Abstract—The causes of the Protestant Reformation have long been debated. This paper seeks to revive and econometrically test the theory that the spread of the Reformation is linked to the spread of the printing press. I test this theory by analyzing data on the spread of the press and the Reformation at the city level. An econometric analysis that instruments for omitted variable bias with a city’s distance from Mainz, the birthplace of printing, suggests that cities with at least one printing press by 1500 were at minimum 29 percentage points more likely to be Protestant by 1600.

I. Introduction

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

The challenge for the economic historian is disentangling these events. Which events were facilitated by other historical events, and, more important, 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 the printing press and the Protestant Reformation. Economists have recently touted both of these events as having monumental long-run economic effects. Baten and van Zanden (2008), Buringh and Van Zanden (2009), Chilosi and Volckart (2010), and Dittmar (2011) are recent additions to the literature stressing the importance of the printing press as an independent factor contributing to subsequent European economic growth.1 Becker and Wössmann (2008, 2009, 2010), in the tradition of Max Weber (1905), connect the spread of Protestantism to subsequent economic growth, although unlike Weber, they emphasize the reformers’ stress on literacy as the causal factor.2 If these two events are related, then the true impact on subsequent economic growth of either (or both) may be overstated.

This paper is far from the first to connect the printing press to the Reformation.3 This argument is centuries old, with arguments in support of (Dickens, 1968; Eisenstein, 1979; Edwards, 1994; Gilmont, 1998) and against (Febvre & Martin, 1958; Scribner, 1989) the causal linkage connecting the press and the Reformation. For example, in their classic book The Coming of the Book: The Impact of Printing, which extols the positive historical significance of the printing press, Febvre and Martin (1958, p. 288) claim that “it is not part of our intention to revive the ridiculous thesis that ‘it was the child of the printing press.’” But is this thesis so ridiculous?

A key problem with past theses connecting the printing press to the Reformation is that the linkage may be spurious. Even if we accept that the press facilitated the reformers’ ability to spread the seeds of dissent, it is certainly possible that cities that were more likely to accept the Reformation were also more likely to adopt printing for reasons correlated with both the press and Protestantism, such as higher pre-printing press literacy rates, a larger population, or local independence from centralized rule.4 If this were 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, this paper contributes a much-needed empirical analysis to the debate on the link between the printing press and the Reformation. It employs a new city-level data set (covering central and western Europe) on conversion to Protestantism, the presence of a printing press by 1500, and a host of variables

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

2 In a related work, Buringh and van Zanden (2009) show that conversion to Protestantism is strongly related to subsequent literacy outcomes. Other recent work connecting religion to human capital accumulations include Berman (2000), Botticini and Eckstein (2005, 2007), and Chaudhry and Rubin (2011). Blum and Dudley (2001) present a pro-Weber argument but suggest that Protestant economic networks, not a “work ethic,” are the root cause. Arruahda (2010) argues that Protestants did not have a unique work ethic, but instead had a “social ethic” that favored market transactions. Cantoni (2013) 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.

3 For example, Cantoni (2012) asks a similar question to the one posed in this paper. He finds that among other things, there was a strong spatial pattern to the spread of Protestantism. This result is consistent with the one I found.

4 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.
controlling for the supply and demand of Protestantism. To address omitted variable biases, such as pre-printing literacy rates correlating with the acceptance of both the press and Reformation, I instrument for the printing press with a city’s distance to Mainz, the birthplace of printing. This instrument is also used by Dittmar (2011) and is similar to the distance-from-Wittenberg instrument employed by Becker and Wössmann (2008, 2009, 2010) and Cantoni (2013). It is a useful instrument because printing spread in a relatively concentric circular pattern outward from Mainz, yet a city’s distance from Mainz should have no direct effect on the adoption of the Reformation. I find a very strong connection between towns that adopted the printing press and those that accepted the Reformation; instrumental variable results indicate that towns with a press by 1500 were 52.1 percentage points more likely to accept the Reformation by 1530, 41.9 percentage points more likely to accept the Reformation by 1560, and 29.0 percentage points more likely to accept the Reformation by 1600. The weakening effect of the press after the initial spread of the Reformation suggests the possibility that cities that were early adopters of printing were more likely to adopt the Reformation in its early stages, but other factors, such as politics and the greater penetration of printing throughout the sixteenth century, played a more important role in the persistence of the Reformation.

The implications of these results are immense for the growing body of literature on religion, economic growth, and printing. Most important, if Dittmar (2011) is correct and the press had an independent effect on economic development, then Weber’s (and Becker and Wössmann’s) linkage between Protestantism and economic development may be spurious, reflecting instead developments associated with the diffusion of print media. In fact, these results suggest that the distance-to-Wittenberg instrument may be problematic; to the extent that it is correlated with distance to Mainz, it may be partially picking up the diffusion of printing, which itself was linked to the spread of the Reformation. Likewise, if Weber (1905) and Becker and Wössmann (2008, 2009, 2010) are correct that Protestantism had an independent effect on development, then the importance of the press may be indirect through its role in facilitating the Reformation. Of course, both the printing press and Protestantism may have had independent effects on economic development, and it is not the purpose of this analysis to differentiate between these two hypotheses. What this analysis does suggest, however, is that any investigation of the long-run economic effects of the printing press (or, more generally, information technologies) and the Reformation (or, more generally, social and political upheaval) cannot ignore the relationship between the two.

II. Historical Background

A. Early Printing

The first printing press using movable type was invented circa 1450 by Johann Gutenberg in Mainz. The first major work employing the new technology, the Gutenberg Bible, was available for sale by 1455. In the fifty years following the invention, the press diffused throughout many of the major cities in western Europe. Although the press met some resistance in some areas at different times, such as in post-Reformation France, 60 of the 100 largest European cities had a press by the end of the fifteenth century (Dittmar, 2011). By 1500, nearly 8 million books had been printed, most of them religious in nature and printed in Latin—perhaps more than the scribes had produced in the previous millennium (Eisenstein, 1979). The early centers of printing in the Holy Roman Empire were Cologne, Augsburg, Strasbourg, Leipzig, and Nuremberg, though numerous other print shops were scattered throughout the empire.

The first print workshops were established by Gutenberg and his assistants. They held a printing monopoly for about a decade, before the Bible was printed in Strasbourg in 1459 (Febvre & Martin, 1958). Printing remained almost exclusively German in its first few decades, and by the 1470s printing was controlled by a small group of printer-scholars, educated laymen who ran the printing presses and played a significant role in editing. The printer-scholars were often former priests or university professors who lived nomadic lives and moved to places where demand for books was the highest: first to the major commercial centers and then to the university towns (Eisenstein, 1979). Most university towns eventually became printing centers, as the guaranteed market they provided attracted printers and encouraged them to settle. Printing expanded rapidly in the 1470s, particularly in Germany and Italy, and by 1480, the

5 However, any problems with the instrument could be avoided by simultaneously instrumenting for the press and the Reformation (with distance to Mainz and distance to Wittenberg, respectively). I thank an anonymous referee for pointing out this problem and its solution.

6 Dittmar (2011) does in fact explore the possibility that the press played a greater role on city growth in Protestant lands. He does this by including a distance-to-Wittenberg variable as a proxy for Protestantism. His results hold with its inclusion.

7 This paper by no means suggests that the Reformation was a monocular event. Another factor differentiating the attempt of previous reformers with Luther, Zwingli, and Calvin was the Ottoman threat on eastern and central Europe in the sixteenth century, which encouraged the pope and Emperor Charles V to make various concessions to the reformers. This complementary thesis is most recently laid out econometrically by Iyyigun (2008). Ekelund, Hébert, and Tollison (2002, 2008) also present a complementary hypothesis that 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 micromechanisms they suggest underscore an important aspect of the reformers’ motivations.

