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Printing and Protestants: An Empirical Test of the Role of Printing in the Reformation*

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Abstract

The causes of the Protestant Reformation have long been debated. This paper attempts to revive and econometrically test the theory that the spread of the Reformation is linked to the spread of the printing press. I test this theory by analyzing data on the spread of the press and the Reformation at the city level. An econometric analysis which instruments for omitted variable bias with a city's distance from Mainz, the birthplace of printing, suggests that cities with at least one printing press by 1500 were 52.1 percentage points more likely to be Protestant by 1530. This economically and statistically significant effect lasted through 1600, though it weakened throughout the century.

Keywords: Printing Press, Protestant Reformation, Information Technology, Revolt
JEL Classifications: N33, N73, O33, Z12

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1. Introduction

The century between 1450 and 1550 is one of incredible importance in European economic history. A far from exhaustive list of important events in this period include the “finding” of the New World, the invention of the printing press, the Ottoman conquering of Constantinople and threatening of Vienna, the height of the Renaissance, and the Protestant Reformation. Many economists have pointed to at least one of these phenomena as heralding the “rise of the West” (Weber 1905; Tawney 1926; Pomeranz 2000; Mokyr 1990, 2002; Acemoglu, Johnson, and Robinson 2001, 2005; Greif 2006; Becker and Wößmann 2008, 2009; Iyigun 2008; Buringh and van Zanden 2009; Chilosi and Volckart 2010; Dittmar 2011).

The problem for the economic historian is disentangling these events. Which events were facilitated by other historical events, and, more importantly, which events were the true “prime movers” of this momentous period of economic history? In this paper, I focus on the relationship between the spread of printing press and the Protestant Reformation. Economists have recently touted both of these events as having monumental long-run economic effects. Baten and Van Zanden (2008), Buringh and Van Zanden (2009), Chilosi and Volckart (2010), and Dittmar (2011) are recent additions to the literature stressing the importance of the printing press as an independent factor contributing to subsequent European economic growth.¹ Becker and Wößmann (2008, 2009, 2010), in the tradition of Max Weber (1905), connect the spread of Protestantism to subsequent economic growth – though unlike Weber, they emphasize the Reformers’ stress on literacy as the causal factor.² If these two events are related, then the true impact on subsequent economic growth of either (or both) may be overstated.³

¹ Classic studies providing a similar linkage include Febvre and Martin (1958) and Eisenstein (1979).

² In a related work, Buringh and van Zanden (2009) show that conversion to Protestantism is strongly related to subsequent literacy outcomes. Other recent works connecting religion to human capital accumulation include Berman (2000), Botticini and Eckstein (2005, 2007), and Chaudhary and Rubin (2011). Blum and Dudley (2001)

This paper is far from the first to connect the printing press to the Reformation.⁴ This argument is centuries old, with arguments in support of (Dickens 1968; Eisenstein 1979; Edwards 1994; Gilmont 1998) and against (Febvre and Martin 1958; Scribner 1989) the causal linkage connecting the press and the Reformation. For example, in their classic book *The Coming of the Book: The Impact of Printing* – which extols the *positive* historical significance of the printing press – Febvre and Martin (1958, p. 288) claim that “it is not part of our intention to revive the ridiculous thesis that the Reformation was the child of the printing press”. But is this thesis so ridiculous?

A key problem with past theses connecting the printing press to the Reformation is that the linkage may be spurious. Even if we accept that the press facilitated the Reformers’ ability to spread the seeds of dissent, it is certainly possible that cities which were more likely to accept the Reformation were also more likely to adopt printing for reasons correlated with both the press and Protestantism, such as higher pre-printing press literacy rates, larger population, or local independence from centralized rule.⁵ If this were the case, then the Reformation may have been accepted in these cities even if the press were never invented.

present a pro-Weber argument, but suggest that Protestant economic networks, not a “work ethic” are the root cause. Arruñada (2010) argues that Protestants did not have a unique work ethic, but instead had a “social ethic” which favored market transactions. Barro and McCleary (2003) and Grier (1997) tackle a similar question, analyzing the connection between Protestantism (amongst other religions) to economic outcomes using cross-country studies. Likewise, Guiso et al. (2003) find a positive correlation between Christian religions and attitudes conducive towards economic growth.

³ Cantoni (2010) employs a similar methodology to Becker and Wößmann on a broader set of German lands and finds little evidence of the effect of Protestantism on human capital accumulation. However, Becker and Wößmann’s data includes rural areas (using complete census data), unlike Cantoni. Indeed, Becker and Wößmann do not find a clear connection between Protestantism and development when looking only at cities.

⁴ Cantoni (2012) asks a similar question to the one posed in this paper. He finds that, amongst other things, there was a strong spatial pattern to the spread of Protestantism. This result is consistent with the one found in this paper. I also show that there was a spatial component to the spread of the Reformation independent of the effect of the press. Cantoni’s work and the present paper also relate to Barro and McCleary’s (2005) work seeking the determinants of state religion. These papers suggest historical roots underlying Barro and McCleary’s findings in the case of European Protestantism, although Barro and McCleary are not concerned with denominational differences.

⁵ Putnam (1993), Guiso, Sapienza, and Zingales (2008), and Jacob (2010) contend that the independence of certain cities in Northern Italy and the Holy Roman Empire led to greater social capital and hence better subsequent economic outcomes.

It is nearly impossible to disentangle these events without careful data collection and analysis. To this end, this paper contributes a much needed empirical analysis to the debate on the link between the printing press and the Reformation. It employs a new city-level data set (covering Central and Western Europe) on conversion to Protestantism, the presence of a printing press by 1500, and a host of variables controlling for the supply and demand of Protestantism. To address omitted variable biases – such as pre-printing literacy rates correlating with the acceptance of both the press and Reformation – I instrument for the printing press with a city’s distance to Mainz, the birthplace of printing. This instrument is also used by Dittmar (2011), and is similar to the “distance from Wittenberg” instrument employed by Becker and Wößmann (2008, 2009, 2010) and Cantoni (2010). It is a useful instrument because printing spread in a relatively concentric circular pattern outward from Mainz; yet a city’s distance from Mainz should have no *direct* effect on the adoption of the Reformation. I find a very strong connection between towns which adopted the printing press and those that accepted the Reformation; instrumental variable results indicate that towns with a press by 1500 were 52.1 percentage points more likely to accept the Reformation by 1530, 43.6 percentage points more likely to accept the Reformation by 1560, and 28.7 percentage points more likely to accept the Reformation by 1600. The weakening effect of the press over the 16th century suggests that cities which were early adopters of printing were more likely to adopt the Reformation as it initially spread, but other factors (e.g., politics, the greater penetration of printing throughout the 16th century) played a more important role in the persistence of the Reformation.

The implications of these results are immense for the growing body of literature on religion, economic growth, and printing. Most importantly, if Dittmar (2011) is correct and the press had an independent effect on economic development, then Weber’s (and Becker and

Wößmann's) linkage between Protestantism and economic development may be spurious, reflecting instead developments associated with the diffusion of print media. In fact, these results suggest that the "distance to Wittenberg" instrument may be problematic; to the extent that it is correlated with distance to Mainz, it may be partially picking up the diffusion of printing, which itself was linked to the spread of the Reformation.⁶ Likewise, if Weber (1905) and Becker and Wößmann (2008, 2009, 2010) are correct that Protestantism had an independent effect on development, then the importance of the press may be indirect through its role in facilitating the Reformation.⁷ Of course, both the printing press and Protestantism may have had independent effects on economic development, and it is not the purpose of this analysis to differentiate between these two hypotheses. What this analysis does suggest, however, is that any investigation of the long-run economic effects of the printing press (or, more generally, information technologies) and the Reformation (or, more generally, social and political upheaval) cannot ignore the relationship between the two.⁸

⁶ This does not mean that the "distance to Wittenberg" instrument is invalid, however. For one, the large F-stat that Becker and Wößmann find on the instrument makes it unlikely that they are *only* picking up phenomena associated with the spread of the printing press, especially since Mainz and Wittenberg are 250 miles apart. Moreover, any problems with the instrument could be avoided by simultaneously instrumenting for the press and the Reformation (with distance to Mainz and distance to Wittenberg, respectively). I thank an anonymous referee for pointing this out.

⁷ Dittmar (2011) does in fact explore the possibility that the press played a greater role on city growth in Protestant lands. He does this by including a "distance to Wittenberg" variable as a proxy for Protestantism. While distance to Wittenberg is correlated with acceptance of Reformation, there is significant variation in print and Reformation adoption in cities far away from Wittenberg (in areas such as in southern Germany, Switzerland, the Netherlands, and England). Yet, it is encouraging the Dittmar's results hold with its inclusion of the "distance to Wittenberg" variable; this lends substantial support to the conjecture that the press had an effect on long run growth independent of its effect on the Reformation.

⁸ This paper by no means suggests that the Reformation was a mono-causal event. Another factor differentiating the attempt of previous reformers with Luther, Zwingli, and Calvin was the Ottoman threat on Eastern and Central Europe in the 16th century, which encouraged the pope and Emperor Charles V to make various concessions to the reformers. This thesis is most recently laid out econometrically by Iyigun (2008). Iyigun's thesis is complementary to the one proposed in this paper, as both help explain the timing of the Reformation, though the present argument also helps explain the spatial pattern of the Reformation. Ekelund, Hébert and Tollison (2002, 2008) also present a complementary hypothesis which views the Church as a discriminating monopolist that encouraged entry by "rival firms". They have difficulty explaining the timing of the Reformation (and the failure of previous reformers), but the micro-mechanisms they suggest underscore an important aspect of the Reformers' motivations.

