Printing and Protestants: Reforming the Economics of 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. The proposed causal pathway is that the printing press permitted the ideas of the Reformation to reach a broader audience. I test this hypothesis 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 suggests that within the Holy Roman Empire, cities with a printing press by 1500 were 19 percentage points more likely to be Protestant by 1560. This result weakens over time and across Europe, indicating that the press was important for the initial spread – but not necessarily the persistence – of the Reformation.

Keywords: Printing Press, Protestant Reformation, Information Technology, Revolt
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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 of this period include the "finding" of the New World, the invention of the printing press, the Ottoman conquering of Constantinople and threatening 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; Dittmar 2010).

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. On the one hand, Baten and Van Zanden (2008), Buringh and Van Zanden (2009) and Dittmar (2010) are recent additions to the literature stressing the importance of the printing press as an independent factor contributing to subsequent European economic growth.[1] Alternatively, Becker and Wößmann (2008, 2009, 2010), in the tradition of Weber and Tawney, connect the spread of Protestantism to subsequent economic growth – though unlike Weber and Tawney, 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.

[1] Classic studies providing a similar linkage include Febvre and Martin (1958) and Eisenstein (1979).
[2] Cantoni (2009) 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. Blum and Dudley (2001) present a pro-Weber argument, but suggest that Protestant economic networks, not a "work ethic" are the root cause. 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.

This paper is far from the first to connect the printing press to the Reformation. This argument is centuries old, with arguments in support of (Dickens 1968; Eisenstein 1979; Gilmont 1998) and against (Febvre and Martin 1958; Scribner 1989) the causal linkage connecting the press and the Reformation.[3] 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? It is clear that the pamphlets, broadsheets, and papal caricatures made possible by the press contributed significantly to the success of the Reformation. Indeed, the Reformation was the first historical movement in the post-Gutenberg era which the press made possible (Eisenstein 1979; Spitz 1985). Moreover, the Church was unable to suppress the Reformers at it had previous "heretics" such as John Wycliffe, Jan Hus, the Albigensians, and the Waldensians. These individuals had similar grievances with Church corruption as did Luther, Zwingli, and Calvin, but lived in a period before the Gutenberg and his press.[4]

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 that were more likely to accept the Reformation were also more likely to accept printing from an early period for an unrelated

[3] In a related work, Buringh and van Zanden (2009) show that conversion to Protestantism is strongly related to subsequent literacy outcomes.

[4] 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 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.

reason 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 is the case, then the Reformation may have been accepted in these cities even if the press were never invented.

It is nearly impossible to disentangle these events without careful data collection and analysis. To this end, I collect city-level data on conversion to Protestantism, the presence of a printing press, the number of books produced in a city by decade (in Germany and Switzerland), and a host of control variables including population, the presence of a university, and many others. I first focus on the Holy Roman Empire (including modern day Germany, Switzerland, Belgium, Netherlands, Austria, Czech Republic, and parts of France and Poland), as there was significant heterogeneity of Protestant adoption in the Empire. A probit analysis suggests that that cities that adopted the press early (prior to 1500) were 8.8 percentage points more likely to become Protestant by 1560, even after controlling for a host of city-level characteristics associated with the acceptance of the Reformation.

To address the omitted variables issues previously mentioned – such as pre-printing literacy rates correlating with the acceptance of both the press and Reformation – I instrument for the printing press with distance from Mainz, the birthplace of printing. This instrument is also used by Dittmar (2010), and is similar to the "distance from Wittenberg" instrument employ by Becker and Wößmann (2008, 2009, 2010) and Cantoni (2009). It is a useful instrument because printing spread in 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 that distance from Mainz is strongly correlated with the presence of a printing press, and that bivariate probit regressions indicate that the impact of the press has an even stronger effect of adoption of the

[5] Indeed, 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.

Reformation than in simple probit estimations where omitted variables are not taken into account – towns with a press were 19.5 percentage points more likely to accept the Reformation by 1560. This suggests that the omitted variables negatively biased the effect of the press on the Reformation. This could have occurred if more literate towns were less likely to adopt the Reformation but more likely to have a press.[6]

The results are similar when print *intensity* (proxied by the number of books printed in a city) is employed instead of the presence of a printing press. The results weaken substantially when data across Europe is employed. This indicates that while the press helped ignite the beginning of the Reformation, political pressure was a more important factor to its persistence.

This paper contributes a much needed empirical analysis to the debate on the link between the printing press and the Reformation. Though it by no means is meant to suggest that the Reformation was a mono-causal event, it suggests a causal linkage which in turn sheds light on broader arguments connecting the events of 1450-1550 to economic development. Most importantly, if Dittmar (2010) is correct and the press had an independent effect on economic development, then Weber's linkage between Protestantism and development may be spurious. Likewise, if Weber (1905) and Becker and Wößmann (2008, 2009) are correct that Protestantism had an independent effect on development, then the role of the press may be muted. 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 and the Reformation cannot ignore the relationship between the two.

[6] The results suggest that the presence of a university if strongly and positively correlated with having a press but strongly and negatively correlated with adopting the Reformation.

2. Historical Background

2.1. Early Printing

The printing press was invented circa 1450 by Johann Gutenberg in Mainz.[7] Within the fifty years following the invention, the press diffused throughout most of the major cities in western Europe. By 1500, nearly eight million books had been printed, most of which were religious in nature (the Bible by far being the most popular early book) and printed in Latin – perhaps more than the scribes had produced in the previous millennium (Eisenstein 1979).[8] Although the press was heavily regulated upon its initial introduction in some places, especially France and England, many large European cities in the Holy Roman Empire, France, Spain, and the Italian states had a press by the end of the century.[9] The early centers of printing in the Holy Roman Empire were Cologne, Augsburg, Strasbourg, Leipzig, Basel, and Nuremberg, though numerous other print shops were scattered throughout the Empire.

The first print workshops were established by Gutenberg and his assistants. They had a 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 often played a significant role in editing. These printer-scholars were often former priests or university professors, living nomadic lives and moving to where demand for books was the highest: first to the major commercial centers and then to the university towns

[7] I am only concerned here with the invention of the press in Europe. Printing had been known in the East for centuries prior to Gutenberg, but was not introduced to Europe until the 1450s.
[8] Johns (1998) notes 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, however – the rapidity of reproduction allowed by the press versus the scribes is the important source of connection between the press and the Reformation.
[9] For a contrast of the regulations imposed by European political authorities and the Ottomans, see Coşgel, Miceli, and Rubin (2010).

(Eisenstein 1979). Most university towns eventually became printing centers, as the guaranteed market they provided attracted printers and encouraged them to settle in the town. Printing 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.[10] Indeed, the Church was one of the biggest early customers of printing, employing presses to print ordinances, works of popular piety, bulls, and indulgences as well as propaganda for its anti-Turkish crusade (Febvre and Martin 1958; Eisenstein 1979). The greatest demand came from war-ravaged churches, where there was a huge demand for 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 large and lucrative market for printed materials provided by the Church is one of the more important factors contributing to the relatively rapid diffusion of the press (Eistenstein 1979).

The price of books fell dramatically after the spread of the press. On top of the large outward supply shift ensuing from 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). Humanist and legal texts became much more popular in the pre-Reformation period due to these changes. In subsequent centuries, the decreased price of

[10] Eisenstein (1979) notes that the early presses attracted wandering scholars, providing part-time jobs and room and board to those who previously would have been dependent on the Church.

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

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's concerns were primarily related to Church abuses – indulgences, relic cults, clerical privileges, clerical concubinage, simony and a broad host of other perceived abuses emanating from the Church hierarchy and papacy – which had become increasingly prominent in the century prior to the Reformation.[11] 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. Political concerns were one reason that the Church did not initially suppress Luther – Pope Leo X hoped to prevent Charles V from rising to Holy Roman Emperor, and to do so needed the support of Friedrich III of Saxony (who oversaw Wittenberg and supported Luther) (Cameron 1991). After Charles V (1519-1555) was elected, the case against Luther was reopened, and Friedrich abducted Luther so that he could escape a likely death sentence. In 1520, a papal bull was announced excommunicating Luther and calling for the burning of all of his books. In 1521, an edict of the imperial representative assembly (Reichstag) at Worms banned his works throughout the Empire. Yet, in these years Luther's literary output was immense – he wrote 30 publications which sold over 300,000 copies between

[11] 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.

1517 and 1520 – and was spread quickly throughout the Empire via printed copies of his works (Spitz 1985).

The Reformation initially spread in what was a highly fragmented Holy Roman Empire. The Reichstag consisted of three archbishop electors (Mainz, Trier, Cologne), three lay electors (Brandenburg, Saxony, Palatinate), 120 prelates, 30 lay princes, and 65 imperial cities, and power was much more decentralized than in the monarchies of Western Europe (Spitz 1985; Cameron 1991). This entailed a loosely federal structure, with princes and electors having significant power within their domains but under the ultimate rule of the emperor, while the free and imperial cities were subordinate only to the emperor. The cities relied on the emperor for protection, but expected him to be largely removed from daily economic happenings (Ozment 1975).

Luther's message was 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).

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 and the pope (Blickle

1984). It was through the efforts of these reformers – many of whom had positions in the established Church and could address the masses from the pulpit – that the movement spread so quickly. These preachers were particularly effective in Saxony and Central Germany in the 1520s, where preachers were successful in spreading the Reformation to towns such as Nuremberg, Reutlingen, Altenburg, Eisenach, and Zwickau. In the late 1520s and 1530s, reforming preachers helped convert larger towns such as Strasbourg and Lübeck, with numerous other Baltic cities following suit. Many major south German cities, such as Augsburg, converted in a similar manner in the 1530s. In numerous cities, these 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).[12] 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.

