

Media, Markets, and Institutional Change: Evidence from the Protestant Reformation

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Abstract

This research studies the role of competition in the diffusion of radical ideas and institutional change during the Protestant Reformation. We construct a new measure of religious content in the media using data on all known books and pamphlets printed in German-speaking Europe 1454-1600. We find that Protestant content was produced in greater quantity in local media markets with more competing firms when Martin Luther circulated his initial arguments for reform in 1517. We find that competition mattered differentially more for the diffusion of Protestant ideas and for institutional change where city governments had the least legal autonomy from feudal lords. We document the relationship between competition and diffusion directly and using the deaths of printers to isolate plausibly exogenous variation in competition. We show that cities where initial competition was greater, and which were more exposed to Protestant ideas, were more likely to adopt the legal institutions of the Reformation.

Key words: competition, firms, media, technology, institutions, religion, politics, high-dimensional data

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1 Introduction

How do revolutionary innovations in media technology drive social change? Internet-based communications technologies appear integral to the diffusion of social movements such as the so-called Color Revolutions, Arab Spring, and Occupy Wall Street. These movements raise questions around how much the diffusion of radical ideas depends on technology, what role competition in media markets plays, and whether the implications of new technologies and of competition depend on the initial institutional conditions. History provides unparalleled evidence on these questions.

The Protestant Reformation is considered a canonical example of the way innovative media technologies may drive profound social change. The technology at the heart of the Reformation was the printing press. During the Reformation, Martin Luther emerged as the first superstar best-seller. But printers also published thousands of publications by unknown authors that were designed to share and shape opinion. This research assembles microdata on all known books and pamphlets printed 1454-1600 and constructs a new measure of content in the media. We apply the measure to study the role of technology, competition, and institutions in the diffusion of the Reformation in central Europe.

The Reformation was the first mass movement to use the printing press and the first successful challenge to the quasi-monopoly of the Catholic Church in Western Europe (Edwards 1994). The printing press was invented in Mainz, Germany around 1450. Between 1454 and the early 1500s the technology was adopted by firms in cities across Europe (Dittmar 2011). By the early 1500s book prices had declined by over 95%. In 1517, Martin Luther circulated a set of theses criticizing Church corruption and calling for a reform of Church practices. Luther was a professor of theology at the University of Wittenberg, in Germany. Within months, Luther's ideas were reprinted in several cities. Over the subsequent years, Protestant thinkers disseminated their ideas in print across German-speaking cities and popular reform movements emerged. The popular movements were not supported by oligarchic city elites or territorial lords over the crucial first years of the reformation (Ozment 1975; Schilling 1983; Cameron 1991; Hamm 1994). Where reformers won power, city councils created new legal institutions, starting in the 1520s. The new laws reformed church governance, social welfare, and education, and were first developed at the municipal level. The diffusion of Protestantism was arrested by the Schmalkaldic War (1546-7). A new institutional and geographic equilibrium for religion in central Europe was settled in law by the Peace of Augsburg (1555).

A debate exists between scholars who argue printing was of overwhelming importance to the diffusion of the Reformation and those who emphasize other modes of transmission.

Most historians argue that printing was critical ([Ozment 1980](#); [Brady 2009](#); [Chrisman 1982](#)). A body of research suggests it was indispensable – “No printing, no Reformation” in Bernd Moeller’s famous aphorism (see also [Hamm \(1994\)](#)). But the Reformation diffused in a world with relatively low literacy, leading some scholars to emphasize the role of oral and visual communication and to suggest the conventional case for print media should be qualified ([Scribner 1994](#)).¹

The debate over the role of the media in the Reformation poses three challenges that motivate our research. The first challenge is that no existing data or research systematically documents the diffusion of Protestant ideas in the media quantitatively. The reason the diffusion of the Reformation in the media has not been documented quantitatively is that the existing data on print media are large, high-dimensional, and do not categorize books or authors by religion.² The second challenge is that evidence on firms competing in markets is required to study whether and how the economics of media industries explain diffusion. No previous research has constructed systematic evidence on firms or studied the role of competition in the diffusion of content and institutional change.³ The third challenge concerns cause and effect. To study how variations in competition impacted the diffusion of content, and how competition and content contributed to institutional change, we need to isolate sources of plausibly exogenous variation.

This research addresses these challenges with three main contributions. First, we assemble data on every known book and pamphlet printed in German-speaking Europe 1454-1600 and construct a measure of religious content in the media using estimators for high dimensional data. Second, we document how city-level variations in media market competition on the eve of the Reformation predict the diffusion of Protestant ideas and subsequent institutional change. We show that variations in competition mattered differentially more where pre-existing institutions limited the legal autonomy of city governments from feudal lords. Third, we show that the relationship between competition and the diffusion of the Reformation holds when we study plausibly exogenous variation in competition induced by (i) the timing of the deaths of printers and/or (ii) lagged measures of competition less likely to embody recent selective entry.

¹A general consensus among historians holds that print media were important despite the fact that literacy levels were low ([Edwards 1994](#)). Print media were read aloud and the ideas transmitted in print were further circulated in sermons and conversations. See [Brady \(2009\)](#) and [Scribner \(1994\)](#).

²For example, the Universal Short Title Catalogue ([of St. Andrews 2012](#)) which we discuss below simply classifies book subject matter as “religious” or not. The same is true of *Das Verzeichnis der im deutschen Sprachbereich erschienenen Drucke des 16. Jahrhunderts*. The history literature has to date examined small subsets of the data. [Edwards \(1994\)](#) is arguably the largest and studies a sample of pamphlets from the 1500s that comprises 3,183 authored by Martin Luther and 1,763 authored by Catholic activists. But a large share of output is by effectively unknown authors, as discussed below.

³The exception is [Dittmar \(2015\)](#), on which we build and which is discussed below.

The first contribution of this research is to construct a new measure of religious content in the media at the local level. We assemble data on all known books and pamphlets printed in German-speaking Europe and use estimators for high-dimensional data to classify content. The data consist of 110,000+ publications printed in 100+ cities 1454-1600. We first use historical sources to identify over 450 leading Protestant and Catholic authors – authors of 18% of the media printed in Germany 1454-1600. We then use statistical models for high-dimensional data to identify the language characteristic of Protestant and Catholic authors in long, historical book titles.⁴ We use these models to generate a measure of the religious content at the author and city level that captures how similar the language of their media output is to the language of known Protestant and Catholic writers.⁵ A large literature uses high-dimensional estimation techniques to document political sentiment in news media and the diffusion of ideas in internet-based social media such as twitter “tweets” (Gentzkow and Shapiro 2010; Taddy 2013b;c; Pak and Paroubek 2010; Bollen et al. 2011). Our research takes these estimators to historical data from the Reformation. Previous work on the economics of the Reformation has studied measures of religious belief observed in the 1800s (Becker and Woessmann 2009) or the binary Protestant-or-Catholic religious denomination of territorial rulers or cities in the mid-1500s (Cantoni 2014; Rubin 2014).⁶

The second contribution of this research is to document the relationship between competition in media markets, the diffusion of Protestant content, and institutions. We find a greater diffusion of Protestant media in cities with an ex ante larger number of competing firms – even controlling for the pre-Reformation size and composition of output.⁷ We also document how competition interacted with pre-Reformation institutions. We show that the relationship between competition and the diffusion of Protestant media was differentially stronger in cities where citizens and city councils had the least institutional autonomy from territorial authorities.⁸ To document the relationship between competition, exposure to Protestant media, and institutional change we construct new data on the city-level laws that institutionalized the Reformation. We find that

⁴The median title in our data has 21 words and 153 characters. For comparison, twitter messages are no longer than 140 characters. Estimation strategies similar to ours are widely used to classify the content of tweets, spam email, and other short texts. We discuss the data and estimation in detail below.

⁵Our estimation strategy builds on Gentzkow and Shapiro (2010), which measures the “slant” (ideology) of US newspapers by determining whether they employ language similar to that used by Democratic or Republican representatives in the US Congress. Details of our strategy are discussed below.

⁶We construct new data on formal changes in city institutions as discussed below.

⁷Gentzkow et al. (2014) similarly find competition has increased ideological diversity in US media.

⁸The city is a key unit of analysis because historic transport costs were very high. Due to transport costs, the key competitive dynamics were within-city and city-level output was the key determinant of city-level exposure. See Dittmar (2015) and the appendix below for micro evidence on the distance-price gradient for books traded between cities in the early 1500s. For a discussion of transport costs and diffusion of Reformation media, see Edwards (1994).

variations in pre-Reformation media market competition mattered most for subsequent institutional change in cities with the least legal autonomy from territorial lords. Our data include city-level laws passed over the crucial period of the 1520s and 1530s, before princes adopted the Reformation at the territorial level ([Hamm 1994](#)). These laws stipulated correct doctrine, reformed social welfare and church governance, set up oversight mechanisms for the administration of church resources, and established Europe’s first mass public education systems. No previous quantitative research has analyzed systematic data on these municipal reformation laws, to the best of our knowledge.

The third contribution of the research provides evidence on quasi-experimental variation in competition. We use the timing of the deaths of printers to isolate variation in competition that is likely unrelated to city-level determinants of the demand for Protestant media. We also study variation in competition that is explained by lagged competition, and is as a result plausibly free of endogenous entry we might imagine occurring on the eve of the Reformation in cities newly receptive to innovation.

These contributions address larger questions in economics about the origins of fundamental beliefs and institutions. An influential body of scholarship traces differences in contemporary economic performance and behavior to historically determined institutions or beliefs ([Acemoglu et al. 2001; 2011; Voigtländer and Voth 2012; Guiso et al. 2003](#)). This literature calls our attention to the persistence of key institutions, but raises the question: What explains the dynamics of fundamental institutional change? Here we study the role of the media and competition in large scale institutional change. We specifically study environments in which the media were used to solve free rider problems and mobilize citizens’ movements that challenged religious and secular elites – somewhat in the spirit of [Acemoglu and Robinson \(2006\)](#) but without democracy on the table. Our research design for constructing an index of religious content in the media is an application of high-dimensional statistical techniques to historical data and builds on [Gentzkow and Shapiro \(2010\)](#). Our strategy for constructing evidence on industrial organization and firm-level shocks in historic media markets builds on [Dittmar \(2015\)](#).⁹ What is innovative here is that we (i) measure the diffusion of ideas using techniques for high-dimensional data, (ii) study how competition shaped the diffusion of revolutionary religious ideas, and (iii) tie the diffusion of ideas and variations in competition to the legal changes that institutionalized the Reformation at the local level. By examining how competition had different effects on the diffusion of religious ideas and the transformation of institutions in ex ante different institutional settings we provide evidence on religion’s “two-way interaction with political economy” ([McCleary and Barro 2006](#)).

⁹[Dittmar \(2015\)](#) studies firm-level competition across all European cities, and documents the relationship between the diffusion of business education literature and growth.

The Reformation interests us as arguably one of the most important changes in social institutions of the last several centuries. A substantial social science literature indicates that the Reformation had a profound, lasting impact on beliefs, institutions, and education. [Weber \(1930\)](#) suggested that Protestantism fostered a work ethic conducive to commerce and growth. Research in economics finds that religion and Protestantism in particular is associated with persistent differences in norms, human capital accumulation, and economic development ([Guiso et al. 2003](#); [McCleary and Barro 2006](#); [Basten and Betz 2013](#)). Recent work suggests that Protestant beliefs generated a demand shift for literacy that explains subsequent variations in technology adoption and economic outcomes across historic Germany ([Becker and Woessmann 2009](#); [Becker et al. 2011](#)).

Our research also responds to economic studies of the Reformation. [Ekelund et al. \(2002\)](#) study differences in the diffusion of Protestantism across more entrepreneurial and more rent-seeking principalities, as measured by differences in inheritance laws. Our research documents the relationship between city-level media market competition and religious change, even within principalities. In research that motivates our study, [Rubin \(2014\)](#) finds Protestantism was more likely to be adopted in cities that had printing before 1500. A key take away from our research is that the diffusion of the Reformation depended on competition, and that competition predicts institutional change while the simple presence of the new technology does not.¹⁰ [Cantoni \(2012\)](#) focuses on the adoption of Protestantism by princes at the territorial level.¹¹ We study the early diffusion of the Reformation at the city-level before princes adopted at the territory level and before the formal legal settlement (The Peace of Augsburg of 1555) that established rules governing the religious geography of greater Germany. [Becker and Woessmann \(2009\)](#) study the relationship between Protestantism and literacy across Prussian counties in the 1800s, and use distance from Wittenberg as an instrument for Protestantism. We confirm that distance from Wittenberg was associated with the diffusion of Protestant ideas in the media, but only through the interaction between distance and pre-Reformation competition in the media.

¹⁰As [Rubin](#) carefully explains, the design in [Rubin \(2014\)](#) cannot disentangle supply and demand side determinants of religious change to rule out alternate ways the correlation between having printing and adopting Protestantism could emerge. While causal arguments should be advanced with caution, the instrumental variable estimates we present below using deaths of printers and lagged measures of competition both support the view that competition was an important determinant of diffusion. In addition, [Rubin \(2014\)](#) does not provide systematic evidence on the actual content of media.

¹¹[Cantoni \(2012\)](#) does not study systematic or high frequency evidence on ideas in the media. As an aside, [Cantoni \(2012\)](#) suggests that distance from Wittenberg may have been unimportant for access to Protestant print media based on evidence from a source recording publications by Luther held at the British Museum as of the 1960s. In the more comprehensive micro-data presented below, we find a relationship between distance from Wittenberg and exposure to Protestant media, and document how the interaction between distance and competition in local media markets mattered for diffusion.

2 History

In this section we present an overview of the history of the Reformation. The Reformation began as a protest of Catholic clerics and scholars against church institutions and their superiors. It became a mass movement that led to profound institutional change. Two key features distinguish the Protestant Reformation from previous attempts to challenge church institutions and practices. First, when the Catholic church attacked the protesting clergy, the reformers responded by developing and disseminating their arguments in print media. Second, politically active laymen adopted and adapted these calls for reform and pressed them on governing elites (Cameron 1991).