2. Historical Background

2.1. *Early Printing*

The first printing press using movable type was invented circa 1450 by Johann Gutenberg in Mainz. The first major work employing the new technology, the Gutenberg bible, was available for sale by 1455.⁹ In the fifty years following the invention, the press diffused throughout many of the major cities in Western Europe. Although the press met some resistance in some areas at different times, such as in post-Reformation France, 60 of the 100 largest European cities had a press by the end of the fifteenth century (Dittmar 2011). By 1500, nearly eight million books had been printed – most of which were religious in nature and printed in Latin – perhaps more than the scribes had produced in the previous millennium (Eisenstein 1979).¹⁰ The early centers of printing in the Holy Roman Empire were Cologne, Augsburg, Strasbourg, Leipzig, and Nuremberg, though numerous other print shops were scattered throughout the Empire.

The first print workshops were established by Gutenberg and his assistants. They held a printing monopoly for about a decade, before the bible was printed in Strasbourg in 1459 (Febvre and Martin 1958). Printing remained almost exclusively German in its first few decades, and by the 1470s printing was controlled by a small group of “printer-scholars”, educated laymen who ran the printing presses and played a significant role in editing. The printer-scholars were often former priests or university professors who lived nomadic lives and moved to places where demand for books was the highest: first to the major commercial centers and then to the university towns (Eisenstein 1979). Most university towns eventually became printing centers, as the guaranteed market they provided attracted printers and encouraged them to settle. Printing

⁹ I am only concerned here with the invention of the press in Europe. Printing was known in the East for centuries prior to Gutenberg, but was not introduced to Europe until the 1450s.

¹⁰ Johns (1998) argues that scribal culture persisted for well over a century after the spread of the press. This should not detract from the primary argument made in this paper – the *rapidity* of reproduction allowed by the press versus the scribes is the important source of connection between the press and the Reformation.

expanded rapidly in the 1470s, particularly in Germany and Italy, and by 1480 the press was in nearly universal use throughout Western Europe (Febvre and Martin 1958).

Although the press ultimately undermined the power of the Church (through the mechanism proposed in this paper), the Church would have had a difficult time suppressing printing had it wanted to. By the mid-fifteenth century, the primary intellectual centers were the universities, many (but far from all) of which were outside the control of the Church. Indeed, the Church was one of the biggest early customers of printing, using presses to print ordinances, works of popular piety, bulls, indulgences, and propaganda for its anti-Turkish crusade (Febvre and Martin 1958; Eisenstein 1979). A significant source of demand came from war-ravaged churches, who desired printed liturgical books (Febvre and Martin 1958). Numerous monasteries welcomed printers to their quarters and printers found a large market for religious works in small Italian cities.

The price of books fell dramatically after the spread of the press. On top of the large outward supply shift following the diffusion of the press, technological changes in the paper production process and the use of ink based on oil decreased the price of books around 85 percent (Spitz 1985; Buringh and van Zanden 2009).¹¹ Humanist and legal texts became much more popular in the pre-Reformation period due to these changes. In subsequent centuries, the decreased price of books also led to dramatic increases in literacy, particularly in Great Britain, the Netherlands, Germany, and Sweden (Buringh and van Zanden 2009).

2.2. *The Spread of Protestantism*

¹¹ Chilosi and Volckart (2010) show that the press also contributed to greater market integration prior to the Reformation, as news-sheets with financial information greatly increased information flows.

On October 31, 1517, Martin Luther nailed his Ninety-five Theses to the door of the All Saints Church at Wittenberg, sparking what would become the Protestant Reformation. Luther was concerned with what he viewed as theological errors (such as whether salvation could come through faith alone) as well as Church abuses that had become increasingly prominent in the century prior to the Reformation – these include indulgences, relic cults, clerical privileges, clerical concubinage, simony and a broad host of other perceived abuses emanating from the Church hierarchy and papacy.¹² Although Luther's complaints were initially focused on reforming the Church from within, his complaints were quickly echoed by lay and clerical interests alike throughout northern Europe, indicating that anti-papal sentiments were deeply rooted well before the Reformation.

Luther initially circulated his theses privately, but printed editions quickly emerged in Leipzig, Magdeburg, Nuremberg, and Basel. Luther's literary output was immense – he wrote 30 publications which sold over 300,000 copies between 1517 and 1520 – and spread quickly throughout the Empire via printed copies (Spitz 1985). Luther's message initially spread in the free cities of central Germany. Cities such as Nuremberg accepted the Reformation, with powerful friends of Luther appointing preachers sympathetic to reform ideas (Cameron 1991). A contemporary movement emerged in the Swiss confederation, where Huldrych Zwingli (1484-1531) espoused many similar principles to Luther and preached to Zürich congregations in the vernacular (although Zwingli was by no means a direct disciple of Luther and the two disagreed on many points of doctrine). A hybrid Luther-Zwingli message caught on in the 1520s in many of the free cities of southern Germany such as Strasbourg and Constance (Cameron 1991).

¹² There were other complaints put forward by the Reformers, many of which were theological in nature. Many had to do with salvation and the corruption of the Church's means to salvation.

The Reformation usually took hold in a city through the efforts of a small cadre of learned, literate priests and scholars who took it upon themselves to spread Luther or Zwingli's message. Many of these reformers were quite fervent, aggressively questioning congregations about the nature of worship and the practices of the Church hierarchy (Blickle 1984). It was through the efforts of these reformers that the movement spread so quickly; most had positions in the established Church and could address the masses directly from the pulpit. These preachers were particularly effective in Saxony and Central Germany in the 1520s, where they were successful in spreading the Reformation to towns such as Altenburg, Eisenach, and Zwickau. In the late 1520s and 1530s, reforming preachers helped convert larger towns such as Strasbourg and Lübeck, with numerous Baltic cities following suit. Many major south German cities, such as Augsburg, converted in a similar manner in the 1530s. In many cities, the reformers were welcomed by the city fathers or princes in order to justify the strength of their position vis-à-vis the Church (Cameron 1991).¹³ This was not the case in all cities however, as the Reformation was rejected or suppressed in a number of German cities such as Cologne, Würzburg, Bamberg, and Freiburg.

An important thesis forwarded by Steven Ozment is that the Reformation was an “urban event”.¹⁴ Indeed, 50 of the 65 imperial cities either permanently or periodically accepted the Reformation (Ozment 1975). The close proximity of urbanites to each other, greater levels of wealth and literary awareness, and relative political sophistication have been given as reasons why the Reformation took off in many of the free cities of the Holy Roman Empire. Ozment

¹³ Ekelund, Hébert and Tollison (2002) suggest, in a similar manner, that civil authorities sought an alternative provider of legal services and a less costly path to salvation through the Reformation, as the Church (a monopolist) was overcharging. Their analysis highlights yet another necessary pre-condition of the Reformation, complementing the one proposed in this paper.

¹⁴ The Reformation also coincided (and was perhaps facilitated by) a series of uprisings amongst the peasant masses between 1524 and 1526. These inter-connected revolts, broadly known as the Peasants' War, occurred throughout most of Germany, except for Bavaria. Luther rejected the Peasant's grievances but urged the lords to come to a peaceful solution (Spitz 1985).

(1975) suggests that such cities permitted a much greater degree of Protestant infiltration than the closed, autocratic regimes of the princes. In many of the cities that accepted the Reformation, such as Strasbourg and Ulm, the city councils took charge of installing the Reformation by bringing in preachers sympathetic to the reform ideas. In the northern Hanseatic cities, it was largely the middling bourgeoisie – who were wealthy but had little political power within the cities – that encouraged the Reformation as a means of confronting the established powers. Some of the members of these council sought economic gains, such as confiscation of Church property, while others undoubtedly felt the pressures for change arising from preachers and the masses (Blickle 1984). In most cases, the Reformation was supported by some literate class with a modicum of power, but far enough removed from the princes or Emperor to not fear direct retribution (Cameron 1991). Once the Reformation was accepted by a town, it generally followed that the old privileges and status of the priesthood and hierarchy were removed, followed by the confiscation or destruction of the Church's material wealth.¹⁵

Protestant ideas eventually spread throughout much of Europe. In France, Calvinist churches rapidly spread in the west and south in the 1550s. These Protestants, known as the Huguenots, were violently suppressed until a series of peace edicts were agreed upon in the 1570s-1590s (Cameron 1991). Similar movements occurred in the Low Countries, where Calvinist ideas spread through the 1540s-1560s. The Spanish Habsburgs reacted quite harshly to Protestants, burning nearly 2,000 between 1523 and 1555. Protestantism was deeply enmeshed with the broader revolt against Spanish rule and was especially popular in the northern half (Netherlands), where William of Orange co-opted the new religion. Political motives were also

¹⁵ The acceptance of the Reformation by no means happened in each town for the same reason. Cameron (1991) lists three primary reasons which are not mutually exclusive: political/material reasons, those based on the Reformation's alleged appropriateness to a class, order, or constitution, and psychological/spiritual reasons. It is not the purpose of this paper to discern between these three.

important in England, where Henry VIII dealt significant blows to the established church, which consolidated as the state-sponsored Anglican Church under Elizabeth I (1558-1603).

