New Media, Firms, Ideas, and Growth: European Cities After Gutenberg

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Abstract

Gutenberg's printing press was the great revolution in Renaissance information technology. This paper presents new evidence on media markets, knowledge transmission, and city growth across Europe 1450-1600. The paper constructs comprehensive firm-level panel data on the number and subjects of book titles printed each year by the 7,000+ printing firms operating in over 300 European cities 1450-1600. Information from historical books is used to identify the dates at which printers died prematurely and management control of their firms passed to widows or heirs. Firms where managers died prematurely experienced large negative shocks to output. However, at the city-level manager deaths were associated with significant increases in (i) entrance and (ii) production by incumbent firms with product line specializations similar to that of the firm losing its manager. On net, manager deaths increased competition and city-level output. The variation in city-level supply induced by heterogeneous manager deaths is used to identify the impact of print media on city-level population growth. Local access to printed merchants' manuals used in business education was particularly associated with growth. New micro data on book prices document the inter-city trade costs that generated local spillovers.

Keywords: Information Technology, IO, Print Media, Growth, History.

JEL Classification: N13, N33, N93, O11, O18, O33

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1 Introduction

Gutenberg's printing press was the great revolution in Renaissance information technology. Historians argue that the printing press was one of the most important innovations in human history (Braudel 1979; Eisenstein 1979; Gilmore 1952). Roberts (1996, p. 220) suggests the outcome was one, "dwarfing in scale anything which had occurred since the invention of writing."

Economists have struggled to identify the impact of the printing press in macroeconomic data on productivity, output per person, or real wages. While printing is recognized as one of the great information technologies in history, economic research has not documented the dynamics of emergent media markets, the content of print media, or the channels through which the media may have impacted the broader economy.[1]

This paper examines the print media revolution from a new perspective by constructing and analyzing firm-level data on book production across Europe 1450-1600. This paper constructs the first comprehensive firm-level database on the production of books during the European Renaissance. The data form an annual panel from the universe of known books printed 1450-1600: 300,000+ titles printed by over 7,000 firms in 300+ European cities. Producing these data is the first contribution of the research.

The firm-level data are used to identify supply shocks and competitive dynamics at the firm and city level. In particular, the data are used to document (i) the precise timing of the deaths of firm managers, (ii) firm-level heterogeneity in output and in firm-level responses to shocks, and (iii) the impact of print media on human capital accumulation and city population growth.

To identify shocks to firm and city level supply, this paper constructs firm-level data on the precise timing of manager deaths. In a subset of firms, master printers died "prematurely" – that is, without grown sons ready and able to assume management control of their firms. These premature printer deaths led to management transitions in which widows and non-son heirs took control of firms. The data I construct identifies the dates when printers died from information recorded on the title pages of historical books. By the mid-1500s over 6% of titles were being produced by widows and heirs.[2]

[1] Dittmar (2011) shows that cities where printing presses were established in the infant industry era (1450-1500), subsequently grew faster than similar cities which were not early adopters. Dittmar (2011) exploits the fact that printing technology was initially a trade secret and the geographic diffusion of printing from Mainz, Germany to identify exogenous variation in early adoption, but does not document the dynamics of firm-level competition or the media content (knowledge) that was associated with growth. Baten and van Zanden (2008) find that observed number of historic books produced at the macroeconomic level over was associated with simulated national-level real wages.

[2] This paper will refer to non-son heirs as "heirs." As described below, the fact that when printers

The timing of premature printer deaths is used to identify the output impact of losing a manager for the directly effected firms and the response to these management transitions observed in their local competitors.[3] The research first measures the large and significant decline in firm output caused by the premature death of a manager. It then documents the response of other firms – in particular the significant increase in entry at the city level and the large, persistent increase in city-level output observed in the precise years and cities when managers died. The nature of the city-level response is further documented using the observed heteroegeneity across firms. The data reveal that, across firms in a given city, the firms that expanded when a printer died were the ones with product line specializations most similar to that of the firm losing its manager.

The key city-level finding is that firm-level shocks increased competition and *raised* total city supply. Total city supply increased through two channels: production by new entrants and increased production by incumbent firms with product lines similar to the product line of the firm losing its manager.

To support these findings, the research constructs and analyzes a new database recording book characteristics and prices for 2,000+ historical purchases made in 42 cities over the 1500s. No previous economic research has constructed this sort of market evidence on the prices and characteristics of books during the Renaissance. The data are used to document three facts. First, the data are used to document the steep price gradient associated with inter-city import distance controlling for observable book characteristics and the overall level of book prices in a given city-year. The price gradient estimates help explain the importance of within-city competition. They also support the view of historians that local exposure to content was very highly correlated with local book production and that cities that printed books experienced local spillovers. Second, the data are used to show that in times and places with management transitions due to premature printer deaths book prices fell dramatically – even controlling for changes in quantities. This suggests that shocks to the competitive environment induced strategic price responses. Third, the data are used to estimate the relationship between book prices and city-level innovations in book supply.

Finally, this paper documents that cities with relatively more premature printer death-

died without a trained son ready and able to assume management control of his business, control passed to a widow or non-son heir is well documented in the primary and secondary literature. This paper uses the fact that the name(s) of the printer(s) managing a given firm are recorded on the title pages of 99% of historical books to identify the timing of printer deaths. Similarly, not all such deaths were strictly "premature." Some printers died at advanced ages with grown daughters but no suitable, grown sons. This paper refers to all such deaths as "premature deaths."

[3]The research thus contributes to the literature on media markets and the literature on the value of managers (e.g. Gentzkow, Shapiro, and Sinkinson 2009; Slovin and Sushka 2012; Johnson, Magee, and Nagarajan 1985; Pérez-González 2006).

s developed thicker media markets, produced more books, and experienced higher population growth over longer time horizons. Using premature printer deaths to instrument for induced supply, I find a 8% return to books in terms of city population growth 1500-1600. However, there was significant heterogeneity in the content of books, in the product specializations of firms competing in media markets, and the specializations of printers who died prematurely.

Across types of content, I find that the emerging literature on business education was uniquely associated with city growth. The business education literature consisted of chiefly of merchants manuals. Merchants' manuals were guides and textbooks that were used in the education of adolescents preparing for commercial careers and as reference texts by active businessmen.[4] Consistent with the theory, the deaths of printers who produced business education materials had a differential positive impact on both the city-level supply of business education books and city growth.

The findings in this paper suggest a several larger conclusions about firms, the value of managers, gender in the economy, and the roots of growth.

Firms matter for the identification strategy in this paper and, more broadly, because they were at heart of the printing revolution. Printing was one of the first industries to use the firm – outside guild control – as its typical organizational form.[5] Profit-seeking firms drove the diffusion of innovations in information technology and media content that characterized the print media revolution. The Romerian meta-idea that characterized the Gutenberg Revolution was not just the physical apparatus of the printing press with moveable type: it was the use of the printing press apparatus by for-profit firms producing content for emergent media markets.[6] In these media markets, the organizational form was the family firm. The social norms that constrained female entrepreneurs generated instability at the firm-level. In a historical irony, these constraints characterized a competitive environment where premature manager deaths were associated with increases in competition that had significant positive spillovers. These spillovers were associated with the diffusion of knowledge, human capital accumulation, and urban dynamism over the transition to the era of modern economic growth.

[4]This literature is known as *ars mercatoria*, meaning mercantile or commercial arts. See Dittmar (2011), Hoock (2008), and below for discussion.

[5]See Brady (1998), Febvre and Martin (1958) and further discussion below.

[6]The Korean counterfactual is as intriguing as the Chinese. Printing with movable metal type was invented in Korea before Gutenberg. Printing in Korea developed in a radically different institutional environment and, pointedly, was never capitalist enterprise. See Sohn (1998) and Park (1998).

2 Historical Background

This section provides a condensed review of the history of printing. The key facts are as follows. First, printing was from the outset undertaken by profit-seeking firms. Second, competition took place in a market setting almost entirely outside the pre-existing guild regulations. Third, printing was an enterprise characterized by substantial fixed costs and imperfect competition. Fourth, inter-city trade was characterized by high transport costs limiting intercity competition. Fifth, the characteristic form of competition was oligopolistic. Sixth, master printers had a valuable combination of skills and knowledge and business contacts. Seventh, when printers died without grown sons ready and able to assume control of their firms, this typically represented a big shock to both their firms and the competitive environment in local media markets.