Perhaps more importantly, the message of the Reformation spread from city to city through pamphlets, most of which were written by the lead reformers, and broadsheets. Although most people were illiterate in this period, the pamphlets were written in such a manner such that they would be read aloud in public meeting places. Oral communication was still prevalent in this period and was the primary way that the printed word spread. The Reformers certainly knew this; for example, Luther's pamphlet in response to a papal bull of condemnation was addressed to "all who read or hear this little book" (Scribner 1989). Likewise, broadsheets were drawn in a manner that was easy to understand for the general population while graphically introducing

[12] 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. This analysis highlights yet another necessary pre-condition of the Reformation, complementing the one proposed in this paper.

complex issues in a simplified manner (Robinson-Hammerstein 1989).[13] Cameron (1991, p. 227) makes this connection clear:

> Luther's *Ninety-Five Theses* were published by his correspondents, in separate editions in at least four cities within a few months … Up to 1530 Germany was flooded with perhaps 4,000 titles of small, short-run pamphlets for mass distribution in a rapid turnover of editions, based in printing centers … However, *printing* a pamphlet was only part of the communication process … Even in the most sophisticated of towns 'literacy' may not have exceeded 30 per cent, while 5 and 10 per cent may have been nearer the norm. Most, therefore, would neither have read pamphlets from start to finish, nor indeed bought their own copies. To have a mass effect they were almost certainly read aloud in inns, workshops, or market-places, or even posted up on walls in public places … In the Lutheran movement especially, much use was made of pictorial pamphlets and flysheets, which served to remind readers of the message they had heard from the pulpit, rather than to convert and instruct believers by themselves.

Much ink has been spilled by historians claiming 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 (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 council 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 pushed for the Reformation as a means of confronting the established powers. Some

[13] Broadsheets were well established by the 1480s and had previously been used to spread news about major events and for propaganda in favor of the Emperor (Robinson-Hammerstein 1989).

[14] On the other hand, the Reformation 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 and whose goal was major social reform, 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).

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 was removed followed by the confiscation or destruction of the Church's material wealth.[15]

This pattern was much different from the one followed in the territories of the princes, where fear of imperial retribution delayed the introduction of the Reformation until the late-1520s, if at all (Cameron 1991). In 1530, many of the Protestant cities and princes signed the Augsburg Confession, which contained 22 articles stating the Lutheran message, despite condemnation from the Reichstag. The houses of Saxony, Hesse, Braunschweig-Lüneburg, Anhalt, and Mansfield all delayed acceptance until the late 1520s, but by 1530-1531 formed an alliance of Protestant electorates known as the Schmalkalden League. By 1535, many of the important Protestant independent cities joined the League, which provided mutual defense against Catholic invasion. They were joined by Denmark, which quickly accepted the Reformation in the 1520s under the imperial edicts of kings Frederick I (1523-1533) and Christian III (1533-1559). The defense provided by the League permitted a truce for over a decade, especially in light of the Ottoman threat on Vienna.[16] Eventually, the League was crushed by the Emperor in the Schmalkaldic War (1547), and most disputes were put to rest at

[15] The acceptance of the Reformation by no means happened in each town for the same reason. Cameron (1991) lists three primary reasons, though they 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 delineate between these reasons.

[16] For a recent economic analysis of the link between the Ottoman threat and the spread of the Reformation, see Iyigun (2008).

the Augsburg Reichstag of 1555, which permitted sovereign princes or lords of the Holy Roman Empire to determine the faith of their subjects.

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, as 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 readily apparent 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)? The hypothesis tested in this paper is that the printing press significantly facilitated the spread of the Reformation in the 16th century. This paper is far from the first one to make this connection, but it is the first one to statistically test the *extent* of the role played by the press.

There are four primary reasons that the printing press facilitated the spread of the Reformation. First, papal caricatures and broadsheets disseminated by the Reformers played an enormous 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.[17] 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 were the driving forces bringing the Reformation into cities. It was primarily literate preachers who brought the message of the Reformation to the masses. The press assisted in increasing the number of would-be reformers and facilitated the spreading of new pamphlets written by the lead reformers. This method of oral transmission of ideas was still the most common information transmission technology for many decades (if not centuries) after the spread of the press, and was employed with great skill by the reformers (Spitz 1985; Johns 1998). Third, the press allowed for rapid dissemination of pamphlets which were verbalized by the literate portion of the population (secular and lay) at taverns and other meeting places. These pamphlets complemented the work of the reforming priests, allowing the masses to hear the message of the Reformation from multiple sources. Luther argued that printing was a special

[17] 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).

sign of God's grace not just because it allowed the mass production of biblical texts, sermons, and the like, but also because it permitted the spread of these ideas through pamphlets and broadsheets (Robinson-Hammerstein 1989). Fourth, 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).[18]

The connection between the printing press and the Reformation is strengthened by considering the attempts made at reforming the Church prior to the spread of the press.[19] Attempts were made within the Church to strip power from the pope and reduce the pomp associated with the Church hierarchy, pushing instead for power to be transferred to Church Councils. Jean Gerson (1362-1429) was the leading proponent of this "reform from within" and was an important influence on Luther's writings (Dolan 1965). Such reform was unsuccessfully attempted in varying degrees at the Councils of Lyons (1274), Vienne (1311-12), Constance (1414-18), Pavia-Sienna (1423-24), and Basel (1431-39).[20] In fact, much of the support for the anti-papist agenda at Basel originated from the free cities of Switzerland and southern Germany that were so important to the initial spread of the Reformation (Cameron 1991). Even on the eve of the Reformation there was considerable pressure to reform the Church from within, but attempts made at Fifth Lateran Council (1512-1517) were unsuccessful.

[18] Another possible role that the press played in the Reformation was, according to Eisenstein (1979), its transformation of concerns faced by individuals to those more broad in nature. She suggests (p. 132) that "while communal solidarity was diminished, vicarious participation in more distant events was also enhanced; and even while local ties loosened, links to larger collective units were being forged. 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."

[19] Dickens (1968) and Eisenstein (1979) also note the failure of pre-press heresies very well may have been due to the lack of access to the press.

[20] For more on the debate between papism and conciliarism, and especially the role played by Gerson, see Dolan (1965, ch. 4).

Perhaps the most serious challenge to the Church came from the Prague preacher Jan Hus (c. 1372-1415), who led the anti-Church movement which would bear his name in the early 15th century. Hus challenged the rights of sinful Churchmen to keep their positions and wealth, a position which caused him to be burned to death as a heretic in 1415. The Hussite movement which followed established rival churches throughout Bohemia based on the denial of the Roman hierarchy, but their influence never expanded beyond Bohemia (Cameron 1991). Other heresies abounded in the century prior to the Reformation. In England, the 15th-century Lollard movement spread the ideas of John Wyclif (d. 1384). Wyclif was an ardent supporter of the rights of lay rulers over the papacy and had significant influence over poorer parish priests, but the Lollard movement he spawned was ultimately suppressed. A similar fate awaited the Waldensians in France, who rejected Church dogma and were brutally suppressed. Dickens (1968, p. 51) makes the contrast between these movements and the Reformation quite clear: "Unlike the Wycliffite and Waldensian heresies, Lutheranism was from the first the child of the printed book."

While I by no means claim that the elements of the Reformation had pervaded Europe for centuries and was merely awaiting the printing press to spread the message, it is striking that all of the attempts at reform prior to the invention and spread of the printing press were rather easily suppressed by the Church. Rubin (2010) predicts such an outcome, suggesting that highly centralized authorities, such as the pre-Reformation Church, are easily able to suppress 'shocks' when the shocks are not spread to a large portion of the population, but are more susceptible to massive changes when shocks are widespread.

The argument being presented in this paper does not necessarily contradict that idea that the Reformation was an outgrowth of a perfect storm of events that came together in the early

16th century, with the printing press being one of many necessary conditions. In fact, the data that I collect does not allow for a test of whether the press was a necessary or a sufficient condition for the Reformation to spread. What it does allow for, however, is a statistical testing of the role that the printing press played in the spread of the Reformation in the factual world where the printing press was invented and diffused just prior to the Reformation. In particular, I explore the question: "How much more likely was a city to adopt the Reformation if it had a printing press?" If it turns out that print cities were much more likely to adopt the Reformation (and indeed, I show that they are), then it suggests that spread of printing was at the very least a necessary condition for 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. To this end, I have constructed a city-level data set which includes whether a city was Protestant in 1530, 1560, and 1600, whether a city had a printing press by 1500, and numerous control variables. Only cities with at least 5,000 inhabitants in 1500 (population data from Bairoch et al. [1988]) are considered in the analysis, although data was collected for all cities in which 1500 population data exists. Details of all variables are available in the Data Appendix.

Protestantism spread quickly throughout much of the German and Swiss parts of the Holy Roman Empire. Many of the cities in these areas adopted Protestantism by 1560, though numerous Catholic enclaves remained. Although Protestant ideas were popular in Bohemia (Czech Republic), it remained nominally Catholic – in some cases by compulsion. 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.

Although I collected data for most of Europe west of Poland-Austria-Czech Republic, I focus the first part of the analysis on the acceptance of Protestantism in the Holy Roman Empire. The reason for this is that there is no variation in religion (Protestant or Catholic) in Spain, Italy, Portugal, England, Ireland, or Scandinavia. While I do include cities in these countries in a robustness check in section 3.4 (without country fixed effects), their inclusion in the primary regressions could provide misleading results, as religion was imposed from above in many of these countries.

I delineate each city as part of the Holy Roman Empire (HRE) by its 1500 boundaries. I denote a city as part of HRE even if it were ruled by local authorities but nominally under the "rule" of HRE. Examples of such cities include independent German cities (e.g. Augsburg, Nuremberg), Italian cities annexed by the Duchies of Savoy or Milan (e.g., Turin, Genoa), or Belgian and French cities annexed by the Duchy of Burgundy (e.g. Lille, Bruges). Cities in HRE with populations of at least 15,000 are listed in Table 1, along with their religious affiliation in 1600 and whether the city had a printing press by 1500.

[INSERT Table 1 HERE]

It is immediately noticeable that a majority of the larger cities of the Holy Roman Empire 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 allows for better identification of the effect of printing on the acceptance of Protestantism: if large cities were likely to adopt printing, it is likely that the biggest impact of printing on the emergence of Protestantism was in smaller cities, where

printing adoption was more "random". This is suggested by Figure 1, where it appears that a greater portion of small Protestant cities had presses than small Catholic cities, especially cities not near Wittenberg (labeled "W" on the map). This can also be seen in Table 2, which breaks down all cities with at least 5,000 inhabitants by press and printing adoption. It is clear from these data that the smaller cities were more likely to adopt Protestantism if they had a press.

[INSERT Figure 1 HERE]

[INSERT Table 2 HERE]

These tables and figures help motivate the analysis. At first glance, it is not clear that printing had an effect on the adoption of Protestantism: 55.2% of press cities became Protestant while 54.7% of non-press cities became Protestant. Yet, breaking down the data by population size suggests that once this factor is controlled for, it is possible that printing had a positive impact on the likelihood of accepting Protestantism.