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

9 Johns (1998) argues that scribal culture persisted for well over a century after the spread of the press. This should not detract from the primary argument I make in this paper: the rapidity of reproduction allowed by the press versus the scribes is the important source of connection between the press and the Reformation.
press was in nearly universal use throughout western Europe (Febvre & Martin, 1958).

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

The price of books fell dramatically in the half-century after the spread of the press. On top of the large outward supply shift following the diffusion of the press, technological changes in the paper production process and the use of ink based on oil decreased the price of books around 85% (Spitz, 1985; Buringh & 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 books also led to dramatic increases in literacy, particularly in Great Britain, the Netherlands, Germany, and Sweden (Buringh & van Zanden, 2009).

B. The Spread of Protestantism

On October 31, 1517, Martin Luther nailed his Ninety-Five Theses to the door of All Saints Church at Wittenberg, sparking what would become the Protestant Reformation. Luther was concerned with what he viewed as theological errors (such as whether salvation could come through faith alone) as well as Church abuses that had become increasingly prominent in the century prior to the Reformation—indulgences, relic cults, clerical privileges, clerical concubinage, simony, and a broad host of other perceived abuses emanating from the Church hierarchy and papacy. 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 antipapal sentiments were deeply rooted well before the Reformation.

Luther initially circulated his theses privately, but printed editions quickly emerged in Leipzig, Magdeburg, Nuremberg, and Basel. Luther’s literary output was immense—he wrote thirteen treatises that sold over 300,000 copies between 1517 and 1520—and spread quickly throughout the empire via printed copies (Spitz, 1985). Luther’s message initially spread in the free cities of central Germany. Cities such as Nuremberg accepted the Reformation, with powerful friends of Luther appointing preachers sympathetic to reform ideas (Cameron, 1991). A contemporary

movement emerged in the Swiss confederation, where Huldrych Zwingli (1484–1531) espoused many similar principles to Luther and preached to Zürich congregations in the vernacular (although Zwingli was by no means a direct disciple of Luther and the two disagreed on many points of doctrine). A hybrid Luther-Zwingli message caught on in the 1520s in many of the free cities of southern Germany such as Strasbourg and Constance (Cameron, 1991).

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

An important thesis forwarded by Steven Ozment (1975) is that the Reformation was an “urban event.”10 Indeed, 50 of the 65 free 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 that 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 councils took charge of installing the Reformation by bringing in preachers sympathetic to reform ideas. In the northern Hanseatic cities, it was largely the middling bourgeoisie, who were wealthy but had little political power within the cities, that encouraged the Reformation as a means of confronting the established powers. Some of the members of these council sought economic

10 The Reformation also coincided with (and was perhaps facilitated by) a series of uprisings among the peasant masses between 1524 and 1526. These interconnected revolts, broadly known as the peasants’ War, occurred throughout most of Germany, except for Bavaria. Luther rejected the peasants’ grievances but urged the lords to come to a peaceful solution (Spitz, 1985).
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 a literate class with some power, but far enough removed from the princes or emperor not to fear direct retribution (Cameron, 1991). Once the Reformation was accepted by a town, it generally followed that the old privileges and status of the priesthood and hierarchy were removed, followed by the confiscation or destruction of the Church’s material wealth.

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 was agreed on from the 1570s to 1590s (Cameron, 1991). Similar movements occurred in the Low Countries, where Calvinist ideas spread from the 1540s to the 1560s. The Spanish Habsburgs reacted quite harshly to Protestants, burning nearly two thousand 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 important in England, where Henry VIII dealt significant blows to the established church, which consolidated as the state-sponsored Anglican church under Elizabeth I (1558–1603).

C. 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 previous 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 & Martin, 1958, p. 288)?

Table 1 provides some preliminary evidence that early printing centers were more likely to adopt the Reformation. This table lists the top German-speaking book-producing cities in each decade of the latter half of the fifteenth century (combining the 1450s and 1460s), as well as the religious status of each of these cities. There is general continuity in the top print centers, with Cologne, Strasbourg, Augsburg, and Nuremberg in the top five in each of the last three decades. Most of the German printing centers were Protestant by 1600, with Cologne as the primary exception. More important, it appears that the top print cities were more likely (on average) to adopt the Reformation by 1530 and by 1600; 70% of the top printing centers of the 1470s adopted the Reformation by 1530, despite only 32.6% of German-speaking cities adopting the Reformation by this date.

Table 1.—Top Ten Cities by Book Production (German Speaking), by Decade

<table>
<thead>
<tr>
<th>City</th>
<th>Books 1450–1469</th>
<th>P/C 1530</th>
<th>P/C 1600</th>
<th>City</th>
<th>Books 1450–1469</th>
<th>P/C 1530</th>
<th>P/C 1600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainz</td>
<td>95</td>
<td>C</td>
<td>C</td>
<td>Cologne</td>
<td>412</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Cologne</td>
<td>44</td>
<td>C</td>
<td>C</td>
<td>Augsburg</td>
<td>298</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Strasbourg</td>
<td>17</td>
<td>P</td>
<td>P</td>
<td>Strasbourg</td>
<td>250</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Bamberg</td>
<td>9</td>
<td>C</td>
<td>C</td>
<td>Nuremberg</td>
<td>165</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Augsburg</td>
<td>6</td>
<td>C</td>
<td>P</td>
<td>Basel</td>
<td>154</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Eltville</td>
<td>3</td>
<td>P</td>
<td>P</td>
<td>Ulm</td>
<td>73</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Basel</td>
<td>1</td>
<td>P</td>
<td>P</td>
<td>Mainz</td>
<td>64</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Nuremberg</td>
<td>1</td>
<td>P</td>
<td>P</td>
<td>Speyer</td>
<td>46</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lübeck</td>
<td>42</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reutlingen</td>
<td>24</td>
<td>P</td>
<td>P</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>City</th>
<th>Books 1480–1489</th>
<th>P/C 1530</th>
<th>P/C 1600</th>
<th>City</th>
<th>Books 1480–1489</th>
<th>P/C 1530</th>
<th>P/C 1600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cologne</td>
<td>441</td>
<td>C</td>
<td>C</td>
<td>Leipzig</td>
<td>1,040</td>
<td>C</td>
<td>P</td>
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<tr>
<td>Augsburg</td>
<td>405</td>
<td>C</td>
<td>P</td>
<td>Cologne</td>
<td>591</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Strasbourg</td>
<td>364</td>
<td>P</td>
<td>P</td>
<td>Nuremberg</td>
<td>492</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Nuremberg</td>
<td>359</td>
<td>P</td>
<td>P</td>
<td>Augsburg</td>
<td>486</td>
<td>C</td>
<td>P</td>
</tr>
<tr>
<td>Leipzig</td>
<td>284</td>
<td>C</td>
<td>P</td>
<td>Strasbourg</td>
<td>484</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Basel</td>
<td>266</td>
<td>P</td>
<td>P</td>
<td>Basel</td>
<td>325</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Ulm</td>
<td>144</td>
<td>P</td>
<td>P</td>
<td>Ulm</td>
<td>163</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Speyer</td>
<td>126</td>
<td>P</td>
<td>P</td>
<td>Speyer</td>
<td>144</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Lübeck</td>
<td>126</td>
<td>P</td>
<td>P</td>
<td>Mainz</td>
<td>126</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Mainz</td>
<td>121</td>
<td>C</td>
<td>C</td>
<td>Lübeck</td>
<td>110</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

Percent of all German-speaking cities Protestant in 1530, 32.58%, and in 1600, 71.35%. P/C in all tables refers to whether the city was Protestant (P) or Catholic (C) at the date shown (for example, “P/C 1500” refers to “Protestant or Catholic in 1500”).

