sense that initially – during the Carolingian and Ottonian Renaissance – agricultural drivers played a large role, but that gradually international trade became a more important driving factor. Finally, the big boom at about 1000 is the single most striking discontinuity in continental church building (a similar break in the series occurs in England after 1066). Changes in religious institutions (the reform movement of that period) are a good candidate for explaining this sudden break, that kick-started this big wave.

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Appendix: the costs of church building and their contribution to GDP.

It is also interesting to estimate of the actual costs involved in medieval church building and make estimates of the share of church construction in medieval GDP. To make the building costs of medieval churches comparable over time and space we expressed them in grams of silver per cubic meter of church (unit: g Ag/m^3). Various medieval contracts and expense books of church factories give an insight in the actual contemporary costs of building (part of) gothic churches.[20] Their building expenses showed large variations, just as the churches themselves could differ enormously in size and execution. The cheapest building cost per cubic meter we found was that of a new chancel in 1348 at a rural church in Sandon (Herts.), where the old materials of the previous chancel could be reused. The building cost of this English church was only some 4 g Ag/m^3 (Salzman, 1967, # 18). The most expensive church was that of Westminster Abbey, which was built in the period 1245-1272 by Henry III as his royal burial church. This exceptional church came to around 120 g Ag/m^3 (see Colvin, 1971, for its church plan). The building costs of more typical churches in England, the Netherlands and Belgium had a considerably smaller range: generally between 13 and 19 g Ag/m^3. The church of Fotheringay (Nothants.) came to 13 g Ag/m^3 (Salzman, 1967, # 66) in 1434. An extension to Saint Gilles' church in Edinburgh in 1387 cost 15 g Ag/m^3 (Salzman, 1967, # 40). Building the major part of the Buurkerk in Utrecht (Netherlands) between 1434 and 1456 had an average building cost of 17 g Ag/m^3 (Vroom, 1981). This cost was similar to that of the Saint Gummanus in Lier (Belgium), which was built between 1378 and 1540 for 17 g Ag/m^3 (Vroom, 1983, 166). The heightening of a bell tower at Saint Asaph's cathedral in North Wales in 1392 came to 18 g Ag/m^3 (Salzman, 1967, # 43). This same amount of 18 g Ag/m^3 was also found for building a rural church in Wyburton (Lincs.) in 1419 (Salzman, 1967, # 57). While pulling down the old church and building a new one in Catterick (Yorks.) in 1412 had a contract price of 19 g Ag/m^3 (Salzman, 1967, # 53). The building of the cathedral of Our lady in Antwerp (Belgium) between 1415 and 1495 had an average construction cost of 30 g Ag/m^3 (Vroom, 1983, 153/4). During the building period of this church the city of Antwerp was at the height of its economic power. The overall geometric

[20] The references that published the various contracts (with one specific year) or expense books (with a range of years) only present the amounts of money concerned. The here presented medieval building costs are our own calculations. We have expressed the monetary sums in the references into their weight in silver, and on the basis of plans and photographs estimated the numbers of cubic meters involved in the building activities. By dividing the weight of silver by the volume in cubic meters we calculated an average cubic meter price of medieval church building at the date in question.

mean of these varying medieval building prices comes to 19 g Ag/m^3 of church.

The average costs of maintenance and repairs were certainly not negligible. The yearly cost of maintenance and repairs in the Buurkerk (Utrecht) were 0.282 % of the building cost for the period 1457 to 1499 and 0.51 % for the period 1553 to 1566 (Vroom, 181, 548-51). For the Dom in Utrecht we also have the expenses on maintenance and repair for the period 1517 to 1565 (Vroom, 1981, 526-29). We do not know its building cost, however. When taking the building cost of the cathedral of Our Lady In Antwerp the yearly maintenance of the Dom in Utrecht comes to 0.246 % of its building cost, and when taking the cost of the Buurkerk we come to 0.435 %. As a rule we expect yearly maintenance costs of a medieval church to have been somewhere between 0.25 % and 0.5 % of its building costs, on average some 0.33%.

For an answer to the question of the contribution to GDP we will concentrate on the situation in England because more quantitative information is available for this country than for any other in our study area. We will thereby look at the period around the end of the 13th and beginning of the 14th century. We will use three different methods to estimate the relative contribution of church building to medieval GDP.

- In the first method we multiply the yearly built new volume of churches in England by an average cubic meter price and estimate how much was spent on maintenance and repairs. By dividing this sum by the British GDP we obtain the sought fraction.
- In the second method we just estimate the yearly numbers of working years that is involved in England in building new churches and in repairing and maintaining the existing churches. By dividing this number by the total numbers of British workers we get an estimate of the contribution of churches to the GDP, assuming off course that every medieval British worker contributed evenly to this variable.
- In the third method we use the building prices per cubic meter of two exceptional churches (Westminster Abbey and Salisbury Cathedral) and their relative rank in the upper tail of the distribution of church building prices as a way to estimate the (currently unknown) lognormal distribution of medieval British building prices. With the found lognormal distribution we then can calculate an arithmetic average building price per cubic meter and afterwards do essentially the same as in the first method.