The econometric analysis controls for numerous features which may have contributed to a city accepting Protestantism. These include whether the city housed a university by 1450, whether the city housed a bishop or archbishop by 1517 (which proxies for depth of Church influence), whether the city was a member of the Hanseatic League (and thus had better access to information flows), whether the city was an independent city in 1517, and the latitude, longitude, and interaction between the two (to control for north/south or east/west biases). 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.[21] Instead, I only employ data available on the eve of the Reformation.[22]

I also control for the distance to Wittenberg, which is shown by Becker and Wößmann (2008, 2009, 2010) to be correlated with the spread of Protestantism. This can clearly be seen in Figure 1.[23] Moreover, Dittmar (2010) shows that the spread of printing is related to distance from Mainz – hence not controlling for distance from Wittenberg may falsely indicate that printing (and not proximity to Wittenberg) had an effect on acceptance of Protestantism.

Finally, I construct a variable which underscores the spatial component of the Reformation. It is possible that cities were more likely to become Protestant if nearby cities were Protestant, with this effect likely depending on the size of the nearby cities. To address this concern, I create a Protestant and Catholic "urban potential" variable, which is based on the urban potential variables in de Vries (1984) and Bosker, Buringh, and van Zanden (2010). I first measure the distance-weighted sum of all other Protestant or Catholic cities as follows:

$$Pot_{Prot,it} = \sum_{j \neq i} \left(\frac{pop_{jt}}{D_{ij}} I_{Prot,jt} \right) \quad (1)$$

$$Pot_{Cath,it} = \sum_{j \neq i} \left(\frac{pop_{jt}}{D_{ij}} I_{Cath,jt} \right) \quad (2)$$

where pop_{jt} is city j's population in year t, D_{ij} is the distance between city i and j, and $I_{Prot,jt}$ and $I_{Cath,jt}$ are indicators equaling one if city j is Protestant or Catholic in year t. I construct a "Protestant potential" variable for each city by dividing its Protestant urban potential by its overall urban potential, or:

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

(3) $$Protestant\ Potential_{it} = \frac{Pot_{Prot,it}}{Pot_{Prot,it}+Pot_{Cath,it}} * 100$$

Summary statistics of all variables for cities in the Holy Roman Empire are listed in Table 3. The correlation matrix for all variables is presented in Table 4.[24]

[INSERT Table 3 HERE]

[INSERT Table 4 HERE]

3.2.Printing Presses and Protestantism in the Holy Roman Empire: 1530-1600

3.2.1. Probit Analysis

The correlation matrix displayed in the previous section suggests that there is little correlation between cities that had a press and those that became Protestant. However, Figure 1 and Table 2 indicate that the correlation may be positive after controlling for city size. The link between the press and Protestantism can therefore be tested by analyzing the following reduced form equation:

(4) $$Protestant\ in\ Year\ t = \alpha_1 + \beta_1 Press + X_t\gamma_1 + \varepsilon_1$$

where t = {1530, 1560, 1600}, Press is a dummy equaling one if a city had a press by 1500, and X is a vector of control variables in year t, including log of population in 1500, dummies for whether the city was a member of the Hanseatic league, an independent city by 1517, had a university by 1450, a bishop by 1517, distance to Wittenberg, its geographic coordinates, and its Protestant potential in year t.

I first run three simple probit regressions for each year in which I have data: 1530, 1560, and 1600. The average marginal effects of all major variables are reported in the first three

[24] Note that the log(distance to cities) variables are actually log(1 + variable), which should not dramatically effect results, since the "distance to city" variable are large numbers. This is done so that the cities in question (Mainz and Wittenberg) remain part of the analysis, as log(0) is undefined.

columns of Table 5.[25] The results indicate that early adopters of the printing press were indeed more likely to become Protestant, all else being equal. Towns with a press were 5 percentage points more likely to be Protestant by 1530 and 8.8 percentage points more likely to be Protestant by 1560.

[INSERT Table 5 HERE]

The coefficient on the printing press dummy is not significant when Protestant in 1600 is the dependent variable (Column 3). This could indicate that the effect of the press weakens over time. On the other hand, it is possible that this is merely picking up actions resulting from the political and religious turmoil occurring in the Low Countries in 1560-1600. As noted in Section 2.2, the Spanish Habsburgs were partially successful in suppressing the Reformation in the Low Countries, keeping it out of Belgium (despite its popularity) but not the Netherlands, where it was used by revolutionaries such as William of Orange in the fight against the Spanish. In other words, the Reformation did not come to individual cities in the Low Countries from below, but was instead imposed (or prohibited) from above.

Since cities in these countries make up nearly one-third of the HRE data, it is worthwhile to re-analyze equation (4) in 1600 without the Low Country cities. Column 4 of Table 5 provide the average marginal effects of a probit regression excluding Low Country cities. The coefficients are quite similar to those in column 2, indicating that cities with a press were 8.8 percentage points more likely to become Protestant.

A few other striking results emerge in Table 5. First, as expected, the coefficient on Protestant potential is positive and highly significant. On average, increasing a city's Protestant potential by one percentage point entailed a 2.5-2.8 percentage increase in the probability that the city became Protestant. Surprisingly, however, the coefficient on distance to Wittenberg is

[25] Robust standard errors, clustered by current country, are employed in this section.

positive and significant in columns 2-4. The most likely explanation for this result is that cities near Wittenberg also had large Protestant potential, so the Wittenberg effect found by Becker and Wößmann (2008, 2009, 2010) works through Protestant potential.

Perhaps more strikingly, the coefficient on the University dummy is highly negative and strongly significant in all regressions. This is not a completely surprising result – while some universities helped facilitate the spread of Reformation ideas (e.g. Wittenberg, Erfurt, Zwickau), others were openly hostile (e.g. Rostock, Cologne, Louvain) (Cameron 1991).[26] This indicates the possibility of an omitted variable – pre-printing press literacy – that could negatively bias the coefficient on the press variable. Indeed, Buringh and van Zanden (2009) show that the presence of a university is positively correlated with the per capita production of manuscript books. Since universities were centers of learning and literacy, printers were attracted to university towns (Eisenstein 1979). This means that if towns with higher exogenous (pre-press) literacy were more likely to attract presses but less likely to convert to Protestantism (as indicated by the negative coefficient on the University dummy), then the coefficient on the press dummy is negatively biased and the effect of the press on the Reformation is greater than indicated by this regression.[27] I tackle this possibility in the following section by "instrumenting" for the press.

Another potential problem with these results is that emphasis is placed on *whether* a city has a press and not the degree to which printing had actually penetrated the city. The causal supposition is that it is not only access to a press, but the ability to widely disseminate information that enabled Protestantism to flourish. I address this concern in Section 3.3, where data on the number of books published in a city is used as a proxy of printing intensity. I also

[26] On the other hand, Spitz (1985) notes that universities were a source of criticism of the Church and can be viewed as the "mother of the Reformation". This view is difficult to reconcile with the evidence presented in this paper.
[27] Cantoni and Yuchtman (2010) 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.

address this issue at present, though more roughly, by considering the date that printing was introduced to a city. The supposition is that the earlier printing was introduced, the more likely it was to be entrenched in a city – and thus, the more likely that Protestant ideas could be spread.

To this end, I create dummy variables for whether a city had a press by 1470, 1480, 1490, and 1500, with the last dummy being the same as the one employed in Table 5. Equation (4) is re-estimated using these dummies in place of the printing press dummy. The average marginal effects of these regressions are reported in Table 6. These results broadly confirm the idea that early adopters of the press were more likely to accept the Reformation, all else being equal, and that earlier adopters were more likely than later adopters to become Protestant.

[INSERT Table 6 HERE]

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

It was suggested in the previous section that omitted variable bias may be affecting the interpretation of the regression results. One such unobservable 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 more (or less) likely to adopt the Reformation. I address this possibility in this section, where I use the city's distance from Mainz (the birthplace of printing) as an instrument for the press.

Distance from Mainz provides an ideal instrument for the adoption of printing because it was an important determinant of adoption while, theoretically, it should have no independent impact on the acceptance of Protestantism. Dittmar (2010), who uses distance from 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 2010).

All else being equal, cities that were closer to Mainz were more likely to adopt printing, though the same can be said for larger cities and university cities, where demand was greater (though the latter two would not qualify as instruments, as they were independently related to the acceptance of Protestantism). This is suggested by Figure 2,[28] which shows the percentage of cities that adopted printing and their population, broken down by distance from Mainz. It is clear that cities closer to Mainz were more likely to adopt printing *in spite of* being smaller on average.

[INSERT Figure 2 HERE]

With this instrument in mind, I analyze the following recursive system of equations:

(5) $$Protestant\ in\ Year\ t = \alpha_2 + \beta_2 Press + X_t^2\gamma_2 + \varepsilon_2$$

(6) $$Press = \alpha_3 + \beta_3 Distance\ from\ Mainz + X_t^3\gamma_3 + \varepsilon_3$$

X_t^2 includes all of the independent variables included in the regressions in the previous section (from equation (4)). X_t^3 includes all of these variables except for Protestant potential and distance from Wittenberg. It makes no temporal or economic sense to suggest that Protestant potential in 1530, 1560, or 1600 affected the spread of the press prior to 1500. Moreover, it also makes little sense to suggest that distance from Wittenberg – a small town hundreds of miles from Mainz – affected the spread of the press.

[28] This figure is similar to one in Dittmar (2010), but the numbers are different since I am analyzing cities with populations of at least 5,000 in the Holy Roman Empire and he analyzes print adoption throughout Europe.

This system of equations is tested using recursive bivariate probit estimation. The average marginal effects are reported in Table 7. First, note that the distance to Mainz is a strong negative predictor of acceptance of the press – in all regressions, the coefficient on distance to Mainz is significant well beyond the 1% level. Much more strikingly, the average marginal effect of having a printing press is substantially larger in regressions 1, 2, and 4 than in their counterparts in Table 5. In those regressions, cities with presses were 5.0-8.8 percentage points more likely to adopt the Reformation. The results in Table 7 suggest that the effect of the press on the likelihood of adopting the Reformation is much larger: 33.2 percentage points in 1530, 19.5 percentage points in 1560, and 17.3 percentage points (excluding the Low Countries) in 1600. Note again that the results do not hold in 1600 when the Low Countries are included, which suggests that political pressures mute the effect of the press. Overall, these results indicate that a negative bias on the press coefficient – stemming from the omitted variables such as pre-press literacy – obscured the true impact of the press, which is shown to be substantial.