11 Edwards (1994, p. 1) begins his book on Luther and the printing press by noting that “the Reformation saw the first major, self-conscious attempt to use the recently invented printing press to shape and channel a mass movement.”
role that the new information technology played in spreading Lutheran ideas. The supply-side argument states that the press permitted a less expensive and more rapid transmission of Protestant ideas, primarily through pamphlets. Numerous factors support the supply-side theory. First, papal caricatures and broadsheets disseminated by the reformers played a significant role in their propaganda efforts among the illiterate masses. These broadsheets were easy to understand and designed to catch the attention of readers, often including direct insults to the Church and the papacy. Robinson-Hammerstein (1989, p. 12) describes how the reformers used broadsheets to reach the masses:

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

Second, the press allowed for the spread of pamphlets to literate preachers and other religious-minded individuals who brought the Reformation into cities and villages. Although most people were illiterate in this period, the pamphlets were written in such a manner that they could be read aloud in public meeting places. They were generally around eight pages and provided an inexpensive and concealable means for would-be reformers to spread the ideas promulgated by the lead reformers. High transport costs and lack of copyright in this period meant that printed works were not often shipped from a printing center to other locations; instead, works more frequently spread through reprinting (Edwards, 1994). Hence, those living in cities with presses or close to presses had much greater access to inexpensive printed works.¹²

Table 2 provides some preliminary evidence that pamphlets were important to the initial spread of the Reformation. Among the German-speaking cities, 43% of those that produced a religious pamphlet prior to 1530 converted to Protestantism, while only 30% of those not producing religious pamphlets converted ($p = 0.163$). This effect appears to go away a bit by 1560 and virtually disappears by 1600.

It is also possible that the printing press affected demand for the Reformation. Eisenstein (1979), for example, argues that the print culture transformed cities, in some cases elevating the desires of the bourgeoisie and middle classes to greater social importance. This in turn could have made the rising bourgeoisie had an incentive to undermine the old order dominated by the Church and landed interests. Eisenstein (1979, p. 132) also suggests that the demand for the Reformation could have been enhanced by the press in a more subtle way: “While communal solidarity was diminished, vicarious participation in more distant events was also enhanced. . . . Printed materials encouraged silent adherence to causes whose advocates could not be found in any one parish and who addressed an invisible public from afar.”

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¹² The press also 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 (Fevre & Martin, 1958).
The data that I have collected cannot fully discern between the demand and supply-side hypotheses, although table 2 provides some support for the latter. What the data can do, however, is permit a statistical test of the role that the printing press played in the initial spread of the Reformation. The primary question explored is, “How much more likely was a city to adopt the Reformation if it had at least one printing press by 1500?”

III. Data

A. Printing Press and Protestantism

The primary relationship of concern is the one between the printing press and the spread of Protestantism. I have gathered city-level data as to whether a city was Protestant in 1530, 1560, and 1600; whether a city had a printing press by 1500; and numerous variables that control for the supply of and demand for Protestantism. The universe of observations is all cities known to have population by 1500. This includes all press cities as well as all cities for which Bairoch, Batou, and Chèvre (1988) collected population data in or prior to 1500 (they also collected population data for every European city that reached five thousand inhabitants at some point by 1800). Details of all variables are available in appendix A.

This analysis focuses on the acceptance of Protestantism in central and western Europe. This includes many areas in which there is no variation in religion, such as Spain, Italy, Portugal, England, and Scandinavia. Although a small amount of religious variation existed in France and Scotland, most of the variation comes from the Holy Roman Empire in the 1570s; and northern Italy (for example, the duchies of Savoy and Milan), which was not de facto subject to the emperor. I thank Davide Cantoni for pointing out to me the nuances of the differences between the de facto and de jure Holy Roman Empire. For more, see Cantoni (2013).

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

14 Areas in the de jure (but not de facto) Holy Roman Empire included Switzerland, which de facto broke away from the empire in 1499; the Netherlands, which revolted and broke away from the Holy Roman Empire in the 1570s; and northern Italy (for example, the duchies of Savoy and Milan), which was not de facto subject to the emperor. I thank Davide Cantoni for pointing out to me the nuances of the differences between the de facto and de jure Holy Roman Empire. For more, see Cantoni (2013).

The facts presented in the previous section suggest that a regression analysis that controls for a host of city-specific features may shed significant light on the causal connection between printing and the Reformation. Such an econometric analysis should control for supply and demand features related to the decision of a city to accept Protestantism. I include demand controls indicating whether the city housed a university by 1450, whether the city housed a bishop or archbishop by 1517 (proxying for depth of Church influence), whether the city was a member of the Hanseatic League (and thus had better access to information flows and greater wealth, affecting both supply and demand), whether the city was an independent Free Imperial City in 1517 (indicating that it was large and economically important; independence from princely rule also affects supply, as ideas often flowed more freely in such cities), and whether a city belonged to a lay magnate (it was neither free nor subject to an ecclesiastical lord). Supply controls include a dummy for the presence of printing, whether the city was on water (ocean, sea, large lake, or river connected to another city; this controls for information flows), and its market potential (the sum of other city’s population divided by their distance to the city in question).15 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 Ninety-Five 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.16

Two final supply-side controls included in the analysis are the city’s distance to Wittenberg and Zürich.17 The market potential variable could also be construed as a demand variable, since proximity to large cities that either converted to Protestantism or remained Catholic may have affected the demand for the Reformation of those in the city in question. It is included as a supply control because proximity to large cities likely had a more important effect on the flow of Protestant ideas.

15 The market potential variable could also be construed as a demand variable, since proximity to large cities that either converted to Protestantism or remained Catholic may have affected the demand for the Reformation of those in the city in question. It is included as a supply control because proximity to large cities likely had a more important effect on the flow of Protestant ideas.

16 Dittmar (2011) suggests that cities that adopted printing early grew faster in subsequent centuries, and Becker and Wossmann (2008, 2009, 2010) suggest that cities and counties that adopted Protestantism had better subsequent economic outcomes due to greater levels of human capital.

17 All of the “distance to” variables are calculated as the crow flies. It would be ideal to use the historical route traveled between cities—a measure would incorporate the ruggedness of the terrain, travel costs, and trade flows—but these data are not available for most of the smaller cities in the sample. Controlling for access to water helps alleviate some of this concern, since most savings in travel time in this period came through access to waterways.
Wittenberg variable is shown by Becker and Wössmann (2008, 2009, 2010) to be correlated with the spread of Protestantism in Prussia, while Zwingli’s brand of Protestantism spread from Zürich to the Swiss cantons and southern Germany. It can clearly be seen in figure 1 that there is a strong geographical component to the spread of the Reformation around Wittenberg and, to a lesser extent, Zürich. Moreover, Dittmar (2011) shows that the spread of printing is related to distance from Mainz; hence not controlling for distance to Wittenberg may falsely indicate that printing (and not proximity to Wittenberg) had an effect on acceptance of Protestantism. A city’s distance to Wittenberg, in combination with nation (as of 1500) and Imperial Circle (in the Holy Roman Empire) fixed effects, serves to control for the spatial component of the Reformation. Summary statistics of all variables for all European cities in the sample are listed in table 3.