The Reformation was based on a critique of existing church institutions and practices. Reformers called for moral renewal within cities (Moeller 1972), emphasized their belief that biblical authority was paramount over and above the authority of existing church institutions (Brady 1978), and were often though not always anti-clerical (Dykema and Oberman 1993). The reforms that were at the heart of the Reformation included the abolition of the Catholic rite mass, rejection of the rule that clergy should be celibate, and moves to reduce and set up safeguards against church corruption. The reformists also moved to eliminate clerical tax exemptions and economic privileges.¹²

The Reformation is usually dated to October 1517, when Martin Luther circulated a set of hand-written theses criticizing church corruption. Luther's theses notably criticized the Catholic church's practice of selling indulgences which were believed to secure the release of dead relatives from purgatory in the afterlife. The proceeds from the sale of indulgences were used to finance church investments (e.g. the basilica of St. Peter in Rome) and consumption.¹³ Cash flows on future indulgences were also used to secure loans used by elites to purchase high church offices.¹⁴ Luther circulated his theses criticizing these practices in letters to three correspondents. Within months they were printed in multiple German-speaking cities.¹⁵

¹²Besides exemption from taxes and civic duties, religious orders enjoyed monopolies on priced religious services (e.g. funeral services) and on the production of products like beer. In a pamphlet published in 1522, Sebastian Meyer provided the following summary to his reader: "Dear layman, it is all done with one purpose in mind and that is your pocketbook...They exist by the founding and confirmation of the pope and they help him make off with your goods." Translation in Ozment (1975; p. 58).

¹³In his 86th thesis, Luther asked: "Why does the pope, whose wealth today is greater than the wealth of the richest Crassus, build the basilica of Saint Peter with the money of poor believers rather than with his own money?" Crassus was the wealthiest individual in Roman history and among the richest of all time. Crassus became wealthy via real estate speculation, the slave trade, and insider political expropriations, and played a role in Rome's transformation from Republic to Empire.

¹⁴Joachim I the Elector of Brandenburg borrowed money from the Fugger bankers to purchase the office of Archbishop of Mainz for his brother. The loan was guaranteed by future revenue on indulgences.

¹⁵The Reformation was not restricted to cities. Religious ideas were central to the so-called peasants' war of 1525 (Blickle 1981). This research focuses on the urban reformations because of the key role cities

Historians argue that print media played a central role in the diffusion of the Protestant Reformation (Edwards 1994; Brady 2009). In the first years, Reformist ideas were innovations with uncertain prospects and printers potentially risked their businesses by printing Protestant content (Chrisman 1982). Chrisman (1982; p. 29) observes that the influence of printers derived from the fact that, “their decision to print or not to print a particular book or tract could have an immediate effect on political and religious events and, in a time of rapid change, on institutions. The most striking example of their influence can be seen in the religious publication of the pivotal years of the Reformation.” Historical research also suggests that Protestant media helped solve free rider problems: “It was the superabundance, the cascade of titles, that created the impression of an overwhelming tide, an unstoppable movement of opinion” (Pettegree 2005; p. 163).¹⁶

While producers were motivated by belief, printing was a competitive business in which religion was a dimension for product differentiation (Reske 2007; Pettegree 2000). As an industry, printing did a Schumpeterian end-run around guild restrictions. Entry and markets were unregulated (Dittmar 2015). Some large cities had no printing, others had 1 firm or several. Just prior to the Reformation, the mean printing city had 4.7 firms and the median 2. A typical pamphlet cost 1/3 of one day’s wages, but transport costs limited inter-city trade and diffusion through reprinting was typical. For these reasons, local production is a reasonable approximation for exposure (Edwards 1994) and the key competitive dynamics were within city (Dittmar 2015). The appendices provide data on prices and estimates of the within city-year price-gradient on transport for traded books.

The ideas of the Reformation spread through a two-part process (Edwards 1994). First, print media impacted “opinion leaders,” notably clergy and educated laymen.¹⁷ Opinion leaders then transmitted ideas orally to the broad public and developed popular movements. In Zürich, Reformation activism dates to March 1522, when printer Christoph Froschauer and his workers engaged in civil disobedience by breaking the Lent fast with pastor Ulrich Zwingli as their witness. City authorities arrested the printers, Zwingli preached in their defense and his sermons were disseminated as pamphlets, opening public debate. In Augsburg, “A wave of religious pamphlets and, from 1520, the introduction of evangelical preaching, spread the new teaching” (Broadhead 1996; p. 581). In Schwabach, reformist activity began with the distribution of pamphlets at the church door before services in September 1524 (Dixon 1996). In Northern cities, reading groups of the 1520s preceded activism and legal change in the 1530s (Schilling 1983).

played as incubators of Reformation ideas and institutional innovations (Hamm 1994).

¹⁶As a counterfactual to the success of Protestantism, historians have studied the failure of pre-print heresies such as Lollardism in England (late 1300s) and the Hussite movement in Bohemia (early 1400s).

¹⁷A number of significant lay reformers were city clerks. For example, Lazarus Spengler and Jörg Vogeli were clerks of Nürnberg and Konstanz, respectively, and published reformist works in the 1520s.

The city-level Reformations were popular movements that developed without support from oligarchic city governments or territorial lords.¹⁸ The constituency for reform came from citizens who were excluded from political power by oligarchic elites, typically lesser merchants and guild members (Ozment 1975; Schilling 1983). Significantly, city councils “seldom or never initiated a local Reformation” (Dickens 1979; p. 20). Thus Cameron (1991; p. 240) observes, “As a rule neither the city patricians nor the local princes showed any sympathy for the Reformation in the crucial period in the late 1520s and early 1530s; they identified themselves with the old Church hierarchy and accordingly shared its unpopularity. Popular agitation on a broad social base led to the formation of a ‘burgher committee’.” This model notably characterized the Reformation in its birth place: “It is undeniable that the Wittenberg movement was borne on a wave of popular enthusiasm. It outran the city magistrates’ ability to control it, and finally forced them to act even against the will of the Elector [the territorial ruler of Wittenberg], who had prohibited any innovations in church matters” (Scribner 1979; p. 53). In Augsburg, the city council was forced to drop its policy of religious neutrality following riots in 1524, 1530, and 1534 (Broadhead 1979). In Northern cities, such as Rostock, Stralsund, Griefswald, Lübeck, Braunschweig, Lüneberg, Göttingen, and Hanover institutional change led by citizens excluded from political power had a *coup d’état* quality (Cameron 1991). In Zwickau, Lutheran publications were printed in 1523; the city council attempted to suppress protests in 1524; the Reformation was formally adopted in 1525 (Scribner 1979).

Political decentralization and the jurisdictional status of cities in the Holy Roman Empire were important features of the environment in which the Reformation spread. Political decentralization limited the capacity of central and regional authorities to regulate media markets (Kapp 1886; Creasman 2012). The Holy Roman Empire was composed of a large number of semi-autonomous principalities and two principal types of cities. Free cities (*Freie und Reichsstädte*) were constitutionally outside the jurisdiction of territorial lords, had city councils with extensive legal autonomy, and have been identified by historians as playing a critical role in the development of the Reformation (Moeller 1972; Cameron 1991). Territorial cities (*landstadt*) fell under the jurisdiction of lords, although distance and state capacity put limits on the extent of lords’ control (Whaley 2011). In this context, suppression of dissent was costly and slow to be tried. Printers producing Protestant media were not censored in the early years of the Reformation and the Edict of Worms (1521) banning Luther’s work was itself not rushed into print (Brady

¹⁸In light of the fact that Church property was expropriated, it is natural to wonder whether rulers’ religious decisions were motivated by financial gain. The evidence indicates, “no clear causal link between confiscating lands and turning Protestant.” (Cameron 1991; p. 296) Several rulers extracted resources from the Church years before defining their religious position. The dukes of Bavaria used the threat of concessions to Protestants to extract resources, but remained Catholic. At the city level, expropriated assets were put to new uses, largely the provision of public goods.

1985; p. 153). By the mid-1520s, urban governments began to defy the emperor and pass ordinances institutionalizing the Reformation. In 1526, a formal magisterial right to reform (*ius reformandi*) was passed into law by the Imperial Diet or parliament of the Holy Roman Empire (Brady 2009; p. 55). At the city-level, censorship rules were endogenous, “as much a product of public opinion as a force acting upon it...enforcement shifted as the...objectives of the communities evolved” (Creasman 2012; p. 227, 64).¹⁹

Institutional change was implemented with lags after the diffusion of ideas (Ozment 1975). For example in Wittenberg, Catholic mass was only abolished in 1525. In Strasbourg, Catholic mass was restricted to specific churches in 1525 and abolished in 1529. In Nürnberg, the legal institutions of the Reformation were installed 1520-1533. In Osnabrück, the process ran 1521-1542.

The formal institutions Protestant reformers set-up were new laws. The new laws governed religious practice and social welfare provision, and established public education. These laws were church ordinances (*kirchenordnungen*) passed first by city magistrates and municipal councils, and only later by princes at the territorial level (Hamm 1994). These ordinances institutionalized ideas that first circulated in the media. Ozment (1975; p. 49) observes that pro-reform media we study, “express viewpoints that were later embodied...in church ordinances that consolidated the final phase of the Reformation...The revolutionary program came to rest in an established religion; the pamphlet became a church ordinance...the new Protestant institutions persisted.”

The overall chronology of the Reformation consists of several partially overlapping phases (Harrington and Smith 1997; Brady 2009). The popular or communal Reformation (*Gemeindereformation*) ran approximately 1518-1525 and saw the initial explosion of debate in the media and the emergence of popular pro-Reform movements.²⁰ The magisterial Reformation 1525-1555 saw significant further use of the media and the institutionalization of the Reformation, starting at the city level. The environment in which Protestant ideas diffused, and the possibilities for translating activism into institutional change, were transformed in the 1540s. In the 1540s, the diffusion of Protestantism was checked by the Catholic victory in the Schmalkaldic War of 1546-1547. The Peace of Augsburg (1555) formalized a legal settlement governing the religious geography of the Holy Roman Empire and the religious prerogatives of rulers – effectively fixing religious institutions.²¹ By the mid-1500s, Protestantism in historic Germany acquired the geographic distribution it would maintain for several centuries (Brady 1998; p. 373).

¹⁹Cologne was the exception to this rule (Scribner 1976). See also Chrisman (1982).

²⁰In 1525, the peasants’ movement for religious and economic reform was crushed (Blickle 1981).

²¹The Peace of Augsburg set the rule *cuius regio, eius religio* (whose rule, his religion) with exceptions for cities where Protestants and Catholics were to share churches and magistracies (Brady 1998; p. 375).

3 Data

The primary source for data on print media is the Universal Short Title Catalogue (USTC) database of [St. Andrews \(2012\)](#). The USTC is designed as a universal catalogue of all known books printed in Europe 1450-1600. We restrict analysis to the set of historically German-speaking cities with printing identified by [Reske \(2007\)](#).²² Our database comprises 114,483 titles that were printed 1457-1600 in these cities. The unit of analysis in this paper is the book or pamphlet title (edition), which can be thought of as a variety.²³ Our baseline data comprises 191 cities. We examine both cities with printing and cities without printing but with population observed in 1500 in [Bairoch et al. \(1988\)](#). Figure 1 shows the cities we examine and the boundaries of principalities in the Holy Roman Empire.

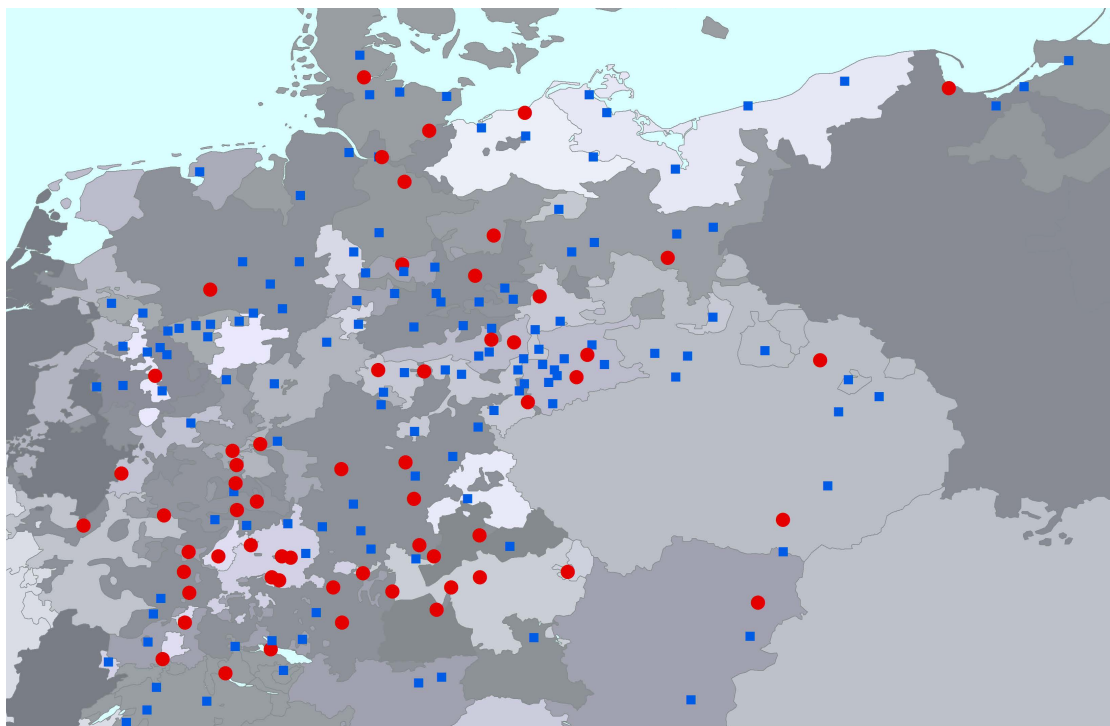


Figure 1: Cities in German-Speaking Europe. Cities with printing before 1517 are red (circles), cities without are blue (squares). Principality boundaries as of 1500.

²²These cities should be considered German-speaking in a qualified sense. Many were characterized by linguistic diversity. Within German-speaking Europe High and Low German co-existed. The set of cities in our data includes cities now in Austria, France (e.g. Metz and Strasbourg), Switzerland (e.g. Zürich and Basel), Poland (e.g. Gdansk, historically known as Danzig, and Szczecin, historically known as Stettin), the Czech Republic (e.g. Brno or Brünn), and Russia (Kaliningrad or Königsberg). Bohemian cities are excluded. Vernacular printing in these cities was overwhelmingly in Czech.