[INSERT Table 7 HERE]

One potential problem with each of the regressions presented thus far is that the Protestant potential variable may suffer from reverse causality. This variable is a function of the distance and size of all Protestant and Catholic cities. Thus, if Protestant potential is a salient factor in a city becoming Protestant, then cities near city i could become Protestant in part due to city i being Protestant. Given the way that the variable is created, this would especially be true for large cities that are near many other cities. Such cities would have a heavy influence on the Protestant potential of many nearby cities, which could in turn effect the Protestant potential of city i.

I address this issue by determining the "maximum effect" that each city could have on its own Protestant or Catholic urban potential. If, for example, city j is Protestant, I first determine what proportion of each non-j city's Protestant urban potential is made up by city j. I then determine the proportion that each non-j city plays in j's Protestant potential. The "maximum effect" that a city has on its own Protestant potential is the sum of the product of each of these two proportions. I denote this the "maximum effect" because it is the effect if Protestant potential is the *only* variable affecting whether a city becomes Protestant. For example, if city j contributes 10% of city k's Protestant potential (meaning that city j is large, the two cities are close, or both), then city j would be assumed to affect 10% of city k's probability of becoming Protestant. If city k in turn contributes 20% of city j's Protestant potential, then city j being Protestant determines 2% of its own Protestant potential just through city k. The maximum effect is determined by summing the total effect for all non-j cities.

The purpose of this exercise is to determine how many cities have a negligible effect on their own Protestant or Catholic potential. If a city's religion determines a sufficiently small portion of its own potential, then the potential variable is ostensibly exogenous, much as prices are to price-taking firms in competitive environments. In fact, most cities contribute well less than 5% to their own Protestant or Catholic potential under the "maximum effect" case. To ensure that the few cities that do have a substantial effect are not driving the results, I re-run the regressions, reported in Table 8, but do not include cities that have a maximum effect on their own Protestant or Catholic urban potential of at least 5%.[29] The only result that changes from those provided in Table 7 is that the effect of the printing press on Protestantism in 1530 is no longer significant. This could indicate that part of the Reformation's early success was

[29] The results are robust to cutoffs of 3% and 4% except in 1530, where there are very few Protestant cities with a small maximum effect.

geographically determined, although the press played an important role in the spread of the Reformation throughout the Holy Roman Empire prior to 1560.

[INSERT Table 8 HERE]

Finally, it is possible that the distance to Mainz "instrument" may be picking up a spatial component related to the spread of printing that would arise by analyzing the distance from *any* city. This possibility would not be the case if printing spread outward from Mainz. I test the robustness of this instrument vis-à-vis other "distance" variables by running probit regressions similar to those in equation (6), but employing distance from other important cities as an instrument. As can be seen in Table 9, distance from Mainz is highly significant but this is not the case with any of the other distance variables.

[INSERT Table 9 HERE]

3.3. Printing Intensity and Protestantism in Germany and Switzerland: 1530-1600

The printing press variable employed in the previous section – a dummy equaling one if the city had a printing press before 1500, helps shed significant light on the determinants affecting the adoption of Protestantism. However, the causal argument suggests that it was the ability to print in vast quantities, not just the ability to print that facilitated spread of the Reformation. That is, a distinction can be made between the *presence* of printing and the *intensity* of printing.

Printing intensity can be measured in numerous ways, including the number of distinct presses or printers in a city, the number of distinct titles produced in a city, or the number of distinct titles/printers present over a recent span of time. To construct a measure of print intensity, I collected data on books written in German between 1450 and 1600 that are currently housed in the British Museum. The list of titles is available in a catalog provided by the British Museum (1962), which lists each publisher, city of publication, and each book published. I

counted each book by city and decade of publication. Only German, Swiss, and three French cities (Metz, Strasbourg, and Haguenau, all of which were part of the Holy Roman Empire) were counted, as these were the primary cities producing books in German. There is a possibility of selection bias – namely, it is possible that the survival rates of books published in different cities are different – but there is little to suggest that the errors stemming from this bias are not classical in nature.

Figure 3 summarizes the number of books in the dataset broken down by decade. It is evident that there is a burst of publication soon after the Reformation (1520-1529), and this burst is likely a result of – not the cause – of the initial spread of the Reformation. For this reason, only book data for the period prior to 1520 is employed in all regressions.

[INSERT Figure 3 HERE]

Table 10 provides a snapshot of the book production centers of Germany and Switzerland and how they were changing over time. It is clear that most of the printing centers of Germany were Protestant by 1560, with Cologne being the primary exception. There is general continuity in the top print centers, with Cologne, Strasbourg, Augsburg, Basel, and Nuremberg in the top six in each decade in question. These data provide much more variation than the print dummy employed in the previous section and can therefore shed a different light on the connection between printing and Protestantism. Table 11 provides summary statistics for all variables employed in the analysis.

[INSERT Table 10 HERE]

[INSERT Table 11 HERE]

These data are much more flexible than that dummy variable used in the previous section. Numerous proxies for print intensity can be created using these data, and I employ six proxies

(all in log form). The first four relate to overall production in a city: the number of books published 1450-1499 and 1450-1519, in overall and per capita terms. The other two proxy for recent book production on the eve of the Reformation: the number of books published 1500-1519 and 1510-1519. Table 12 reports the average marginal effects of regressions using each of these proxies in place of the press dummy in equation (4). Only the marginal effects of these proxies are reported.[30]

[INSERT Table 12 HERE]

These results lend strong support to the observations made in the previous section. No matter the proxy employed, cities with greater print intensity were more likely to adopt Protestantism. Increasing the log number of books by 1 increases the probability that a city is Protestant by 5.0 to 14.0 percentage points, depending on the proxy and time period. This is not surprising given that, as shown in Table 10, most of the biggest print intensity cities eventually adopted the Reformation.

As noted in the previous section, it is possible that the probit regressions suffer from an omitted variable problem related to print intensity. If cities that were more likely to become print centers were also more (or less) likely to adopt the Reformation, then the correlation is spurious. To address this issue, I again employ "distance from Mainz" as an instrument. As can be seen in Table 13, many of the printing centers were relatively close to Mainz (closer than 150 miles), with Augsburg, Basel, and Leipzig being the biggest exceptions. This table also shows, as expected, that the center of printing moved away from Mainz as the decades progressed. The average and the weighted average of distance from Mainz amongst the top 10 print centers are generally increasing over time.

[30] Non-clustered standard errors are used, since most cities are German. Complete regression results are available upon request.

[INSERT Table 13 HERE]

I re-estimate the system of equations (5) and (6) using the six print intensity proxies in place of the print dummy. The system is estimated using seemingly unrelated regressions, where the "first stage" (print intensity) is estimated using OLS and the "second stage" (Protestant in year t) is estimated using probit.[31] The average marginal effects are reported in Table 14. The distance to Mainz "instrument' is highly significant in all specifications. The statistical significance of the marginal effects is a little weaker than in regressions where the press dummy is employed, but cities with greater print intensity do appear to be more likely to become Protestant by 1530 or 1600 (the results for 1600 are always significant or close to 10% significance). The results are weaker for 1560, but the sign on the print intensity proxy is always positive and in most cases is close to statistically significant. Overall, these results support the conclusions reached in the previous section – both the presence of the printing press and greater print intensity are associated with a higher probability of a city accepting the Reformation.[32]

[INSERT Table 14 HERE]

3.4.Printing Presses and Protestantism throughout Europe: 1530-1600

In this section I test the robustness of the results reported in the previous sections by analyzing the relationship between printing presses and Protestantism throughout Europe. In addition to the cities considered in Section 3.2, I also include data from Spain, Portugal, France, Italy, England, Ireland, Scotland, Denmark, Norway, and Sweden. These countries are not analyzed in Section 3.2 because there is no variation with respect to adoption of Protestantism at any point in any of

[31] The cmp program in Stata (Roodman 2008) is employed to run the seemingly unrelated regressions. An ivprobit is not employed because, as explained in the previous section, some independent variables (such as Protestant potential) belong in the second stage but not the first.

[32] These results also support the pattern found by Buringh and van Zanden (2009) that the countries that became the centers of book production (on a per capita basis) after the spread of the press were not coincidentally Protestant. These countries include Switzerland, Netherlands, Great Britain, and Sweden.

these countries. Thus, the regressions reported in Section 3.2 give the same results as cross-Europe country fixed-effects regressions (if the Holy Roman Empire is considered to be one country). For this reason, I do not include country fixed effects in these regressions. This reduces the causal power provided by these regressions, but they are merely robustness checks.

The map in Figure 4 suggests that the patterns found in the Holy Roman Empire are consistent with those found across Europe. Most importantly, while a great deal of Catholic cities adopted the press by 1500, most of these cities were *large* (over 20,000). On the other hand, a large portion of the Protestant cities with presses were small. Since larger cities were more likely to have a press, all else being equal, this indicates that we should expect that the presence of a press is positively correlated with acceptance of Protestantism after controlling for city size (and other features controlled for in previous regressions).

[INSERT Figure 4 HERE]

There are 373 cities with populations of at least 5,000 in the dataset. I use this data to check the robustness of the results reported in Section 3.2, re-analyzing equation (4) and the system of equations (5) and (6), again using distance from Mainz as an instrument. These average marginal effects of these regressions are reported in Table 15 and Table 16.

[INSERT Table 15 HERE]

[INSERT Table 16 HERE]

These results differ from those reported in previous sections. In the probit regressions reported in Table 15, the average marginal effect of the press is much smaller than in previous regressions, and it is not significant in the 1600 regression. The presence of a university and Protestant potential are the only variables that have a statistically significant effect on whether a city accepted Protestantism. More interestingly, the bivariate probit regressions reported in Table

16 suggest that the effect of the press weakens substantially in 1560 and is *negative* in 1600. The negative coefficient on the 1600 results disappear, however, when results from Great Britain and the Low Countries (both of which had Protestantism forced or forbidden from above) are omitted.

These results, when combined with the results of regressions run using data from only the Holy Roman Empire, suggest that *the printing press is positively correlated with the acceptance of the Reformation in areas where religion was not forced from above, but it had little effect in cities where religion was forced*. In the absence of historical data, it may seem easy to discount the impact that the printing press had on the Reformation, as there are numerous factors that may be correlated with both. However, the analysis presented in this paper allow us to address these issues and suggests that the link between printing and Protestantism is indeed causal.

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 have faced is one of spurious correlation – it is quite possible that the city-level characteristics that encouraged adoption of the printing press *also* encouraged acceptance of the Reformation.