C. Distance to Mainz as an Instrument

The printing press was not randomly assigned to cities. Even with the inclusion of the control variables listed in the previous section, omitted variable bias may exist. One such unobserved factor, pre-printing press literacy, is related to the adoption of printing and possibly related to the acceptance of the Reformation. Cities that were more literate prior to the advent of printing were almost certainly more likely to adopt printing, and it is possible that such cities were less (or more) likely to adopt the Reformation. Since the presence of a printing press may be correlated with omitted variables that are themselves correlated with conversion to Protestantism, some source of exogenous variation in printing is needed to obtain unbiased results. I address this problem by employing the city’s distance to Mainz (the birthplace of printing) as an instrument for the adoption of the printing press.

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

All else being equal, cities that were closer to Mainz were more likely to adopt printing, though the same can also be said for larger cities, university cities, and bishoprics, where demand was greater (though the last three would not qualify as instruments, as they were independently related to the acceptance of Protestantism). This is suggested by figure 2, which shows the share of cities that adopted printing, broken down by distance from Mainz. There is a clear trend that cities closer to Mainz were more likely to adopt printing. This is also suggested by table 4, which lists the top German-speaking cities by book production in each decade, along with their distance to Mainz. As printing spread in the fifteenth century, it appears that the center of the printing universe moved farther and farther.
away from Mainz (as noted by the weighted distance to Mainz).

After controlling for a host city characteristics, there are still unobserved variables, such as pre-press literacy, idiosyncrasies among powerful printers, and printer networks, that affected where printing spread. While these characteristics provide some of the variation needed to obtain causal results (to the extent that the variation is random), there is concern that the variation is not truly exogenous. In order for distance to Mainz to provide a source of exogenous variation, it must be correlated with the Protestant variables only through its correlation with the press. In other words, distance to Mainz works as an instrument only if it is unrelated to the determinants of whether a city adopted the Reformation. Although Mainz was not an unimportant town (it housed an archbishop who was an elector on the Reichstag), the results reported in table 5 suggest that distance to Mainz was not an economic or religious center prior to the invention of the press.20 These estimations, which control for all covariates listed in the previous section,21 show that distance to Mainz does not predict preprinting economic status (measured by the Free Imperial City dummy), religious status (measured by the Bishop dummy), or other supply-side determinants of Reformation adoption (water, Hanseatic, and distance to Wittenberg).

It is also possible that cities that were growing in the fifteenth and sixteenth centuries had atmospheres more

<p>| TABLE 4.—DISTANCE FROM MAINZ OF TOP TEN CITIES BY BOOK PRODUCTION (GERMAN SPEAKING) |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th>City</th>
<th>Books</th>
<th>Distance (miles)</th>
<th>City</th>
<th>Books</th>
<th>Distance (miles)</th>
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<tbody>
<tr>
<td>Mainz</td>
<td>95</td>
<td>0</td>
<td>Cologne</td>
<td>44</td>
<td>90</td>
</tr>
<tr>
<td>Cologne</td>
<td>44</td>
<td>90</td>
<td>Strasbourg</td>
<td>17</td>
<td>102</td>
</tr>
<tr>
<td>Strasbourg</td>
<td>17</td>
<td>102</td>
<td>Bamberg</td>
<td>9</td>
<td>129</td>
</tr>
<tr>
<td>Bamberg</td>
<td>9</td>
<td>129</td>
<td>Augsburg</td>
<td>6</td>
<td>172</td>
</tr>
<tr>
<td>Augsburg</td>
<td>6</td>
<td>172</td>
<td>Eltville</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Eltville</td>
<td>3</td>
<td>7</td>
<td>Basel</td>
<td>1</td>
<td>173</td>
</tr>
<tr>
<td>Basel</td>
<td>1</td>
<td>173</td>
<td>Nuremberg</td>
<td>1</td>
<td>143</td>
</tr>
<tr>
<td>Nuremberg</td>
<td>1</td>
<td>143</td>
<td>Average</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Weighted average (by books)</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1450–1469</td>
<td></td>
<td></td>
<td>1480–1489</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cologne</td>
<td>441</td>
<td>90</td>
<td>Leipzig</td>
<td>1,040</td>
<td>219</td>
</tr>
<tr>
<td>Augsburg</td>
<td>405</td>
<td>172</td>
<td>Cologne</td>
<td>591</td>
<td>90</td>
</tr>
<tr>
<td>Strasbourg</td>
<td>364</td>
<td>102</td>
<td>Nuremberg</td>
<td>492</td>
<td>143</td>
</tr>
<tr>
<td>Nuremberg</td>
<td>359</td>
<td>143</td>
<td>Augsburg</td>
<td>486</td>
<td>172</td>
</tr>
<tr>
<td>Leipzig</td>
<td>284</td>
<td>219</td>
<td>Strasbourg</td>
<td>484</td>
<td>102</td>
</tr>
<tr>
<td>Basel</td>
<td>266</td>
<td>173</td>
<td>Ulm</td>
<td>163</td>
<td>140</td>
</tr>
<tr>
<td>Ulm</td>
<td>144</td>
<td>140</td>
<td>Speyer</td>
<td>144</td>
<td>49</td>
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<tr>
<td>Speyer</td>
<td>126</td>
<td>49</td>
<td>Mainz</td>
<td>126</td>
<td>0</td>
</tr>
<tr>
<td>Mainz</td>
<td>121</td>
<td>0</td>
<td>Lübeck</td>
<td>110</td>
<td>291</td>
</tr>
<tr>
<td>Average</td>
<td>138</td>
<td></td>
<td></td>
<td>138</td>
<td></td>
</tr>
<tr>
<td>Weighted average (by books)</td>
<td>140</td>
<td></td>
<td></td>
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</tbody>
</table>

| TABLE 5.—E XOGENEITY OF DISTANCE-TO-MAINZ INSTRUMENT |
|---------------------------------|---------------------------------|---------------------------------|
| Printing Press | Free Imperial City | Bishop | Water | Hanseatic | Log Distance to Wittenberge | Log Sixteenth-Century Growth | Log Fifteenth-Century Growth |
| (1)            | (2)                  | (3)    | (4)   | (5)       | (6)                        | (7)                          | (8)                          |
| Log            | –0.184***            | –0.048 | 0.062 | –0.025    | –0.017                     | 0.086                        | 0.063                        | 0.098                        |
| Distance to Mainz | (0.050)               | (0.043) | (0.046) | (0.050)   | (0.034)                    | (0.122)                      | (0.106)                      | (0.121)                      |
| Observations   | 352                  | 352    | 352   | 352       | 352                        | 352                         | 189                         | 134                          |
| Number of clusters | 157                  | 157    | 157   | 157       | 157                        | 157                         | 105                         | 89                           |
| R²             | 0.37                 | 0.66   | 0.34  | 0.14      | 0.46                       | 0.81                        | 0.14                        | 0.15                         |

OLS regression; robust standard errors clustered by territory in parentheses—city-specific, geographic control variables, and constant included as in previous regression. Cities included if they are included in any of the final three specifications of table 6. All controls are employed in each regression except for the dependent variable in question except for the bishop regression, which does not include lay magnate and the fifteenth-century growth regression, which does not include market potential. Cities included in regressions reported in column 7 only if population data are available for 1500 and 1600. Cities included in regressions reported in column 8 only if population data are available for 1400 and 1500. *p < 0.10, **p < 0.05, ***p < 0.01.

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

The bishop regression does not control for the lay magnate dummy because many bishoprics were by definition located in a religious territory. The fifteenth-century city growth regression does not control for market potential, since the latter was in part the result of the former. Columns 7 and 8 use data only from cities in which population figures are available for years at both of the end points of the century in question.