²³For a subset of several hundred books we have data on the number of copies printed per edition. These data and evidence from book contracts indicate that the typical print run rose from 400-800 copies around 1500 to 1,000-1,400 copies in the later 1500s. See [Dittmar \(2015\)](#).

We construct data on firms from two sources. First, we identify the printer or printers that produced each publication from inscriptions on the front pages of books and pamphlets, to obtain “firms from publications.”²⁴ Second, we construct a measure of the number of printers from Reske (2007), *Die Buchdrucker des 16 und 17 Jahrhunderts im deutschen Sprachgebiet*, which is the authoritative biographical dictionary of historical printers active in German-speaking Europe, giving us “firms from biographies.” The key difference between these sources is that the data on firms from publications includes a fringe of small, short-lived producers who do not appear in Reske (2007). Our results on content diffusion are robust to using either measure, but stronger using the Reske biographies measure. We discuss these differences and implications below and in the appendix.²⁵ We code the year of death for all printers where this is known in historical sources (Reske 2007; CERL 2012). We consider deaths occurring more within 1 year of a printer’s last observed publication as the death of an active printer; other deaths are inactive (“retirees”). Table 1 presents summary statistics on the information we observe in media markets before estimation. For further statistics see appendix.

We construct data on the religious affiliation of a subset of authors from several sources. Klaiber (1978) provides data on 224 Catholic authors and “controversialists” working in German-speaking Europe before 1600. For Protestant authors we rely on Mullett (2010), Carey and Lienhard (2000), and Wikipedia’s list of Protestant Reformers.²⁶ Based on these sources, known Catholic authors account for 2,937 titles (3% of books) and known Protestants account for 15,142 (15% of books).²⁷

The research uses the text of book and pamphlet titles to identify the language most characteristic of Protestant and Catholic print media. Historical titles provided extended descriptions of content. We study titles using statistical methods a substantial literature employs to identify sentiment in twitter messages (Taddy 2013c; Go et al. 2009; Pak and Paroubek 2010; Bollen et al. 2011; Bifet and Frank 2010). The median title in our data has 153 characters (mean 171.6), whereas twitter messages are no longer than 140. Table 2 summarizes the distribution of the lengths of titles in our data, as is and dropping

²⁴Information identifying firms is available on 98% of historic media in a non-standardized form. Printers are identified in multiple languages (e.g. Latinized and German variants of the same name), with non-standard spelling, abbreviations, and in some instances aliases. We research each name and printer and construct standardized firm identifiers as described in Dittmar (2015) and the appendix.

²⁵It is possible that Reske misses printers or that some names provided on books are name variants or aliases we ideally would but are unable to match. It is also possible that occasional publications appeared under the names of publishers in collaboration with the known printers listed in Reske (2007).

²⁶See www.wikipedia.org/wiki/List_of_Protestant_Reformers (downloaded 12/15/2012).

²⁷The print media dominance of Protestant reformers has been observed by social historians and in earlier research based on small samples of historical print media. For instance, Edwards (1994; p. 29) finds in a sample of vernacular (German-language) pamphlets that the ratio of works by Martin Luther to works by Catholic publicists was approximately 5 to 1.

“stop words” (words such as *and* and *the*). We provide detailed discussion of the text data, and applications of high-dimensional statistical models, below.

To identify the institutions of the Reformation we code municipal Reformation ordinances (*kirchenordnungen*). These laws were passed by local magistrates to institutionalize the Reformation (Hamm 1994; Ozment 1975). The ordinances have provisions governing: religious dogma; public morality; sex, family, and marriage; social welfare and poor relief; and education. Our principal source on ordinances is, *Die evangelischen Kirchenordnungen des 16 Jahrhunderts* (21 volumes 1902-2013).²⁸ Additional sources described in the appendix are used to identify ordinances in cities outside Germany. The appendix provides summary statistics on cities that did and did not pass these laws.

Decade Starting	Cities Printing	Firms Printing	Total Varieties	Religious Varieties	Religious by Known	
					Protestants	Catholics
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1450	1	3	47	12	0	0
1460	7	10	109	75	0	0
1470	24	72	1,657	871	1	6
1480	40	129	3,199	1,608	4	0
1490	38	138	4,194	1,505	4	2
1500	47	185	4,159	1,452	15	79
1510	41	175	5,381	1,836	395	190
1520	65	222	11,246	7,386	3,815	517
1530	55	246	7,885	3,300	1,550	443
1540	63	243	8,379	3,728	1,940	338
1550	77	331	9,993	4,782	2,368	436
1560	78	386	11,456	5,241	2,252	425
1570	93	395	10,943	4,398	1,396	327
1580	103	458	14,303	5,514	1,268	196
1590	113	547	19,252	6,922	867	120

Table 1: Summary statistics on the media from publications data. “Total Varieties” and “Religious Varieties” are counts of all publications and of publications classified as religious in the USTC, respectively. “Religious by Known” is the count of religious publications by authors whose religion we observe and code directly.

	Mean	5%	25%	50%	75%	95%
	(1)	(2)	(3)	(4)	(5)	(6)
Titles with stop words	23.2	3.0	11.0	21.0	33.0	51.0
Titles excluding stop words	14.2	2.0	7.0	13.0	20.0	32.0

Table 2: Number of words in titles. Mean and designated percentiles.

²⁸We refer to these volumes collectively as [Sehling et al. \(2009\)](#).

4 Measuring Religious Ideas in Media

4.1 Overview

We construct an index of the religious content of print media as follows. First, we use historical sources to identify the religious denomination – Protestant or Catholic – of a subset of 450+ authors. Second, we estimate a model of how the distribution of language chosen by authors changes with religion to determine which features of language are important in identifying authors’ religious denomination. Third, we use the estimated partisan ideology of language to predict the religious content of media where authors’ religious affiliations may not be known. These predictions form our index. Methodologically we build on [Gentzkow and Shapiro \(2010\)](#) and [Taddy \(2013b\)](#).²⁹

The distinction between Catholic and Protestant provides a powerful first model for thinking about media markets and religious change in historic Germany. In part this is because later divisions between Lutheran and Calvinist Protestants were only incipient in the first half of the 1500s. That said, the distinction between Catholics and Protestants does not exhaust the distinctions one could draw among authors’ religious views.³⁰

Our estimation strategy has traction because historical titles provide extensive glosses on content in books. To understand the information in titles, we first provide two examples of English-language books printed in 16th century Germany that may be useful for English language readers.³¹ An example of a Protestant title is a book written by Martin Luther and printed in Wesel:

The last wil and last Confeßion of martyn Luthers faith concerning the principal articles of religion which are in controversy, which he wil defend & maiteine until his death, agaynst the pope and the gates of hell.

An example of a Catholic title is a book written by John Old and printed in Emden:

A Confeßion of the most auncient and true christen catholike olde belefe accordyng to the ordre of the .XII. Articles of our comon crede, set furthe in

²⁹[Gentzkow and Shapiro \(2010\)](#) develop a similar estimation strategy to identify the dimensions of political ideology in Congressional speeches and to measure the political “slant” of US newspapers by documenting the extent to which these media use language characteristic of Democrats or Republicans. [Taddy \(2013b\)](#) extends the Gentzkow and Shapiro (henceforth “GS”) approach, and [Taddy \(2013c\)](#) applies a similar strategy to measure political sentiment in twitter “tweets.”

³⁰Extensions could distinguish Lutheran, Calvinist, and Zwinglian ideas in Protestant media and different types of Catholic authors. We discuss time-varying features of religious language below.

³¹In our database, 96% of books and pamphlets are in German and Latin. We provide examples of German titles with translations in the appendix.

Englishe to the glory of almightye God, and to the confirmacion of Christes people in Christes catholike olde faith.

These examples illustrate how titles provide information about content. They also suggest potential challenges in analyzing historical data in which spelling is not standardized. The results below suggest these challenges do not preclude obtaining useful estimates.³²

Below we show that our estimation strategy accurately predicts the religion of known religious authors in out-of-sample tests. We also are able to classify content in the majority of output, which is by unknown authors, and to classify content in 136 cities while books produced by our set of known religious authors appeared in only 104.

4.2 Estimator

Using the subset of titles for which we code whether the author is Protestant or Catholic, we apply an estimation strategy that first provides a low-dimensional representation of each text that preserves the religious sentiment and second classifies this low-dimensional representation according to the religion of the authors. We are then able to find low-dimensional representations of religious content those texts for which we do not know the author’s religious affiliation and to predict religion. The estimation framework is the multinomial inverse regression (MNIR) model introduced by [Taddy \(2013b\)](#).³³

Formally, let a document be denoted $\mathbf{X}_i = [x_{i1}, \dots, x_{iW}]$ where x_{iw} represents the number of times phrase w appears in document i for each of the W words in the the *vocabulary* V . We are interested in identifying the features that allow us to classify the documents according to their religious content r with $r \in P, C$ for Protestant or Catholic. Since the distribution of a sum of multinomial draws from the same distribution is multinomial, we are able to pool the observations into (at least) two classes P and C such that $\mathbf{X}_r = \sum_i x_{iwr}$ for $r \in P, C$. Our model for documents is

³²While it is possible to identify spelling variants as the same word, it is not clear that introducing standardizations or model features to capture orthographic variations would improve the precision of our estimates. Because spelling conventions reflect both regional and ideological influences, orthographic standardization could entail the loss of potentially valuable information. For this reason, and because standardizing orthography is a difficult computational problem exacerbated by the fact that we have nearly 70 different languages and language combinations in the texts, we analyze texts “as is.”

³³The estimation strategy follows the literature in high-dimensional estimation and machine learning, assumes that the order of phrases or words within a document is relatively unimportant in classifying the content of the text, and views documents as a *bag of words* ([Salton and McGill 1986](#)). This assumption allows documents to be treated as as multinomial random variables in which the phrases or words are the categories and the support is called the *vocabulary*. We thus increase efficiency by making an assumption about the functional relationship between text and sentiment ([Taddy 2013c](#)).

$$\begin{aligned} \mathbf{X}_r &\sim MN(\mathbf{q}_r, m_r) \text{ where} \\ q_{rw} &= \frac{\exp[\alpha_w + r\varphi_w]}{\sum_{j=1}^W \exp[\alpha_j + r\varphi_j]} \text{ for } w = 1, \dots, W, r \in P, C \end{aligned} \quad (1)$$

Each \mathbf{X}_r is a W -dimensional multinomial variable with size $m_r = \sum_i m_{ir}$ with $m_{ir} = \sum_w x_{iwr}$ and probabilities $\mathbf{q}_r = [q_{r1}, \dots, q_{rW}]$. The estimated *factor loadings* φ allow us to compute a *sufficient reduction* (SR) score z_i for document word frequencies $\mathbf{f}_i = \frac{\mathbf{x}_i}{m_i}$. The identifying assumption is that the sufficient reduction score z_i is a scalar containing all relevant sentiment information in document i independent of the full \mathbf{X}_i and its length.

$$z_i = \boldsymbol{\varphi}' \mathbf{f}_i \Rightarrow r_i \perp \mathbf{X}_i, m_i \mid z_i \quad (2)$$

This assumption allows us to ignore the full-dimensional \mathbf{X}_i and model the classification problem as a univariate regression problem, called the *forward regression* in the inverse regression literature:

$$Pr(r_i = r \mid z_i) = \frac{1}{1 + \exp[\beta_0 + \beta_1 z_i]} \quad (3)$$

Finally, to estimate the religious content of texts, we take the projection of the factor loadings estimated in (1) onto the frequencies of these out-of-sample texts to obtain SR scores \hat{z}_i . We then use the coefficients from (3) to infer the religious content of the texts.

Text analysis problems commonly lead to both fat-tailed and sparse distributions. To address this possibility, independent Laplace priors with unknown variance are placed on the factor loadings φ_w . The unknown rate parameter λ_w accounts for our uncertainty as to how much variable-specific regularization is appropriate. The rate parameter is given a gamma hyperprior $\Gamma(\alpha, \beta)$ such that:

$$\Pr(\varphi_w, \lambda_w) = \frac{\lambda_w}{2} e^{-\lambda_w |\varphi_w|} \frac{\beta^\alpha}{\Gamma(\alpha)} \lambda_w^{\alpha-1} e^{-\beta \lambda_w}, \quad \alpha, \beta, \lambda_w > 0. \quad (4)$$

Estimation of the likelihood implied by the multinomial distribution in (1) and the prior (4) takes place via the gamma-lasso algorithm to maximize the joint posterior over coefficients and their prior scale (Taddy 2013b;a).

4.3 Estimation Results

To estimate the MNIR model, the research constructs the estimating vocabulary using the log-odds ratio statistic with an informative Dirichlet prior for each term (Monroe et al. 2008). We use the log-odds ratio to select the vocabulary based on its performance in

cross-validation tests over held-out subsamples of the data. The log-odds ratio vocabulary has superior performance in terms of precision (the absence of Type I errors) and recall (the absence of Type II errors) when compared to a vocabulary constructed using the χ^2 measure of [Gentzkow and Shapiro \(2010\)](#) and estimates that rely only on model-based feature selection obtained via regularization inherent in the estimator. The Appendix [Identifying Partisan Language B](#) provides detailed comparisons of these methods.³⁴

When estimating the forward regression in-sample and when doing out-of-sample predictions, we collapse all the titles for one author to obtain a single *oeuvre*. We do this because it improves the accuracy of classification, by making the multinomial observations less sparse.³⁵ After eliminating words not in the vocabulary and collapsing by author, we have on average 362 words per author in the training set where we know authors' religious affiliation and 40 words per author in the data where religious affiliation is unknown.

We show the high overall performance of the estimator in two ways. First examine, we examine in-sample classification results. The estimator predicts correctly in-sample 86% of the time. This success rate compares favorably to results in similar prediction problems in the literature.³⁶ Second, we perform cross-validation and present results showing how the estimation strategy performs under different prior specifications to address concerns about overfitting. To perform the cross-validation, we split the data for which we know the author's religious affiliation into a training subset and a testing subset. We use 80% of the data for training and 20% to test out-of-sample performance.³⁷ We do this for 100 random sub-samples. In the process, we vary the shape parameter α of the gamma hyperprior which controls the sparsity of the estimates. Increasing α can reduce problems with overfitting through a stronger preference for regularization.