In this paper, I address this issue through an econometric analysis. Probit and bivariate probit regressions suggest that cities which adopted printing early (in the Holy Roman Empire) were much more likely to accept the Reformation. This result weakens over time and with the

inclusion of cities that were forced to accept or reject the Reformation (such as English cities under Henry VIII). This suggests that political pressures were important to the persistence of the Reformation, though the press was essential for its initial spread.

These results have broader implications for economic history. For one, by connecting the printing press to an event which undermined the power of religious authorities in Europe, it has implications for what the *lack* of printing meant in the contemporary Ottoman Empire. It is well known that the Ottomans highly regulated the press despite being aware of its invention and economic potential. A more complete analysis of the impact of printing and its role in the interplay between political and religious authorities, therefore, should be comparative in nature, as the Ottoman anti-printing policy provides a "control experiment" for understanding the economic, political, and religious trajectory of a society where the introduction of the press was delayed for nearly three centuries. Moreover, a number of recent studies have suggested that the printing press (Baten and Van Zanden 2008; Buringh and Van Zanden 2009; Dittmar 2010) or the Reformation (Becker and Wößmann 2008, 2009, 2010) have played a significant role in the subsequent economic development of Europe and "the West". 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 that accepted the Reformation were in a better position to succeed due to earlier acceptance of the press. Conversely, it is possible that cities that adopted 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 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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Data Appendix

Dependent Variable: Protestant Dummies

The dependent variable is a dummy equaling one if a city is Protestant in the year in question (1530, 1560, or 1600). In some cases, delineation by religion is obvious – all Spanish, Portuguese, and Italian were always Catholic, while and Danish and Swedish cities are Protestant throughout the period, British and Norwegian cities are Protestant after 1530, and Dutch cities are Protestant after 1560. Although Protestantism made some inroads into present-day Austria, Belgium, and Czech Republic (Bohemia), it ended up being suppressed and all cities are considered Catholic. The cities with the most difficult religions to determine are located in northern and eastern France, western Poland, Germany, and Switzerland. Most of France and Poland remained Catholic, but there were parts of each country (under current boundaries) which were part of the Holy Roman Empire at the beginning of the 16th century. Examples in France include Haguenau, Strasbourg, Metz, and Douai, while examples in Poland include Breslau (Wroclaw) and Stettin (Szczecin). Any French or Polish city not in the Holy Roman Empire (HRE) is considered Catholic. The religion of cities in the Polish and French parts of the HRE is determined in the same manner as the religion of German and Swiss cities. The method for determining whether a city was in the Holy Roman Empire is explained below (in the "Independent Variables" section).

For German and Swiss cities (and Polish and French cities in the HRE), there is significant religious variation over time and place. The first step in determining which cities were Protestant and when they became Protestant was to search historical atlases which marked the spread of Protestantism prior to the Thirty Years War (Ward et al. 1912; O'Brien 2002). There is some variation in these maps, particularly near the Catholic-Protestant boundaries, but most cities quite obviously became Protestant or remained Catholic in a given period. For example, northern Germany was mostly Protestant by 1560, with the cities near the Jutland peninsula becoming Protestant prior to 1530. The Swiss cities were also relatively easy to delineate, as most of the cantons explicitly accepted (e.g., Zürich, St. Gallen, and eventually Geneva) or rejected (e.g., Fribourg) Protestantism (of the Zwingli and Calvin variety). The German, French, and Polish border cities were more difficult to determine, as in some instances cities were not fully Protestant or Catholic. In these cases, especially where the historical atlases disagreed, the Catholic Encyclopedia was consulted (http://www.newadvent.org/cathen/). The Encyclopedia has an entry for every remotely large city (10,000 or greater) and in almost every case discusses the city's history around the Reformation period. A city was considered Protestant if it accepted the Augsburg Confession, Catholics were forced to flee, or the Encyclopedia explicitly states the Protestantism was accepted.

Independent Variables

Printing Press: Cities with printing presses prior to 1500 are found in Febvre and Martin (1958) and Clair (1976). There is some disagreement between these two sources (Febrve and Martin list 15 press cities not included in Clair, and Clair lists 12 press cities not included in Febvre and Martin). The "Printing Press" dummy takes a value of 1 if either of these sources lists a printing press being present in the city in 1500. Population data (see below) does not exist for a number

of the cities with presses, as many of the presses arose near monasteries (such as Cluny). These presses are omitted from the analysis.

For German book data, entries found in the British Museum's *Catalogue of German Books* (1962) were counted. This book lists all publications produced in German between 1450 and 1600 that are currently in the British library. The index lists each publisher, city of publication, and each book published. I counted each book by city and decade of publication. Only German, Swiss, and three French cities (Metz, Strasbourg, and Haguenau, all of which were part of the HRE) were counted, as these were the primary cities producing books in German (for example, there are some entries of publications from Amsterdam, but this would not be representative of the Amsterdam publishing industry, which certainly published much more in Dutch than in German).

"Nation" in 1500: Much of the nation data is straight-forward. Cities currently in Spain, Portugal, Ireland, England, Scotland, Sweden, Norway, and Southern Italy were all delineated as within these country's borders in 1500. All cities in Austria, Belgium, Czech Republic, Germany (except Flensburg and Schleswig, which were part of Denmark, and Königsberg, which belonged to the Order of the Teutonic Knights (Prussia)), Netherlands, and Switzerland (who were nominally ruled by the HRE) were denoted as part of the Holy Roman Empire (HRE). Parts of northern and eastern France, western Poland, and Central-Northern Italy were also subject to the HRE. To determine which cities were under HRE rule, I employed numerous atlases showing the boundaries of the HRE in 1500 (Ward et al. 1912; O'Brien 2002; Ionita 2006). All entries in these countries were double-checked with internet searches of the various cities' histories. Any French city under Burgundian influence (such as Lille) or any Italian city annexed by the Duchy of Savoy (such as Turin) were counted as part of the Holy Roman Empire.

Population: Population data is from Bairoch et al. (1988), who collected population data on every European city that reached 5,000 inhabitants at some point by 1800. As noted in De Long and Shleifer (1993), these data are broadly consistent with those found in Chandler and Fox (1974) and de Vries (1984), but are much more complete. I collected data for every city in which Bairoch et al. have population data for 1500. I did not collect data for Eastern Europe, and thus Hungary, Romania, Bulgaria, Russia (and former Soviet republics), Greece, Albania, and the former Yugoslavian republics are not included. My method has the unfortunate consequence of omitting a few cities (but no large cities) for which population data exists before 1500 but not in 1500. One way to overcome this could have been by taking the average pre-1500 and post-1500 populations, but this is highly problematic, as Dittmar (2010) suggests that cities with printing presses showed greater growth rates by the 16th century (and the data would thus be skewed). I have thus left these cities out of the analysis.

City Coordinates and Distance: City coordinates are acquired from Bairoch et al. (1988) and double-checked using the website http://www.itouchmap.com/latlong.html, a site which uses Google Maps to pinpoint the exact latitude and longitude of any point (searchable in Google) on the globe. The distance variables (e.g. distance from Wittenberg, distance from Mainz) were calculated "as the crow flies", using city coordinates and the distance formula (and translating degrees into miles).

Bishop and University: The erection and promotion date to Diocese or Archdiocese (where bishops and archbishops preside, respectively) of all cities in the Catholic sphere of influence is available at http://catholic-hierarchy.org/. The date recorded in the data is the first one in which a city housed a Diocese or Archdiocese. The dummy variable "Bishop" takes a value of 1 if the city housed a Diocese or Archdiocese prior to (and including) 1517, when Luther published the 95 Theses. The University dummy also takes a value of 1 if the city housed a university prior to (and including) 1450. University data is acquired from Darby and Fullard (1957-1979). 15 universities from Darby and Fullard (including 9 in Germany) are located in cities where population data in 1500 did not exist, and these universities are excluded from the data.

Independent City and Hanseatic League: Jacob (2010) provides beginning and end dates for the independence of cities in the Holy Roman Empire. The Independent City dummy variable takes a value of 1 if the city was independent in 1517. Jacob (2010) also provides data on whether cities in the Holy Roman Empire were part of the Hanseatic League. Various internet searches (by city) confirmed whether or not cities in present day Poland were members of the Hanseatic League (Polish Hanseatic members are Kolobrzeg (Colberg), Opole, Slupsk, and Stettin (Szczecin)).

TABLES

Table 1: Cities in the Holy Roman Empire (population ≥ 15,000)

Cities (with population ≥ 15,000) with Printing Presses by 1500

City	Population (in 1500)	P/C (by 1600)
Milan	100,000	C
Prague	70,000	C
Genoa	58,000	C
Ghent	55,000	C
Cologne	45,000	C
Nuremberg	38,000	P
Bruges	35,000	C
Brussels	33,000	C
Antwerp	30,000	C
Augsburg	30,000	P
Valenciennes	30,000	C
Breslau	25,000	P
Lübeck	25,000	P
Piacenza	25,000	C
Regensburg	22,000	P
Strasbourg	20,000	P
Utrecht	20,000	P
Vienna	20,000	C
Erfurt	19,000	P
Magdeburg	18,000	P
Leuven	17,000	C
Pavia	16,000	C
s'Hertogenbosch	16,000	P
Ulm	16,000	P
Brno	15,000	C
Hamburg	15,000	P
Metz	15,000	C
Turin	15,000	C

Cities (with population ≥ 15,000) without Printing Presses by 1500

City	Population (in 1500)	P/C (by 1600)
Tournai	35,000	C
Lille	26,000	C
Mechelen	25,000	C
Liège	20,000	C
Aachen	18,000	C
Bremen	18,000	P
Brunswick	18,000	P
Schwaz	17,000	C
Amsterdam	15,000	P
Mons (Bergen)	15,000	C

Table 2: Catholic and Protestant Cities in Holy Roman Empire (population ≥ 5,000)

	Cites With Press by 1500		Cites With No Press by 1500	
	N	%	N	%
Total Catholic:	30	44.8%	39	45.3%
Total Protestant:	37	55.2%	47	54.7%
Total Catholic, pop ≥ 10,000	22	48.9%	12	48.0%
Total Protestant, pop ≥ 10,000	23	51.1%	13	52.0%
Total Catholic, pop < 10,000	8	36.4%	27	44.3%
Total Protestant, pop < 10,000	14	63.6%	34	55.7%