2.3. *The Causal Mechanism: Connecting Printing and Protestantism*

“[The printing press is] God’s highest and ultimate gift of grace by which He would have His Gospel carried forward.” – Martin Luther (quoted in Spitz 1985)

Is it a coincidence that two of the most important events in the Western world of the last millennium – the spread of the printing press and the Protestant Reformation – sprouted 250 miles apart in the Holy Roman Empire, with the Reformation commencing soon after the press became entrenched throughout Europe? Is it a coincidence that the Reformers employed the “first propaganda campaign conducted through the medium of the press” (Febrve and Martin, p. 288)?¹⁶ This paper is far from the first one to suggest a connection between the printing press and the Reformation, but it is the first one to statistically test the *extent* of this connection.

Table 1 provides some preliminary evidence that early printing centers were more likely to adopt the Reformation. This table lists the top German-speaking book producing cities in each decade of the latter half of the 15th century (combining the 1450s and 1460s) as well as the religious status of each of these cities.¹⁷ There is general continuity in the top print centers, with Cologne, Strasbourg, Augsburg, and Nuremberg in the top five in each of the last three decades.

¹⁶ Edwards (1994, p. 1) begins his book on Luther and the printing press by noting that “The Reformation saw the first major, self-conscious attempt to use the recently invented printing press to shape and channel a mass movement.”

¹⁷ These data are cataloged by the Incunabula Short Title Catalog (ISTC 2008), a massive project spearheaded by the British Library to catalog all incunabula (books published between 1450 and 1500) still in existence. These data include the number of editions, not the number of books, printed by each publisher. It should be noted that major selection issues may exist with these data, which is a primary reason why they are not employed in the analysis. Namely, it is possible that there were different survival rates of books published in different cities. The most likely cause of bias is that some areas faced greater destruction during the Thirty Years War and thus manuscripts were less likely to have survived from these areas. (I thank Jeremiah Dittmar for this insight). The greatest destruction, in terms of casualties, occurred in southwest and northeast Germany, both of which were predominantly Protestant. This means, therefore, that any bias would likely be *against* finding more books in Protestant areas, meaning that the effect of the press may be understated. Data on books in German which were collected as part of the ISTC project as of 1962 is also available (British Library 1962).

Most of the German printing centers were Protestant by 1600, with Cologne as the primary exception. More importantly, it appears that the top print cities were more likely (on average) to adopt the Reformation by 1530 and by 1600; 70% of the top printing centers of the 1470s and 60% of the top printing centers of the 1480s and 1490s adopted the Reformation by 1530, despite only 32.6% of overall German-speaking cities adopting the Reformation by this date.

[INSERT Table 1 HERE]

The classic connection made between the printing press and the Reformation is a supply-side one, focusing on the role that the new information technology played in spreading Lutheran ideas. The supply-side argument states that the press permitted a less expensive and more rapid transmission of Protestant ideas, primarily through pamphlets. There are numerous factors supporting the supply-side theory. First, papal caricatures and broadsheets disseminated by the Reformers played a significant role in their propaganda efforts amongst the illiterate masses. These broadsheets were easy to understand and designed to catch the attention of the reader, often including direct insults to the Church and the papacy.¹⁸ Robinson-Hammerstein (1989, p. 12) describes how the Reformers used broadsheets to reach the masses as follows:

Even if the people confronting the broadsheet were unable to read, they could still have received the message, since it was customary and indeed made good business sense for a pedlar to recite the title in order to attract the attention of prospective buyers. However, to forestall all ambiguities and conjectures, a fuller text was also provided, designed to assist further in decoding and communicating a message which was considered by its originators as of vital interest to the spectators. Again, the unlettered were more than likely to find literate bystanders willing to read out and talk about the text, thus initiating a process of intensified communication.

Second, the press allowed for the spread of pamphlets to literate preachers and other religious-minded individuals who brought the Reformation into cities and villages. Although

¹⁸ The effect of printed religious drawings was significant prior to the Reformation as well and likely provided motivation for its use as propaganda by the reformers (Ozment 1975).

most people were illiterate in this period, the pamphlets were written in such a manner that they could be read aloud in public meeting places. They were generally around eight pages and provided an inexpensive and concealable means for would-be reformers to spread the ideas promulgated by the lead reformers. High transport costs and lack of copyright in this period meant that printed works were not often shipped from a printing center to other locations – instead, works more frequently spread through reprinting (Edwards 1994). Hence, those living in cities with presses or close to presses had much greater access to inexpensive printed works.¹⁹

Table 2 provides some preliminary evidence that pamphlets were important to the initial spread of the Reformation. Amongst the German-speaking cities, 43% of those that produced a religious pamphlet prior to 1530 converted to Protestantism, while only 30% of those not producing religious pamphlets converted ($p = 0.163$).²⁰ This effect appears to go away a bit by 1560 and virtually disappears by 1600. This is consistent with evidence provided in the next section on the relationship between the printing press and conversion to Protestantism.

[INSERT Table 2 HERE]

It is also possible that the printing press affected demand for the Reformation. Eisenstein (1979), for example, argues that print culture transformed cities, in some cases elevating the desires of the bourgeoisie and middle classes to greater social importance. This in turn could have made print cities more receptive to the Reformation, as the rising bourgeoisie had incentive to undermine the old order dominated by the Church and landed interests. Eisenstein (1979, p.

¹⁹ Likewise, the press allowed for information dissemination through posters. Before most big Reformation events, posters were placed to advertise, ensuring a large audience and giving the event a sense of importance (Febvre and Martin 1958).

²⁰ The data on 16th century theological pamphlets written in German is from the Bavarian State Library (BSL 2011), which has conducted a massive digitalization project of early printed works. This library houses the largest collection of documents written in German in the 16th century. Much like the book edition data from ISTC, there are possible selection and survival biases associated with these data. Yet, if Bavarian records are overly sampled, this works against the hypothesis proposed in this paper, as Bavaria remained Catholic to a much greater extent than most of the rest of the Holy Roman Empire.

132) also suggests that the demand for the Reformation could have been enhanced by the press in a more subtle way: “while communal solidarity was diminished, vicarious participation in more distant events was also enhanced ... Printed materials encouraged silent adherence to causes whose advocates could not be found in any one parish and who addressed an invisible public from afar.”

The data that I have collected cannot fully discern between the demand and supply-side hypotheses, although Table 2 provides some support for the latter. What the data can do, however, is permit a statistical test of the role that the printing press played in the spread of the Reformation. The primary question explored is: “How much more likely was a city to adopt the Reformation if it had at least one printing press by 1500?” If it turns out that print cities were much more likely to adopt the Reformation (and indeed, I show that they were), then it suggests an important linkage between the spread of printing and the success of the Reformation.

3. Analysis

3.1. Data

The primary relationship of concern is the one between the printing press and the spread of Protestantism. I have gathered city-level data which includes whether a city was Protestant in 1530, 1560, and 1600, whether a city had a printing press by 1500, and numerous variables which control for the supply and demand of Protestantism. The universe of observations is all cities known to have population by 1500. This includes all press cities as well as all cities for which Bairoch et al. (1988) collected population data in or prior to 1500 (Bairoch et al. (1988)

collected population data for every European city that reached 5,000 inhabitants at some point by 1800).²¹ Details of all variables are available in the Appendix.

Protestantism spread quickly throughout the German parts of the Holy Roman Empire. Many of the cities in these areas adopted Protestantism by 1560, though numerous Catholic enclaves remained. Protestant ideas were popular in Bohemia (Czech Republic) though it remained nominally Catholic – in some cases by compulsion. Numerous Austrian cities adopted the Reformation by 1560, but were “re-Catholicized” by the counter-Reformation in the latter half of the century. Protestant ideas eventually spread to the Low Countries – the Netherlands adopted Protestantism by 1600 and Protestantism was popular, though suppressed by the Spanish, in Belgium.

This analysis focuses on the acceptance of Protestantism in Central and Western Europe. This includes numerous areas in which there is no variation in religion, such as Spain, Italy, Portugal, England, and Scandinavia. Although a small amount of religious variation existed in France, Ireland, and Scotland, most of the variation comes from the Holy Roman Empire, which de facto included cities in present day Germany, Austria, Czech Republic, Belgium, Luxembourg, eastern France, and western Poland.²² Areas in the de jure (but not de facto) Holy Roman Empire included Switzerland, which de facto broke away from the Empire in 1499, the Netherlands, which revolted and broke away from the Holy Roman Empire in the 1570s, and northern Italy (e.g., the Duchies of Savoy and Milan), which was not de facto subject to the Emperor. German-speaking cities with populations of at least 15,000 are listed in Table 3, along with their religious affiliation in 1600 and whether the city had a printing press by 1500.

²¹ Seven press “cities” were monasteries or abbeys, such as the abbey in Schussenried, which obtained a press in 1478. These “cities” are excluded from the analysis.

²² I thank Davide Cantoni for pointing out to me the nuances of the differences between the de facto and de jure Holy Roman Empire. For more, see Cantoni (2010).