Around 1300 we assume England housed a population of some 4 million inhabitants. Our database indicates that the urban population then totaled 380,000, which leads to an urbanization rate of approximately 10 %. Around 15 % of the medieval urban population in England was working in the building trade. This leads to an estimate of at least some 15,000 fulltime building workers in medieval England (4×10^6 / ($4 \times 0.10 \times 0.15$). English GDP then was around £ 7×10^6 (Broadberry et al, 2015), which then with a value of 0.3146 kg silver per £ was equivalent to a total of some 2.2×10^6 kg Ag per year. The average wage of a construction worker was some 4 g Ag/day, and generally 150 working days were assumed per year in the building trade.

Previous calculations of medieval church building costs per cubic meter of various churches in England, the Netherlands and Belgium have come to around 18 grams of silver per cubic meter of church. (See: Salzman (1967), Vroom (1981, 1983)). From the Buurkerk in Utrecht (Vroom, 1981) we know that during actual church building periods on average the ratio of wages to materials was 1 : 1.35, which implies that with 18 g Ag/ m^3 we can assume that 18/2.35 or 8 g Ag was wage and 10 g Ag was for the various materials to build that cubic meter of church. This wage of 8 g Ag implies that on average two full working days were needed to build a cubic meter of church.[21]

Method 1.

The first method we apply is that we multiply the numbers of cubic meters of church by an average cubic meter price to find the total cost of church building. In the 13^{th} century our database indicates that in total 1,292,000 m^3 of new church was built in England at the 94 churches in our sample. This means that on average per year 12,920 m^3 of new church was built, which would have cost some 26,000 working days or would have occupied some 172 fulltime medieval construction workers, and its total cost on average is estimated to have been 233 kg Ag/year. Next to new churches there were also existing churches, which in 1300 came to 1,500,000 m^3. For these existing churches we can estimate their maintenance cost at 0.33 % per year of the building cost. The average maintenance costs in our sample that we have to add to the cost of the newly built churches are

[21] That such a figure (2 working days/m^3) is credible can be corroborated by the building cost of a new chancel for a rural church in Sandon in 1348 (Salzman, 1967, #18) for which the existing fundaments and old materials could be used, and which came to an average cost of only 4 g Ag/m^3. That this church seems to be built more than twice as quick (less than 1 working day/m^3) as on average other churches should not come as a surprise, because it was a rather small church and its materials had been used already and probably needed less fitting than new (but in the Middle Ages in no way standardized) materials generally used for other medieval churches.

1,500*18*.0033= 89 kg Ag. Leading to a total of 322 kg Ag as the yearly contribution of our churches to the English GDP.

This contribution may seem low but we have to realize that the 94 churches in our sample are only 1 % of all English churches. Alford and Smith (1969, 167) come to 563 religious houses and 8,838 parish churches in England. Of course the 94 churches in our sample are the largest 1% of all English churches, but nevertheless we will have missed a substantial volume of church buildings. We can make an estimate of the missed volumes. In our sample in 1300 the larger churches in England have on average 7.5 m^3 per urban inhabitant (overall in Europe: 7.8 m^3/inhab in 1300), for rural churches this value will have been considerably smaller and a value of 1 m^3/inhabitant seems to be a reasonable lower bound estimate. For a rural parish of on average 400 souls (see Buringh, 2011, 289) this would imply a small but not unrealistic church of with a surface area of say 6*12 m^2 with a nave height of around 6 m or some 400 m^3. For England this would imply that we missed 3,700,000 m^3 of church. Assuming that an average church was rebuilt every 300 years we expect a yearly building of 12,000 m^3, at a cost of 223 kg Ag. The yearly maintenance of the rural stock is 0.33 % of the building cost, which would add 221 kg Ag to the contribution to the GDP. A lower bound estimate of the overall contribution of churches to English GDP around 1300 would be (322 + 223 + 221) 566 kg Ag or a contribution of some 0.026 % of GDP. A higher bound of this estimate would be to assume that on average we have a rural church volume of 3 m^3/inhabitant, which would then come to 0.075 % of GDP (1,645/2.2E6*100).

The estimate of Hohenberg and McCants (2010, 14) of a cathedral costing over 100,000 £ while not including more than minimal decoration, seems to be a factor of four too high for the wages, while no substantiation is given for the numbers of workers or the building period. Johnsen (1967, 201) indicates that in 1253 a total of 427 construction workers spent a year working on a cathedral for a sum of 1,027 £. Therefore I think H&McC's estimate (on which he bases the value of 100,000 £ for a cathedral) of the total wages of 1,000 £ for a 100 workers for one year seems too high. One hundred workers working for 4 g Ag/day in a 150 day work year, cost 60 kg silver, which would have been some 190 £ on wages (not 1000 £) and by adding 135 % for including the materials, we would come to 450 £ (not 2000 £) for 100 workers building on a cathedral for a year.