Table 3: Summary Statistics (cities with population ≥ 5,000 in 1500)

Variable	Obs.	Mean	Std Dev	Min	Max
			Protestant and Printing Variables		
Protestant in 1530	153	0.170	0.377	0	1
Protestant in 1560	153	0.399	0.491	0	1
Protestant in 1600	153	0.549	0.499	0	1
Printing Press in 1500	153	0.438	0.498	0	1
			Control Variables		
Log (population in 1500, in thousands)	153	2.288	0.631	1.6094379	4.6051702
University in 1450	153	0.078	0.270	0	1
Bishop in 1517	153	0.275	0.448	0	1
Hanseatic	153	0.196	0.398	0	1
Independent City	153	0.196	0.398	0	1
Log (distance to Wittenberg, in miles)	153	5.588	0.634	3.367	6.354
Log (distance to Mainz, in miles)	153	5.292	0.659	0	6.280
Protestant potential, 1530	153	10.283	5.506	3.491	22.360
Protestant potential, 1560	153	23.615	9.862	8.630	44.468
Protestant potential, 1600	153	31.905	10.832	10.263	48.624
City Coordinate N/S	153	49.917	2.369	44.230	54.190
City Coordinate E/W	153	8.307	3.746	2.150	18.560

**All log values are log (1 + variable) except for log of population and Protestant and Catholic potential

Table 4: Correlation Matrix, All Variables

	Prot in 1530	Prot in 1560	Prot in 1600	Press in 1500	Population
Prot in 1560	0.556				
Prot in 1600	0.410	0.711			
Press in 1500	0.057	0.062	0.006		
Population	-0.018	-0.106	-0.172	0.408	
University	-0.067	-0.039	-0.126	0.331	0.215
Bishop	-0.005	-0.022	-0.208	0.313	0.317
Hanseatic	0.171	0.438	0.315	-0.071	0.042
Independent City	0.390	0.338	0.249	0.095	0.126
Dist to Wittenberg	-0.275	-0.626	-0.476	0.024	0.097
Dist to Mainz	-0.343	-0.231	-0.225	-0.095	0.095
Prot potential, 1530	0.432	0.746	0.533	0.054	-0.162
Prot potential, 1560	0.404	0.755	0.550	0.026	-0.137
Prot potential, 1600	0.254	0.456	0.743	0.009	-0.136
Coord N/S	0.031	0.205	0.441	-0.143	0.011
Coord E/W	0.140	0.436	0.181	0.078	-0.040

	University	Bishop	Hanseatic	Independent City	Dist to Wittenberg
Bishop	0.202				
Hanseatic	0.040	0.102			
Independent City	-0.022	0.176	0.088		
Dist to Wittenberg	-0.082	0.052	-0.575	-0.037	
Dist to Mainz	-0.052	-0.075	0.057	-0.351	0.071
Prot potential, 1530	0.087	0.036	0.528	0.341	-0.817
Prot potential, 1560	0.066	-0.020	0.587	0.276	-0.890
Prot potential, 1600	-0.018	-0.219	0.450	0.133	-0.668
Coord N/S	-0.058	-0.348	0.473	-0.107	-0.446
Coord E/W	0.117	0.158	0.338	0.058	-0.601

	Dist to Mainz	Prot potential, 1530	Prot potential, 1560	Prot potential, 1600	Coord N/S
Prot potential, 1530	-0.322				
Prot potential, 1560	-0.247	0.966			
Prot potential, 1600	-0.258	0.651	0.698		
Coord N/S	-0.076	0.245	0.387	0.713	
Coord E/W	0.188	0.581	0.593	0.206	-0.074

Table 5: Average Marginal Effects, Protestantism in the Holy Roman Empire, 1530-1600

	(5.1)	(5.2)	(5.3)	(5.4)
Probit Regressions	Protestant in 1530	Protestant in 1560	Protestant in 1600	Protestant in 1600 No Low Countries
Printing Press by 1500	0.050***	0.088***	0.045	0.088***
	(0.014)	(0.020)	(0.031)	(0.024)
Log Population in 1500	0.034	0.040*	0.006	0.001
	(0.029)	(0.020)	(0.018)	(0.011)
University	-0.148***	-0.158***	-0.150***	-0.176***
	(0.044)	(0.045)	(0.039)	(0.056)
Bishop	-0.062**	-0.095***	-0.114**	-0.132**
	(0.031)	(0.037)	(0.054)	(0.062)
Hanseatic	0.009	-0.060*	-0.101***	-0.062***
	(0.026)	(0.032)	(0.020)	(0.020)
Independent City	0.130**	0.081*	0.094	0.171***
	(0.065)	(0.048)	(0.063)	(0.062)
Log Distance to Wittenberg	-0.031	0.141***	0.178***	0.125**
	(0.066)	(0.023)	(0.063)	(0.051)
Protestant Potential	0.027***	0.025***	0.028***	0.027***
	(0.009)	(0.004)	(0.006)	(0.009)
Geographical Controls	Yes	Yes	Yes	Yes
Observations	153	153	153	103
Psuedo R-squared	0.324	0.649	0.640	0.560

Robust standard errors clustered by current country in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Geographic control variables are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 are analyzed

Table 6: Average Marginal Effects, Introduction of Printing Press at Various Times

	(6.1)	(6.2)	(6.3)	(6.4)
Probit Regressions	Protestant in 1530	Protestant in 1560	Protestant in 1600	Protestant in 1600 No Low Countries
Printing Press by 1500	0.050***	0.088***	0.045	0.088***
	(0.014)	(0.020)	(0.031)	(0.024)
Printing Press by 1490	0.104***	0.034	0.051	0.083**
	(0.029)	(0.034)	(0.034)	(0.033)
Printing Press by 1480	0.179***	0.067	0.103***	0.144***
	(0.052)	(0.041)	(0.037)	(0.039)
Printing Press by 1470	0.165***	0.076***	0.069***	0.111***
	(0.052)	(0.013)	(0.012)	(0.008)
City-Specific Controls	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes

Robust standard errors clustered by current country in parentheses; *** p<0.01, ** p<0.05, * p<0.1
City-specific control variables are: log of population in 1500, log of distance to Wittenberg, and dummies for university by 1450, bishop by 1517, Hanseatic League, Independent City in 1517, and Protestant potential; Geographic control variables are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 are analyzed

Table 7: Average Marginal Effects, Bivariate Probit – "Instrumenting" for the Printing Press

	(7.1)		(7.2)	
Bivariate Probit Regressions	Press by 1500	Prot in 1530	Press by 1500	Prot in 1560
Log Distance to Mainz	-0.093***		-0.073***	
	(0.016)		(0.016)	
Printing Press by 1500		0.332***		0.195***
		(0.057)		(0.069)
Observations	153		153	
Log Likelihood	-123.6		-113.6	
Rho	-0.866		-0.468	

	(7.3)		(7.4) No Low Countries	
Bivariate Probit Regressions	Press by 1500	Prot in 1600	Press by 1500	Prot in 1600
Log Distance to Mainz	-0.082***		-0.082***	
	(0.023)		(0.020)	
Printing Press by 1500		0.022		0.173***
		(0.096)		(0.062)
Observations	153		103	
Log Likelihood	-115.5		-79.25	
Rho	0.107		-0.319	

Robust standard errors clustered by current country in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Protestant regression controls include log population, log distance to Wittenberg, a university dummy, bishop dummy, Hanseatic dummy, Independent City dummy, and Protestant potential; Press by 1500 regressions controls are the same as the Protestant regressions, except that log of distance to Wittenberg and Protestant potential are omitted; Geographic control variables, used in both stages, are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 analyzed

Table 8: Average Marginal Effects, Bivariate Probit – "Instrumenting" for the Printing Press Omitting Endogenous Protestant Potential

	(8.1)		(8.2)	
Bivariate Probit Regressions	Press by 1500	Prot in 1530	Press by 1500	Prot in 1560
Log Distance to Mainz	-0.120***		-0.073***	
	(0.015)		(0.017)	
Printing Press by 1500		0.169		0.213***
		(0.237)		(0.067)
Observations	140		150	
Log Likelihood	-101.5		-112.7	
Rho	-0.654		-0.523	

	(8.3)		(8.4) No Low Countries	
Bivariate Probit Regressions	Press by 1500	Prot in 1600	Press by 1500	Prot in 1600
Log Distance to Mainz	-0.085***		-0.083***	
	(0.025)		(0.020)	
Printing Press by 1500		0.028		0.175***
		(0.096)		(0.063)
Observations	150		102	
Log Likelihood	-113.7		-79.25	
Rho	0.0797		-0.320	

Robust standard errors clustered by current country in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Protestant regression controls include log population, log distance to Wittenberg, a university dummy, bishop dummy, Hanseatic dummy, Independent City dummy, and Protestant potential; Press by 1500 regressions controls are the same as the Protestant regressions, except that log of distance to Wittenberg and Protestant potential are omitted; Geographic control variables, used in both stages, are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 analyzed

Table 9: Validity of Various Distance Instruments - Average Marginal Effects

Probit Regressions	(9.1) Printing Press by 1500
Log Distance to Mainz	-0.086***
	(0.018)
Log Distance to Vienna	-0.057
	(0.339)
Log Distance to Rome	0.081
	(0.860)
Log Distance to Paris	0.227
	(0.371)
Log Distance to Genoa	0.067
	(0.124)

Robust standard errors clustered by current country in parentheses;
*** p<0.01, ** p<0.05, * p<0.1
City-specific control variables are: log of population in 1500, log of distance to Wittenberg, and dummies for university by 1450, bishop by 1517, Hanseatic League, Independent City in 1517, and Protestant potential; Geographic control variables are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 are analyzed

Table 10: Top 10 Cities by Book Production (in German) and Religion in 1560, by decade