[INSERT Table 3 HERE]

It is immediately noticeable from Table 3 that a majority of the larger German-speaking cities had printing presses. Printing spread outward from Mainz soon after its invention in 1450, and printers generally moved to large population centers, where demand for printed works was greatest. This stylized fact suggests that printing presses were not randomly assigned to cities; city-level characteristics (such as population) – which also may have been correlated with the demand for the Reformation – clearly played a role in determining which cities adopted the press. Table 4 illustrates this point. The top section of this table, which breaks down all European cities in the sample printing press and Reformation adoption, suggests that cities with a press were *less likely* to adopt the Reformation than cities without a press ($p=0.205$). However, the bottom two sections indicate that this may be an artifact of not controlling for city size. The middle section indicates that bigger cities may have been more likely to adopt the Reformation if they had a press ($p=0.164$), while there appears to be almost no difference in small press and non-press cities in their decision to adopt the Reformation ($p=0.897$). These results should not be taken as causal – no other cities characteristics are controlled for and endogeneity issues exist – but instead are intended to provide motivation for a well-designed empirical analysis; it is quite clear from Table 4 that mere correlations can provide misleading results.

[INSERT Table 4 HERE]

Figure 1 provides further motivation for an empirical analysis that controls for a variety of city-level characteristics. A quick glance at this figure indicates that proximity to Wittenberg played a role in a city's likelihood of adopting the Reformation. It also lends support to the supposition that city size was a determinant of print adoption, and possibly a determinant of Reformation adoption and thus should be accounted for in an empirical analysis.

[INSERT Figure 1 HERE]

More generally, these facts suggest that a regression analysis which controls for a host of city-specific features may shed significant light on the causal connection between printing and the Reformation. Such an econometric analysis should control for numerous supply and demand features related to the decision of a city to accept Protestantism. To this end, I include demand controls indicating whether the city housed a university by 1450, whether the city housed a bishop or archbishop by 1517 (proxying for depth of Church influence), whether the city was a member of the Hanseatic League (and thus had better access to information flows and greater wealth, affecting both supply and demand), whether the city was an independent, Free Imperial city in 1517 (indicating that it was large and economically important; independence from princely rule also affects supply, as ideas often flowed more freely in such cities), and whether a city belonged to a lay magnate (it was neither free nor subject to an ecclesiastical lord). Supply controls include a dummy for the presence of printing, whether the city was on water (ocean, sea, large lake, or river connected to another city; this controls for information flows), and its market potential (the sum of other city's population divided by their distance to the city in question). I use the presence of a university as of 1450 instead of 1517 because it is possible that the presence of a press (which was invented in 1450) could have attracted scholars and thus encouraged the building of a university. I employ other controls as of 1517, the year that Luther posted his 95 Theses, despite testing the spread of Protestantism as late as 1600, because any post-1517 universities, bishoprics, or changes in population may be endogenous to Protestantism, and reverse-causality would result.²³

²³ Dittmar (2011) suggests that cities that adopted printing early grew faster in subsequent centuries, and Becker and Wößmann (2008, 2009, 2010) suggest that cities and counties which adopted Protestantism had better subsequent economic outcomes due to greater levels of human capital. Data on printing presses is readily available and reliable prior to 1500 but not 1517 (Febvre and Martin 1958; Clair 1976).

Two other supply-side controls included in the analysis are the city's distance to Wittenberg and its distance to Zürich.²⁴ The former is shown by Becker and Wößmann (2008, 2009, 2010) to be correlated with the spread of Protestantism in Prussia, and the latter is included to account for the fact that Huldrych Zwingli based his Protestant revolt out of Zürich, and many of the Swiss and southern German cities that converted did so as a result of Zwingli's efforts.²⁵ It can clearly be seen in Figure 1 that there is a strong geographical component to the spread of the Reformation around both Wittenberg and Zürich. Moreover, Dittmar (2011) shows that the spread of printing is related to distance from Mainz – hence not controlling for distance to Wittenberg and Zürich may falsely indicate that printing (and not proximity to Wittenberg or Zürich) had an effect on acceptance of Protestantism. A city's distance to Wittenberg and Zürich, in combination with nation (as of 1500) and Imperial Circle (in the Holy Roman Empire)²⁶ fixed effects, serves to control for the spatial component of the Reformation. Summary statistics of all variables for all European cities in the sample are listed in Table 5.²⁷

[INSERT Table 5 HERE]

3.2. *Printing Presses and Protestantism in Europe, 1530-1600*

3.2.1. *Probit Analysis*

²⁴ All of the “distance to” variables are calculated “as the crow flies”. It would be ideal to use the historical route traveled between cities, but such data are not available for most of the smaller cities in the sample. Controlling for access to water helps alleviate some of this concern, since most savings in travel time in this period came through access to waterways.

²⁵ Likewise, Spitz (1985, p. 190) suggests that “perhaps because of its greatest distance from Wittenberg and Zurich, the progress of reform was slow and inconsistent, as compared with progress in the north and northeast [of Germany] as well as the southwest.”

²⁶ Much of the Holy Roman Empire was split into 6 Imperial Circles in 1500, and most of the remainder was split into 4 Imperial Circles in 1512. I include Imperial Circle fixed effects in many of the regressions presented in the following section, with the Upper Saxon Circle and Electoral Rhenish Circle combined into one “Elector” fixed effect, since these two circles encompassed the Electors of the Holy Roman Empire.

²⁷ A correlation matrix of all of the primary variables is located in the Appendix, Table A1.

The discussion in the previous section suggests that city-specific characteristics must be controlled for in order to understand the relationship between the spread of printing and the spread of the Reformation. To this end, I estimate the following reduced form model:

$$(1) Pr(\text{city } i \text{ Protestant in Year } t = 1 | X_i, Press_i) = \Phi(\alpha_1 + \beta_1 Press_i + \gamma_1 X_i + \delta_i + \varepsilon_1),$$

where $t = \{1530, 1560, 1600\}$, $Press_i$ is a dummy indicating whether city i had a printing press by 1500, Φ is the normal cdf, δ_i is a vector of nation and Imperial Circle fixed effects (the latter being employed for cities in the Holy Roman Empire), and X_i is a vector of supply and demand control variables,²⁸ including log of population in 1500, market potential in 1500, dummies for whether the city was a member of the Hanseatic league, a Free Imperial city by 1517, subject to a Lay magnate in 1517, had a university by 1450, a bishop by 1517, had access to water, and its distance to Wittenberg and Zürich. In all regressions, standard errors are clustered by the city's territory at the beginning of the Reformation.²⁹

I estimate equation (1) using a probit regression for each year in which I have data: 1530, 1560, and 1600. The average marginal effects of all major variables are reported in Table 6.³⁰ The first three columns report only the simple correlation (using the probit specification) between Protestantism and the presence of printing. There appears to be a strong negative correlation between the two when all controls are omitted. However, this negative correlation goes away in Columns 4-6, which include city population and the Free Imperial city dummy, which proxy for city size and economic importance. As expected, the Free Imperial city dummy

²⁸ X_i does not differ over time since all control variables are time invariant. Some variables, such as population, changed over time in reality but not in the data set, as data restrictions do not allow for such a panel to be collected.

²⁹ The Holy Roman Empire was ruled by numerous territorial princes, both lay and religious. Some territories were quite large, such as Saxony and Brandenburg, while others were much smaller. Independent cities are considered their own territory, since the citizens were not responsible to a prince. Andree (1886) provides a map detailing the territorial breakdown of the Holy Roman Empire at the time of the Reformation.

³⁰ Results in columns 4-15 are robust to using an OLS, linear probability model specification, although the LPM model shows a positive correlation in the first 3 columns. These results are available upon request. The probit coefficients for all regressions are also available upon request.

enters positively and significantly – in the spirit of Ozment’s (1975) claim that the Reformation was an urban event. The average marginal effects of the press are positive in this specification, but not statistically significant. The difference between these results and the raw correlations can be explained by the negative coefficient on the log population variable; since more populous cities were more likely to have the press but less likely to adopt the Reformation (controlling for Free city status), the coefficients in the raw correlations are severely biased downward.³¹ Columns 7-9 include controls for the demand for the Reformation: a university dummy, bishop dummy, and lay magnate dummy. The bishop coefficient enters with a negative sign (as expected) and is highly significant in all three specifications. Adding these controls increases the estimate of the average marginal effect of the press dummy in all three specifications, and it is statistically significant in the 1600 specification ($p=0.011$) and nearly so in the 1560 specification ($p=0.124$). With the addition of supply-side variables controlling for information flows (Hanseatic and water dummies, and market potential) in columns 10-12 and geography (distance to Wittenberg, distance to Zürich, and region fixed effects) in columns 13-15, the press coefficient becomes positive and highly significant 1560 and 1600 specifications ($p=0.046$ and $p=0.000$, respectively), though with a lower point estimate in the latter. These results indicate that after controlling for geography, cities with presses by 1500 were on average 9.4 percentage points more likely to adopt the Reformation by 1560 and 11.0 percentage points more likely to adopt the Reformation by 1600.³² All of the statistically significant controls except for market

³¹ This discussion along with the one in the previous section indicates the possibility that the interaction between population and the presence of a press should be considered. Appendix Table A2 shows the results of regressions which include this interaction term. The coefficient of the interaction term is insignificant in all 3 specifications (1530, 1560, and 1600). Hence, it is not included in the primary analysis.