1. From the outset printing was a for-profit enterprise. The first movable type printing press enterprise was established in Mainz, Germany around 1450 by Johannes Gutenberg and his business partners. The research and development for Gutenberg's printing press was financed by local capitalists and undertaken in great secrecy. Over the subsequent decades the technology diffused to cities across Europe as it was adopted by firms.[7]

2. The diffusion of printing occurred in an overwhelmingly unregulated, free market setting. The subsequent development of guild regulation was limited, uneven, and broadly late in coming. Printing with movable type was a radical break from past practice and fell outside existing guild regulations. The break through in printing was suited to and exploited by firms rather than the guilds (Brady 1998). Füssel (2005: 59) observes that into the 16th century, the business was, "free to develop without regulation by governments, princely houses or the Church, nor is there any evidence that any restrictions were imposed by guilds." Barbier (2006) and Nicholas (2003) confirm that printing fell outside the set of regulated trades and that entry was free and unregulated. Jastrebizkaja (1992) similarly observes that printers did not have to conform to guild regulations on production quantities or the length of the work day.[8] In France, regulation of printing trades was imposed only in late 1500s (Davis 1966).[9]

[7]Dittmar (2012) provides additional discussion of the key technological breakthrough and trade secret – the precise combination of alloys used to cast the movable metal type – and the pattern of technology diffusion over the period 1450-1500. The important point is that printing was a quasi-proprietary technology developed in a period when intellectual property rights were virtually non-existent.

[8]Barbier (2006: 173): "les métiers nouveaux liés à l'imprimerie ne s'insèrent pas dans le cadre des anciennes corporations...dans les faits la liberté rest tout à fait réele et les voies d'ascension ouvertes." Nicholas (2003: 125): "Trades that became large after the list of officially approved guilds was drawn up often escaped guild regulation...Printing is the most obvious example." Jastrebizkaja (1992): "Les restrictions dans la corporations concernant la taille de production et de la durée de la journee de travail ne s'appliquaient pas aux imprimeries."

[9]Gadd (2012) provides a list of book trade guilds that identifies only 14 cities with book guilds founded

3. Printing was characterized by substantial fixed costs and hence imperfect competition. There were fixed costs at the firm-level associated with establishing a printing press apparatus and at the book-level associated with securing contracts with authors and setting the type from which to print. The big fixed capital cost was the cost of moveable metal type. The process and specific combination of alloys used in casting moveable metal type was the central technological break-through in printing and remained semi-secret until 1540 when the first blueprint guide to the production process was printed (Biringuccio 1540). For those unable to manufacture movable type, the cost of a complete set of equipment in the mid-1500s was equivalent to the wages a craftsman would earn over a period of 4 to 10 years.[10] In addition, paper was expensive, printers realized returns on print runs only over time, and successful printing required a minimum efficient scale. As a result, entrepreneurial printers typically required substantial wealth or financial backing. At the book level, production required up front investments in maintaining and signing contracts with authors and in setting the type to print books.

4. The media markets that emerged with print media were characterized by the extremely high historical costs of inter-city trade. Print media was heavy and costly to transport overland. It was also fragile and in particular susceptible to damp and water damage. For these reasons it was often typical to take texts to be printed in cities with potential demand, rather than to export over even distances of a few hundred miles (Edwards 1994). Section 5 assembles new evidence on book purchases to document the price-distance gradient that characterized the Renaissance-era book trade. Here the crucial point is that in a world with very high transport costs, city-level media markets were partially sheltered from import competition and as a result local production was strongly correlated (positively) with access and (negatively) with prices.

5. The characteristic form of competition was oligopolistic. In 1550, for example, the mean city producing books had 6.1 active book-producing firms and the median city had just 2 firms. In 1550, Paris, Lyon, and Venice were the largest book producers and had several dozens of printing press enterprises, but only 14 European cities had 10 or more firms that produced books in 1550.[11]

6. Printing firms were family businesses to which the master printer brought a valuable and rare combination of skills and knowledge and business contacts. The printer was

1450-1600. Several of these guilds did not directly regulate printing. England is exceptional in having a highly regulated printing industry over the period 1450-1600. In England printing was organized under the auspices of the Stationers' Company and the King's Printers and un-authorized entry was tightly controlled. The results I report below are robust to controlling for the presence of local regulation of the book industry. The results are similarly robust to excluding England from the analysis.

[10] Dittmar (2011) provides evidence from bequests and appraisals and details for this calculation.

[11] See sections 4.1 and 6.2 for further discussion and evidence on the distribution of firms across cities.

a capitalist worker-entrepreneur: "Almost all the printers were investors, organizers, and managers of their firms." (Brady 1998) In addtion to being an entrepreneur, a master printer had to be multi-lingual, a skilled mechanic, and a flexible intellectual. In Elizabeth Eisenstein's words, the printer was: "a 'new man'...adept in handling machines and marketing products even while editing texts, founding learned societies, promoting artists and authors, [and] advancing new forms of data collection." (Eisenstein 1980)

7. The deaths of printers generated more than minor perturbations in city industrial organization. Febvre and Martin (1958) observe that the competitive environment was characterized by a generalized propensity to "savage" and "cut-throat" competition, and a "struggle to keep competition at bay." Informal agreements were often successfully used to limit competition (Pettegree 2010). In this environment, Parker (1996) observes, "It is difficult to overestimate the disruption caused by the death of a master printer."

3 Data Construction

The primary source for data on print media is the Universal Short Title Catalogue (USTC) database. The USTC is designed as a universal catalogue of all known books printed in Europe 1450-1600.[12] Figure 1 presents summary statistics on the number of cities and firms producing each decade. Figure 1 also records the number of titles printed each decade and the number of titles printed by widows and heirs.[13]

The firm-level data are constructed as follows. First, the USTC catalogue is downloaded.[14] Second, the "noisy" text string containing information on the printing city, publication year, and printer is parsed to provide separate records for city, year, and printer. This text is taken from the front pages of historical books and is noisy in the sense that the information on the printer's firm is highly non-standardized.[15] Printer names appear with variable spelling and in multiple language conventions (e.g. a French spelling and a distinct Spanish or Latin spelling for the same printer). In addition, the text string often contains complicated descriptive text in multiple languages as well as

[12]The closest competitor dataset is the Consortium of European Research Libraries' *Heritage of the Printed Book* (HPB) database (CERL 2012). The HPB is essentially a master catalog of the major national research library catalogs. However, since these catalogs are themselves incomplete for several countries the USTC provides much more comprehensive coverage. The USTC and HPB data are compared in the data appendix.

[13]These data are examined in detail below.

[14]The USTC has an on-line interface one can search for individual books or authors or cities. To collect the complete data, the entire catalogue is downloaded using a Python program.

[15]Almost all historical books identify the printer. Of the 299,578 books in Figure 1, 296,162 (98.9%) identify the printer.

Decade Starting	Cities Producing	Firms Producing	Titles Printed	Titles by Widows & Heirs
(1)	(2)	(3)	(4)	(5)
1450	3	5	5	0
1460	7	15	64	0
1470	91	370	3,385	0
1480	136	566	6,615	6
1490	128	671	9,616	0
1500	138	875	10,396	287
1510	153	888	13,926	286
1520	186	1,007	19,983	559
1530	187	1,132	20,117	332
1540	201	1,436	25,002	617
1550	209	1,785	29,538	1,822
1560	224	1,953	33,103	2,633
1570	252	2,098	32,940	2,380
1580	281	2,447	43,008	2,932
1590	312	2,480	46,525	2,304

Figure 1: Summary statistics on cities, firms, and book titles by decade. Note this table records 299,578 books. It excludes 43,407 observations on books for which the publication date is unknown and a further 15,219 observations for books printed in monasteries, small towns, and other locations not included in the database of 2,204 European cities compiled by Bairoch, Batou, and Chèvre (1988).

the non-standardized printer name. Third, the names are cleaned and standardized and books by widows and heirs are identified.