Of course there were churches that were more costly than the average sum of 18 g Ag/m^3, Westminster Abbey being the most obvious example. Taking Scott (2003, 36) with 45,000 £ for its cost [during Henry III], which comes to 14,220 kg Ag for 103,000 m^3 and leads to an average cost of 138 g Ag/m^3. Salisbury cathedral, Scott (2003, 36), with 28,000 £ comes to 8,848 kg Ag and with a volume of some 100,000 m^3 its building cost comes to approximately 88 g Ag/m^3. For this last cathedral H&McC (2010: 18) indicate that Salisbury had financially considerably overstretched itself with building such a luxurious cathedral. These two examples of very costly English cathedrals show that H&McC's estimate of 100,000 £ probably is way too high, and certainly not typical.

Method 2.

A different way of approaching the question of the contribution to GDP would be by taking the numbers of worker years on churches and comparing those to the total numbers of worker years in a country (the basic assumption being that all workers contribute evenly to the GDP, which will not be absolutely true). For the lower bound of the yearly English church cost we have 566 kg Ag and for the higher 1,645 kg. Assuming 4 g Ag/day and 150 workdays a year you come to 0.6 kg Ag that an average construction worker earned. We know that wages are 1/2.35 of the building cost, this leads to 400 fulltime worker years in the lower bound and 1,170 workers years in the upper bound for 13^{th} century English church building. When divided by 1E6 workers assumed for England in 1300 we come at respectively 0.040 % and 0.117% of GDP.

One could assume that a 14^{th}-c building worker contributes somewhat more to the economy than the average farmworker (which is where the bulk of the economy was), of course then the relative contribution of churches to the GDP in method 2 increases with the fraction that one assumes the building worker's productivity to have been higher.

Method 3.

The basic presumption of this method is that the average building prices of churches per cubic meter (in 14^{th}-c. England) are distributed lognormally. By using two exceptional churches from the upper tail of the distribution we can in principle estimate the m and s of the lognormal distribution of medieval building prices in England. For Westminster abbey the average 14^{th}-c building price comes to some 120 g Ag/m^3 and for Salisbury cathedral we find approximately 88 g Ag/m^3. There are 9,401 churches in Britain in this period and when we -in our opinion quite plausibly- assume that the building cost of the royal church of Westminster abbey was the highest of all, we can find 1/9401 or 0.0001064 for its accompanying chance in a normal distribution. This leads to a z-value of ~ 4.10 (see Snedecor and Cochran, 1967, 547). We now have an expressions with two unknowns:

$m = 4.7875 - 4.10 * s$

The relative rank of Salisbury cathedral is less certain and this makes it tricky to use its data in a procedure to estimate a distribution of building prices of churches. Salisbury cathedral was one of the greatest in England, but the relative rank in the Anglican church hierarchy of five other British churches is higher. Currently Salisbury's rank order is somewhere between the sixth and 26th position.[22] Though we know that the building of this cathedral probably was well beyond the economic means of the inhabitants of Salisbury its exact rank (and thereby a z-value) in the distribution is difficult to establish with any certainty. However, a way around this ambiguity is to use the median of the estimated medieval church prices of 18 g Ag/m^3 in combination with the price of Westminster abbey to estimate the unknown lognormal distribution. Because it is a median value: $z = 0$, which leads to $m = 2.89$, and in its turn this then leads to $s = 0.463$, which eventually produces an overall arithmetic average of the lognormal distribution of 20 g Ag/m^3 (see Boleij et al, 1995, 102). With this value of 20 we can do the same sums as previously done with method 1. The 13,000 m^3 of new churches in our sample of 94 churches leads to a yearly cost of 260 kg Ag, the maintenance of this sample comes to 1,500*20*0.0033 or 99 kg Ag per year. For the lower bound assumption of 1m^3/inhab. we find 12,000 new church m^3 that have to be built yearly for the missed churches, or 240 kg Ag, while their yearly maintenance comes to 3,700,000 * 20 * 0.0033 or 244 kg Ag. In the lower bound we come to a total of 843 kg Ag yearly. This leads to an estimate of some 0.038 % of GDP. For the higher bound estimate of 3 m^3/inhab. we find a total cost of 1,811 kg Ag or 0.082 % of GDP.[23]

In this third method the first place for Westminster abbey is not very critical. If it would have had the third rank order (instead of the currently assumed first) its z-value would have been ~3.8 which would have led to slightly higher $s = 0.499$ and an arithmetic mean of 20.3 g Ag/m3. Which dos not really change the above estimates of the percentage of GDP.

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