³² The results reported in Table 6 employ a dummy for whether a city had a printing press as a proxy for accessibility to printed works. Yet, it is not immediately clear that this is the best proxy for a city’s accessibility to printed works. Is actually having a press in a town important, or is being *near* a press town sufficient? As noted before, high transport costs and lack of copyright meant that works primarily spread through reprinting. Hence, cities that were too far away from print towns were unlikely to have access to inexpensive printed works, but cities

potential enter with the expected sign. Controlling for geography appears to be especially important; one striking result is the large negative coefficient on the distance to Wittenberg variable, a finding which supports that validity of Becker and Wößmann's (2008, 2009, 2010) "distance to Wittenberg" instrument. The R^2 of the final set of regressions is substantially larger in the 1560 and 1600 specifications, as well, further indicating the importance of including geographic controls.³³

[INSERT Table 6 HERE]

Note that the number of observations in the final three columns drops substantially compared to the previous columns. This is because the probit specification omits observations where one of the independent variables predicts success or failure perfectly. Since there is no variation in religious choice in Italy, England, Spain, Portugal, Scandinavia, the Netherlands, or (non-Holy Roman Empire) Poland, these observations are dropped in all specifications.³⁴ The average marginal effects in the final 3 columns are reported at the Electorate Imperial Circle dummy (where Mainz is located) equaling 1 and all other dummies equaling 0, and results are robust for all other Imperial Circle dummies equaling 1.³⁵

close to print towns may have. To address this concern, I include in the Appendix (Table A3) results which replace the printing press dummy with dummies equaling one if the city has a press located within 10 or 20 miles. Given transportation costs of the period, it is unlikely that printed works frequently traveled much further. The results are broadly similar to those reported in Table 6.

³³ The results in Table 6 are robust to a variety of specifications. Appendix Table A4 replicates the last 3 columns in Table 6, replacing distance to Zürich with distance to Geneva (where Calvin was based). These results are broadly similar to those reported in Table 6. Appendix Table A5 replicates the last 3 columns, restricting the data to regions important to the spread of the Reformation. These include the German speaking lands (as in Cantoni [2010, 2012]), and the de jure and de facto Holy Roman Empire. Not surprisingly, the point estimates for the 1560 and 1600 specifications are larger in all three cases, although the general patterns in terms of statistical significance remain the same. The results are also broadly similar when different press data are used (Febrvre and Martin (1958), Clair (1976), ISTC (2008)). Table A6 indicates that the results hold if each of these sources is used individually to construct the press dummy.

³⁴ In addition, Scotland, France, Ireland, Belgium and the Bavarian and Austrian Imperial Circles are dropped in 1530 and Belgium is dropped in 1600.

³⁵ Table A13 in the Appendix reports that average marginal effects of the press coefficient at different Imperial Circles for the two stage regressions analyzed in the following section.

The results presented in Table 6 call for further inspection. First, the coefficient on the press dummy is insignificant in the 1530 specification. This is the opposite of what is expected – if the press were truly an important mechanism for spreading the ideas of the Reformation, it is reasonable to expect that the *largest* effect of the press would come early in the Reformation, when towns were initially subjected to the Protestant propaganda. Another point of consideration is that the Bishop coefficient is always negative and often significant. This is not surprising, since the Bishop dummy proxies for the depth of Catholic influence. Yet, this variable may be correlated with an omitted variable that is also correlated with the presence of printing: pre-press literacy. The Church was one of the most important early users of printing technology, and most of the literati were found somewhere in the Church hierarchy. The same could be said for universities, many of which were filled with Churchmen, although this coefficient is not significant in Table 6.³⁶ There are thus two qualifications of the interpretation of the coefficient on the press dummy. First, this coefficient should be interpreted as the *net* effect of the press on acceptance of Protestantism; it is possible that the Church also used the press to help keep some towns Catholic.³⁷ Second, and more importantly, the printing press coefficient may be *negatively* biased. If towns with higher exogenous (pre-press) literacy were more likely to attract presses but less likely to convert to Protestantism (a possibility indicated by the negative coefficient on the Bishop dummy), then the coefficient on the press dummy is biased downward and the effect

³⁶ While some universities helped facilitate the spread of Reformation ideas (e.g. Wittenberg, Erfurt, Zwickau), others were openly hostile (e.g. Rostock, Cologne, Leuven) (Cameron 1991). Indeed, despite the Church losing its monopoly on university curricula at some major universities such as Paris, entrenched Church power and ideology were associated with many institutions of higher education at the time of the Reformation. Likewise, Cantoni (2011), citing Walter Ziegler, notes that university employees had an interest in keeping the status quo, since they were further advanced in the state bureaucracy, which required training in formal law. Cantoni and Yuchtman (2012) argue that the Papal Schism of the 14th century encouraged the building of universities in the German lands. They use the Schism as a “natural experiment” to argue that universities contributed positively to economic growth. Chilosi and Volckart (2010) show that financial integration was greater in university towns that had a printing press.

³⁷ The Counter-Reformation did not likely have any effect on the 1530 results and at best a small effect on the 1560 results, as it formally began with the Council of Trent (1545-1563).

of the press on the Reformation is *greater* than indicated by this regression. This is especially true of the 1530 specification, as Church influence was likely more pertinent in slowing the spread of the Reformation in the short run – though eventually failing in some areas in the long run. I tackle this omitted variable bias in the following section by instrumenting for the press.³⁸

3.2.2. *Testing for Endogeneity: Distance to Mainz as an Instrument*

Since the printing press was not randomly assigned to cities, omitted variable bias may affect the interpretation of the regression results reported in the previous section. One such unobserved factor, pre-printing press literacy, is related to the adoption of printing and possibly related to the acceptance of the Reformation. Cities that were more literate prior to the advent of printing were almost certainly more likely to adopt printing, and it is possible that such cities were less (or more) likely to adopt the Reformation. Since the presence of a printing press may be correlated with omitted variables that are themselves correlated with conversion to Protestantism, some source of exogenous variation in printing is needed to obtain causal results. I address this

³⁸ Another potential problem with the results reported in this section is that the dates in which press data were collected, 1450-1500, are arbitrary. To alleviate such a concern, I create variables for whether a city had a press by 1480 and 1490. These results are reported in Appendix Table A7. These results broadly confirm the idea that early adopters of the press were more likely to accept the Reformation, all else being equal. I also estimate equation (1) using different metrics for inclusion in the data set. It is possible that including any city known to have population in 1500 biases the results in favor of finding a connection between the press and the Reformation. Table A8 presents similar, though statistically weaker results when only cities with 1500 population data in Bairoch et al (1988) are included, when cities with population data from 1500 and before are included, and when these cities and other print cities with post-1500 population data are included. Omitting these cities does not appear to substantially bias the results connecting the press to the Reformation, though it does bias the results against the instrument employed in the following section (distance to Mainz). If only cities with population data are included, then small print cities are the ones most likely to be omitted. Yet, these are *precisely* the cities for which being close to Mainz was an important determinant of adoption. Table A9 reports results where dummies for 50-mile concentric circles emanating from Wittenberg and Zürich replace the log of distance to these cities (to remove concerns about non-linearities). These results are similar to those found in Table 6, though the statistical significance is weaker in the 1600 specification. Finally, Table A10 presents the results of a random effects panel regression model, where the data are reconstituted as a panel. The results are similar, although the coefficient on the press is not significant ($p=0.159$). The hazard ratios are also reported in this table; they indicate that cities with presses were 23.1 percentage points more likely to adopt the Reformation in any given period given that it was Catholic at the beginning of the period (though this effect is not statistically significant, $p=0.243$). Concerns of statistical insignificance are alleviated in Table A19, which presents a two-stage regression using the panel data and finds results similar to the other two-stage regressions analyzed in the following section.

problem in this section, where the city's distance to Mainz (the birthplace of printing) is employed as an instrument for the adoption of the printing press.

Distance to Mainz provides an ideal instrument for the adoption of printing because it was an important determinant of adoption while, theoretically, it should have had no independent impact on the acceptance of Protestantism. Dittmar (2011), who uses distance to Mainz as an instrument for printing (to test the effects of early print adoption on subsequent city growth), notes in great detail that early printers were either apprentices or business partners of Gutenberg in Mainz. Due to the proprietary nature of the technology, significant barriers to entry existed, and printing technology hence spread *outward* from Mainz in a series of concentric circles. The largest barrier to entry was the acquisition of metal type, as the process used to cast movable metal type required a specific combination of alloys that remained a secret amongst a small group of printers (Dittmar 2011).³⁹

All else being equal, cities that were closer to Mainz were more likely to adopt printing, though the same can also be said for larger cities, university cities, and bishoprics, where demand was greater (though the last three would not qualify as instruments, as they were independently related to the acceptance of Protestantism). This is suggested by Figure 2, which shows the share of cities that adopted printing,⁴⁰ broken down by distance from Mainz. There is a clear trend that cities closer to Mainz were more likely to adopt printing. This is also suggested by Table 7, which lists the top German-speaking cities by book production in each decade along with their distance to Mainz. As printing spread in the 15th century, it appears that the center of the printing

³⁹ Dittmar (2011) also notes that the locations of paper mills, which had been established for centuries prior to the press, were not a determinant of the diffusion of printing.