To illustrate the approach, [Figure 2](#) shows the results of a single training-test split. This figure shows only the performance of the classifier on the held-out test data, and highlights how well we predict prominent authors Martin Luther and Johannes Eck.³⁸

[Figure 3](#) documents the strong out-of-sample performance of the estimation strategy in

³⁴The appendix also describes how we prepare titles for use in the classifier by dropping punctuation and converting all letters to lower-case, and compares estimates with and without stop words retained.

³⁵By collapsing to the author level, we defer a study of within-author variation. The sacrifice here is minimized by the fact that, while first generation Protestant reformers were former Catholics, extremely few Protestant authors had any substantial publication record as Catholics. As a result, the "within author" variation available to study is largely within religion.

³⁶For comparison, [Gentzkow and Shapiro \(2010\)](#) predict the party of US Congress members based on the text of their speeches, and obtain a correlation of 0.61 between true and predicted affiliation. In our setting, in-sample mis-classification is partly explained by the information available for prediction. The median number of publications for authors we correctly predict is 6. For mis-classified authors it is 2.

³⁷We obtain nearly identical results using a 65:35 split between training and test data.

³⁸As discussed in relation to in-sample prediction, our out-of-sample prediction failures are systematically authors on whom we have less information due to their more limited publication record.

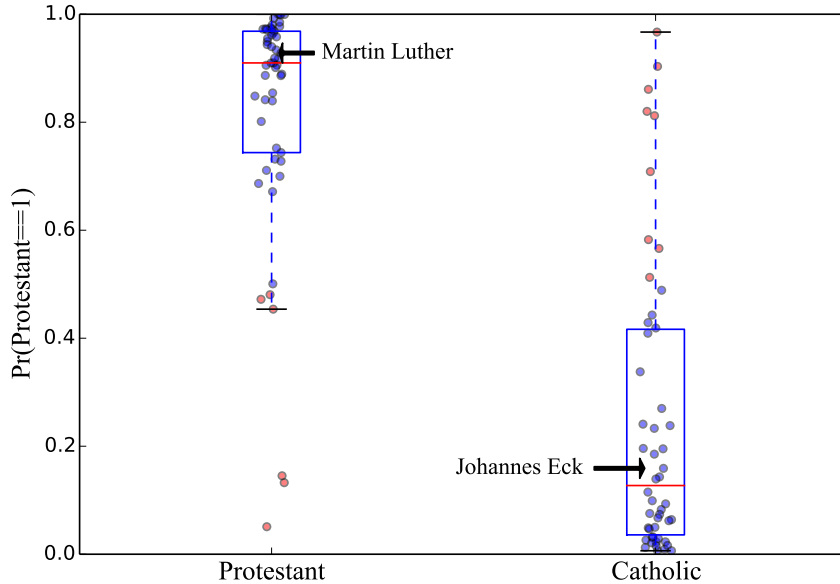


Figure 2: Out of sample-performance for a single draw. The model is trained on 80% of the data and predicted on the held-out 20%, using our preferred specification.

terms of precision and recall as measured by the F1 score, across repeated cross-validation draws from the data. The F1 score provides a summary measure of accuracy – the harmonic mean of precision (the absence of Type I errors) and recall (the absence of Type II errors).³⁹ Figure 3 shows hyperprior $\alpha = 1$ has the best out-of-sample performance and that the model performs best when stop words are included during vocabulary selection and estimation. These cross-validation results are consistent with the estimators in-sample performance. In-sample we predict correctly 86% of authors. Figure 3 shows our preferred out-of-sample specification is very similar.

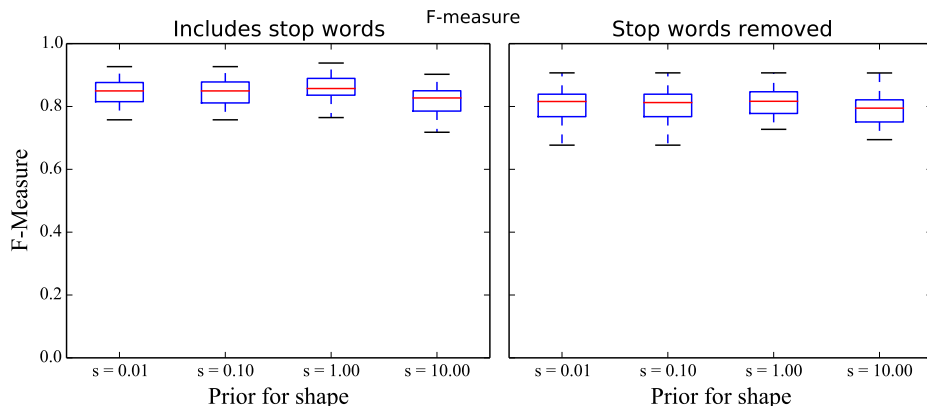


Figure 3: F1-measure on held-out data. s is the hyperprior parameter in $\Gamma(s, .5)$. 100 runs of the model trained on 80% of the data and predicted on the held-out 20%.

³⁹The F1 score is discussed in detail in the Appendix [Identifying Partisan Language B](#).

5 Summary of the Diffusion of Religious Ideas

In this section we use our measure of media content to provide a descriptive summary of the diffusion of Protestant ideas across time and media markets.

First, we highlight the sharp and previously undocumented discontinuity observed in media content in 1517 – the year Luther circulated his theses. Figure 4 presents the mean of the estimated index of religious content in print media for all of Germany 1475-1600. Figure 4 shows that the relative intensity of Catholic-type speech was approximately stable in the run up to the Reformation, at which point there is a discontinuous shift towards Protestant-type speech. The first panel shows our estimates for all religious publications. The second panel examines religious publications in German and suggests a positive pre-1517 trend away from Catholic-type speech in vernacular media. In German language media, there is also a relatively much larger increase in the number of publications printed in the post-1517 period as indicated by the scale of the annual markers. The evidence of a trend away from Catholic-type media in the vernacular before Luther’s 1517 intervention is consistent with the observation that Protestantism was in part a response to underlying cultural trends.⁴⁰ The third panel documents that the discontinuous shift towards Protestant-type speech also characterizes religious media in Latin.

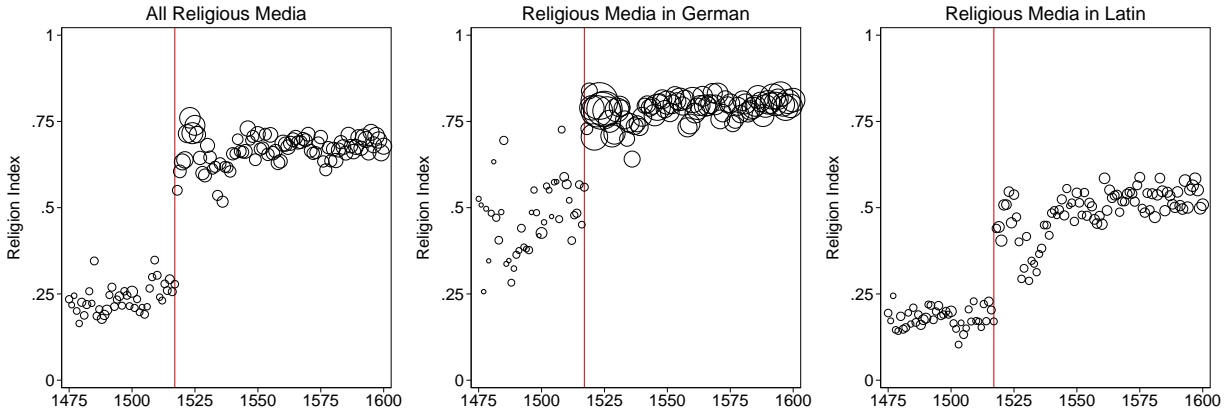


Figure 4: Religion index in historic Germany. Protestant = 1. Catholic = 0. Markers present the annual mean of the religion index across all religious publications. Marker sizes are scaled to represent the relative number of publications in each year.

Second, in Figure 5 we map the evolution of media output at the city level. In Figure 5, city markers are scaled to reflect the number of titles produced and shaded to reflect the average value of the Religion Index for city-level output. Lighter markers

⁴⁰The majority of first-generation reformers had been influenced by Renaissance humanism before they became advocates of religious reform (Cameron 1991; p. 175).

indicate Catholic-type media. Darker markers indicate Protestant-type media. Panel A presents data for the period up to 1517, when Martin Luther posted his Theses. Panel B presents data for the period 1518-1555, when the Peace of Augsburg established the new institutional equilibrium.

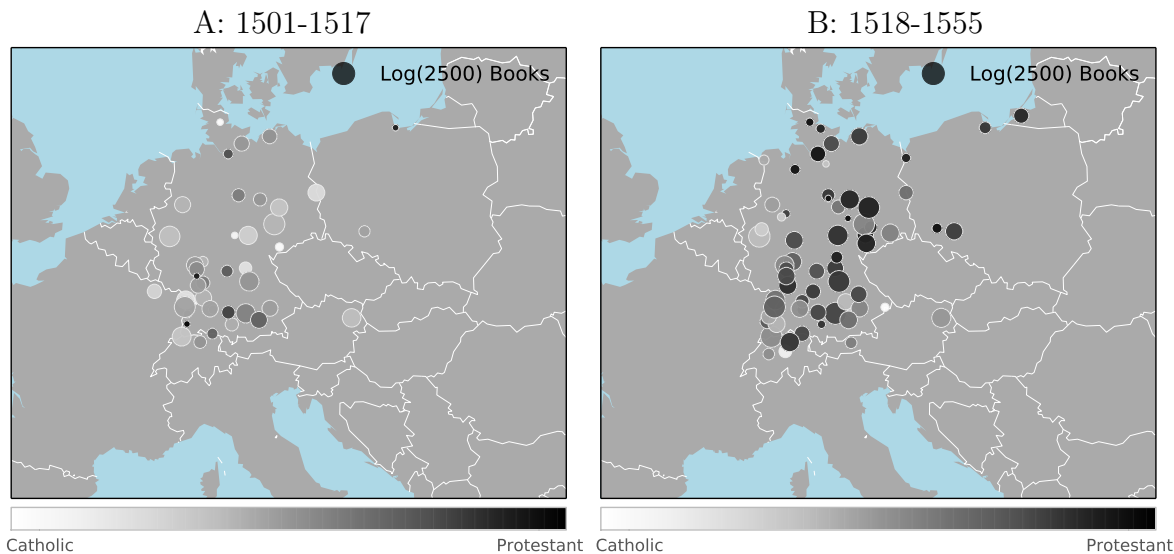


Figure 5: City-level print media output. Markers are scaled to reflect the number of publications produced and shaded to reflect the average value of the Religion Index for city-level output. Darker markers represent more Protestant-type media.

6 Determinants of Diffusion in the Media

6.1 Motivation

We study several dimensions of the media industries and the diffusion of Protestant content in the media. We test the view that, “Where a market was controlled, the free flow of innovative theological speculation was greatly inhibited” (Pettegree 2000; p. 114).

First, we study the relationship between the competition in media markets on the eve of the Reformation and the subsequent diffusion of Protestant media. Prior variations in competition are interesting because they are plausibly exogenous to the Reformation.⁴¹ The key variable we examine is the number of firms active in a given city in the period just before the Reformation. As a baseline, we use the ten-year period 1508-1517, however similar results obtain for other relatively short windows pre-1518. We find a strong relationship between initial competition and subsequent diffusion of Protestant content

⁴¹Our focus on prior competition imposes limits on the scope of our study. We defer an examination of selective entry that may have been induced by the Reformation for future work.

unconditionally and controlling for the number and subject composition of print media varieties produced pre-1518.⁴²

Second, we study how variations in initial city institutions impacted the diffusion of Protestant ideas through their interaction with the media market competition channel. Historical research suggests that free cities played a central role in the development of the Reformation (Moeller 1972; Brady 2009; Cameron 1991). Constitutionally, city councils and magistrates in free cities had extensive legal autonomy relative to policy makers in cities subject to lords.⁴³ Historians’ observation that free cities were unconditionally more likely to adopt the Reformation is confirmed in our data.⁴⁴ However, we find that the competition effect was larger in cities subject to lords and that conditional on other city attributes, there was no reduction in Protestant media in these not-free cities.

In addition, we examine how the relationship between initial competition and subsequent diffusion of the Reformation changed with the institutional settlement of the mid-1500s. The change followed the Peace of Augsburg (1555), which introduced a legal settlement governing the geography and institutions of religion, and altered the way evangelical propaganda could influence social change.

6.2 Key Findings

The research presents quantitative evidence documenting three new facts.

First, we document how industrial structure in media markets was associated with city-level variation in adoption of Protestant media. We show that cities in which more firms were competing in media markets just prior to the Reformation produced more Protestant media 1518-1554. We document that this relationship between market structure and the diffusion of Protestant media holds controlling for a rich set of observables, including the presence of any printing. We also document nonlinearities that suggest

⁴²Because discrete changes in the number of competitors matter in media markets (Gentzkow et al. 2014), we focus on firms rather than indices of concentration.

⁴³For example, the feudal lord might appoint a district official (*Amtmann*) or a jurisdictional officer (*Stadtrichter*) who would reside in a territorial city located within his domains and assume responsibility for local policy and governance alongside a less fully empowered city council. See Dixon (1996). Lords could be non-resident ecclesiastical (e.g. prince-bishops) or secular (dukes, counts, etc.) rulers.

⁴⁴In our baseline sample of Reske printing cities, 25 of 43 free cities passed Reformation laws, while 56 of 148 territorial cities did. Our econometric results below are robust in an alternate larger samples of cities that includes cities without printing and without population observed in 1500. Of the 85 free imperial cities recorded in the tax register of 1521 (*Reichsmatrikel*), 73 fall within the geographic bounds of this study and of these 50 ultimately adopted the formal legal reforms of the Reformation. Schmidt (1984) argues that only 69 of the 85 cities listed in the Reichsmatrikel truly met the criteria for institutional autonomy typically understood to define an imperial city. The results we report below follow the Reichsmatrikel classification, but are robust to using the alternative Schmidt classification.

going from 1 to 2 firms mattered.⁴⁵ Beyond standard product differentiation, one reason why competition mattered is that in most cities municipal contracts to produce official publications (i) were a desirable source of business for printers and (ii) could be threatened by the decision to print Protestant content at odds with city council policy (Reske 2007). In cities with 1 printer, that printer was de facto if not de jure the city printer. Faced by an adversarial monopolist, city councils might encourage a new entrant. In cities with multiple printers, one printer was typically the official city printer (*ratsbuchdrucker*) and the rest were not. The fact that known city printers were not early advocates of the Reformation is consistent with the view that they did not want to endanger official work orders or antagonize city governments. Consistent with this view, we also show that the strong positive relationship between competition and diffusion is specific to Protestant media (below section 6.5).