The cleaning and standardization of printer names is the key challenge in the data construction. To determine standardized printing firm names, 11,000+ non-standardized printer text strings are programmatically parsed to eliminate non-name text and identify which books are printed by widows and heirs. Widows and heirs are identified by a tremendously wide range of descriptions and abbreviations across the full range of European languages (see below for a relatively simple example).[16] This preliminary work delivers a set of clean but non-standardized names. An automated query is run to look up each of these clean but non-standardized names in the Thesaurus of early modern printers

[16]For example: "apud Jean de Foigny veuve" (a widow), "appresso haer. Francesco I Rampazetto" (heirs), "vid. Dietrich Baum" (a widow), or "en casa de la viuda de Querino Gerardo" (a widow). Some widows also printed under their own names and are not directly identified as widows, for example: "Gedruckt und volendt von Anna Rügerin in der keyserlichen stat Augspurg..." In these cases, we search for and identify the former husbands of the female managers. In the case of Anna Rügerin – the first known woman printer and operating in Augsburg, Germany in the 1480s – her husband was the printer Thomas Ruger. Cleaning these data is non-trivial and one of the significant contributions of the research.

mainted by the Consortium of European Research Libraries (CERL).[17] For each name found, the Thesaurus provides a set of variants and aliases (sometimes none, sometimes a dozen) used on the title pages of books printed by individual printer's firms. These name variants and aliases provide a first name standardization. Minor spelling errors are corrected using a program that matches names by minimizing a Levenshtein-distance metric. The names are then automatically and manually checked against digitized versions of printed bibliographic dictionaries of known historical printers (Benzing 1963; Reske 2007; Müller 1970; Gruys and de Wolf 1989; Casado 1996). To identify, father-son transitions (as opposed to transitions to widows or heirs) we similarly search for documentation of relationships in the CERL Thesaurus, the existing printed sources, and on-line. To link named women printers to their husbands, we search for each individual across all available sources.[18] To illustrate the data construction, Table 2 presents the underlying data for seven individual books produced by a single Antwerp-based printer in the mid-1500s. In the analysis below, the timing of manager deaths is taken to be defined as the first year a book by a widow or heir appears.[19]

Text String Denoting Printer Extracted from Book-Level Metadata	Standardized Printer Name #1	Widow or Heirs #1	Standardized Printer Name #2	Widow or Heirs #2
(1)	(2)	(3)	(4)	(5)
chez Martin Nutius	Martinus I Nutius			
excudebat Martinus I Nutius	Martinus I Nutius			
Martinus I Nutius ex officina	Martinus I Nutius			
vend Martin Nutius et Jean Rijekaerts	Martinus I Nutius		Jean Rijekaerts	
en casa de la vid. Martinus I Nutius	Martinus I Nutius	Yes		
vid. Martinus I Nutius	Martinus I Nutius	Yes		
apud vid. & haer. Martinus I Nutius	Martinus I Nutius	Yes		

Figure 2: Example of data construction. The table presents information for seven individual books produced by the firm of the Antwerp-based printer Martin Nutius in the mid-1500s. Each row in the table presents information from one historical book. Column 1 shows the information on printing firm available in the source data. Columns 2 to 5 presents the cleaned data from the new database used in this paper.

Data on the content of books is constructed from two principal sources. First, USTC subject codes are collected from the USTC database. The database records 37 subject codes.[20] The subjects include: art and architecture; bibles; culinary arts; educational

[17] See: http://www.cerl.org/en/resources/cerl_thesaurus/main.

[18] Most female printers are designated as "the widow of" or "heirs of" (Parker 1996). A subset of female printers published books under their own names. Here named female printers are in two independent ways: manually and using the database of names maintained by www.genderchecker.com. To form the linked firm-level panel, we search for the husbands or other predecessors of each female printer.

[19] As discussed below, this evidence allows us to identify a local average treatment effect. The data do not enable us to distinguish between firms that exit due to deaths and exits unrelated to deaths.

[20] A small number of books are assigned multiple subject codes. The USTC database is slowly but

books; games and recreations; jurisprudence; literature; medical texts; political tracts; religion; and science and mathematics. (For a complete set of subject codes see section 4.2.3 below.) The USTC subject codes are valuable but coarse. In particular, the USTC does not identify books belonging to the business education literature which historians argue was an important conduit of useful knowledge.[21] Merchants' manuals are coded from Jeannin and Hoock (1991, 1993, 2001). Jeannin and Hoock catalogue 1,151 merchants' manuals printed across Europe 1474-1600. These manuals were used specifically in business education (Hoock 1998; Dittmar 2011). Jeannin and Hoock (1991, 1993, 2001) is designed to be a comprehensive catalogue of all known merchant manuals, but misses several hundred merchants' manuals, including a large number of revised editions. These additional data are recorded manually.

Figure 3 summarizes the annual data on the production of new titles in four subject areas: education, bibles, science, and merchants' manuals. Three notable facts are: (1) a large share of books was devoted to educational topics; (2) science and merchants' manuals accounted for small but steady shares of titles; (3) there was a shock to bible production coinciding with the advent of the Protestant Reformation in 1517.[22]

The book-level unit of analysis in this paper is the book edition – defined as a given title produced in a given place and year. For the purposes of this paper different titles are considered as different varieties produced at the firm (or city) level. The use of book titles as the unit of analysis is in part dictated by the available data. We have records on the print runs for hundreds of individual books. However, we do not know the size of print runs for a sample that is sufficiently large to directly use this information in estimation. The empirical results show that titles are a meaningful measure of local exposure, consistent with the findings of social historians.[23]

For book prices the principal sources are the purchasing notebooks kept by Hernando Colón. Colón was Christopher Columbus' son and an official of the Spanish Crown. Over

continually being expanded as and when new books are discovered in previously unknown collections. This research works with the database as it was constituted in November 2011.

[21] USTC subject number 16 comprises "Economics (treatises on the economy, regulation of guilds)." This subject code encompasses a heterogeneneous range of print media, only a small subset of which consists of the business education literature historians suggest was important in the transmission of knowledge that was valuable in commercial activity.

[22] A companion paper takes the diffusion of the Protestant Reformation as its object (Dittmar and Seabold 2013).

[23] The data appendix presents data on print runs for 393 titles and documents that print runs rose from typically about 500 volumes in the 1470s to 1,000 by 1500 and 1,500 by the 1590s. A possible empirical strategy would be to estimate the relationship between the number of copies printed and book and city characteristics for those books where print run information is available. These estimates could then be used to predict the number of books per edition given the year and subject topic, in effect weighting titles by expected copies printed. I defer this exercise to draft 0.2.

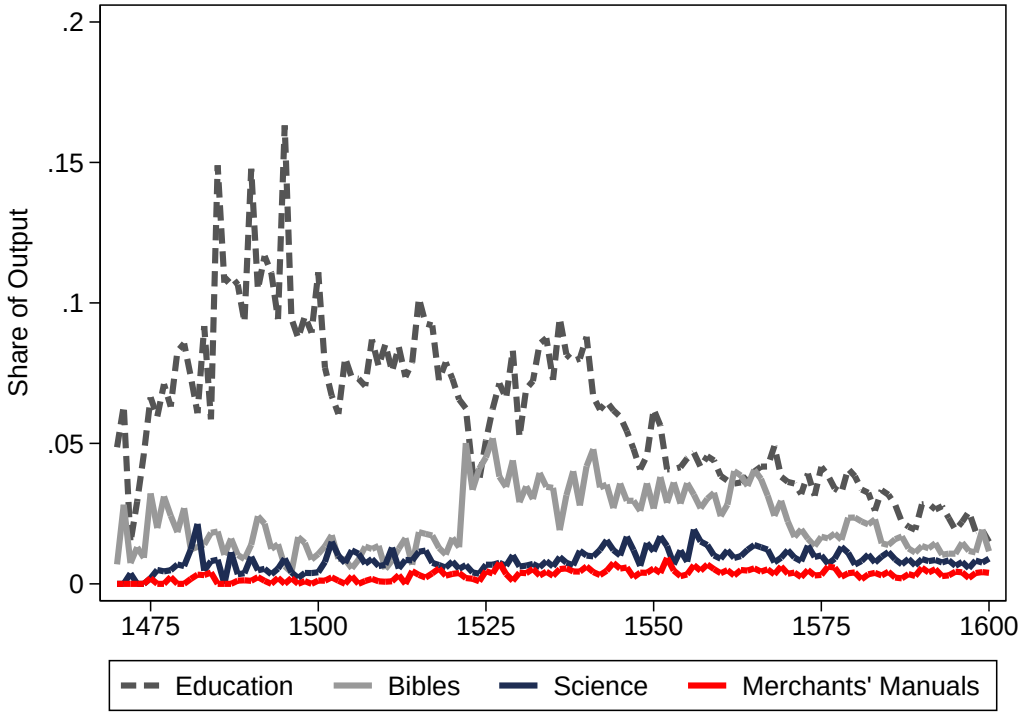

Figure 3: Annual data on the share of book titles: bibles, science, primary education, and merchants' manuals. Data are for all European cities with printing 1450-1600. Cities are the 2,204 urban places identified by Bairoch, Batou, and Chèvre (1988). Merchants' manuals are individually identified and coded as described in the text. Metadata on Education, Bibles, and Science titles are from the USTC (2012).