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

21 The bishop regression does not control for the lay magnate dummy because many bishoprics were by definition located in a religious territory. The fifteenth-century city growth regression does not control for market potential, since the latter was in part the result of the former. Columns 7 and 8 use data only from cities in which population figures are available for years at both of the end points of the century in question.
The discussion in the previous section suggests that city-specific characteristics must be controlled for in order to understand the relationship between the spread of printing and the spread of the Reformation. To this end, I begin by estimating the following reduced-form model, for the moment ignoring the potential endogeneity of the spread of printing:

\[
Pr(\text{city } i \text{ Protestant in Year } t = 1 | X_i, \text{Press}_i) = \Phi(\alpha_1 + \beta_1 \text{Press}_i + \gamma_1 X_i + \delta_t + \varepsilon_i),
\]

where \( t = \{1530, 1560, 1600\} \), \( \text{Press}_i \) is a dummy indicating whether city \( i \) had a printing press by 1500, \( \Phi \) is the normal cdf, \( \delta_t \) is a vector of nation and Imperial Circle fixed effects (the latter being employed for cities in the Holy Roman Empire), and \( X_i \) is a vector of supply-and-demand control variables listed in the previous section.22 In all regressions, standard errors are clustered by the city’s territory at the beginning of the Reformation.

I estimate equation (1) using a probit regression for each year for which I have data: 1530, 1560, and 1600. The average marginal effects of all major variables are reported in table 6. When all demand and supply controls are included (columns 10–12), the press coefficient is positive and highly significant in the 1560 and 1600 specifications. Cities with presses by 1500 were on average 9.9 percentage points more likely to adopt the Reformation by 1560 and 12.6 percentage points more likely to adopt the Reformation by 1600.23

I now turn to the problem of omitted variable bias. The fact that the coefficient on the Bishop dummy enters negatively and often significantly in table 6 suggests that the printing press coefficient may be negatively biased. If towns with higher exogenous (pre-press) literacy were more likely to attract presses but less likely to convert to Protestantism (a possibility indicated by the negative coefficient on the Bishop dummy), then the coefficient on the press dummy is biased downward, and the effect of the press on the Reformation is greater than indicated by this regression. This is especially true of the 1530 specification, as Church influence was likely more pertinent in slowing the spread of the Reformation in the short run though eventually failing in some areas in the long run. Indeed, this is one of the most puzzling observations of the results reported in table 6: if the press had an effect on the spread of the Reformation, we would expect the strongest effect to occur early in the Reformation, by 1530, before political pressures became a more salient feature of Reformation adoption.

To address these concerns, I analyze the following system of equations, where \( X_i \) includes all of the independent variables included in the regressions in equation (1):

\[
\begin{align*}
\text{Press}_i = \alpha_2 + \beta_2 \text{Distance to Mainz}_i + \gamma_2 X_i + \delta_t + \varepsilon_i, \\
Pr(\text{city } i \text{ Protestant in Year } t = 1 | X_i, \text{Press}_i) = \Phi(\alpha_3 + \beta_3 \text{Press}_i + \gamma_3 X_i + \delta_t + \varepsilon_i)
\end{align*}
\]

I estimate equation (2) using an OLS estimation and equation (3) using a probit estimation.24 The OLS results of the first stage and the average marginal effects of the second stage are reported in table 7. The F-statistic on the instrument is above the Stock and Yogo (2002) strong instrument threshold in all specifications,25 suggesting that distance to Mainz is strongly correlated with the probability that a city had a printing press; a 10% increase in a city’s distance to Mainz decreases the probability that a city had a press by 1.80 to 1.92 percentage points.

The instrumental variable results indicate that the average marginal effect of the printing dummy is economically and statistically significant in all specifications. More important, the magnitude of these results is enormous: the mere presence of a printing press prior to 1500 increased the probability that a city would become Protestant in 1530

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

23 The number of observations in the final three columns drops substantially compared to the other columns. This is because the probit specification omits observations where one of the independent variables predicts success or failure perfectly. Since there is no variation in religious choice in Italy, England, Ireland, Spain, Portugal, Scandinavia, the Netherlands, or (non-Holy Roman Empire) Poland, these observations are dropped in these three specifications. Identification is thus based on observations from the de facto Holy Roman Empire, France, Scotland, Belgium, and Switzerland.

24 The estimation method that I employ has the major benefit of being straightforward and transparent, as it can be completed by using Stata’s ivprobit command. It has the additional benefit of confining predicted values to the 0–1 range, but this comes with the cost of dropping observations in regions where there is no variation in religious choice. Moreover, the ivprobit command is not ideal for handling dummy endogenous regressors. As a robustness check, I estimate the system of equations using recursive bivariate probit (as in Greene, 2003). These results, available in table A3, are broadly similar to those reported in table 7. This functional form does not drop any observations, and it is designed to handle dichotomous endogenous regressors as long as it is assumed that the errors in the two equations are distributed jointly normal. In results that are available on request, I show that identification indeed comes from the exclusion restriction and not the bivariate probit functional form (using a strategy in Altonji, Elder, & Taber, 2005). Table A2 reports the estimation of a 2SLS linear probability model. The 1530 result on the printing press drops in magnitude and significance, but these LPM results suffer from the classic problem of interpretability: in all three specifications, over 43% of predicted values fall outside of the 0–1 range.

25 The F-statistic is derived from the first stage of a 2SLS regression, which has the same first stage as an ivprobit regression. All other test statistics are available on request.
<table>
<thead>
<tr>
<th></th>
<th>Protestant in 1530</th>
<th>Protestant in 1560</th>
<th>Protestant in 1600</th>
<th>Protestant in 1530</th>
<th>Protestant in 1560</th>
<th>Protestant in 1600</th>
<th>Protestant in 1530</th>
<th>Protestant in 1560</th>
<th>Protestant in 1600</th>
<th>Protestant in 1530</th>
<th>Protestant in 1560</th>
<th>Protestant in 1600</th>
<th>Protestant in 1530</th>
<th>Protestant in 1560</th>
<th>Protestant in 1600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing press by 1500</td>
<td>0.097*** (0.026)</td>
<td>0.233*** (0.045)</td>
<td>0.295*** (0.054)</td>
<td>0.042</td>
<td>0.087</td>
<td>0.152** (0.061)</td>
<td>0.018</td>
<td>0.013</td>
<td>0.050</td>
<td>0.001</td>
<td>0.099*** (0.045)</td>
<td>0.126*** (0.030)</td>
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<tr>
<td>Log population in 1500</td>
<td>-0.069*** (0.030)</td>
<td>-0.151*** (0.031)</td>
<td>-0.130*** (0.031)</td>
<td>-0.042*** (0.028)</td>
<td>-0.086*** (0.027)</td>
<td>-0.090*** (0.038)</td>
<td>-0.004</td>
<td>-0.001</td>
<td>-0.027</td>
<td>-0.004</td>
<td>-0.001</td>
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<td></td>
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<tr>
<td>Free Imperial City</td>
<td>0.185* (0.111)</td>
<td>0.465*** (0.099)</td>
<td>0.509*** (0.084)</td>
<td>0.053</td>
<td>0.372*** (0.096)</td>
<td>0.485*** (0.072)</td>
<td>0.026</td>
<td>0.242*** (0.081)</td>
<td>0.322*** (0.088)</td>
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<tr>
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<td>-0.010 (0.056)</td>
<td>0.087</td>
<td>-0.028</td>
<td>-0.027</td>
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<td>-0.017</td>
<td>-0.080</td>
<td>-0.017</td>
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<tr>
<td>Bishop</td>
<td>-0.082*** (0.028)</td>
<td>-0.207*** (0.047)</td>
<td>-0.299*** (0.055)</td>
<td>-0.047*** (0.035)</td>
<td>-0.121*** (0.034)</td>
<td>-0.173*** (0.056)</td>
<td>-0.053</td>
<td>-0.135* (0.069)</td>
<td>-0.091* (0.046)</td>
<td></td>
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<tr>
<td>Lay magnate</td>
<td>-0.131* (0.076)</td>
<td>0.019</td>
<td>0.054</td>
<td>-0.115*** (0.066)</td>
<td>0.091* (0.055)</td>
<td>0.159*** (0.055)</td>
<td>-0.193* (0.083)</td>
<td>0.315*** (0.049)</td>
<td>0.171*** (0.049)</td>
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<td></td>
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<tr>
<td>Market potential</td>
<td>-0.026*** (0.066)</td>
<td>-0.021*** (0.004)</td>
<td>-0.005</td>
<td>-0.058*** (0.004)</td>
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<td>Hanseatic</td>
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<td>Log distance to Wittenberg</td>
<td>-0.103*** (0.021)</td>
<td>-0.197*** (0.024)</td>
<td>-0.237*** (0.035)</td>
<td>-0.131** (0.036)</td>
<td>-0.306*** (0.041)</td>
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<td>Log distance to Zürich</td>
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<td>-0.042</td>
<td>0.049</td>
<td>-0.224</td>
<td>-0.002</td>
<td>-0.051</td>
<td>0.156</td>
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<td>N</td>
<td>N</td>
<td>N</td>
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<td>Y</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>753</td>
<td>753</td>
<td>753</td>
<td>753</td>
<td>753</td>
<td>753</td>
<td>200</td>
<td>157</td>
<td>147</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of clusters</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>102</td>
<td>157</td>
<td>147</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pseudo) $R^2$</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.14</td>
<td>0.16</td>
<td>0.18</td>
<td>0.44</td>
<td>0.46</td>
<td>0.46</td>
<td>0.21</td>
<td>0.61</td>
<td>0.67</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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