⁴⁰ Only cities located in regions that had some variation in Reformation adoption in at least one of the time periods in question are included in this figure.

universe moved further and further away from Mainz (as noted by the weighted distance to Mainz).

[INSERT Figure 2 HERE]

[INSERT Table 7 HERE]

After controlling for a host city characteristics, there are still some unobserved variables such as pre-press literacy, idiosyncrasies amongst powerful printers, and printer networks which affected where printing spread. While these characteristics provide some of the variation needed to obtain causal results (to the extent that the variation is random), there is concern that the variation is not truly exogenous. In order for distance to Mainz to provide a source of exogenous variation, it must be correlated to the Protestant variables *only* through its correlation to the press. In other words, distance to Mainz works as an instrument only if it is unrelated to the determinants of whether a city adopted the Reformation. Although Mainz was not an unimportant town (it housed an archbishop who was an elector on the Reichstag), the results reported in Table 8 suggest that distance to Mainz was not an economic or religious center prior to the invention of the press.⁴¹ These estimations, which control for all other covariates in X_i ,⁴² show that distance to Mainz does not predict pre-printing economic status (measured by the Free Imperial city dummy), religious status (measured by the Bishop dummy), or other supply-side determinants of Reformation adoption (water, Hanseatic, and distance to Wittenberg).

It is also possible that cities which were growing in the 15th and 16th centuries had atmospheres more conducive to both the new ideas of the Reformers as well as the new

⁴¹ To save space, I do not report the coefficients on the control variables. These results are available upon request. Only cities located in regions that had some variation in Reformation adoption in at least one of the time periods in question are included in these regressions.

⁴² The bishop regression does not control for the free imperial city or lay magnate dummies because many bishoprics were by definition located in a religious territory. The 15th century city growth regression does not control for market potential, since the latter was in part the result of the former. Columns 6 and 7 only use data from cities in which population figures are available for years at both of the endpoints of the century in question.

technology of the printers. In fact, Dittmar (2011) finds that distance to Mainz is correlated with 16th century city growth. This does not appear to be the case in this sample, however, as columns 6 and 7 indicate that neither 15th nor 16th century city growth is related to distance to Mainz. This entails that distance to Mainz provides a plausible source of exogenous variation which can be exploited in an instrumental variables analysis.

[INSERT Table 8 HERE]

With these concerns regarding the instrument alleviated, I analyze the following system of equations, where X_i includes all of the independent variables included in the regressions in the previous section (equation (1)):

$$(2) \quad Press_i = \alpha_2 + \beta_2 Distance\ to\ Mainz_i + \gamma_2 X_i + \delta_i + \varepsilon_2,$$

$$(3) \quad Pr(Protestant\ in\ Year\ t = 1 | X_i, \widehat{Press}_i) = \Phi(\alpha_3 + \beta_3 \widehat{Press}_i + \gamma_3 X_i + \delta_i + \varepsilon_3).$$

Following Angrist (2001), I estimate equation (2) using an OLS estimation and equation (3) using a probit estimation.⁴³ The OLS results of the first stage and the average marginal effects of the second stage are reported in Table 9.⁴⁴ The instrument is above the Stock and Yogo (2002) strong instrument threshold in all specifications, indicating the strength of the relationship between the instrument and the potentially endogenous regressor.⁴⁵

[INSERT Table 9 HERE]

⁴³ The OLS estimation is more properly called a linear probability model since the printing dummy is dichotomous. The estimation method that I employ has the major benefit of being straight-forward and transparent, as it can be completed by using Stata's `ivprobit` command. Results are broadly robust, though statistically weaker, to bivariate probit estimation. Those results are available in Table A18 of the Appendix. The coefficient on the press in the 1600 specification is negative but not statistically significant.

⁴⁴ In the Appendix (Table A11), I include the results of a "reduced form" two-stage regression where distance to Mainz is included as a regressor in place of the printing dummy. In a 2SLS regression, the coefficient on log distance to Mainz would simply equal $\beta_2\beta_3$ (if equation (3) were estimated with OLS instead of probit), but the value is slightly different when (3) is estimated with probit. Regardless, the magnitude of the coefficient on log distance to Mainz is very close to expected ($\beta_2\beta_3$), and it is statistically significant in all three specifications.

⁴⁵ All other test statistics are available upon request.

The instrumental variables results indicate that the average marginal effect of the printing dummy is economically and statistically significant in all three specifications, although the point estimate is declining as the date in question progresses. More importantly, the magnitude of these results is enormous: the mere presence of a printing press prior to 1500 increased the probability that a city would become Protestant in 1530 by 52.1 percentage points, Protestant in 1560 by 43.6 percentage points, and Protestant in 1600 by 28.7 percentage points, *ceteris paribus*. These results indicate that there is a *massive* negative bias in all three specifications, although the bias weakens by 1600. The most obvious explanation for this downward bias is that the Church was one of the largest early users of print media (indeed, the Bishop and University coefficients are strongly positive in the first stage), and areas with extensive Church influence were slower to adopt the Reformation. This finding is also in line with the idea that the early adoption of the printing press was important for the initial spread of the Reformation, but its effect diminished by the end of the century (as more cities attained presses, political influences became more salient, and the Counter-Reformation emerged).⁴⁶

4. Conclusion

The connection between the printing press and the spread of the Protestant Reformation has long been debated. Despite the fact that the Reformers employed the printing press effectively to spread anti-papal propaganda, there is no counter-factual history to determine whether the Reformation would have been a success in the absence of the press. The biggest difficulty that previous studies faced is one of spurious correlation – it is quite possible that the city-level

⁴⁶ The Appendix provides results of two-stage regressions where i) a dummy for a press being located within 10 or 20 miles is the independent variable of interest (Table A12), ii) German-speaking regions (Table A14), iii) the de facto Holy Roman Empire (Table A15), iv) the de jure Holy Roman Empire (Table A16), and v) the 1560 and 1600 specifications limited to cities that are included in the 1530 specification (Table A17). The results are broadly similar, although the instrument is weaker in Tables A12, A14, and A15.

characteristics that encouraged adoption of the printing press *also* encouraged or discouraged acceptance of the Reformation.

In this paper, I address this issue through an econometric analysis. Probit and instrumental variable regressions suggest that cities which adopted printing early were much more likely to accept the Reformation. I find that in the European nations where some variation in religious choice existed, cities that were early print adopters were 52.1 percentage points more likely to adopt Protestantism by 1530, 43.6 percentage points more likely to adopt Protestantism by 1560, and 28.7 percentage points more likely to adopt Protestantism by 1600. These results suggest that early print adoption played a significant role in the initial spread of the Reformation, but other forces (such as political motives, the further spread of printing, and the Counter-Reformation) contributed to its persistence.

These results have broader implications for economic history. A number of recent studies have suggested that the printing press (Baten and Van Zanden 2008; Buringh and Van Zanden 2009; Chilosì and Volckart 2010; Dittmar 2011) or the Reformation (Becker and Wößmann 2008, 2009, 2010; Boppart et al. 2010) played a significant role in the subsequent economic development of Europe and “the West”.⁴⁷ The present study suggests that any linkages between the press or the Reformation and economic growth must be taken with extreme caution. It is possible that the true economic effects of the Reformation arose because cities which accepted the Reformation were in a better position to succeed due to earlier adoption of the press. Conversely, it is possible that cities that were early adopters of the printing press were successful in subsequent centuries because they were more likely to become Protestant and thus had some unique “work ethic” or incentive to acquire human capital. Though it is not the point of this

⁴⁷ For a contrast of the printing regulations imposed by European political authorities and the Ottomans, see Coşgel, Miceli, and Rubin (2012). For more on the political economy differences underlying this contrast, see Kuran (2010) and Rubin (2011).

paper to discern between these possibilities, it provides strong evidence that the historical connection between the printing press and the Reformation needs to be considered in any such investigations.

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TABLES

Table 1: Top 10 Cities by Book Production (German speaking), by decade

1450-1469				1470-1479			
City	Books	P/C 1530	P/C 1600	City	Books	P/C 1530	P/C 1600
Mainz	95	C	C	Cologne	412	C	C
Cologne	44	C	C	Augsburg	298	C	P
Strasbourg	17	P	P	Strasbourg	250	P	P
Bamberg	9	C	C	Nuremberg	165	P	P
Augsburg	6	C	P	Basel	154	P	P
Eltvil	3	P	P	Ulm	73	P	P
Basel	1	P	P	Mainz	64	C	C
Nuremberg	1	P	P	Speyer	46	P	P
				Lübeck	42	P	P
				Reutlingen	24	P	P
1480-1489				1490-1500			
City	Books	P/C 1530	P/C 1600	City	Books	P/C 1530	P/C 1600
Cologne	441	C	C	Leipzig	1040	C	P
Augsburg	405	C	P	Cologne	591	C	C
Strasbourg	364	P	P	Nuremberg	492	P	P
Nuremberg	359	P	P	Augsburg	486	C	P
Leipzig	284	C	P	Strasbourg	484	P	P
Basel	266	P	P	Basel	325	P	P
Ulm	144	P	P	Ulm	163	P	P
Speyer	126	P	P	Speyer	144	P	P
Lübeck	126	P	P	Mainz	126	C	C
Mainz	121	C	C	Lübeck	110	P	P