the period 1509-1540, Colón purchased several thousand books in 42 cities across Europe. Colón recorded the price paid for individual books in local currency and the current exchange rate in a notebook that has survived (Martínez, Asencio, Wagner 1993; Biblioteca de Huelva 2012). The data in the notebooks are to my knowledge (1) our best and most comprehensive currently available source of data on book prices and characteristics in the 16th century and (2) have not previously been used in economic research.[24]

I extract data on book prices in local historical currencies, the contemporaneous exchange rate, and book characteristics from the Hernando Colón notebooks and the archive catalogue.[25] The characteristics include the city and date where the book was

[24]The data comprise purchases made by a single individual likely known to book dealers, and thus the prices may embody knowledge about the purchasers' ability and willingness to pay. However, the wide geographic distribution of cities in which books were purchased and produced makes it unlikely that unobserved book characteristics vary systematically with export distance. I discuss the relationship between prices, distance between printing city and purchase city, and city level output in detail below.

[25]A typical example of how the notebooks record prices is as follows: "Este libro costó 8 negmit en Anvers a 29 de julio de 1531 y el ducado de oro vale 320 negmit." In my translation: "This book cost 8 negmit in Anvers [Antwerp] on July 29, 1531 when the gold ducat was worth 320 negmit."

purchased, the city and date where it was printed, the length in pages, the physical size of the pages, the format (octavo, quarto, folio, etc.), and whether there are illuminations. The catalogue also provides a subject classification that is used to identify book subject matter.[26] Price data exist for 2,145 purchases in 42 different cities. Figure 4 shows the distribution of book prices in terms of the prevailing historical wage for laborers.[27]

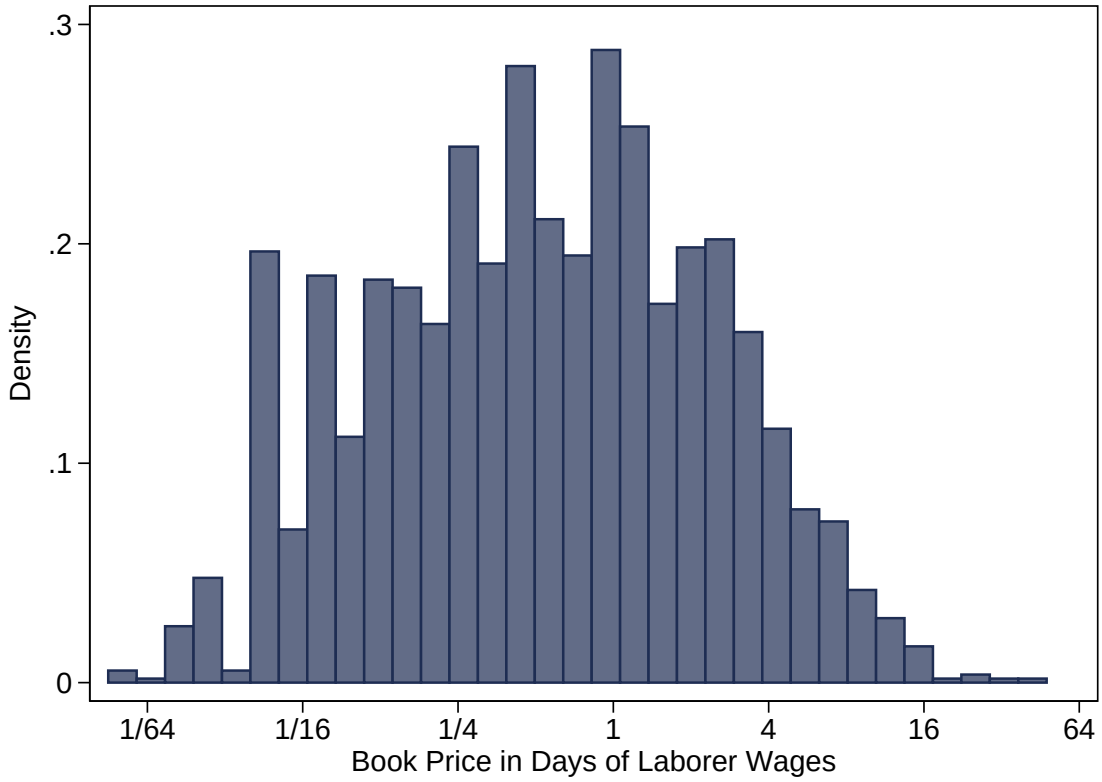

Figure 4: Distribution of book prices recorded by Hernando Colon 1510-1540. Laborer wages are computed as the mean of silver wages for laborers in Antwerp, Amsterdam, Paris, Strasbourg, Florence, Milan, Naples, Valencia, Madrid, Augsburg, Leipzig, and Vienna. See text for details.

[26] The classification includes bibles, jurisprudence, philosophy, literature, orations, poetry, theology, medicine, languages, religion, and history and legislation.

[27] To compute the value of books in laborer days, all prices are converted into gold ducat values using the historical exchange rate. Ducat values are converted into silver equivalents using the fact that between 1510-1530, the ducat and the florin traded at par and the silver content of the florin from the Global Income and Price History database. (I thank John Monro of University of Toronto for guidance on ducat-florin exchange rates.) The silver prices of books are deflated by silver laborers' wages. I take as the European laborers' wage the mean of silver wages for Antwerp, Amsterdam, Paris, Strasbourg, Florence, Milan, Naples, Valencia, Madrid, Augsburg, Leipzig, and Vienna as recorded in Allen (2012).

4 The Premature Deaths of Managers as Shocks

4.1 The Mechanism

The premature death of a master printer was a big shock to his firm and to the competitive environment in his firm's city.

The premature death of a printer typically represented a big negative shock to his firm because master printers needed a combination of skills that was hard to replace and because social norms restricted the ability of women to operate as entrepreneurs. Printers had to cultivate authors and then decide which books to market and how many copies to print – in a competitive industry where the typical firm produced few books per year and one bad business decision could be disasterous (Pettegree 2010, p. 69). Firms passing to widows and heirs faced difficulties maintaining previous levels of output, because the new managers typically did not have the human capital or business networks of their predecessors. Widows took over hundreds of printing firms, but typically faced additional constraints in managing workers and cultivating and signing contracts with authors (Driver 1998; Parker 1996; Postel-Lecocq 1998; Broomhall 2002).[28]

The death of a printer was a shock to the city-level competitive environment because media markets in Renaissance Europe were characterized by a small number of producers competing at the city level. Figure 5 documents the fact that most cities had few producers by showing the fraction of cities with 1 firm, 2-5 firms, 6-10 firms, 21-50 firms, and 51+ firms in 1510 and 1570. Over 40% of cities had 1 firm and over 40% of cities had 2-10 firms in both periods. Less than 4% of cities had more than 20 firms in both periods. A printer's death impacted competition at the city level because inter-city trade was limited by high transport costs. Section 5 (below), documents the significant price gradient associated with shipping books over even short distances.

Premature printer deaths were shocks to an environment characterized by both agreements among printers to limit competition and strategic quantity and price competition. Informal agreements to limit competition were common (Pettegree 2010). Printers also formed formal arrangements to split or share markets. These formal associations were typically for a fixed duration of several years (Parent 1974, p. 139). However, we also have archival evidence of price-fixing for specific products. For example, in 1552 four Parisian printers (Vivant Gaultherot, Poncet Le Preux, Oudin Petit, and Jean Foucher)

[28]Employment across firms varied. Even firms with a single printing press apparatus typically had one or two compositors setting the text and two pressmen – one inking the type and the other setting the paper and "pulling" the press. It was common in addition to employ apprentices, proof-readers, and family members of the master printer. See Richardson (1999), Febvre and Martin (1958).