TABLE 6.—AVERAGE MARGINAL EFFECTS, PROTESTANTISM IN EUROPE
by 52.1 percentage points, Protestant in 1560 by 41.9 percentage points, and Protestant in 1600 by 29.0 percentage points, ceteris paribus. These results differ substantially from the non-IV results reported in table 6. The most interesting difference is that the effect of the press was practically 0 in the 1530 specification using probit, but press cities were 52.1 percentage points more likely to adopt printing in the 1530 specification in which IV is used. This suggests that the negative bias on the printing coefficient was strongest early in the Reformation, confirming the previously stated notion that the Church was able to suppress the Reformation in the short run but not the long run in cities where it was the most influential (incidentally, these cities were also early adopters of printing due to the higher demand from literate churchmen).

All of the statistically significant controls except for market potential enter with the expected sign in both stages. Controlling for geography appears to be especially important; one striking result is the large negative coefficient on the distance to Wittenberg in the second-stage regressions, a finding that supports that validity of Becker and Woessmann’s (2008, 2009, 2010) distance-to-Wittenberg instrument.

In sum, these results indicate a massive negative bias in the relationship between the spread of printing and the acceptance of the Reformation if omitted variables (such as pre-press literacy) are unaccounted for. The most obvious explanation for this downward bias is that the Church was one of the largest early users of print media, and areas with extensive Church influence were slower to adopt the Reformation. This explanation is consistent with findings that the downward bias is strongest early in the Reformation and that the Bishop and University coefficients are strongly positive in the first stage (indicating that cities where Church influence was strong were more likely to adopt printing).27

A series of robustness checks confirms the validity of the results. These tests analyze equations (1), (2), and (3) using different data, restricting the universe of observations, testing marginal effects at different points, using different data, and including interactions. In every robustness check, the primary results remain, although the instrument is weaker in a subset of the tests. All of these results are available in an online appendix housed at http://www.jaredcrubin.com/.

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26 It could be the case that cities close to big Catholic cities were less likely to adopt the Reformation, with this effect outweighing the similar positive effect for Protestantism. In fact, if we replace the Market Potential variable with a Protestant Potential variable (equaling the sum of the population of all Protestant cities divided by their distance), this variable enters positively and significantly (in both tables 6 and 7).

27 Table 7.—Average Marginal Effects, Two-Stage Regression with Distance to Mainz Instrument

<table>
<thead>
<tr>
<th></th>
<th>First Stage</th>
<th>Second Stage</th>
<th>First Stage</th>
<th>Second Stage</th>
<th>First Stage</th>
<th>Second Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Press by 1500</td>
<td>Protestant in 1530</td>
<td>Press by 1500</td>
<td>Protestant in 1560</td>
<td>Press by 1500</td>
<td>Protestant in 1600</td>
</tr>
<tr>
<td>Press by 1500</td>
<td>−0.180***</td>
<td>0.521***</td>
<td>−0.184***</td>
<td>0.419***</td>
<td>−0.192**</td>
<td>0.290***</td>
</tr>
<tr>
<td>(0.054)</td>
<td>(0.096)</td>
<td>(0.050)</td>
<td>(0.124)</td>
<td>(0.032)</td>
<td>(0.050)</td>
<td>(0.136)</td>
</tr>
<tr>
<td>Log population in 1500</td>
<td>0.128***</td>
<td>−0.059*</td>
<td>0.132***</td>
<td>−0.040*</td>
<td>0.127***</td>
<td>−0.043**</td>
</tr>
<tr>
<td>(0.043)</td>
<td>(0.032)</td>
<td>(0.027)</td>
<td>(0.021)</td>
<td>(0.032)</td>
<td>(0.021)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>Free Imperial</td>
<td>−0.174</td>
<td>0.107</td>
<td>−0.173*</td>
<td>0.213***</td>
<td>−0.183*</td>
<td>0.308***</td>
</tr>
<tr>
<td>(0.113)</td>
<td>(0.090)</td>
<td>(0.101)</td>
<td>(0.057)</td>
<td>(0.105)</td>
<td>(0.067)</td>
<td>(0.067)</td>
</tr>
<tr>
<td>City</td>
<td>0.433***</td>
<td>−0.218***</td>
<td>0.383***</td>
<td>−0.145*</td>
<td>0.365***</td>
<td>−0.091</td>
</tr>
<tr>
<td>(0.129)</td>
<td>(0.084)</td>
<td>(0.074)</td>
<td>(0.084)</td>
<td>(0.082)</td>
<td>(0.092)</td>
<td>(0.092)</td>
</tr>
<tr>
<td>University</td>
<td>0.276***</td>
<td>−0.141***</td>
<td>0.193***</td>
<td>−0.155***</td>
<td>0.214***</td>
<td>−0.119***</td>
</tr>
<tr>
<td>(0.105)</td>
<td>(0.057)</td>
<td>(0.067)</td>
<td>(0.049)</td>
<td>(0.071)</td>
<td>(0.045)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Lay magnate</td>
<td>−0.023</td>
<td>−0.060</td>
<td>−0.029</td>
<td>0.126***</td>
<td>−0.020</td>
<td>0.169***</td>
</tr>
<tr>
<td>(0.107)</td>
<td>(0.087)</td>
<td>(0.085)</td>
<td>(0.047)</td>
<td>(0.085)</td>
<td>(0.046)</td>
<td>(0.046)</td>
</tr>
<tr>
<td>Market</td>
<td>0.008</td>
<td>−0.048***</td>
<td>0.000</td>
<td>−0.028***</td>
<td>−0.000</td>
<td>−0.025***</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.007)</td>
<td>(0.009)</td>
<td>(0.007)</td>
<td>(0.010)</td>
<td>(0.008)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Potential</td>
<td>−0.024</td>
<td>−0.012</td>
<td>0.025</td>
<td>−0.008</td>
<td>0.021</td>
<td>−0.002</td>
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<tr>
<td>(0.056)</td>
<td>(0.046)</td>
<td>(0.042)</td>
<td>(0.029)</td>
<td>(0.048)</td>
<td>(0.026)</td>
<td>(0.026)</td>
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<tr>
<td>Hanseatic</td>
<td>−0.023</td>
<td>−0.067</td>
<td>0.082</td>
<td>−0.057</td>
<td>0.033</td>
<td>−0.045</td>
</tr>
<tr>
<td>(0.076)</td>
<td>(0.073)</td>
<td>(0.073)</td>
<td>(0.050)</td>
<td>(0.073)</td>
<td>(0.055)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>Log distance to Wittenberg</td>
<td>0.096*</td>
<td>−0.137***</td>
<td>0.078*</td>
<td>−0.234***</td>
<td>0.088**</td>
<td>−0.343***</td>
</tr>
<tr>
<td>(0.050)</td>
<td>(0.051)</td>
<td>(0.044)</td>
<td>(0.049)</td>
<td>(0.043)</td>
<td>(0.047)</td>
<td>(0.047)</td>
</tr>
<tr>
<td>Log distance to Zürich</td>
<td>0.080</td>
<td>−0.161</td>
<td>−0.096</td>
<td>0.039</td>
<td>−0.065</td>
<td>−0.033</td>
</tr>
<tr>
<td>(0.094)</td>
<td>(0.100)</td>
<td>(0.081)</td>
<td>(0.059)</td>
<td>(0.084)</td>
<td>(0.052)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>Imperial Circle Dummies</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Dummy observations</td>
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<td>200</td>
<td>352</td>
<td>352</td>
<td>307</td>
<td>307</td>
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<tr>
<td>Number of clusters</td>
<td>102</td>
<td>102</td>
<td>157</td>
<td>157</td>
<td>147</td>
<td>147</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>−70.07</td>
<td>−162.54</td>
<td>−133.78</td>
<td>−222.91</td>
<td>−118.27</td>
<td>−186.73</td>
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<tr>
<td>p-value, Wald exogenous test</td>
<td>0.008</td>
<td>0.025</td>
<td>0.091</td>
<td>0.229</td>
<td></td>
<td></td>
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<tr>
<td>F-statistic on instrument</td>
<td>10.97</td>
<td>13.88</td>
<td>14.85</td>
<td>20.06</td>
<td></td>
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</tr>
</tbody>
</table>
V. 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 antipapal propaganda, there is no counterfactual history to determine whether the Reformation would have been a success in the absence of the press. The biggest difficulty that previous studies faced is one of spurious correlation: it is quite possible that the city-level characteristics that encouraged adoption of the printing press also encouraged or discouraged acceptance of the Reformation.