1460-69			1470-79		
City	Books	P/C (1560)	City	Books	P/C (1560)
Cologne	20	C	Cologne	230	C
Mainz	18	P	Augsburg	150	P
Strasbourg	17	P	Strasbourg	127	P
Augsburg	3	P	Nuremberg	112	P
Basel	2	P	Basel	76	P
Bamberg	1	C	Mainz	33	P
Eltvil	1	P	Esslingen	31	P
			Ulm	29	P
			Speyer	28	P
			Merseburg	12	P
1480-89			1490-99		
City	Books	P/C (1560)	City	Books	P/C (1560)
Strasbourg	201	P	Strasbourg	195	P
Cologne	174	C	Leipzig	179	P
Nuremberg	112	P	Cologne	169	C
Basel	110	P	Basel	141	P
Augsburg	101	P	Nuremberg	132	P
Ulm	49	P	Augsburg	106	P
Speyer	45	P	Speyer	55	P
Reutlingen	36	P	Mainz	35	P
Leipzig	25	P	Ulm	35	P
Mainz	21	P	Reutlingen	33	P
1500-09			1510-19		
City	Books	P/C (1560)	City	Books	P/C (1560)
Cologne	226	C	Strasbourg	310	P
Strasbourg	197	P	Augsburg	213	P
Leipzig	135	P	Basel	183	P
Augsburg	102	P	Leipzig	183	P
Nuremberg	86	P	Nuremberg	183	P
Basel	65	P	Cologne	109	C
Haguenau	33	P	Vienna	91	C
Pforzheim	31	P	Pforzheim	55	P
Reutlingen	25	P	Haguenau	35	P
Erfurt	24	P	Wittenberg	35	P

Table 11: Summary Statistics (cities with population ≥ 5,000 in 1500), Germany and Switzerland

Variable	Obs.	Mean	Std Dev	Min	Max
			Protestant and Printing Variables		
Protestant in 1530	84	0.321	0.470	0	1
Protestant in 1560	84	0.726	0.449	0	1
Protestant in 1600	84	0.750	0.436	0	1
Log (# of books published, 1450 - 1499)	84	1.148	1.892	0	6.387
Log (# of books published, 1450 - 1519)	84	1.382	2.053	0	6.955
Log (# of books published, 1500 - 1519)	84	0.506	0.965	0	3.523
Log (# of books published, 1510 - 1519)	84	0.620	1.125	0	4.072
Log (# of books published, 1450 - 1499, per capita)	84	0.924	1.692	0	6.230
Log (# of books published, 1450 - 1519, per capita)	84	0.678	1.496	0	5.740
			Control Variables		
Log (population in 1500, in thousands)	84	2.230	0.560	1.609	3.807
University in 1450	84	0.095	0.295	0	1
Bishop in 1517	84	0.310	0.465	0	1
Hanseatic	84	0.369	0.485	0	1
Independent City	84	0.417	0.496	0	1
Log (distance to Wittenberg, in miles)	84	5.259	0.664	3.367	6.282
Log (distance to Mainz, in miles)	84	5.160	0.862	0	6.526
Protestant potential, 1530	84	14.404	3.908	5.910	22.360
Protestant potential, 1560	84	30.928	7.078	15.145	44.468
Protestant potential, 1600	84	36.336	7.224	18.351	48.624
City Coordinate N/S	84	50.467	2.196	46.120	54.430
City Coordinate E/W	84	10.597	3.529	5.130	21.000

**All log values are log (1 + variable) except for log of population; per capita in terms of thousands

Table 12: Average Marginal Effects, Protestantism in Germany and Switzerland: 1530-1600

Probit Regressions	(12.1) Prot in 1530	(12.2) Prot in 1560	(12.3) Prot in 1600
Log of # of books published, 1450 - 1499	0.081***	0.052**	0.059**
	(0.027)	(0.024)	(0.024)
Log of # of books published, 1450 - 1519	0.083***	0.050**	0.056**
	(0.025)	(0.023)	(0.023)
Log of # of books published, 1450 - 1499, per capita	0.140***	0.098**	0.109***
	(0.047)	(0.042)	(0.042)
Log of # of books published, 1450 - 1519, per capita	0.124***	0.091**	0.099***
	(0.042)	(0.036)	(0.037)
Log of # of books published, 1500 - 1519	0.099***	0.065***	0.063**
	(0.034)	(0.024)	(0.025)
Log of # of books published, 1510 - 1519	0.085**	0.080***	0.074***
	(0.037)	(0.027)	(0.026)
Observations	84	84	84

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
City-specific control variables are: log of population in 1500, log of distance to Wittenberg, and dummies for university by 1450, bishop by 1517, Hanseatic League, Independent City in 1517, and Protestant potential; Geographic control variables are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 are analyzed

Table 13: Distance from Mainz (in miles); Top 10 Cities by Book Production (in German)

1460-69		1470-79	
City	Distance	City	Distance
Cologne	90	Cologne	90
Mainz	0	Augsburg	172
Strasbourg	102	Strasbourg	102
Augsburg	172	Nuremberg	143
Basel	173	Basel	173
Bamberg	129	Mainz	0
Eltvil	7	Esslingen	101
		Ulm	140
		Speyer	49
		Merseburg	204
Average	96	Average	117
Weighted Avg (by Books)	73	Weighted Avg (by Books)	120
1480-89		1490-99	
City	Distance	City	Distance
Strasbourg	102	Strasbourg	102
Cologne	90	Leipzig	219
Nuremberg	143	Cologne	90
Basel	173	Basel	173
Augsburg	172	Nuremberg	143
Ulm	140	Augsburg	172
Speyer	49	Speyer	49
Reutlingen	115	Mainz	0
Leipzig	219	Ulm	140
Mainz	0	Reutlingen	115
Average	120	Average	120
Weighted Avg (by Books)	123	Weighted Avg (by Books)	136
1500-09		1510-19	
City	Distance	City	Distance
Cologne	90	Strasbourg	102
Strasbourg	102	Augsburg	172
Leipzig	219	Basel	173
Augsburg	172	Leipzig	219
Nuremberg	143	Nuremberg	143
Basel	173	Cologne	90
Haguenau	86	Vienna	414
Pforzheim	80	Pforzheim	80
Reutlingen	115	Haguenau	86
Erfurt	150	Wittenberg	250
Average	133	Average	173
Weighted Avg (by Books)	133	Weighted Avg (by Books)	164

Table 14: Average Marginal Effects, SUR Regression – "Instrumenting" for the Printing Press

First Stage: OLS Coefficient Second Stage: Probit (Avg. Marginal Effect)	(14.1) First Stage: Print Intensity	(14.2) Second Stage: Prot in 1530	(14.3) Second Stage: Prot in 1560	(14.4) Second Stage: Prot in 1600
Log Distance to Mainz	-0.704***			
	(0.257)			
Log of # of books published, 1450 - 1499		0.171***	0.138*	0.158**
		(0.030)	(0.080)	(0.073)
Observations	84	84	84	84
Log Distance to Mainz	-0.908***			
	(0.268)			
Log of # of books published, 1450 - 1519		0.152***	0.107	0.125*
		(0.035)	(0.072)	(0.075)
Observations	84	84	84	84
Log Distance to Mainz	-0.423***			
	(0.136)			
Log of # of books published, 1450 - 1499, per capita		0.306***	0.244	0.285*
		(0.077)	(0.169)	(0.156)
Observations	84	84	84	84
Log Distance to Mainz	-0.503***			
	(0.157)			
Log of # of books published, 1450 - 1519, per capita		0.263***	0.204	0.240*
		(0.071)	(0.146)	(0.143)
Observations	84	84	84	84
Log Distance to Mainz	-0.716***			
	(0.222)			
Log of # of books published, 1500 - 1519		0.184***	0.125	0.144
		(0.053)	(0.095)	(0.093)
Observations	84	84	84	84
Log Distance to Mainz	-0.581***			
	(0.204)			
Log of # of books published, 1510 - 1519		0.204***	0.156	0.180
		(0.062)	(0.123)	(0.110)
Observations	84	84	84	84

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Estimates derived using cmp function in Stata from Roodman (2008)
Protestant regression controls include log population, log distance to Wittenberg, a university dummy, bishop dummy, Hanseatic dummy, Independent City dummy, and Protestant potential; Print intensity regressions controls are the same as the Protestant regressions, except that log of distance to Wittenberg and Protestant potential are omitted; Geographic control variables are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 are analyzed

Table 15: Average Marginal Effects, Protestantism in Europe, 1530-1600

Probit Regressions	(15.1) Prot in 1530	(15.2) Prot in 1560	(15.3) Prot in 1600
Printing Press by 1500	0.032***	0.043**	0.035
	(0.007)	(0.020)	(0.026)
Log Population in 1500	0.008	0.007	-0.020
	(0.009)	(0.015)	(0.017)
University	-0.082***	-0.101***	-0.094***
	(0.021)	(0.030)	(0.029)
Bishop	-0.025*	-0.027	-0.036
	(0.013)	(0.027)	(0.041)
Hanseatic	-0.005	0.026*	0.007
	(0.012)	(0.015)	(0.027)
Independent City	0.033	-0.014	0.014
	(0.035)	(0.044)	(0.046)
Log Distance to Wittenberg	0.035	0.089*	0.063
	(0.034)	(0.051)	(0.061)
Protestant Potential	0.017***	0.020***	0.017***
	(0.005)	(0.004)	(0.004)
Geographical Controls	Yes	Yes	Yes
Observations	373	373	373
Psuedo R-squared	0.462	0.708	0.735

Robust standard errors clustered by current country in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Geographic control variables are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 are analyzed

Table 16: Average Marginal Effects, Bivariate Probit - "Instrumenting" for the Printing Press

Bivariate Probit Regressions	(16.1) Press by 1500	(16.1) Prot in 1530	(16.2) Press by 1500	(16.2) Prot in 1560
Log Distance to Mainz	-0.124***		-0.115***	
	(0.019)		(0.019)	
Printing Press by 1500		0.163***		0.055
		(0.053)		(0.049)
Observations	373		373	
Log Likelihood	-231.5		-233.4	
Rho	-0.727		-0.0894	

Bivariate Probit Regressions	(16.3) Press by 1500	(16.3) Prot in 1600	(16.4) No Britain or Low Countries Press by 1500	(16.4) No Britain or Low Countries Prot in 1600
Log Distance to Mainz	-0.128***		-0.103***	
	(0.017)		(0.023)	
Printing Press by 1500		-0.195***		0.080
		(0.025)		(0.065)
Observations	373		308	
Log Likelihood	-233.7		-188.9	
Rho	1.000		-0.203	

Robust standard errors clustered by current country in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Protestant regression controls include log population, log distance to Wittenberg, a university dummy, bishop dummy, Hanseatic dummy, Independent City dummy, and Protestant potential; Press by 1500 regressions controls are the same as the Protestant regressions, except that log of distance to Wittenberg and Protestant potential variables are omitted; Geographic control variables, used in both stages, are: the city's coordinates (east/west, north/south, and the interaction); only cities with population ≥ 5,000 in 1500 analyzed