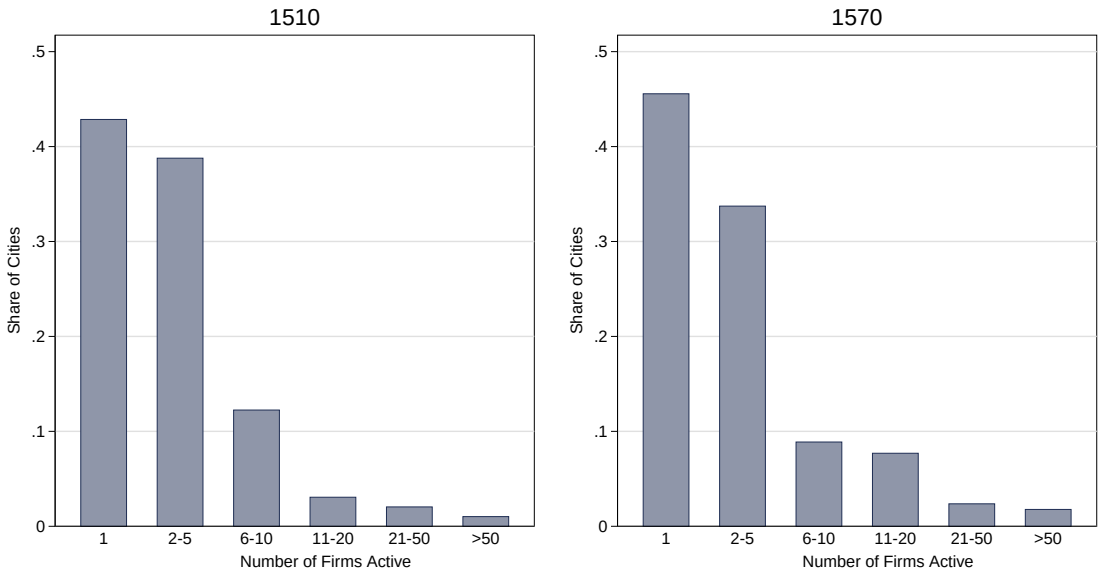

Figure 5: The distribution of the number of firms per city in cities publishing a book in 1510 (left panel) and 1570 (right panel).

signed an agreement to jointly produce an edition of Saint Thomas Aquinas, to split the books printed equally, and to maintain a price floor for all sales (Parent 1974, p.141). We also observe evidence of "price wars" and quantity competition designed to capture market share and dissuade entrance. André Wechel, a printer based first in Paris and then in Frankfurt am Main, was a leading producer for the lucrative textbook market in the later 1500s. Maclean (2009: p. 177) observes that when competitors printed school books, Wechel used a quantity competition response strategy and unleashed, "a massive and systematic onslaught...Wechel was aiming at little short of a monopoly...by putting into practice the commercial principle: if a competitor produces an edition, do the same."

The death of a printer presented incumbents and potential entrants with new, ex ante profitable incentives.[29] Consistent with the historical evidence, I show that premature printer deaths were systematically associated with significant increases in entry and in city-level output – and that the output increases that occured in the precise years when printers died were persistent. I also find that city-level prices were significantly lower in years when a printer died prematurely, even controlling for changes in quantities.[30]

[29]Occasionally premature deaths may have been business-related. Symphorien Beraud, a prominent merchant publisher, was murdered in Lyon in 1586: "according to the records that survive, this happened a day after having broken off his three-year-old commercial association in the book trade with another Lyonnais merchant publisher, Etienne Michel." (Maclean 2009, p. 227)

[30]An alternative theory could be that the output response of surviving incumbents represented something like optimal investment under uncertainty. However, theories of demand uncertainty cannot explain a key feature of the data: the fact that surviving incumbents dramatically lower prices in years when

4.2 Quantity Responses to Premature Manager Deaths

This subsection documents the impact of management transitions due to premature deaths on firm-level output, the response of city level output to these deaths, and how firm-level heterogeneity determined the competitive response to these shocks. There are three key findings. First, the death of a manager was associated with a large and significant negative shock to output at the firm level. Second, when a manager died, competing firms located in the same city responded by dramatically increasing their output. Third, when a manager died, the competitive response was largest for firms with product line specializations similar to the specialization of the firm losing its manager. The response was effectively non-existent for firms with entirely different product lines.

4.2.1 The Impact of a Manager Death on the Manager's Firm

In years when firm managers died, their firms' output fell significantly – by at least 1/4. The firm-level estimating framework in this section documents the relationship between manager deaths and firm output, controlling for time-invariant firm productivity and the general level of output at any given time and place. The identifying variation is thus variation induced by the loss of a manager controlling for variations in overall business conditions in local media markets. A baseline estimating equation is:

$$\ln titles_{ijt} = \alpha death_{it} + \theta_i + X'_{jt}\beta + \delta_{it}^{pre} + \delta_{it}^{post} + \epsilon_{it} \quad (1)$$

Here i indexes firms, j indexes cities, and t indexes time. The parameter of interest is α, which captures firm-level variation in output ($titles$) associated with a management transition due to a premature printer death ($death$). The θ_i is a firm fixed effect. The vector X controls either for city j and year t as separate fixed effects or as interacted city-year fixed effects. The δit capture pre- and post-trends.

Figure 6 documents the relationship between management transitions due to printer deaths and book title output at the firm level. Column (2) show that manager deaths were associated with a 24% decline (-0.28 log points) in firm output. Column (3) shows that this result is robust to controlling for firm level trends before and after manager deaths – and that after a manager died firms experienced further declines in output. Column (4) restricts the analysis to firms that were exposed to manager deaths and adds city cross five year period fixed effects. In Column (5) the estimation is restricted to identify variation within firms and within city-years. As we would expect, by restricting

one of their local competitors experiences a management transition. I discuss the price data below.

	All Firms		Firms with Transitions		
Regression Variables	Ln Titles	Ln Titles	Ln Titles	Ln Titles	Ln Titles
(1)	(2)	(3)	(4)	(5)	(6)
Printer Death	-0.28***	-0.29***	-0.28***	-0.40***	-0.40***
	(0.04)	(0.04)	(0.05)	(0.08)	(0.08)
Trend		0.01***	-0.00	-0.03**	-0.02
		(0.00)	(0.01)	(0.01)	(0.01)
Post Death Trend		-0.01*	-0.03***	-0.03***	-0.05***
		(0.00)	(0.01)	(0.01)	(0.01)
Trend Squared					-0.00
					(0.00)
Post Death Trend Squared					0.00**
					(0.00)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes			
City x 5 Year Period FE			Yes		
City x Year FE				Yes	Yes
Observations	53514	53514	7230	7230	7230

Figure 6: Premature printer deaths and firm-level book production. Firm-level output is measured by the number of titles published per year. Standard errors are clustered at the firm level for columns (2) and (3), and at the city-cross-time level in columns (4) to (6). The sample restricts to firms with at least two years of data.

to within city-year variation we obtain an even stronger signal on manager deaths: a 32% decline (-0.4 log points) in output.

Figure 7 further documents the fact that for firms exposed to a printer death in period $t = 0$ the large and sharp decline in output occurs only in the period when the manager dies and not before. To document this fact, Figure 7 presents the parameter estimating the relationship between current firm-level output and leads of printer death variable, in effect documenting the assocation between output today and a manager's death tomorrow. Thus the the estimates for periods $t < 0$ can be taken as placebos and the decline in period $t = 0$ is the parameter estimate from Figure 6 (above). While the big output shock comes in the period when the manager dies, there appears to be some decline in output in the years running up to the death. This is consistent with a manager's productivity declining with age and/or towards the end of life.