In this paper, I address this issue through an econometric analysis. Probit and instrumental variable regressions suggest that cities that adopted printing early were much more likely to accept the Reformation. I find that within the European nations where some variation in religious choice existed, cities that were early print adopters were 52.1 percentage points more likely to adopt Protestantism by 1530, 41.9 percentage points more likely to adopt Protestantism by 1560, and 29.0 percentage points more likely to adopt Protestantism by 1600.

These results have broader implications for economic history. A number of recent studies have suggested that the printing press (Baten & van Zanden, 2008; Buringh & Van Zanden, 2009; Chilosi & Volckart, 2010; Dittmar, 2011) or the Reformation (Becker & Wössmann 2008, 2009, 2010; Boppart et al., 2010) played a significant role in the subsequent economic development of Europe and “the West.”

This 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 thier earlier adoption of the press. Conversely, it is possible that cities that were early adopters of the printing press were successful in subsequent centuries because they were more likely to become Protestant and thus had some unique “work ethic” or incentive to acquire human capital. Though it is not the point of this 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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APPENDIX A

Data Sources

Dependent Variable: Protestant Dummies

The dependent variable is a dummy equaling 1 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 cities 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 (although some Austrian cities briefly converted and are counted as Protestant in 1560). The cities with the most difficult religions to determine were located in northern and eastern France, western Poland, northern Germany, and Switzerland. Most of France and Poland remained Catholic, but parts of each country (under current boundaries) were part of the Holy Roman Empire (HRE) at the beginning of the sixteenth century. Examples in France include Haguenau, Strasbourg, Metz, and Douai, while examples in Poland include Breslaw (Wrocław) and Sztettin (Szczecin). The delineation 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 HRE is explained 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 that marked the spread of Protestantism prior to the Thirty Years War (Ward, Prothero, & Leathes, 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 (for example, Zürich, St. Gallen, and eventually Geneva) or rejected (for example, 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, I consulted the Catholic Encyclopedia (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. 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 (Febvre and Martin list fifteen press cities not included in Clair, and Clair lists twelve 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) do not exist for a number of the cities with presses, as some of the presses arose near monasteries (such as Cluny). These presses are omitted from the analysis.

For book data at the city level, all data were found at the website for the Incunabula Short Title Catalogue (British Library, 2008). This catalog has been pieced together over the past century by the British Library and
records nearly every item printed from movable type before 1501, but
not material printed entirely from woodblocks or engraved plates. 29,777
editions are listed as at January 8th 2008.' ' These records include year
and place of publication, both of which were recorded in the data. The
search engine on the website has some bugs, so each record was double-
checked to ensure that the count of books published in each city was cor-
rect. These data include the number of editions, not the number of books,
printed by each publisher. It should be noted that major selection issues
may exist with these data, which is a primary reason I do not employ them
in the analysis. It is possible that there were different survival rates of
books published in different cities. The most likely cause of bias is that
some cities faced greater destruction during the Thirty Years War and
thus manuscripts were less likely to have survived from these areas. (I
thank Jeremiah Dittmar for this insight.) The greatest destruction in
terms of casualties occurred in southwest and northeast Germany, both of
which were predominantly Protestant. This means that any bias would likely be
against finding more books in Protestant areas, meaning that the effect
of the press may be understated. Data on books in German which were col-
lected as part of the Incunabula Short Title Catalogue project as of 1962
is also available (British Library, 1962).
Pamphlets. The Munich Digitization Center at the Bavarian State
Library (Bayerische Staatsbibliothek, http://www.digital-collections.de/) has
digitized its collection of fifteenth- and sixteenth-century manuscripts
and incunabula. The library claims to have the largest collection of writ-
ten works in German from this period. It has documented all works by
type (manuscript, pamphlet, and so on), subject (for example, theology,
philosophy), publication date, and city of publication. I collected data on
place and decade of publication for all theological pamphlets published in
the HRE to 1600. As of September 20, 2011, the library offered 525,111
titles online. Much like the book edition data from Incunabula Short Title
Catalogue, there are possible selection and survival biases associated with
these data. Yet if Bavarian records are over sampled, this works against
the hypothesis proposed in this paper, as Bavaria remained Catholic to a
much greater extent than most of the rest of the Holy Roman Empire.

Population. Population data are from Bairoch et al. (1988), who col-
lected population data on every European city that reached five thousand
inhabitants at some point by 1800. As De Long and Shleifer (1993) noted,
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 the former Soviet republics), Greece, Albania, and the former
Yugoslavian republics are not included. I also collected data for any city
with population data prior to 1500. I linearly interpolated the population
with a later population date to estimate the 1500 population. Finally, I
collected population data on all cities with a printing press but no
population data prior to 1500. I linearly interpolated backward the popula-
tion values of 1,000 in 1500 did not exist, and these universities are excluded from the data.