Second, we document that the relationship between media market competition and the diffusion of Protestant media was strongest in cities with the least legal and institutional autonomy from territorial princes. This finding suggests that competition mattered most for the diffusion of ideas where political freedom was otherwise most restricted. The variation we highlight is between cities subject to territorial lords and constitutionally free cities, which exists across cities located in close proximity and even within territories.⁴⁶

Third, we show that this relationship holds when we examine two sources of plausibly exogenous variation in competition. First, we use evidence on the timing of the deaths of printers, which induced variations in competition that were plausibly unrelated to unobserved characteristics that may have delivered both a larger number of firms and a greater propensity to adopt Protestant ideas. Second, we use evidence on lagged competition to isolate variation not driven by endogenous entry just prior to the Reformation.

6.3 Baseline Empirical Results

We study the relationship between (i) pre-Reformation competition measured by the number of firms active and (ii) the diffusion of Protestant media at the city level. Our

⁴⁵Our proxy measure of competition allows us to respond to the interesting research by Rubin (2014) documenting the correlation between a binary indicator for printing and subsequent Protestantism, both by showing that the mean effect really embodies a competition effect and by studying sources of plausibly exogenous variation in competition.

⁴⁶Within the boundaries of Electoral Palatinate, Landau was free city while Kaiserslautern, Heidelberg, Mannheim, Oppenheim, and Zweibrücken were subject to the lord. In the Duchy of Württemberg, Esslingen was a free city while Reutlingen, Stuttgart, Tübingen, and Ludwigsburg were subject to the Duke. In the Swiss Confederation, Basel, Schaffhausen, and Sankt Gallen were free, while Bern, Solothurn, and Zürich were not. However, many principalities had no free cities or just one city in total.

baseline estimates are obtained from regressions of the form:

$$protestant_{i,post} = \alpha firms_{i,pre} + \beta X_{i,pre} + \epsilon_i \quad (5)$$

Here $protestant_{i,post}$ measures Protestant content produced 1518-1554 in city i . We examine the count of Protestant varieties with negative binomial regressions and the log of count ($\ln[protestant + 1]$) with OLS regressions.⁴⁷ $firms_{i,pre}$ is the number of firms active 1508-1517 measured from either publication data or biographic data. The X control for: the size and composition of total media output pre-Reformation; indicators for cities subject to lords and Hanseatic cities; population in 1500; distance to Wittenberg; and latitude, longitude, and their interaction.⁴⁸

Table 3 reports results from OLS and negative binomial estimates of the relationship between the number of firms in media markets on the eve of the reformation and the number of Protestant media varieties produced 1518-1554. Across specifications an additional firm was associated with roughly a 20% increase in Protestant media. We also observe a differential relationship between the number of pre-Reformation firms and subsequent diffusion for cities that were subject to territorial lords. In the OLS estimates, the relationship is twice as strong for cities subject to lords. This suggests that competition in media markets mattered more where municipal rulers were legally subject to authoritarian rulers. We also find having ever any printing was associated with elevated Protestant output. Below we show that our measure of ex ante competition predicts formal institutional change, while the simple presence of printing does not.⁴⁹

The estimated relationship between competition and diffusion holds within political territories and within local geographic regions. Table 4 presents regression estimates with fixed effects for principalities and for latitude-longitude grid cells. Columns 1 and 2 restrict to principalities with at least two cities, and column 2 employs principality fixed

⁴⁷We obtain similar results examining the continuous measure of predicted “protestant”.

⁴⁸To test the hypothesis that the presence of religious establishments was a determinant of diffusion, we construct comprehensive city-level data on monasteries in each city as of 1517. We find no significant relationship between religious establishments and diffusion and that our estimates for competition are not changed when we control for these establishments. We also find that controlling for pre-reformation diffusion of Germanic humanism does not change our estimates – using as our measure publications by Johannes Trithemius, Johannes Geiler von Kaisersberg, Sebastian Brant, Jakob Wimpfeling, Johann Aventinus, and Conrad Celtis. We also observe whether a city had formal market rights as of 1517 and the number of market rights granted using data from [Cantoni and Yuchtman \(2014\)](#) that are restricted to cities located in contemporary Germany. We find no systematic relationship between the market rights and the diffusion of the Reformation in media or law. We do not report all these specifications.

⁴⁹We report standard errors clustered by historical principalities. Standard errors are almost unchanged if we do not cluster at the territorial level. Historical territories are mapped in Figure 1 and discussed in the appendix. We present estimates clustering on administrative units despite having a number of units with just one observation. Below we present results clustering on alternative geographic units and adjusting standard errors with the wild bootstrap methodology of [Cameron et al. \(2008\)](#).

Panel A: Dependent Variable is Ln of Protestant 1518-1554 - OLS Regression							
	Protestant	Protestant	Protestant	Protestant	Protestant	Protestant	Protestant
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firms 1508-1517	0.37*** (0.04)	0.34*** (0.06)	0.22** (0.09)	0.19** (0.08)	0.18** (0.08)	0.17** (0.07)	0.18** (0.07)
Firms 1508-1517 x Lord Rule					0.44*** (0.14)	0.32** (0.13)	0.33*** (0.12)
Indicator: Lord Rule			0.14 (0.30)	0.03 (0.29)	-0.18 (0.32)	-0.17 (0.31)	-0.06 (0.31)
Latin Media pre-1517			0.06 (0.07)	0.04 (0.05)	0.00 (0.04)	0.00 (0.04)	0.00 (0.04)
Vernacular Media pre-1517			0.24 (0.17)	0.24* (0.14)	0.30* (0.15)	0.29** (0.14)	0.28** (0.13)
Religious Media pre-1517			1.43** (0.63)	-1.01 (0.92)	1.26** (0.58)	-0.49 (0.92)	-0.37 (0.94)
Indicator: Hanseatic			0.11 (0.27)	0.16 (0.25)	0.14 (0.26)	0.17 (0.25)	0.19 (0.29)
Distance to Wittenberg			0.00 (0.11)	-0.03 (0.10)	-0.00 (0.11)	-0.03 (0.11)	-0.11 (0.12)
Indicator Pre-1517 Printing				1.69*** (0.54)		1.25** (0.56)	1.13** (0.57)
Population at 1500		Yes	Yes	Yes	Yes	Yes	Yes
Latitude, Longitude							Yes
Observations	191	191	191	191	191	191	191

Panel B: Dependent Variable is Count of Protestant 1518-1554 - Negative Binomial Regression							
	Protestant	Protestant	Protestant	Protestant	Protestant	Protestant	Protestant
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firms 1508-1517	0.72** (0.34)	0.55* (0.28)	0.41* (0.23)	0.22*** (0.06)	0.45*** (0.12)	0.28** (0.13)	0.25*** (0.07)
Firms 1508-1517 x Lord Rule					1.17*** (0.34)	0.41 (0.48)	0.32 (0.21)

Table 3: City level regressions of Protestant media on pre-Reformation firms. Panel A estimates OLS regressions. Panel B estimates negative binomial regressions and uses the same sets of controls. “Firms 1508-1517” is the number of firms active 1508-1517, from publications data. “Latin Media pre-1517” and “Vernacular Media pre-1517” are measured in hundreds of titles. “Religious Media pre-1517” is the share of titles on religious topics. Distance to Wittenberg is measured in hundreds of kilometers. Population in 1500 is controlled for with fixed effects for bins: unknown (omitted), 1000-5000, 6000-1000, 11000-25000, 26000+. “Latitude, Longitude” controls for individual and interaction effects. Standard errors clustered on territorial principality. Significance at the 99%, 95%, and 90% levels denoted “***”, “**”, and “*”.

effects. In this subset of the data the magnitude of the relationship between firms and protestant content is larger than in the baseline, with and without fixed effects. This is because the set of places located in principalities with two or more cities excludes almost all free cities, so we recover a slope for cities subject to feudal lords. In columns 3 and 4,

we re-examine the complete sample by grouping cities into grid cells of approximately 220 km by 220 km (2-degree by 2-degree). Within these grid cells, we find the relationship between ex ante competition and subsequent diffusion is very similar to our baseline results without region fixed effects (see Table 3).⁵⁰

Dependent Variable is Ln Count of Protestant 1518-1554 - OLS Regression				
	Sample: Principalities with 2+ Cities		Sample: All Cities	
	(1)	(2)	(3)	(4)
Firms 1508-1517	0.76** (0.29)	0.74* (0.40)	0.22*** (0.06)	0.20*** (0.06)
Firms 1508-1517 x Lord Rule				0.35** (0.16)
Cluster Definition	Principality	Principality	Grid Cell	Grid Cell
Cluster Fixed Effects		Yes	Yes	Yes
Observations	101	101	191	191

Table 4: Regressions with fixed effects for principalities and for geographic regions. “Firms 1508-1517” is the number of firms active 1508-1517, from publications data. All regressions use the complete set of controls from Table 3, excluding latitude, longitude, and distance from Wittenberg. Standard errors are clustered on principality in columns 1 and 2 and on latitude-longitude grid cells in columns 3 and 4. Significance at the 99%, 95%, and 90% levels denoted “***”, “**”, and “*”. Grid cells are 2-degrees by 2-degrees.

The baseline results embody an underlying nonlinear relationship between the number of firms and diffusion. Table 5 documents nonlinearities by introducing quadratic terms. Table 5 also shows that the results hold dropping Wittenberg or excluding the cities with 10+ printers from our analysis and that the significance of our estimates holds when we cluster standard errors using the wild bootstrap methodology of Cameron et al. (2008).⁵¹ Figure 6 documents the nonlinearity more flexibly, plotting the local polynomial regression estimate of the relationship between residual Protestant media and the number of firms active before the Reformation. Figure 6 shows that the marked increase in Protestant content that is unexplained by other observables occurs for cities moving from 1 to 2 firms, suggesting variations in market structure mattered.

To study how measurement error may influence our estimates and where the important variation lies, we examine the measure of firms coded from biographical data (Reske 2007). Table 6 shows that the relationship between initial 1508-1517 the number of firms and the subsequent diffusion of Protestantism strengthens when we use the alternate biographical measure as the explanatory variable or as an instrumental variable (IV) for

⁵⁰The appendix provides the number of towns in each principality and discusses the decentralized nature of governance within principalities. The 191 cities in the sample are located in 29 grid cells.

⁵¹The cities with more than 10 printers are Augsburg, Basel, Köln, Nürnberg, and Strasbourg.

Dependent Variable is Ln Count of Protestant 1518-1554 - OLS Regression						
	Baseline Sample		Exclude Wittenberg		Exclude if 10+ Firms	
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.20**	0.64***	0.17**	0.59***	0.47***	1.39***
Clustering SE	(0.08)	(0.13)	(0.07)	(0.10)	(0.13)	(0.47)
Wild Bootstrap p-value	(0.03)	(0.00)	(0.05)	(0.00)	(0.00)	(0.01)
Firms Square		-0.03***		-0.02***		-0.17**
Clustering SE		(0.01)		(0.00)		(0.07)
Wild Bootstrap p-value		(0.00)		(0.00)		(0.04)
Indicator Pre-1517 Printing	1.60***	0.88	1.27**	0.61	0.94	0.23
Clustering SE	(0.54)	(0.55)	(0.60)	(0.60)	(0.57)	(0.61)
Wild Bootstrap p-value	(0.01)	(0.11)	(0.06)	(0.32)	(0.09)	(0.73)
Observations	191	191	190	190	186	186

Table 5: Regressions documenting nonlinearity and robustness. “Firms 1508-1517” is the number of firms active 1508-1517, from publications data. All regressions use the complete set of controls from Table 3. Significance at the 99%, 95%, and 90% levels denoted “***”, “**”, and “*”, using standard errors clustered on territorial principality. Wild bootstrap p-values are estimated using the methodology of [Cameron et al. \(2008\)](#).

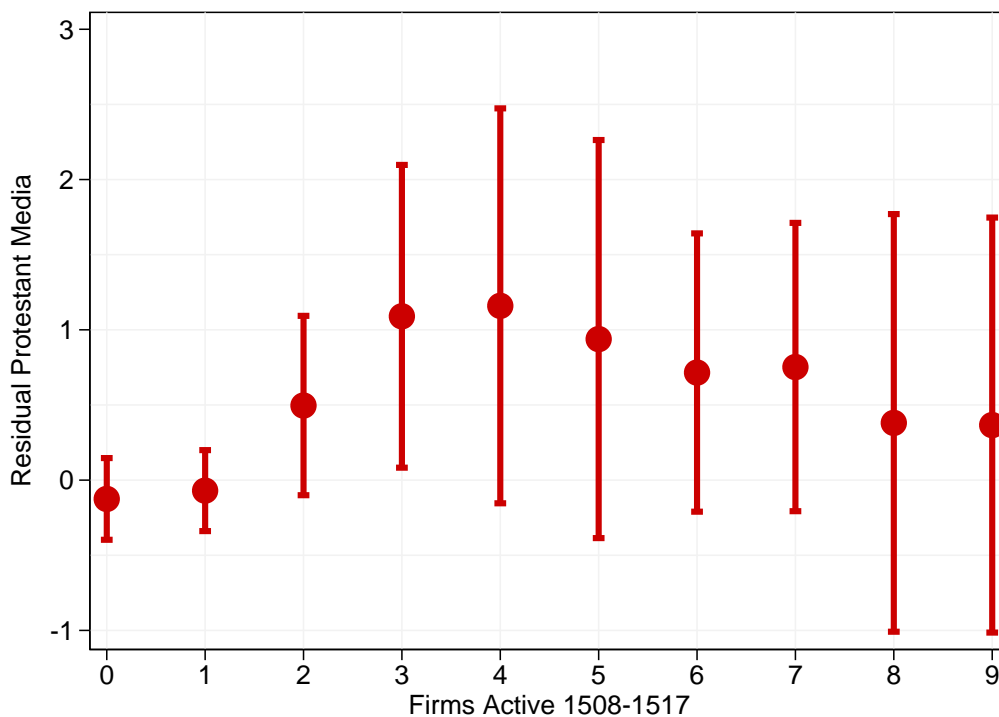


Figure 6: Local polynomial regression estimate of the relationship between residual Protestant content 1518-1554 and firms active 1508-1517, measured from publications data. Residual Protestant media 1518-1554 is estimated with OLS, conditional on the complete set of city observables in Table 3 except the number of firms active 1508-1517.

the measure of firms from publications. Because the publications data includes a fringe of very small producers on whom biographical data does not exist, this suggests that the important variation is not induced by minor printers who appear in just a few book inscriptions, but by variation in the number of more substantial firms.