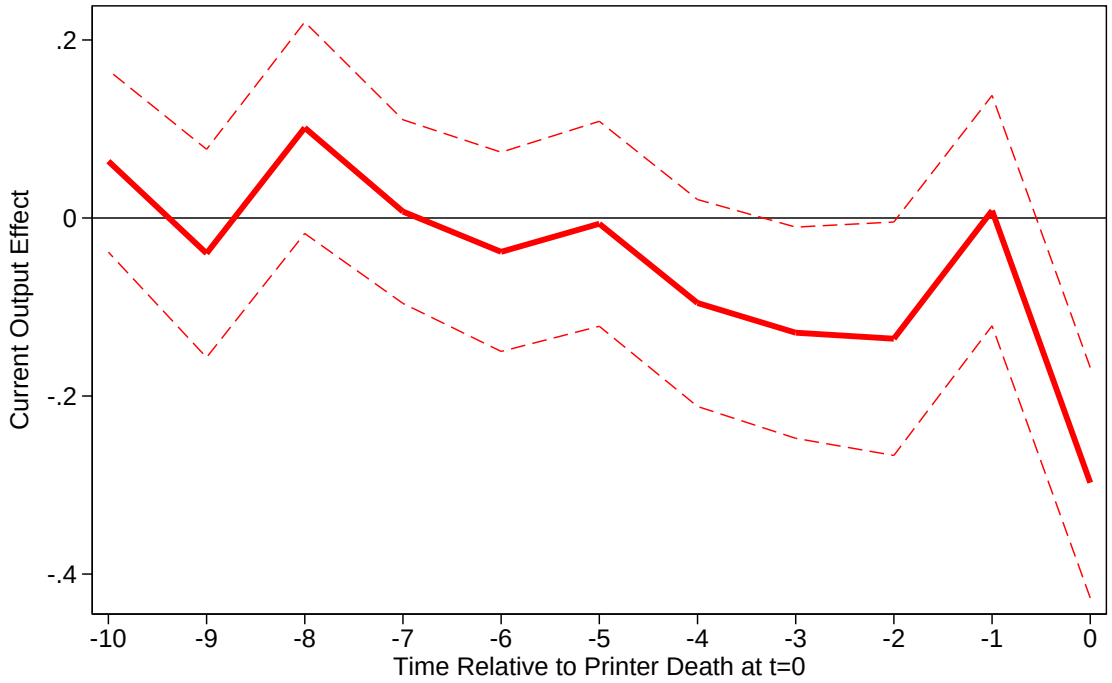

Figure 7: The relationship between premature printer deaths occurring at time $t = 0$ and firm-level output in years up to and including the year of the shock. Years $t < 0$ are years before a premature printer death. Dashed lines represent the 95% confidence interval.

4.2.2 The Impact of a Manager Death on Entrants and City Output

This section first documents the significant increase in new entrants observed in the city-years with manager deaths. It then documents the positive relation between city-level output and the timing of manager deaths. In particular, the evidence shows that when a manager died in a given city the firms that expanded production were the firms with product line specializations most similar to the specialization of the firm with the manager death.[31]

Entrants

New entrants could either come from within a city or from other cities. Social historians emphasize the intercity mobility of printers.[32] In the database assembled here, 8% of printers made permanent inter-city moves.[33]

[31] The next section documents the city-level price declines associated with innovations in quantities and manager deaths.

[32] For instance, Febvre and Martin (1958) and Clair (1976, p. 23) describe 16th century printers as "nomadic" and "veritable nomads."

[33] For the purposes of this calculation, "permanent" moves are defined narrowly as moves where the year of the last book printed in city A is equal to or earlier than the year of the first book printed in city B. This definition is narrow in the sense that some printers brought out books in multiple cities simultaneously, sometimes in partnership with or subcontracting to other printers.

To document the relationship between the timing of manager deaths and the arrival of new entrants at the city level, consider the estimating equation:

$$entrant_{j,t} = \alpha death_{j,t} + \beta \ln titles_{j,t-1} + \delta_{j,decade} + \epsilon_{j,t} \quad (2)$$

Here $entrant_{j,t}$ is a binary variable recording whether there was a new entrant producing books in city j in year t and the parameter of interest is α, which describes the relationship between the premature printer deaths ($death_{j,t}$) and the appearance of a new entrant. The regression controls for lagged book output, and city-cross-decade fixed effects ($\delta_{j,decade}$). I also present specifications with separate city and year fixed effects.

Figure 8 presents regression results documenting that in city-years with premature printer deaths, we observe a large and highly significant increase in entrance by new competitors. Column (2) shows that in a simple linear probability model with year and city fixed effects, the probability of an entrant rose by over 15% in years with printer deaths. Column (3) shows similar result restricting the identifying variation to within city-decade periods. Columns (4) and (5) present the marginal effect of a printer death estimated in probit models with the same sets of controls.

	Linear Probability (OLS)		Probit Marginal Effects	
Regression Variables	Entrant	Entrant	Entrant	Entrant
(1)	(2)	(3)	(4)	(5)
Printer Death	0.12***	0.10***	0.13***	0.15***
	(0.03)	(0.25)	(0.03)	(0.04)
Ln Quantity Lagged	0.04***	-0.01	0.04***	-0.01
	(0.01)	(0.01)	(0.00)	(0.01)
City Fixed Effects	Yes		Yes	
Year Fixed Effects	Yes		Yes	
City x Decade		Yes		Yes
Observations	12610	12610	11409	11409

Figure 8: The annual city-level relationship between entry by new competitors and management transitions due to printers' deaths. The dependent variable in all specifications is an indicator for new entrants in a given city-year (1 = a new firm enters the market, 0 = no new firms enter the market). Standard errors are clustered at the city level for columns (2) and (4), and at the city-cross-decade level in columns (3) and (5).

City Output

To document the relationship between overall city production and the timing of manager deaths, this section uses a "naive" OLS estimator, a GMM dynamic panel estimator (Arellano and Bond 1991; Roodman 2006), and a "shift share" strategy that exploits the heterogeneity of both firms experiencing manager deaths and firms surviving without

deaths. These estimators all find printer deaths were associated with significant increases in book supply of at minimum 9%. The OLS estimates provide a useful check on theoretically superior estimators in the spirit of Bond (2002). The shift share strategy shows that when a printer died, the firms that responded most were the competing firms with product lines (content specializations) most similar to the firm losing its manager. This heterogeneity will be exploited below to consider the differential impact of the deaths of different types of printers on city growth.

The basic OLS estimating equation for output considered in this section is:

$$\ln titles_{j,t} = \alpha death_{j,t} + \gamma \ln titles_{j,t-1} + \delta_{j,decade} + \epsilon_{j,t} \tag{3}$$

Here j indexes cities and t indexes years. The parameter of interest is α, which captures the relationship between premature manager deaths and city-level book output. The estimating equation controls for city-cross-decade fixed effects ($\delta_{j,decade}$). The identifying variation is thus variation in output for a given city within a ten year window. Thus $\hat{\alpha}$ measures how much book production measured in titles printed goes up in a given city-year when there is a management transition – controlling for the determinants of book production in that city that are invariant over the decade in which the management transition happens to fall. The identifying assumption is thus that the precise timing of printer deaths within these city-decade windows is random. Results with separate city and year fixed effects are also reported.

Figure 9 documents the large and statistically significant positive relationship between book title output at the city level and management transitions. Column (2) presents estimates in logarithms and shows that a management transition was associated with an output increase of 0.16 log points (18 percentage points). Column (4) presents estimates where book output is in levels and shows that management transitions were associated with a highly significant increase of 4+ book per year. The key assumption for identification is that the precise timing of printer deaths was effectively exogenous from the perspective of local competitors and potential entrants. However, it is natural to wonder whether printer deaths may have been anticipated, and whether the output increases when printers died were offset by subsequent declines.

To document that printer deaths were unanticipated shocks that induced increase supply and that there were not subsequent offsetting declines in output, it is useful to consider a set of placebo regressions. Equation (3) documents the relationship between output growth in a city i at year t hit by a management transition due to a death in year 0. The placebo versions of this regression considered here documents the association between printer deaths at time $t = 0$ and output at different points in time $\tau = t - 8, t -$

Regression Variables	Ln Books	Ln Books	Books	Books
(1)	(2)	(3)	(4)	(5)
Printer Death	0.16***	0.10***	5.57***	2.81*
	(0.03)	(0.03)	(1.48)	(1.68)
Ln Books Lagged	0.56***	0.17***		
	(0.02)	(0.01)		
Books Lagged			0.92***	0.42***
			(0.02)	(0.05)
City FE	Yes		Yes	
Half Decade FE	Yes		Yes	
City x Decade FE		Yes		Yes
Observations	11237	11237	17761	17761

Figure 9: The annual city-level relationship between book production and premature printers' deaths. Book production measure as natural logarithm of titles published in columns (2) and (3) and the number of books in columns (4) and (5). Standard errors are clustered at the city level in columns (2) and (4) and at the city-cross-decade level in columns (3) and (5).