% of German speaking cities Protestant in 1530: 32.58%

% of German speaking cities Protestant in 1600: 71.35%

Table 2: Cities producing at least 10 religious pamphlets, 1517-1600

1517-1530			1530-1560			1560-1600		
City	Religious Pamphlets, 1517-1530	P/C 1530	City	Religious Pamphlets, 1530-1560	P/C 1560	City	Religious Pamphlets, 1560-1600	P/C 1600
Augsburg	123	C	Wittenberg	50	P	Ingolstadt	102	C
Strasbourg	68	P	Augsburg	35	P	Tübingen	89	P
Nuremberg	41	P	Cologne	30	C	Cologne	40	C
Wittenberg	40	P	Magdeburg	29	P	Heidelberg	33	P
Zürich	33	P	Zürich	25	P	Wittenberg	22	P
Basel	28	P	Leipzig	24	P	Munich	21	C
Cologne	26	C	Strasbourg	19	P	Eisleben	20	P
Leipzig	22	C	Basel	17	P	Regensburg	20	P
Munich	14	C	Ingolstadt	17	C	Iena	19	P
			Nuremberg	15	P	Strasbourg	15	P
			Tübingen	14	P	Bremen	14	P
			Ulm	12	P	Basel	14	P
			Frankfurt (A. M.)	11	P	Zürich	14	P
			Mainz	10	C	Frankfurt (A. M.)	13	P
						Lauingen	10	P
% of German speaking cities producing religious pamphlets (1517-1530) that were Protestant in 1530:			% of German speaking cities producing religious pamphlets (1530-1560) that were Protestant in 1560:			% of German speaking cities producing religious pamphlets (1560-1600) that were Protestant in 1600:		
42.9%			75.9%			71.8%		
% of German speaking cities not producing religious pamphlets (1517-1530) that were Protestant in 1530:			% of German speaking cities not producing religious pamphlets (1530-1560) that were Protestant in 1560:			% of German speaking cities not producing religious pamphlets (1560-1600) that were Protestant in 1600:		
30.1%			69.8%			71.2%		
Fisher test p-value (difference) 0.163			Fisher test p-value (difference) 0.657			Fisher test p-value (difference) 1.000		

Table 3: German Speaking Cities, population $\geq 15,000$

German Speaking Cities (with population $\geq 15,000$) with Printing Presses by 1500			German Speaking Cities (with population $\geq 15,000$) without Printing Presses by 1500		
City	Population (in 1500)	P/C (by 1600)	City	Population (in 1500)	P/C (by 1600)
Cologne	45,000	C	Aachen	18,000	C
Nuremberg	38,000	P	Bremen	18,000	P
Augsburg	30,000	P	Brunswick	18,000	P
Lübeck	25,000	P	Schwaz	17,000	C
Regensburg	22,000	P			
Strasbourg	20,000	P			
Vienna	20,000	C			
Erfurt	19,000	P			
Magdeburg	18,000	P			
Ulm	16,000	P			
Hamburg	15,000	P			
Metz	15,000	C			

Table 4: European Cities by Religion, Printing Status

	Cites With Press by 1500		Cites With No Press by 1500		Total	Fisher test p-value (difference)
	N	%	N	%		
Total Catholic in 1600:	125	70.2%	375	64.9%	500	0.205
Total Protestant in 1600:	53	29.8%	203	35.1%	256	
<u>Big Cities (pop ≥ 10,000)</u>						
Total Catholic in 1600:	79	75.2%	76	83.5%	155	0.164
Total Protestant in 1600:	26	24.8%	15	16.5%	41	
<u>Small Cities (pop < 10,000)</u>						
Total Catholic in 1600:	46	63.0%	299	61.4%	345	0.897
Total Protestant in 1600:	27	37.0%	188	38.6%	215	

Table 5: Summary Statistics

Variable	Obs.	Mean	Std Dev	Min	Max
<u>Protestant and Printing Variables</u>					
Protestant in 1530	756	0.112	0.316	0	1
Protestant in 1560	756	0.294	0.456	0	1
Protestant in 1600	756	0.339	0.474	0	1
Printing Press in 1500	756	0.235	0.425	0	1
<u>Control Variables</u>					
Log (population in 1500, in thousands)	756	1.742	0.895	0	5.416
Free Imperial City	756	0.057	0.232	0	1
University in 1450	756	0.066	0.249	0	1
Bishop in 1517	756	0.310	0.463	0	1
Lay Magnate	756	0.905	0.294	0	1
Market Potential	756	19.330	6.525	5.920	85.900
Water	756	0.655	0.476	0	1
Hanseatic	756	0.107	0.309	0	1
Log (distance to Wittenberg, in miles)	755	6.176	0.758	3.045	7.270
Log (distance to Zürich, in miles)	755	6.001	0.639	2.523	7.038
Log (distance to Mainz, in miles)	755	5.972	0.746	1.946	7.087

Table 6: Average Marginal Effects, Protestantism in Europe

	(6.1)	(6.2)	(6.3)	(6.4)	(6.5)	(6.6)	(6.7)	(6.8)	(6.9)	(6.10)	(6.11)	(6.12)	(6.13)	(6.14)	(6.15)
	Basic Correlation			City Size			Demand for Reformation			Supply of Reformation			Geography		
	Prot in 1530	Prot in 1560	Prot in 1600	Prot in 1530	Prot in 1560	Prot in 1600	Prot in 1530	Prot in 1560	Prot in 1600	Prot in 1530	Prot in 1560	Prot in 1600	Prot in 1530	Prot in 1560	Prot in 1600
Printing Press by 1500	-0.442*** (0.041)	-0.272*** (0.049)	-0.205*** (0.056)	0.032 (0.031)	0.046 (0.054)	0.065 (0.056)	0.043 (0.032)	0.086 (0.056)	0.149** (0.059)	0.051* (0.031)	0.087* (0.049)	0.112** (0.047)	0.001 (0.091)	0.094** (0.047)	0.110*** (0.030)
Log Population in 1500				-0.083*** (0.032)	-0.180*** (0.033)	-0.176*** (0.031)	-0.070** (0.030)	-0.152*** (0.031)	-0.131*** (0.032)	-0.072*** (0.021)	-0.154*** (0.024)	-0.142*** (0.025)	-0.004 (0.049)	0.004 (0.024)	-0.019 (0.017)
Free Imperial City				0.226*** (0.042)	0.404*** (0.065)	0.467*** (0.072)	0.091 (0.064)	0.352*** (0.118)	0.454*** (0.130)	0.089* (0.052)	0.317*** (0.091)	0.425*** (0.095)	0.026 (0.133)	0.231*** (0.072)	0.294*** (0.062)
University							-0.017 (0.062)	0.083 (0.070)	-0.029 (0.080)	-0.039 (0.054)	0.062 (0.062)	-0.032 (0.071)	-0.085 (0.141)	-0.026 (0.072)	-0.047 (0.072)
Bishop							-0.097*** (0.036)	-0.230*** (0.049)	-0.333*** (0.055)	-0.101*** (0.036)	-0.217*** (0.044)	-0.298*** (0.049)	-0.054 (0.093)	-0.116* (0.063)	-0.062 (0.042)
Lay Magnate							-0.138*** (0.049)	-0.054 (0.110)	-0.015 (0.125)	-0.147*** (0.044)	-0.049 (0.081)	0.046 (0.095)	-0.189* (0.102)	0.166** (0.072)	0.205*** (0.063)
Market Potential										-0.008* (0.004)	-0.013** (0.006)	-0.002 (0.006)	-0.058*** (0.019)	-0.032*** (0.010)	-0.022*** (0.008)
Water										0.039 (0.024)	0.119*** (0.035)	0.182*** (0.038)	-0.029 (0.065)	0.007 (0.036)	0.004 (0.027)
Hanseatic										0.118*** (0.031)	0.291*** (0.054)	0.387*** (0.054)	-0.081 (0.121)	-0.054 (0.068)	-0.015 (0.061)
Log Distance to Witt													-0.131** (0.063)	-0.326*** (0.043)	-0.392*** (0.035)
Log Distance to Zürich													-0.224 (0.156)	-0.006 (0.067)	-0.054 (0.053)
Imperial Circle Dummies	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y
Nation (as of 1500) Dum	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y
Observations	756	756	756	756	756	756	756	756	756	756	756	756	200	361	316
No. of Clusters	205	205	205	205	205	205	205	205	205	205	205	205	102	166	156
pseudo R-squared				0.12	0.12	0.11	0.15	0.16	0.18	0.24	0.29	0.31	0.21	0.60	0.66

Robust standard errors clustered by territory in parentheses; probit model, average marginal effects reported; in final three columns, marginal effects reported at the Electorate Imperial Circle equaling 1 and all other dummies equaling 0; a constant term is included in all regressions except for first three columns; *** p<0.01, ** p<0.05, * p<0.1

Table 7: Distance from Mainz (in miles), Top 10 Cities by Book Production (German-speaking)