FIGURES

Figure 1: Protestantism and Printing in the Holy Roman Empire (cities with population ≥ 5,000 in 1500)

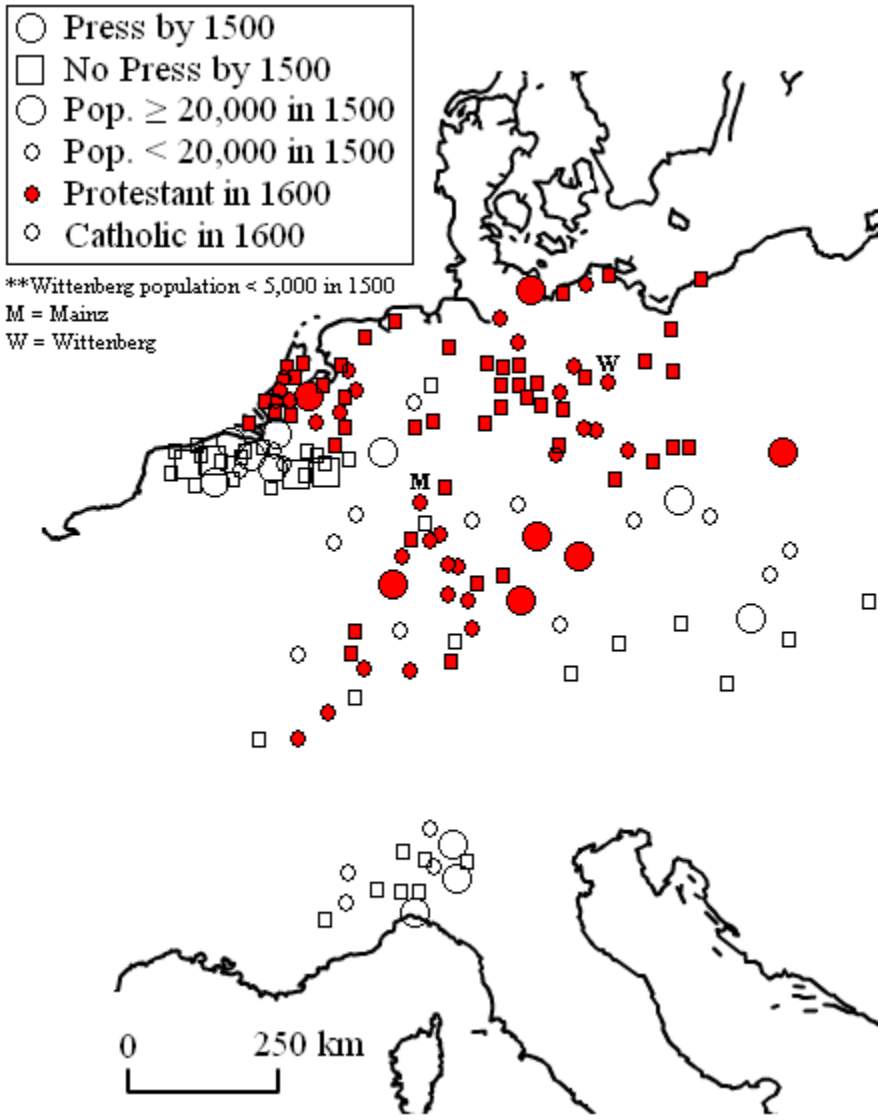

Figure 2: Distance to Mainz, Population, and Adoption of Printing before 1500

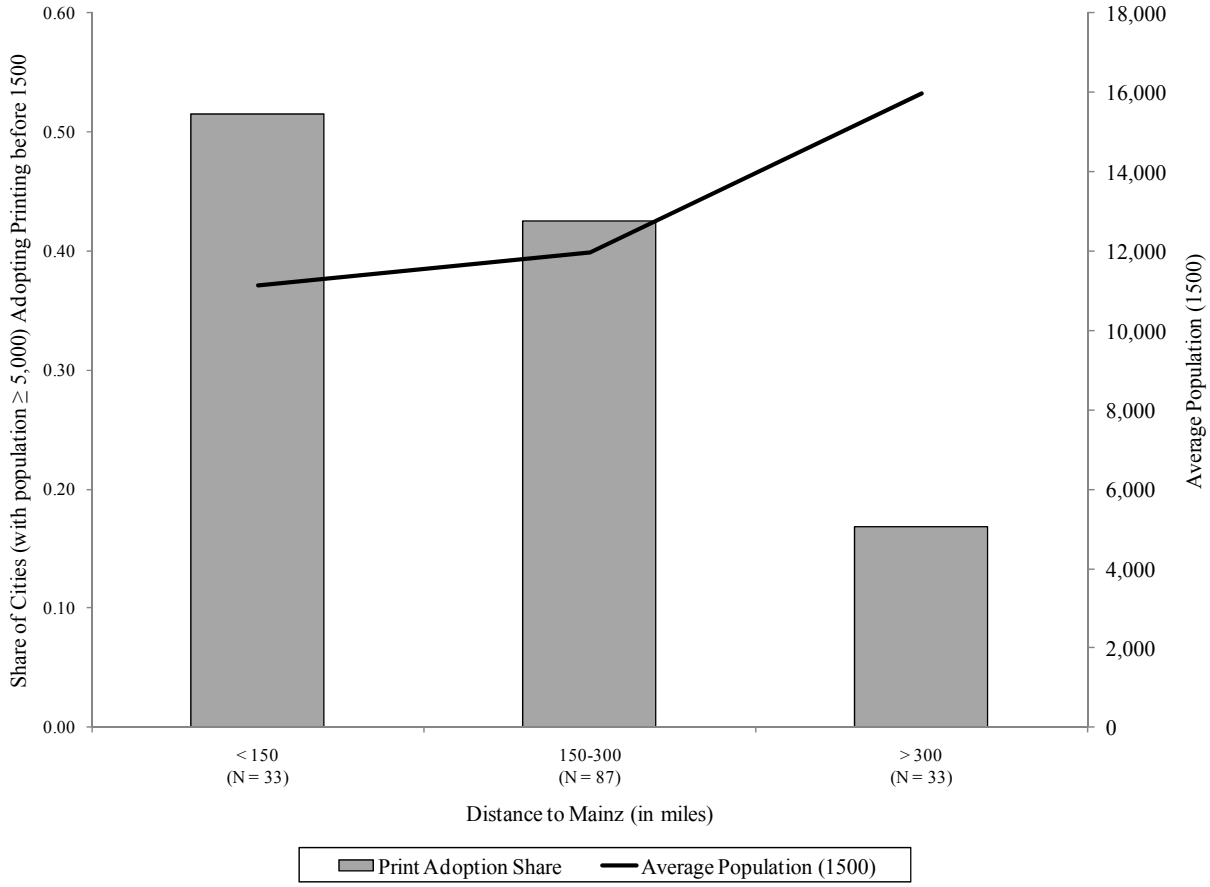

Figure 3: Number of Books (in German) by Decade

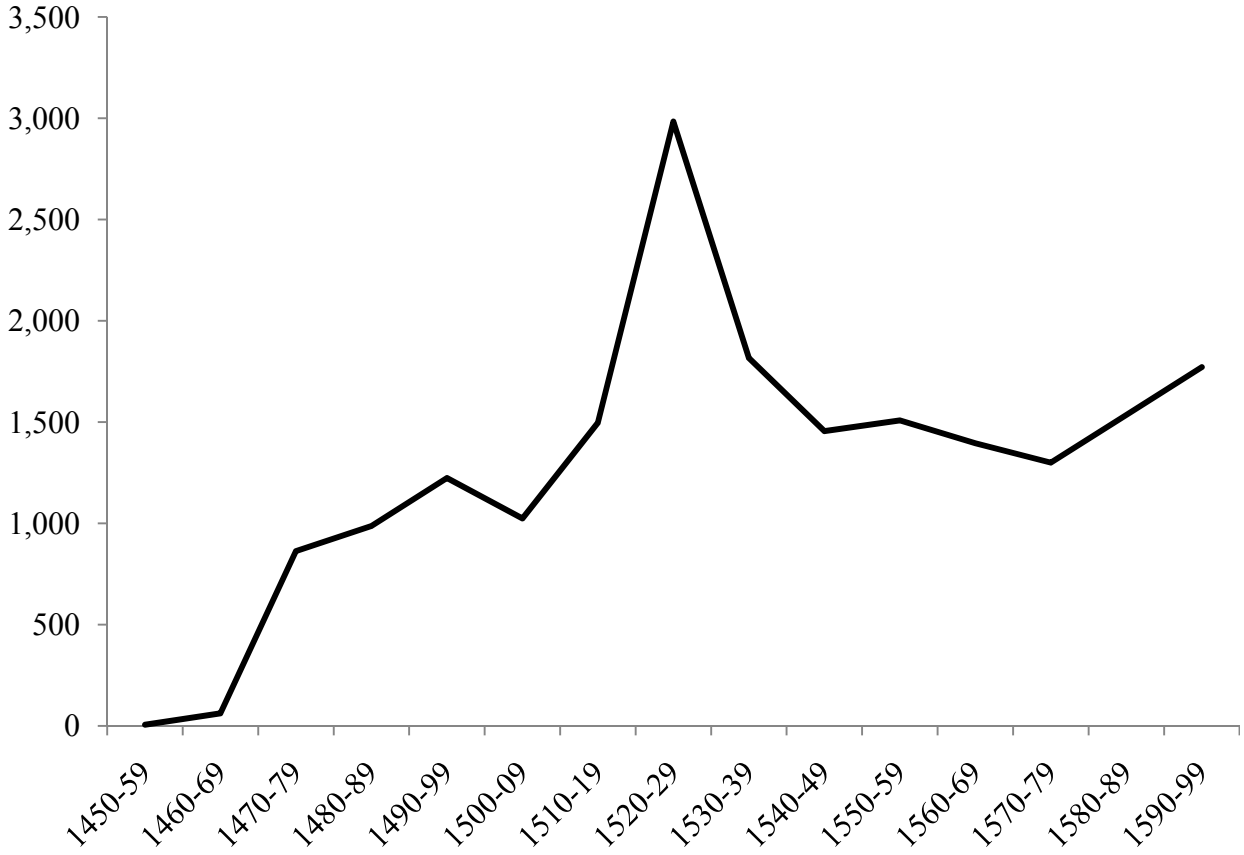

Figure 4: Protestantism and Printing in Western Europe (cities with population ≥ 5,000 in 1500) – Press Cities Only