$7, \ldots, t+7, t+8$.

$$\ln titles_{j,\tau} = \alpha_\tau death_{j,t} + \delta_s \cdot \theta_j + \gamma \ln titles_{j,\tau-1} + X'_{j\tau}\beta + \epsilon_{j,\tau} \tag{4}$$

Figure 10 shows first that the big significant output effect occurs in the year when managers die by plotting the estimated $\hat{\alpha}_\tau$'s and confidence intervals from (4) for different time periods τ. Figure 10 documents that output does not revert to pre-shock levels. Instead, the fact that growth does not fall in years $1, 2, \ldots, 8$ indicates that an increase in the level of output is carried forwards. This tells us that the story in the data embodies something like a ratchet effect. If any thing, Figure 10 suggests that there may be some slight positive trend in output in years following a manager's death, however this effect is not statistically significant. This finding suggests that a printer death induced new entry and by so doing delivered permanent innovations in city-level supply.

To address potential dynamic panel bias, this section also considers the Arellano and Bond (1991) GMM estimation set up. Here the data are first differenced and deep lags of the endogenous variables are used to instrument for lagged first differences:

$$\Delta \ln(titles)_{j,t} = \alpha \Delta \ln(titles)_{j,t-1} + \beta \Delta death_{j,t} + \Delta \nu_{j,t} \tag{5}$$

Figure 11 presents Arellano-Bond estimates of the impact of printer deaths on city-level output. Columns (2) and (4) provide baseline specifications but exhibit implausibly

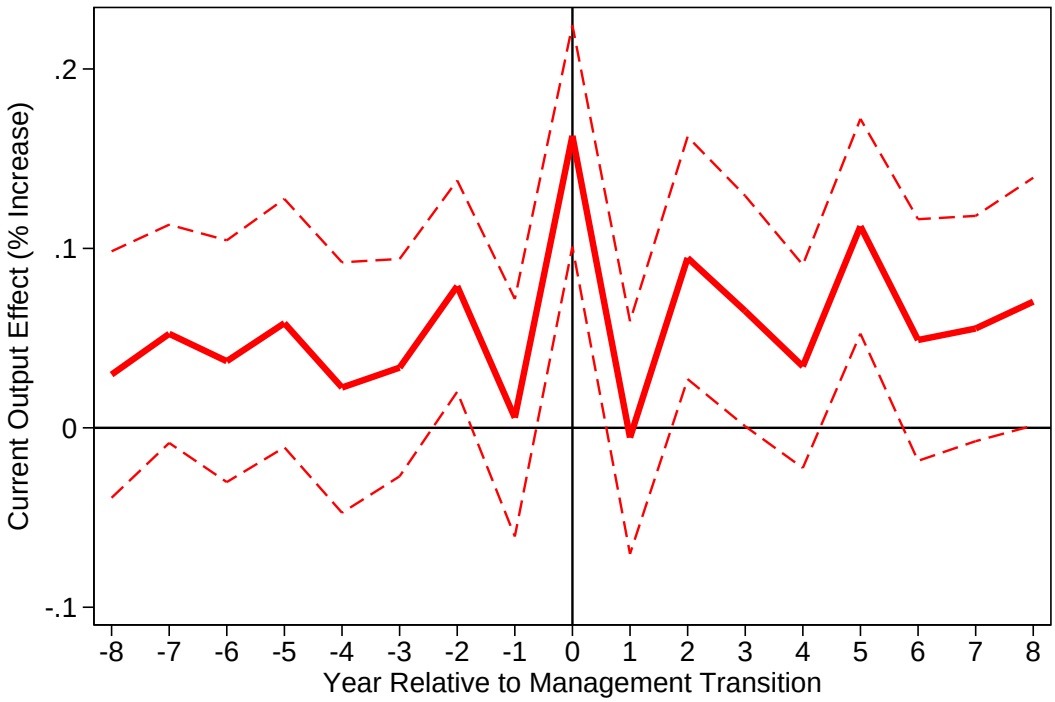

Figure 10: Placebo regression estimates of the city-level response of book titles to premature printer deaths over different time leads and lags. This figure plots the estimated slope parameters $\hat{\alpha}_\tau$ that relate growth in output at time τ to printer deaths at time $t = 0$. Heteroskedasticity-robust standard errors clustered at the city level.

large p-values for Hansen's J-statistic testing over-identification. Columns (3) and (5) collapse the instrument matric into a vector of lagged first differences following Roodman (2009) and serves to provide a minimally arbitrary robustness test of model over-fitting. While this change doubles the magnitude of the estimated relationship between current and past books, it has a quantitatively small (though positive) impact on the estimated relationship between printer deaths and city-level books output.

4.2.3 Heterogeneity in Manager Deaths and Competitor Responses

To document the role of firm-level heterogeneity in the transmission of shocks, I document that the response to a manager's death was largest for firms that were specialized in the same product lines as the the firm losing its manager.[34] To measure the distance (proximity) between firms I develop a shift share instrument in spirit of Moretti (2010). For a firm i in city j which does not lose its manager $s^n_{ij,t-1}$ is n^{th} variety output share, where varieties are the 38 varieties described in the data section above. For firms experi-

[34]It is natural to wonder about another dimension of heterogeneity: the relative size of the firm experiencing the manager death. I find that there is no relationship between the market share of the firm experiencing the loss of the manager and competitors' responses.

	Data 1454-1600		Data 1500-1600	
Regression Variables	Ln Books	Ln Books	Ln Books	Ln Books
(1)	(2)	(3)	(4)	(5)
Ln Books at time t-1	0.06*	0.18***	0.09**	0.20***
	(0.03)	(0.03)	(0.03)	(0.03)
Ln Books at time t-2	-0.00	0.05***	0.01	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)
Printer Death at time t	0.10***	0.11***	0.10***	0.11***
	(0.03)	(0.03)	(0.03)	(0.03)
Printer Death at time t-1	0.02	0.01	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Observations	9342	9342	8392	8392
AR(1) in first diff p-value	0.00	0.00	0.00	0.00
AR(2) in first diff p-value	0.35	0.67	0.66	0.46
Over-id: Hansen J p-value	1.00	0.68	1.00	0.29
Instruments	397.00	278.00	305.00	245.00
Roodman IV Reduction		Yes		Yes

Figure 11: Dynamic panel (GMM) estimates of the city-level relationship between book production and management transitions due to printers' deaths. Columns (3) and (5) employ the Roodman (2009) IV reduction (or "collapse"). See text for details. Heteroskedasticity-robust standard errors.

encing manager deaths, denote their output shares in the year just before the death with $s^n_{Dj,t-1}$ (when these firms experience no deaths, $s^n_{Dj,t-1} = 0$). The shift share instrument is then:

$$SS_{ij,t} = \sum_{n=1}^{N} s^n_{ij,t-1} s^n_{Dj,t-1}$$

The baseline empirical specification these estimates a firm-level regression, in which variations in output are explained by a variable for city-level printer deaths, the shift share instrument, and city and year or city-cross-decade controls. The regression is estimated for firm-years in no "own deaths" occur, so the variation is entirely from the deaths of competitors.

$$\ln titles_{ij,t} = \alpha death_{j,t} + \beta SS_{ij,t} + \delta_t + \theta_i + \nu_{i,t} \tag{6}$$

Table 12 shows that the output response to premature printer deaths was overwhelmingly accounted for by competitor firms with similar product specializations. Table 12 estimates equation (6) and shows in columns (4) and (5) that the entire city-level output impact is explained by the shift share instrument for firm-level heterogeneity which captures the differential impact of the death of a manager death in one firm across surviving competitors. This fact will be exploited below in the examination of book supply and city growth.

Regression	Ln Books	Ln Books	Ln Books	Ln Books
(1)	(2)	(3)	(4)	(5)
Shift Share	0.276***	0.314***	0.089**	0.108**
	(0.044)	(0.047)	(0.043)	(0.048)
Printer Death		-0.032**		-0.015
		(0.015)		(0.015)
Firm FE	Yes	Yes		
Year FE	Yes	Yes		
Firm x Decade FE			Yes	Yes
Observations	55750	55750	55750	55750

Figure 12: Shift share estimates of the differential impact of printer deaths across heterogeneous firms. The shift share index captures the similarity between the product specialization of firm i and the product specialization of the firm(s) that experience a printer death in a given city-year. See text for details. Standard errors clustered at the city level in columns (2) and (3) and at the city-decade level in columns (4) and (5).

4.3 Price Responses to Premature Manager Deaths

This subsection documents that (1) year-on-year increases in city level output were associated with significant price declines at the city level and (2) management transitions due to printer death were associated very large price declines, even conditional on variations in quantities. To document the relationship between quantities and prices, and between management transitions and prices, I rely on price data from the book purchasing notebooks of Hernando Colón.