	Dependent Variable Ln Protestant Media 1518-1554			
	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)
Firms 1508-1517 - Publications Measure	0.20*** (0.08)	0.35*** (0.13)		
Firms 1508-1517 - Biographical Measure			0.47*** (0.14)	0.40*** (0.14)
Observations	191	191	191	191
IV for Firms Measure		Biographical		Publications

Table 6: Regressions using the alternate measures of firms from publications data and from biographical data (Reske 2007). Columns 1 and 3 report OLS estimates. Columns 2 and 4 report 2SLS estimates. All regressions use the complete set of controls from Table 3. Standard errors clustered on territorial principality. Significance at the 99%, 95%, and 90% levels denoted “***”, “**”, and “*”.

Our data also allow us to test the hypothesis that the relationship between competition and diffusion changed in the mid-1500s, when war arrested the diffusion of Protestantism and a new institutional equilibrium was settled in law. Consistent with this hypothesis, Table 7 shows that the number of firms competing on the eve of the Schmalkaldic War (1546-7) does not predict variations in Protestant output under the new institutional equilibrium established with the Peace of Augsburg (1555). We estimate these specifications controlling for previous period Protestant media.⁵²

	Ln Protestant 1518-1554			Ln Protestant 1555-1599	
	(1)	(2)		(3)	(4)
Firms 1508-1517	0.27** (0.12)	0.21** (0.10)	Firms 1538-1547	-0.02 (0.13)	0.06 (0.19)
Firms 1508-1517 x Lord Rule		0.36*** (0.11)	Firms 1538-1547 x Lord Rule		0.19 (0.17)
Observations	191	191	Observations	191	191

Table 7: OLS estimates of the relationship between initial number of firms and subsequent Protestant output before and after the Schmalkaldic War of 1546-1547, using measure of firms from biographical data. All specifications control for lagged Protestant content and the complete set of controls from Table 3. Standard errors clustered on territorial principality. Significance at the 99%, 95%, and 90% levels denoted “***”, “**”, and “*”.

⁵²In the regressions examining output 1518-1554, this means controlling for publications we index as “Protestant” that appear pre-1517.

6.4 Endogeneity

The natural question is whether variations in initial competitive environments caused subsequent differences in the diffusion of Protestant ideas, or whether the variations in competition and diffusion reflect underlying differences in preferences or institutions.

We emphasize questions and research designs that address two specific types of potential endogeneity. The first question is whether the underlying but slowly evolving characteristics that led some cities to have more competitive media markets also made these cities more receptive to reformist ideas. Maybe these cities were always more open to innovation? To address this question we examine how media content responds to variations in competition induced by the chance timing of the deaths of printers, which imparted sudden shocks to industrial organization unrelated to underlying city characteristics. The second question is whether cultural ferment in newly vibrant cities in the immediate pre-Reformation period may have induced firms to differentially enter markets that would subsequently display a taste for Protestantism. Maybe the places where Protestantism diffused were taking off just before the Reformation? To address this question we consider a strategy that uses lagged competition to instrument for immediate pre-Reformation competition. These questions and designs concern two different types of potentially confounding variation. Our instrumental variables strategies isolate two correspondingly different types of variation in competition, both embodied in the measure of firms competing. Because identification using variations in competition due to printer deaths is more novel we provide further discussion of how deaths impacted competition.

The death of a master printer had a very significant impact on the local competitive environment (Dittmar 2015). Deaths had an impact because the competitive environment was characterized by a small number of firms involved in strategic behavior designed to limit entrance and competition, including collusive arrangements (Reske 2007), and because the costs of inter-city trade were very high.⁵³ Most cities with printing were served by a few firms: in the pre-Reformation period the mean printing city had 4.7 firms and the median city had 2. The deaths of printers shocked local industrial organization and prompted significant increases in entrance (Dittmar 2015). The measure of printer deaths used in the analysis is the number of deaths recorded in (Reske 2007) not more than 1 year after the last observed publication. Our measure is designed to capture the deaths of active as opposed to retired printers.⁵⁴ By construction this measure only

⁵³The costs of trade are discussed in the appendix and in (Dittmar 2015).

⁵⁴Deaths of retired printers can be taken as a placebo treatment. Dittmar (2015) assembles panel data for all firms printing in Europe 1454-1600 and documents that there were significant increases in entrance in the precise city-years in which master printers died, even controlling for the general nature of media markets in specific cities in a tight window around the year of a manager's death as captured

exists for firms (printers) observed in our biographical data (Reske 2007). For this reason, we consider the relationship between deaths recorded by Reske and both (i) our measure of firms from publications and (ii) our measure of firms from biographical data. Both relationships are statistically significant, but the latter is more precisely estimated.

The relationship between shocks and the number of firms competing is robust. We observe it in our data at the city-year level across the 1500s and in the immediate pre-Reformation cross-section.⁵⁵ In our complete data (1454-1600) we observe statistically significant increases in entrance and in the number of firms competing in the precise city-year in which a manager death is observed. This relationship holds controlling for the overall business environment in a given city in that time period as absorbed in city-decade fixed effects (we report this in the appendix). Figure 7 plots regression estimates of the relationship between firms competing and leads and lags of printer deaths within-city, controlling for time and city fixed effects.

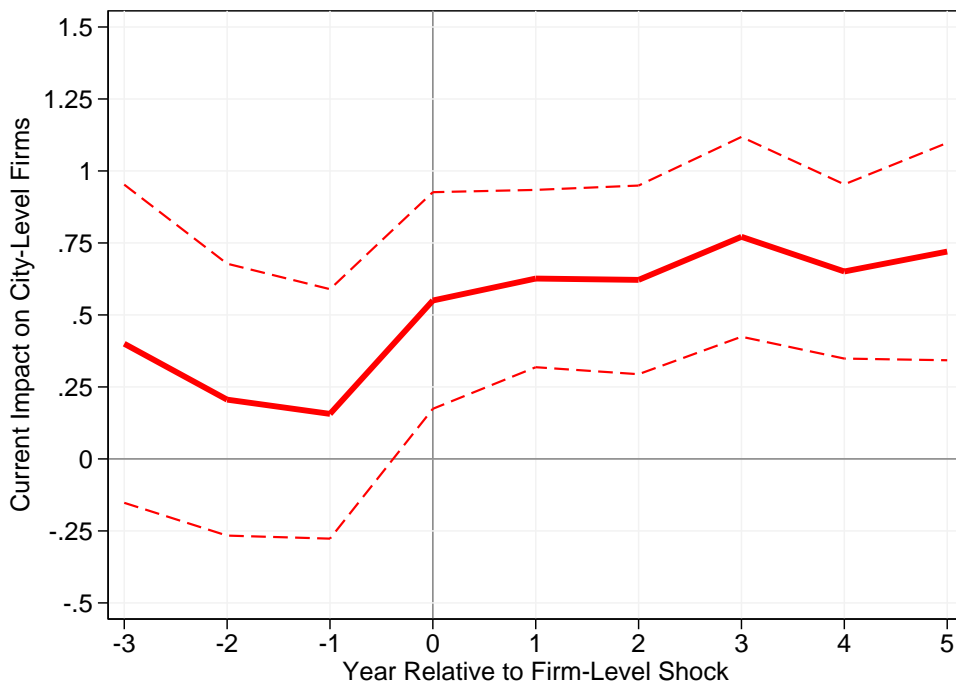


Figure 7: Regression estimates of the relationship between the number of firms active at the city-year level and leads and lags of within-city printer deaths, controlling for city and time fixed effects. The basic specification is: $firms_{it} = \alpha death_{it} \sum_{s_1=1}^5 \beta_{s_1} death_{i,t-s_1} + \sum_{s_2=1}^5 \beta_{s_2} death_{i,t+s_2} + \theta_i + \delta_t + \epsilon_{it}$, and uses publication data for firms.

In the immediate pre-Reformation period we similarly find that cities with a printer

by city-cross-five-year-period fixed effects. However, Dittmar (2015) is only able to examine the subset of deaths recorded for surviving firms in book inscriptions. This is because existing evidence does not allow us to replicate the information in Reske (2007) outside Germany.

⁵⁵Dittmar (2015) documents this relationship in city printing industries across European economies.

death in the period experienced a net increase in the number competing firms. Figure 8 presents the raw data in graphical form to show how cities in which printers died on the eve of the Reformation saw more growth (lower declines) in the number of firms serving their markets.⁵⁶

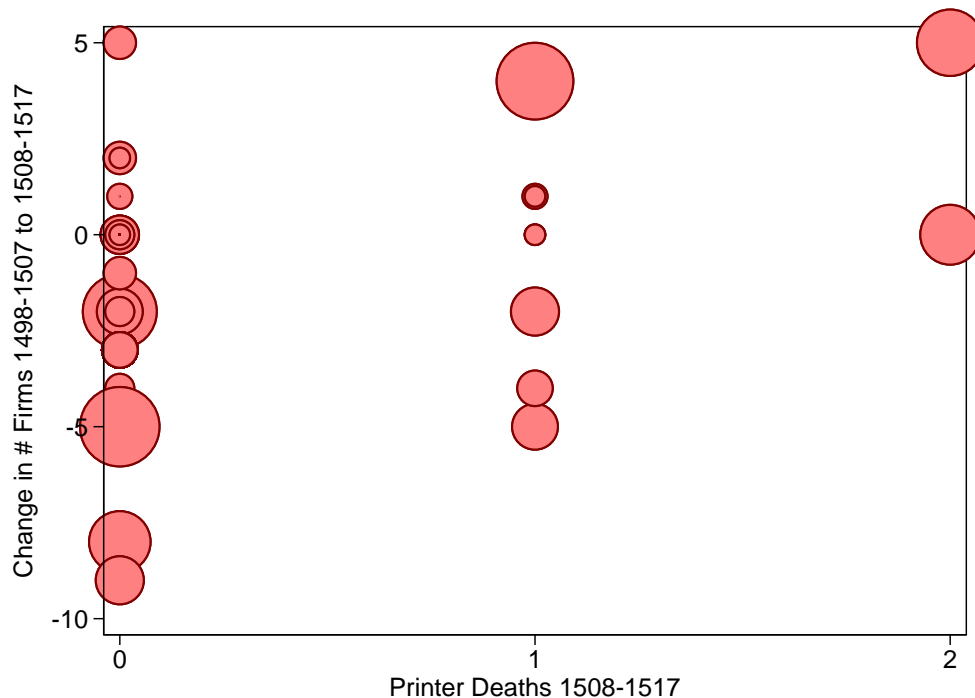


Figure 8: Change in number of firms active between 1508-1517 against the number of observed deaths of master printers 1508-1517. Change in the number of firms calculated as the number active 1508-1517 less the number active 1498-1507, measured from publication data. Markers are scaled to reflect the number of firms active 1498-1507.

Using printer deaths and lagged firms as sources of plausibly exogenous variation, we find significant positive relationship in the number of firms and diffusion of Protestant content. Table 8 documents the relationship between firms competing and the logarithm of Protestant output, using the measure of firms from publications and from biographical data (Reske 2007). Variations in the number of firms induced by manager deaths are associated with quantitatively very large output effects – over 100% – while variations induced by the long-run competitive structure of a city’s media markets are associated with an increase in output of approximately 44% in our publications data, almost exactly the same as when we instrument using the Reske (2007) measure of firms as the IV (above). When we examine the biographical measure of firms we have similar results,

⁵⁶Consistent with social history evidence, we find deaths of retirees have no significant relationship on variations in competition or on Protestant media. We also find no systematic evidence suggesting that new entrants were acquiring their printing press equipment from the firms experiencing the death, in the over 200 individual instances where Reske (2007) records how printers acquired their machinery.

but greater precision and more decisively cannot reject overidentifying assumptions. The fact that variations in firms due to deaths are associated with a larger effect on subsequent Protestantism than variations in firms explained by past industrial structure may reflect underlying heterogeneity in the variation we study. A large body of evidence suggests that printer deaths were very large shocks to local media markets that led permanent changes in industrial organization. In addition, deaths changed the age composition of firm owners. This is relevant because even within cities we find that younger firms were conditionally more likely to produce Protestant media than otherwise similar older firms. In contrast, the IV estimates using past industrial structure recover precisely the effects of variations in competition that were not changing over the immediate pre-Reformation period. It is also possible that we observe deaths selectively in the sorts of cities that were ex ante predisposed to innovation in religion. While we cannot rule this out definitively, we observe no relationship between the city-level rate of printer deaths in earlier periods and death rates in this key period and the key identifying assumption is that the timing of premature death is effectively random.

Panel A: 2SLS Dependent Variable Ln Protestant Media 1518-1554						
	Data on Firms from Publications			Data on Firms from Biographies		
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	1.67** (0.74)	0.47*** (0.15)	0.56*** (0.16)	1.27*** (0.16)	0.95*** (0.28)	1.03*** (0.24)
Observations	191	191	191	191	191	191
F Statistic on IV	6.51	16.60	10.53	101.43	8.76	119.50
Hansen's J p-value			0.11			0.35
IV for Firms 1508-1517						
Deaths 1508-1517	Yes		Yes	Yes		Yes
Firms 1498-1507		Yes	Yes		Yes	Yes

Panel B: First Stage Dependent Variable Firms 1508-1517						
	Data on Firms from Publications			Data on Firms from Biographies		
	(1)	(2)	(3)	(4)	(5)	(6)
Deaths 1508-1517	0.97** (0.38)		0.97** (0.38)	1.06*** (0.11)		1.06*** (0.11)
Firms 1498-1507	0.71*** (0.15)	0.70*** (0.17)	0.71*** (0.15)	0.52*** (0.14)	0.54*** (0.18)	0.52*** (0.14)

Table 8: 2SLS estimates of relationship between initial firms and the diffusion of Protestantism. Dependent variable is logarithm of Protestant titles 1518-1554. Columns 1-3 use the measure of firms constructed from publications data. Columns 4-6 use the measure of firms constructed from Reske (2007). All specifications include the complete set of controls from Table 3. Standard errors clustered by territory. Significance at the 99%, 95%, and 90% levels denoted “***”, “**”, and “*”, respectively.