1450-1469			1470-1479		
City	Books	Distance	City	Books	Distance
Mainz	95	0	Cologne	412	90
Cologne	44	90	Augsburg	298	172
Strasbourg	17	102	Strasbourg	250	102
Bamberg	9	129	Nuremberg	165	143
Augsburg	6	172	Basel	154	173
Eltvil	3	7	Ulm	73	140
Basel	1	173	Mainz	64	0
Nuremberg	1	143	Speyer	46	49
			Lübeck	42	291
			Reutlingen	24	115
Average		102	Average		127
Weighted Avg (by Books)		47	Weighted Avg (by Books)		125
1480-1489			1490-1500		
City	Books	Distance	City	Books	Distance
Cologne	441	90	Leipzig	1040	219
Augsburg	405	172	Cologne	591	90
Strasbourg	364	102	Nuremberg	492	143
Nuremberg	359	143	Augsburg	486	172
Leipzig	284	219	Strasbourg	484	102
Basel	266	173	Basel	325	173
Ulm	144	140	Ulm	163	140
Speyer	126	49	Speyer	144	49
Lübeck	126	291	Mainz	126	0
Mainz	121	0	Lübeck	110	291
Average		138	Average		138
Weighted Avg (by Books)		140	Weighted Avg (by Books)		152

Table 8: Exogeneity of Distance to Mainz Instrument

	(8.1)	(8.2)	(8.3)	(8.4)	(8.5)	(8.6)	(8.7)
	Free Imp. City	Bishop	Water	Hanseatic	Log Dist to Witt	Log 16th C Growth	Log 15th C Growth
Log Distance to Mainz	-0.039 (0.042)	0.051 (0.045)	-0.024 (0.049)	-0.017 (0.034)	0.088 (0.121)	0.057 (0.107)	0.096 (0.123)
Observations	361	361	361	361	361	192	135
No. of Clusters	166	166	166	166	166	108	90
R-squared	0.68	0.33	0.13	0.46	0.82	0.20	0.16

OLS regression; robust standard errors clustered by territory in parentheses; city specific, geographic control variables, and constant included as in previous regression; cities included if they are included in any of the final 3 specifications of Table 6; all controls are employed in each regression except for the dependent variable in question except for the Bishop regression, which does not include free imperial city or lay magnate controls and the 15th century growth regression, which does not include market potential; all controls are employed in columns 4 and 5; cities included in regressions reported in column 4 only if non-interpolated population data available in 1500 and 1600; cities included in regressions reported in column 5 only if non-interpolated population data available in 1400 and 1500; *** p<0.01, ** p<0.05, * p<0.1

Table 9: Average Marginal Effects, two stage regression with distance to Mainz instrument

	(9.1)	(9.2)	(9.3)	(9.4)	(9.5)	(9.6)
	First	Second	First	Second	First	Second
	Stage	Stage	Stage	Stage	Stage	Stage
	Press by	Prot in	Press by	Prot in	Press by	Prot in
	1500	1530	1500	1560	1500	1600
Log Distance to Mainz	-0.180*** (0.054)		-0.183*** (0.050)		-0.190*** (0.050)	
Printing Press by 1500		0.521*** (0.096)		0.436*** (0.126)		0.287** (0.140)
Log Population in 1500	0.128*** (0.043)	-0.059* (0.032)	0.132*** (0.026)	-0.039* (0.021)	0.127*** (0.032)	-0.038* (0.021)
Free Imperial City	-0.174 (0.113)	0.103 (0.085)	-0.179* (0.105)	0.219*** (0.059)	-0.189* (0.106)	0.294*** (0.067)
University	0.433*** (0.129)	-0.275** (0.115)	0.386*** (0.074)	-0.168* (0.095)	0.368*** (0.082)	-0.107 (0.099)
Bishop	0.276*** (0.105)	-0.160** (0.073)	0.184*** (0.063)	-0.143*** (0.049)	0.203*** (0.066)	-0.094** (0.042)
Lay Magnate	-0.023 (0.107)	-0.059 (0.084)	-0.039 (0.089)	0.144*** (0.054)	-0.029 (0.091)	0.190*** (0.057)
Market Potential	0.008 (0.008)	-0.048*** (0.016)	0.000 (0.009)	-0.028*** (0.008)	-0.000 (0.010)	-0.024*** (0.008)
Water	-0.024 (0.056)	-0.012 (0.046)	0.026 (0.042)	-0.010 (0.030)	0.022 (0.047)	-0.005 (0.025)
Hanseatic	0.023 (0.076)	-0.069 (0.076)	0.083 (0.073)	-0.066 (0.054)	0.035 (0.073)	-0.018 (0.055)
Log Distance to Wittenberg	0.096* (0.050)	-0.137*** (0.051)	0.077* (0.044)	-0.238*** (0.052)	0.087** (0.043)	-0.341*** (0.045)
Log Distance to Zürich	0.080 (0.094)	-0.161 (0.100)	-0.096 (0.081)	0.039 (0.061)	-0.064 (0.084)	-0.035 (0.051)
Imperial Circle Dummies	Y	Y	Y	Y	Y	Y
Nation (as of 1500) Dummies	Y	Y	Y	Y	Y	Y
Observations	200	200	361	361	316	316
No. of Clusters	102	102	166	166	156	156
Log Likelihood	-70.07	-162.54	-133.12	-226.02	-117.70	-190.06
p-value, Wald exogeneity test		0.008		0.020		0.202
F-stat on instrument	10.97		13.51		14.46	

Robust standard errors clustered by territory in parentheses; ivprobit estimation - first stage is OLS, second stage is probit, regressed on predicted values from first stage; average marginal effects reported at the Electorate Imperial Circle equaling 1 and all other dummies equaling 0; constant included; *** p < 0.01, ** p < 0.05, * p < 0.1

FIGURES

Figure 1: Protestantism and Printing in Europe, cities with population $\geq 5,000$ in 1500

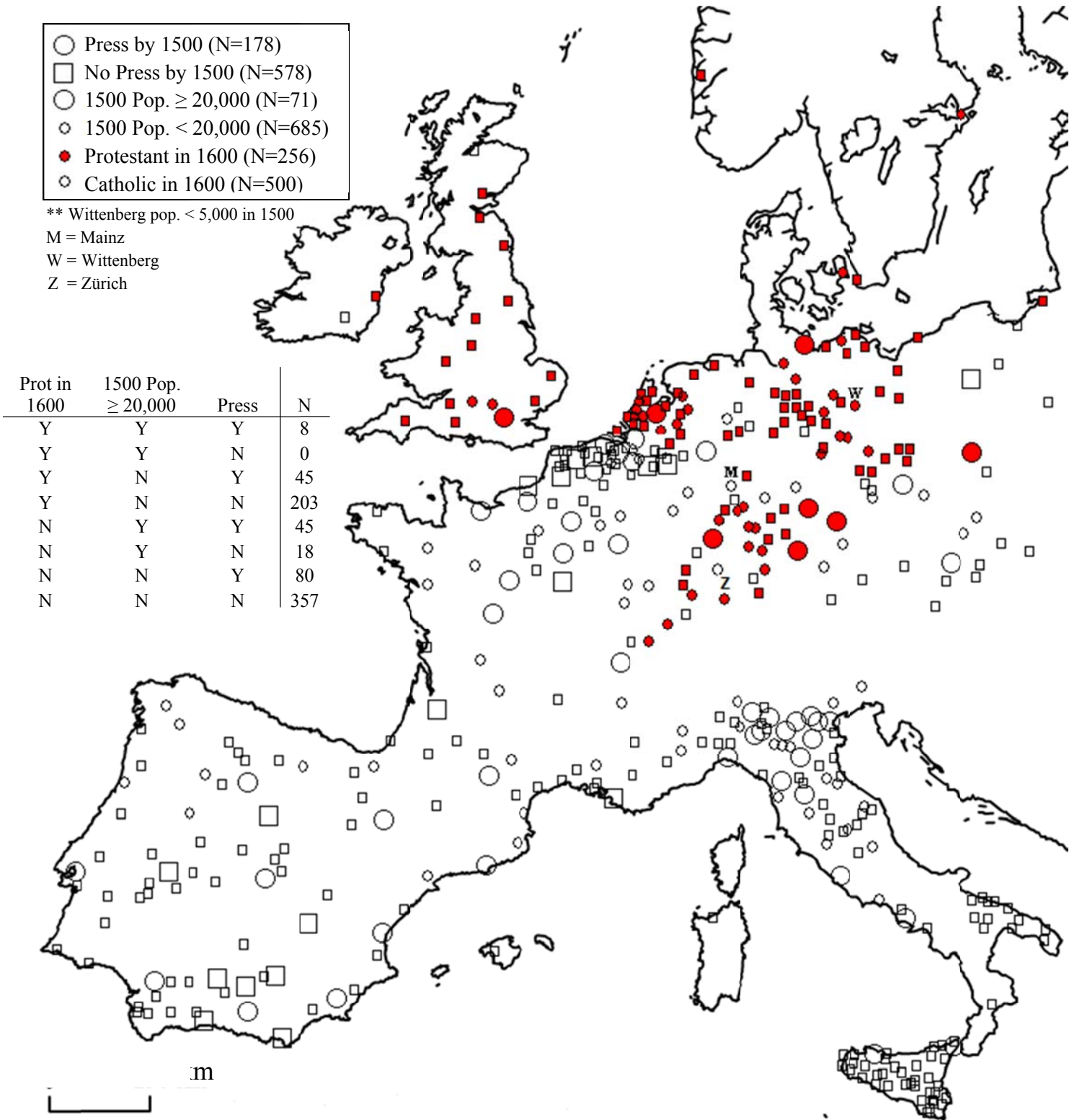


Figure 2: Portion of cities with printing press by 1500