Independent city and Hanseatic League. Jacob (2010) provides begin-
ning and end dates for the independence of cities in the HRE. The Inde-
pendent City dummy variable takes a value of 1 if the city was indepen-
dent in 1517. Jacob (2010) also provides data on whether cities in the
HRE were part of the Hanseatic League. Various Internet searches (by
city) confirmed whether cities in present day Poland were members of the
Hanseatic League: Polish Hanseatic members are Kolberg (Kolobrzeg),
Opole, Slupsk, and Stettin (Szczecin).

Water. A city is considered to be on water if it borders a sea, ocean,
large lake, or a river that flows to another city. These metrics were chosen
because the important aspect of being near water relative to the question
posed in this paper was the access to information it provided. All data
points were collected by searching Google Maps and determining each
city’s access to water. Cities that border the Atlantic, a sea, a large lake,
or a major river were easy to determine, as were those far from any water.
The only ambiguity arose for cities with access to minor rivers or far-off
tributaries of major rivers. The metric employed in this data set is that
any city with a river running through it that also connected to another city
was counted as having access to water.

Territory and imperial circle. The territory encompassing each city is
used to cluster standard errors. Independent cities are considered to be in
their own territory. All other territories in the HRE are from Andre (1886),
whose map 38/39 gives a detailed account of Germany at the time of the
Reformation. Most cities in the data set are included in the map. For cities
that were not on the map, a Google Map search was used to pinpoint its loca-
tion, and the corresponding territory in Andre was documented. The
Imperial Circles are composed of multiple territories, so knowing which ter-
ritory a city is in allows for calculation of the Imperial Circle as well.

APPENDIX B
Additional Tables and Robustness Checks

### Table A1.—Correlation Matrix, All Variables

<table>
<thead>
<tr>
<th></th>
<th>Protestant in 1550</th>
<th>Protestant in 1600</th>
<th>Protestant in 1550</th>
<th>Protestant in 1600</th>
<th>Press in 1500</th>
<th>Population</th>
<th>Free Imperial</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protestant in 1550</td>
<td>0.539</td>
<td>-0.024</td>
<td>0.857</td>
<td>-0.049</td>
<td>0.440</td>
<td>0.121</td>
<td>0.128</td>
<td></td>
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<tr>
<td>Protestant in 1600</td>
<td>0.475</td>
<td>-0.072</td>
<td>-0.260</td>
<td>0.015</td>
<td>0.660</td>
<td>0.326</td>
<td>0.393</td>
<td>0.033</td>
</tr>
<tr>
<td>Press in 1500</td>
<td>-0.024</td>
<td>-0.285</td>
<td>0.212</td>
<td>0.033</td>
<td>0.123</td>
<td>0.168</td>
<td>0.123</td>
<td>0.072</td>
</tr>
<tr>
<td>Population</td>
<td>-0.167</td>
<td>0.194</td>
<td>0.212</td>
<td>0.121</td>
<td>0.369</td>
<td>0.339</td>
<td>0.339</td>
<td>-0.020</td>
</tr>
<tr>
<td>Free Imperial City</td>
<td>0.224</td>
<td>0.121</td>
<td>0.128</td>
<td>0.100</td>
<td>0.369</td>
<td>0.339</td>
<td>0.339</td>
<td>-0.020</td>
</tr>
<tr>
<td>University</td>
<td>0.060</td>
<td>0.369</td>
<td>0.123</td>
<td>0.168</td>
<td>0.077</td>
<td>0.163</td>
<td>0.169</td>
<td>0.096</td>
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<td>Bishop</td>
<td>-0.135</td>
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<td>0.123</td>
<td>0.077</td>
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<td>-0.799</td>
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</tr>
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<td>Market potential</td>
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</table>
TABLE A2.—Two-Stage Linear Probability Model, Distance to Mainz as Instrument

<table>
<thead>
<tr>
<th>Press by 1500</th>
<th>Protestant in 1530</th>
<th>Protestant in 1560</th>
<th>Protestant in 1600</th>
<th>Population</th>
<th>Free Imperial</th>
<th>University</th>
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</thead>
<tbody>
<tr>
<td>Log distance to Mainz</td>
<td>0.133</td>
<td>0.397</td>
<td>−0.521</td>
<td>−0.171</td>
<td>−0.146</td>
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<td>−0.235</td>
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<td>0.230***</td>
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<td>0.018</td>
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<tr>
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<td>0.157***</td>
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<tr>
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<td>0.332***</td>
<td>0.423***</td>
<td>0.230***</td>
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<tr>
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Robust standard errors clustered by territory in parentheses. Linear probability model estimation. Constant included. **p < 0.01, *p < 0.05, p < 0.1.
### Table A3.—Average Marginal Effects, Recursive Bivariate Probit with Distance to Mainz as Excluded Variable

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<tr>
<th></th>
<th>Press by 1500</th>
<th>Protestant in 1530</th>
<th>Press by 1500</th>
<th>Protestant in 1560</th>
<th>Press by 1500</th>
<th>Protestant in 1600</th>
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<tr>
<td>Log distance to Mainz</td>
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<td>−0.184***</td>
<td>−0.181***</td>
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<td></td>
<td>(0.045)</td>
<td>(0.080)</td>
<td>(0.050)</td>
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<tr>
<td>Printing press by 1500</td>
<td>0.305***</td>
<td>0.204</td>
<td>0.204</td>
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<td>(0.100)</td>
<td>(0.214)</td>
<td>(0.214)</td>
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<tr>
<td>Log population in 1500</td>
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<td>−0.037</td>
<td>0.145***</td>
<td>−0.011</td>
<td>0.145***</td>
<td>−0.033***</td>
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<td></td>
<td>(0.029)</td>
<td>(0.032)</td>
<td>(0.024)</td>
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<td>(0.031)</td>
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<tr>
<td>Free Imperial City</td>
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<td>0.058</td>
<td>−0.168***</td>
<td>0.257***</td>
<td>−0.158***</td>
<td>0.343***</td>
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<td></td>
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<td>(0.060)</td>
<td>(0.102)</td>
<td></td>
<td>(0.062)</td>
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<td>0.325***</td>
<td>−0.124</td>
<td>0.323***</td>
<td>−0.036</td>
<td>0.322***</td>
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<td></td>
<td>(0.068)</td>
<td>(0.067)</td>
<td>(0.075)</td>
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<tr>
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<td>0.172***</td>
<td>−0.076</td>
<td>0.177***</td>
<td>−0.132</td>
<td>0.182***</td>
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<td>(0.050)</td>
<td>(0.086)</td>
<td></td>
<td>(0.053)</td>
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<td>−0.074</td>
<td>−0.090</td>
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<td>(0.054)</td>
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<tr>
<td>Market</td>
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<td>−0.038**</td>
<td>−0.003</td>
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<td>−0.002</td>
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<td>(0.003)</td>
<td>(0.012)</td>
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<td>(0.004)</td>
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<td>0.073**</td>
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<td>0.003</td>
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<tr>
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<td>−0.160***</td>
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<td>−0.120**</td>
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</table>

Robust standard errors clustered by territory in parentheses. Bivariate probit estimation. Average marginal effects reported at the Electorate Imperial Circle equaling 1 and all other dummies equaling 0. Constant included. In the 1600 specification, the Bohemian and Austrian Imperial Circle dummies were combined in order to achieve convergence. *** p < 0.01, ** p < 0.05, * p < 0.1.