6.5 The Catholic Placebo and Evolution over Time

In this subsection, we document strength of the relationship between initial competition and the diffusion of Protestant media by comparing it to the relationship between initial competition and the diffusion of religious media in general. We also present evidence on the way competition interacted with geography, and how these relationships evolved.

To document how competition and geography played different roles in determining the diffusion of different types of media, the research documents the relationship between these pre-characteristics and subsequent diffusion that is (i) common across Protestant and Catholic media and (ii) specific to Protestant media alone. The empirical specification we consider documents how these relationships evolve by introducing time interactions and distinguishing between output in Protestant and Catholic varieties in a given city-year. We also document how the relationship between distance from Wittenberg and the two types of religious output evolves, and how the interaction between competition and distance explains religious output over time. The estimating model is:

$$\begin{aligned}
 Y_{ikt} = & \sum_{t=1500}^{1600} \beta_t^f (D_t \cdot firms_i) + \sum_{t=1500}^{1600} \beta_t^{fp} (D_t \cdot prot_k \cdot firms_i) \\
 & + \sum_{t=1500}^{1600} \beta_t^d (D_t \cdot dist_i) + \sum_{t=1500}^{1600} \beta_t^{dp} (D_t \cdot prot_k \cdot dist_i) + \\
 & \sum_{t=1500}^{1600} \beta_t^{fd} (D_t \cdot firms_i \cdot dist_i) + \sum_{t=1500}^{1600} \beta_t^{fdp} (D_t \cdot prot_k \cdot firms_i \cdot dist_i) \\
 & + \delta_t + \theta_i + \epsilon_{it}
 \end{aligned} \tag{6}$$

The outcome Y_{ikt} is the the logarithm of the number of media varieties plus 1 in city i of religion k at time t , where we observe in each city-year an observation for $k = protestant$ and $k = catholic$ and $prot_k$ is an indicator for Protestant. The time-varying relationship between pre-1517 determinants and subsequent media diffusion is captured by interacting fixed precharacteristics like $firms_i$ (firms active 1508-1517) with annual indicators D_t . Equation (6) is estimated using OLS.⁵⁷ For estimation, the sample is restricted to cities with printing by or before 1517 and the period 1500-1599.

To summarize the results, Figure 9 plots the coefficient estimates to show the time-varying relationships between (i) competition measured by the number of firms, geographic distance from Wittenberg, and their interaction and (ii) our measures of religious media. Figure 9 documents three principal facts. First, there is a strong and persistent

⁵⁷We obtain very similar results using negative binomial regression and examining the untransformed counts of Protestant and Catholic publications.

relationship between pre-Reformation competition and post-1517 Protestant media (bottom row left panel), but there a weakly negative relationship between pre-Reformation competition and religious media in general (top row left panel). Second, there is a weakly negative relationship between distance from Wittenberg and religious media in general (top row center panel) and a weakly positive relationship between the interaction between firms and distance and religious media in general (top row right panel). Third, there is a negative relationship between Protestant media and distance to Wittenberg, but this relationship operates through the interaction between distance and pre-Reformation competition. Specifically, cities with more competitive media markets that were farther from Wittenberg produced less Protestant media (bottom row right panel). Distance by itself is weakly but positively associated with greater Protestant output (bottom row center panel).⁵⁸

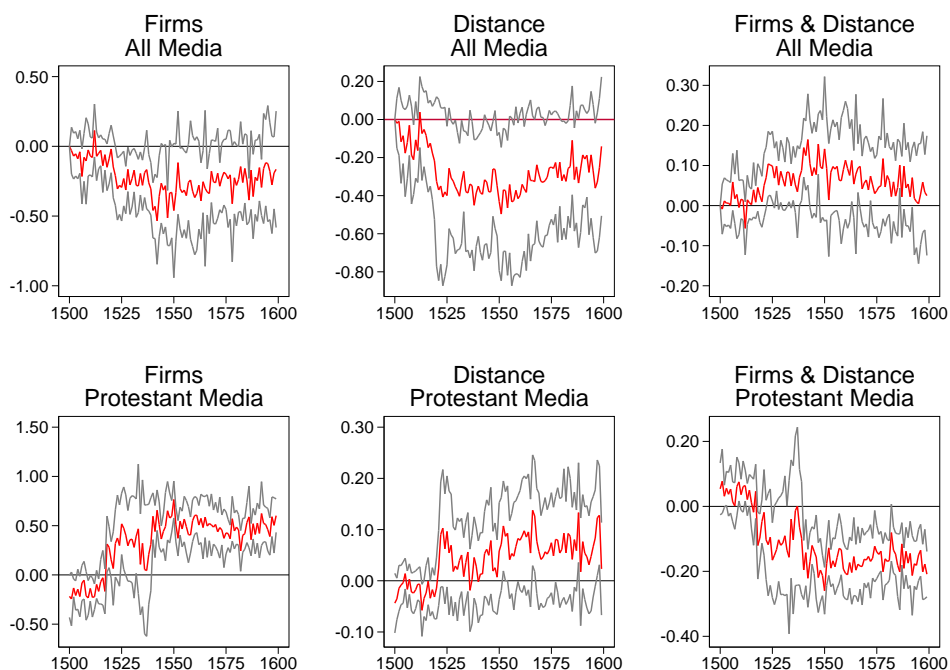


Figure 9: The time-varying relationship between the diffusion of religious media and pre-1517 city-level determinants of output. OLS regression estimates. The top row graphs report estimates of $\hat{\beta}_t^f$, $\hat{\beta}_t^d$, and $\hat{\beta}_t^{fd}$ from Equation (6). The second row reports estimates of $\hat{\beta}_t^{fp}$, $\hat{\beta}_t^{dp}$, and $\hat{\beta}_t^{fdp}$. Point estimates are in red and 95% confidence bands in gray. Standard errors are clustered at the city level.

⁵⁸It is natural to compare these findings to the identification argument in [Becker and Woessmann \(2009\)](#), which used distance from Wittenberg as an IV for Protestantism across Prussian counties. In this connection, it is important to also observe that our data include Swiss and Western German cities that were relatively far from Wittenberg and produced considerable quantities of Protestant media. Swiss and other German-speaking locations outside historical Prussia are excluded from the data in [Becker and Woessmann \(2009\)](#).

7 Institutional Change

This section presents evidence on competition and institutional change.

The Reformation was characterized by formal institutional change (Witte and Marty 2002). Over the critical first decades, the diffusion of new legal institutions was overwhelmingly an urban phenomenon (Hamm 1994; Cameron 1991). Where the reform movements were successful, legal ordinances were passed by municipal councils and city magistrates. Ozment (1975; p. 49) observes, “the pamphlet became a church ordinance.”

Figure 10 shows the number of cities passing their first Reformation law and the total number of Reformation laws passed each year. Figure 10 documents that cities’ first reformation laws are almost all observed before the Peace of Augsburg (1555).

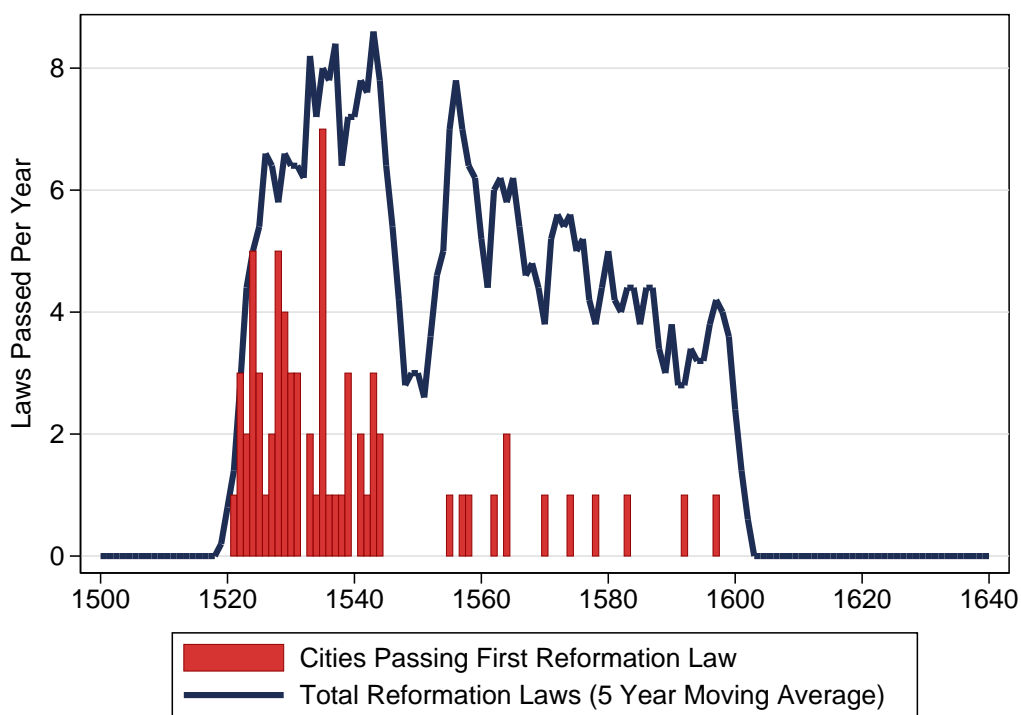


Figure 10: The city-level laws of the Reformation.

In Figure 11 we show the relative intensity of Protestant content in cities that did and did not adopt city-level Reformation laws. Prior to the Reformation, these cities were producing similar religious media and there are no pre-trends, as measured by our index. During the first years of the Reformation, Protestant content increases in all cities, but cities that pass laws produce more. From the 1520s, a gap opens and stabilizes. Figure 12 maps the geographic distribution of city-level legal reform and shows the spatial heterogeneity of institutional change.

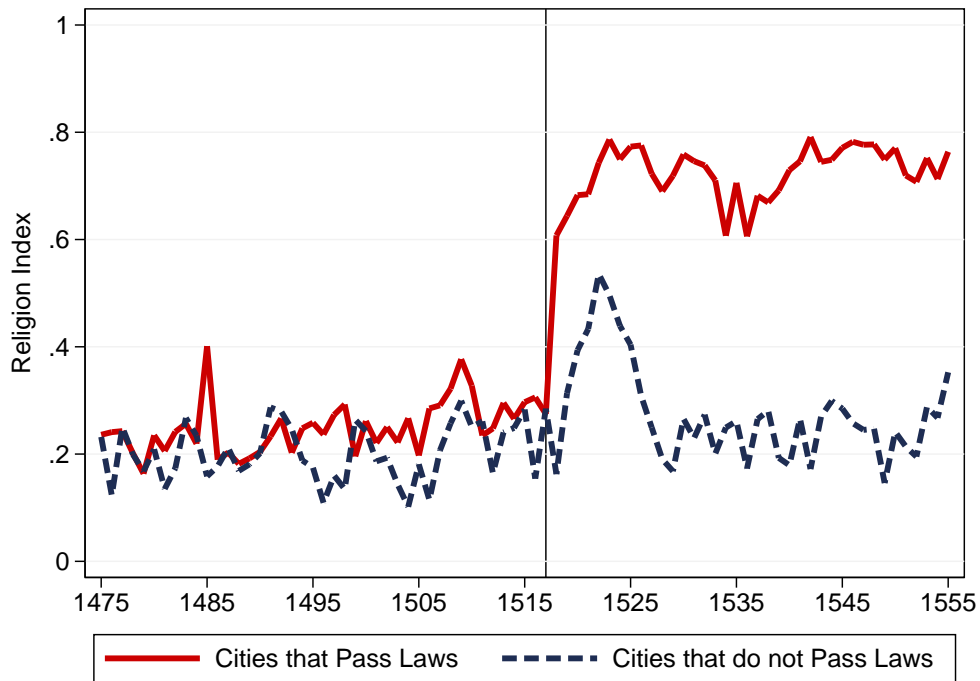


Figure 11: Mean religious content in the media for cities that did and did not reform legal institutions. “Cities that Pass Laws” institute *kirchenordnungen* 1522-1600.

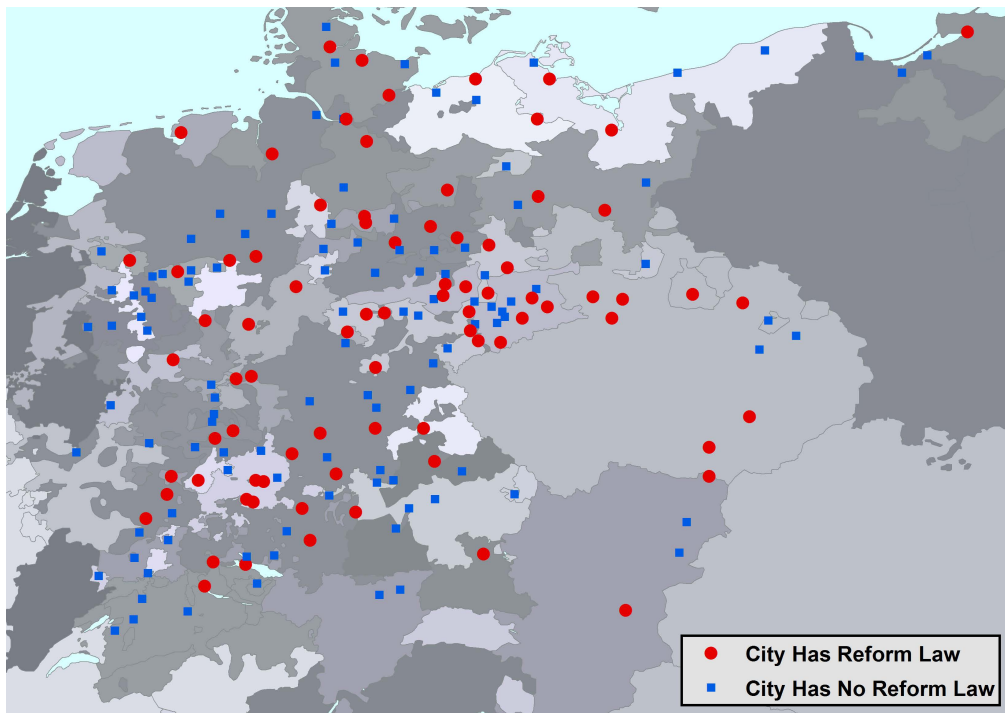


Figure 12: Cities that do and do not pass Reformation laws.

We study the relationship between market structure and institutions on the eve of the Reformation and subsequent legal change.

Consistent with evidence on Protestant content, the number of firms active pre-Reformation is a positive predictor of legal reform in cities under the jurisdiction of lords.⁵⁹ In contrast, the presence of printing pre-1517 is not a robust predictor of institutional change. Table 9 presents estimates from regressions where the dependent variable is an indicator for legal reform 1518-1555. These regressions take the form:

$$law_{i,post} = \alpha firms_{i,pre} + \beta X_{i,pre} + \epsilon_i$$

We estimate this model using 2SLS, instrumenting for our publications-based measure of firms with the measure from biographical data. Panel A shows that an additional firm was associated with a 10%-17% increase in the probability of legal reform for cities subject to lords. In contrast, the sign on the indicator for printing pre-1517 printing is negative and the parameter estimate is insignificant once we control for our full set of covariates. Columns 5 and 6 show that an additional 100 kilometers of distance from Wittenberg was associated with a 8%-10% decrease in the chance of passing a law. Panel B shows that in the complete data, including free and feudal cities, variations in initial competition are not a strong or statistically significant predictor of reform. These results support the view that relationship between initial competition and subsequent institutional change was strongest in cities with reduced institutional and policy autonomy.

The underlying relationship between competition and institutional change was non-linear. We illustrate this by estimating regressions with polynomial terms and by presenting flexible polynomial regression estimates graphically. Table 10 presents OLS regression estimates documenting the non-linear relationship between competition and firms holds in territorial cities. Figure 13 presents flexible polynomial regressions estimates documenting a sharp increase in the odds a city adopted the institutions of the Reformation if there were 2+ firms active. Figure 13 restricts to the sample of territorial cities.

To address questions about cause and effect, we also examine variations in market structure that are induced by lagged market structure and by firm-level shocks.

Table 11 presents designs that use lagged firms as an IV for initial firms. Panel A shows the relatively strong relationship between market structure and legal change observed for cities subject to lords: one extra firm is associated with roughly a 20% increase in the probability of legal reform. Panel B shows that the relationship is weaker and no longer statistically significant for complete set of cities. However, Panel C shows the precision of the estimates in the complete dataset go up and become statistically significant when we exclude the key Catholic outlier, Cologne, which was a free city with

⁵⁹In on-going research, we study the flow of exposure to Protestant content and religious change.

Panel A: Lords' Cities - Binary Dependent Variable for Reformation Law 1518-1554						
	Law	Law	Law	Law	Law	Law
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.13*** (0.04)	0.10** (0.04)	0.13*** (0.05)	0.18*** (0.06)	0.15** (0.06)	0.14** (0.06)
Latin Media pre-1517	0.05* (0.03)	0.07** (0.03)	0.06 (0.04)	0.06* (0.03)	0.05* (0.03)	0.05** (0.02)
Vernacular Media pre-1517	-0.58** (0.23)	-0.64*** (0.22)	-0.57** (0.27)	-0.57** (0.24)	-0.52*** (0.20)	-0.52*** (0.19)
Religious Share pre-1517		0.47*** (0.18)	0.86*** (0.26)	0.73*** (0.26)	0.60*** (0.21)	0.65*** (0.22)
Indicator Pre-1517 Printing			-0.29** (0.13)	-0.14 (0.13)	-0.04 (0.09)	-0.07 (0.10)
Indicator: Hanseatic				0.15 (0.09)	0.13* (0.08)	0.13 (0.09)
Distance to Wittenberg					-0.08*** (0.03)	-0.10*** (0.03)
Lat, Long, Lat x Long					Yes	Yes
F Statistic on IV	21.48	21.31	18.71	21.40	21.02	20.56
Observations	148	148	148	148	148	148

Panel B: All Cities - Binary Dependent Variable for Reformation Law 1518-1554						
	Law	Law	Law	Law	Law	Law
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.05 (0.03)	0.02 (0.03)	0.03 (0.03)	0.03 (0.04)	0.03 (0.03)	0.03 (0.03)
Observations	191	191	191	191	191	191

Table 9: Regressions with binary outcome whether or not a city adopted legal reform estimated with 2SLS. “Firms 1508-1517” is the count of firms active 1508-1517 from publications data and is instrumented with the biographical measure of firms constructed from [Reske \(2007\)](#). Distance to Wittenberg is measured in hundreds of kilometers. Latin and vernacular books are measured in hundreds. All specifications control for population in 1500 with categorical fixed effects as in previous regressions. Columns 4-7 also control for the presence of universities. Standard errors clustered at the principality level.

many printers where censorship was exceptionally successful ([Scribner 1976](#)).

Table 12 presents estimates in which printer deaths in the period 1508-1517 are the IV for firms active 1508-1517, conditional on the number of firms active in earlier periods. Using variation induced by deaths an additional firm active 1508-1517 was associated with a 15% to 20% greater likelihood of a city passing a reformation law. The first stage F-statistics suggest we potentially face a weak instruments problem, however we report these estimates as just-identified 2SLS is median-unbiased and for comparison with our results examining other sources of variation in market structure.

The combined evidence strongly supports the view that competition was a key deter-

Binary Dependent Variable for Passage of Reformation Law						
	Sample: All Cities			Sample: Lords' Cities		
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.04 (0.04)	0.02 (0.10)	0.15 (0.13)	0.14*** (0.04)	0.46** (0.17)	0.88*** (0.30)
Firms 1508-1517 Square		0.02 (0.02)	-0.03 (0.03)		-0.20** (0.07)	-0.41** (0.16)
Firms 1508-1517 Cube		-0.00 (0.00)	0.00 (0.00)		0.03*** (0.01)	0.06** (0.02)
Territory Fixed Effects			Yes			Yes
Observations	191	191	191	148	148	148

Table 10: Regression estimates testing for non-linear relationship between initial firms and legal reform. Firms measured from biographical data. All specifications include the complete set of controls from Table 3 and cluster standard errors at the principality level.

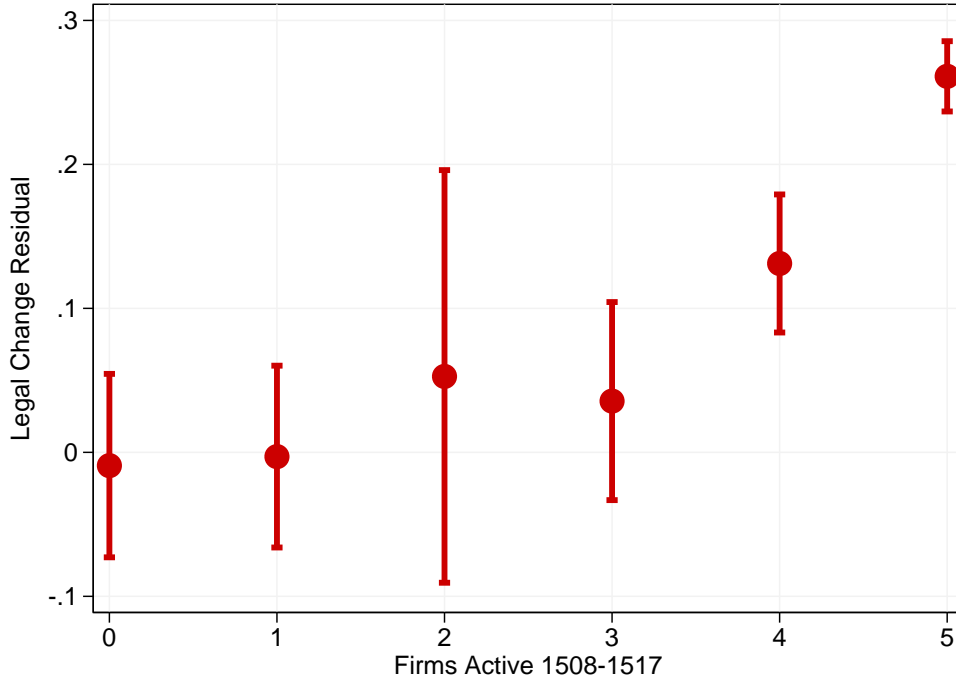


Figure 13: Local polynomial regression estimate of the relationship between residual legal change 1518-1554 and firms active 1508-1517. The sample is restricted to territorial cities. Firms are measured from biographical data. Residual legal change is estimated with OLS conditional all city observables from Table 3 except firms active.

minant of institutional change. The narrative historical record, regression estimates that document the non-linear relationship between market structure and legal change, and by instrumental variable designs that isolate plausibly exogenous variations in market structure – all point in the same direction.

Panel A: Lords' Cities - Binary Dependent Variable for Reformation Law 1518-1554						
	Law	Law	Law	Law	Law	Law
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.18*** (0.07)	0.13* (0.07)	0.19** (0.09)	0.31** (0.15)	0.22* (0.12)	0.19* (0.11)
Latin Media pre-1517	0.04 (0.03)	0.06** (0.03)	0.04 (0.04)	0.04 (0.03)	0.04* (0.02)	0.04** (0.02)
Vernacular Media pre-1517	-0.55*** (0.15)	-0.61*** (0.17)	-0.52** (0.20)	-0.54*** (0.17)	-0.48*** (0.14)	-0.46*** (0.13)
Religious Share pre-1517		0.47** (0.18)	0.89*** (0.26)	0.75*** (0.25)	0.62*** (0.21)	0.65*** (0.21)
Indicator Pre-1517 Printing			-0.32** (0.15)	-0.18 (0.14)	-0.06 (0.10)	-0.08 (0.10)
Indicator: Hanseatic				0.09 (0.10)	0.10 (0.08)	0.11 (0.08)
Distance to Wittenberg					-0.07** (0.03)	-0.09*** (0.03)
Lat, Long, Lat x Long						Yes
F Statistic on IV	29.24	29.19	25.50	18.20	17.21	16.65
Observations	148	148	148	148	148	148

Panel B: All Cities - Binary Dependent Variable for Reformation Law 1518-1554						
	Law	Law	Law	Law	Law	Law
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.13 (0.08)	0.07 (0.07)	0.08 (0.08)	0.09 (0.08)	0.08 (0.06)	0.07 (0.05)
F Statistic on IV	10.43	10.36	8.75	9.24	9.57	9.46
Observations	191	191	191	191	191	191

Panel C: All Except Cologne - Binary Dependent Variable for Reformation Law 1518-1554						
	Law	Law	Law	Law	Law	Law
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.13*** (0.05)	0.06 (0.04)	0.08* (0.04)	0.08* (0.05)	0.07* (0.04)	0.07** (0.03)
F Statistic on IV	14.13	14.32	12.42	13.01	13.38	13.82
Observations	190	190	190	190	190	190

Table 11: Estimates of the relationship between pre-reformation firms and legal reform, instrumenting for firms with lagged firms. The outcome is a binary variable for whether or not a city ordinance was passed 1518-1554. “Firms 1508-1517” is the count of firms active and is instrumented with its lag (“Firms 1498-1507”), measured from biographical data. Controls, standard errors, and significance are as in Table 9.

8 Conclusion

The Protestant Reformation is widely considered a canonical example of the way breakthroughs in information technology may drive large scale social change. The Reformation was the first mass movement to exploit the printing press as a media technology. Using

Binary Dependent Variable for Reformation Law 1518-1554						
	Law	Law	Law	Law	Law	Law
	(1)	(2)	(3)	(4)	(5)	(6)
Firms 1508-1517	0.22*** (0.07)	0.15** (0.07)	0.16** (0.08)	0.18* (0.09)	0.18 (0.11)	0.17* (0.09)
Latin Media pre-1517	-0.06 (0.07)	-0.04 (0.06)	-0.05 (0.06)	-0.04 (0.06)	-0.04 (0.05)	-0.04 (0.05)
Vernacular Media pre-1517	-0.11 (0.09)	-0.06 (0.08)	-0.06 (0.09)	-0.08 (0.10)	-0.07 (0.11)	-0.06 (0.09)
Religious Share pre-1517		0.57*** (0.15)	0.69*** (0.20)	0.56** (0.22)	0.48** (0.21)	0.53** (0.21)
Indicator Pre-1517 Printing			-0.09 (0.11)	0.04 (0.13)	0.11 (0.13)	0.08 (0.12)
Indicator: Lord Rule				-0.06 (0.08)	-0.20*** (0.07)	-0.20*** (0.07)
Indicator: Hanseatic				0.08 (0.06)	0.05 (0.06)	0.06 (0.07)
Distance to Wittenberg					-0.09*** (0.03)	-0.11*** (0.02)
Lat, Long, Lat x Long						Yes
F Statistic on IV	5.04	5.48	5.64	4.52	5.86	5.93
Observations	191	191	191	191	191	191

Table 12: 2SLS estimates of the relationship between pre-reformation firms and legal reform, instrumenting for firms with printer deaths. The binary outcome is whether or not a city ordinance was passed 1518-1554. “Firms 1508-1517” is the count of firms active in a city 1508-1517 and is instrumented with printer deaths 1508-1517. Controls, standard errors, and significance are as in Table 9.

this technology, the reformist movement introduced new forms of religious competition and delivered profound changes in institutions and beliefs. No previous research has documented the diffusion of Protestant ideas in the media in quantitative terms or the relationship between media market competition and diffusion.

We assemble data on the universe of known books and pamphlets printed in Germany-speaking Europe and construct a measure of religious content using methods for high dimensional data. We apply the measure to study the determinants of the diffusion of the Reformation in the media and in law across cities in central Europe.

Our key findings suggest that the diffusion of the Reformation was not driven by information technology acting alone. We find that competition in media markets mattered. In the cities where political freedom was most limited – where the legal prerogatives of authoritarian rulers were greatest – competition and openness in the media delivered their biggest effects.

We emphasize that on a topic as large and complex as the Reformation, our findings may be taken as a contribution to and motivation for further research, including work that may speak more fully to the dynamics of belief, the nature of Protestant and Catholic social movements and networks, and institutional design at the local level.

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