The basic approach is to to document the relationship between book prices, on the one hand, and city level supply and printer deaths, on the other. The estimating strategy involves controlling for a rich set of book characteristics. The regressions also control for either separate city and year fixed effects or city cross five year period fixed effects. The identifying variation is thus always within city and either within a year separate from city variation or within tight city-time-period blocks. The estimating equation is:

$$\ln P_{ijkt} = \alpha \ln Q_{j,t} + \beta \ln Q_{j,t-1} + \theta death_{j,t} + X_i'\gamma + \epsilon_i$$

Here i indexes books, j cities where purchases are made, k cities where books are printed, and t time in years. $Q_{j,t}$ is the aggregate number of book title produced in city j at time t. As before, the variable $death_{j,t}$ records whether there was a management transition due to a premature printer death. The parameter of interest is θ. The controls X_i include a dummy for domestic (non-traded) books and the interaction between an indicator

Regression Variables	Ln Price	Ln Price	Ln Price	Ln Price	Ln Price	Ln Price
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln Quantity	-0.635***	-1.491***			-0.626***	-0.691**
	(0.147)	(0.400)			(0.149)	(0.296)
Ln Quantity Lagged	0.589**	0.322			0.605**	0.526***
	(0.253)	(0.323)			(0.241)	(0.062)
New Owner			-0.833***	-0.812***	-0.835***	-0.833***
			(0.190)	(0.198)	(0.189)	(0.189)
Ln Distance	0.442***	0.445***	0.447***	0.460***	0.443***	0.448***
	(0.077)	(0.081)	(0.082)	(0.085)	(0.082)	(0.082)
City Fixed Effects	Yes		Yes		Yes	
Year Fixed Effects	Yes		Yes		Yes	
City x Five Year Period		Yes		Yes		Yes
Observations	1511	1511	1511	1511	1511	1511

Figure 13: The relationship between book prices, city-level book production, and city-level management transitions. Estimated standard errors are clustered at the city level in columns (2), (4), and (6) and at the city-five-year-period level in columns (3), (5), and (7).

for imports and the log of transport distance for imported books calculated as straight line (as the crow flies) distance. The X_i also control for book length in pages, page dimensions, the presence of illuminations, the book format (octavo, quarto, folio, etc.), subject matter, and book age calculated as the number of years between printing and sale.

Table 13 documents that increases in aggregate, city-level output were associated with very large and highly significant price declines.[35] These regressions are not well identified in the sense that variations in quantities and prices embody both shocks to supply and demand. However, Column (3) documents that – within five year periods in a given city when it is plausible that demand preferences were relatively stable – variation in the number of titles produced is associated with more than one-to-one variations in book prices in that city. Columns (4) and (5) show that in city-years with printer deaths book prices were 0.8 log points (approximately 55 percentage points) lower controlling either for city and year variation separately or for the overall level of prices in a given city over five year intervals.[36] Finally, columns (6) and (7) show that the association between management transitions due to printer deaths and prices is robust controlling for variations in quantities.

These results indicate that variations in quantities and management transitions due to

[35] Alternative specifications where observations are weighted (e.g. by a city's share in production) yield similar results.

[36] In the Hernando Colon data, we have records of purchases in eight city-years with printer deaths: Augsburg (1531), Basel (1531), Bologna (1530), Cologne (1522), Milan (1531), Nuremberg (1521), Perugia (1530), Venice (1530).

printer deaths were associated with very large fluctuations in prices. While the evidence is not definitive, it is consistent with historical observations about the propensity to "cut throat" price competition. From an economic perspective, these fluctuations are suggestive of predatory pricing.

It is again useful to consider how the estimates vary as we look forward and back in time. Figure 14 shows that quantity innovations at time $t = -2$ are associated with significant reductions in prices at $t = 0$ – on the order of almost 100%. Quantity innovations at time $t = -1$ are associated with even larger price reductions.

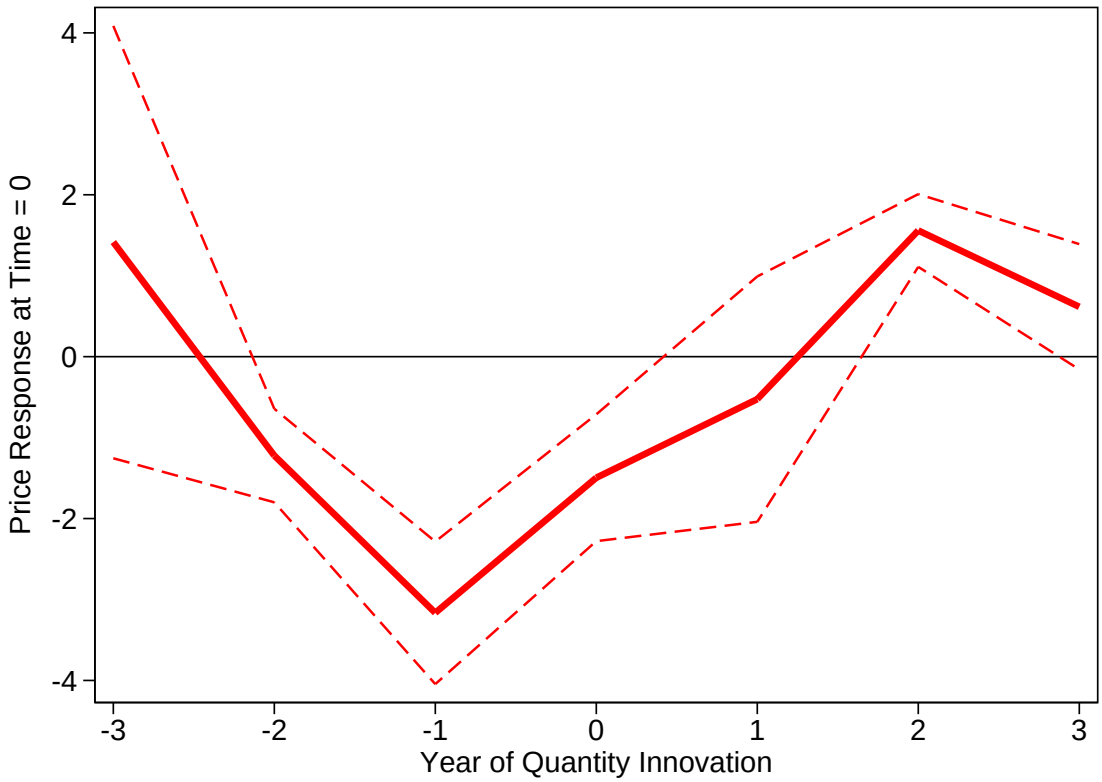

Figure 14: Response of book prices to year-on-year increases in city-level output.

5 The Cost of Inter-City Trade

If trade was not costly, the death of a printer in one city would not have a differential impact on competition in that city. Similarly, if trade was not costly, any relationship between local production and access to content would likely break down. The historical literature provides qualitative evidence that inter-city trade was very costly and that transport costs limited the diffusion of print media and the extent of cross-city competi-

tion. However, to my knowledge no research provides systematic, quantitative evidence on trade costs.

This section reviews evidence on transport costs from the historical literature and presents data on the book trade from a new database of over 2,000 book purchases. These data provide detailed information on book characteristics and purchase prices. The data allow us to document the price gradient associated with transport between point of production and point of sale. The estimated price gradient provides support for the historical observation that local exposure to print media was highly correlated with local production (Edwards 1994), the salience of city-level competition, and a causal interpretation of the relation between supply shocks to local production and city growth.

5.1 Historical Evidence on Transport Costs

Print media was costly to transport because it was a heavy and fragile commodity, sensitive to damp and water damage (Barbier 2006; Febvre and Martin 1958; Richardson 1999).[37] The inter-city trade in books was extensive (Pettegree 2011) but still significantly limited. Outside printing cities, information on the range of available print media was incomplete and many books were not offered for sale – implying tremendously high shadow prices. Flood (1998, p. 55) observes that, "Outside the towns where books were printed or which were main centers of the burgeoning book trade the public were dependent on what itinerant traders offered them and on word of mouth."[38] Booklets and ephemera termed "city printing" (*l'imprimerie de ville*) accounted for a large share of production and were typically even less widely traded.[39] Transport costs in early modern Europe were sufficiently high that print media often spread through reprinting rather than inter-city trade.[40] Books were often shipped unbound and in very small lots – a few copies of a few texts (Febvre and Martin 1958, pp. 335-339). Records from the archives of the Ruiz merchant family indicate that insurance and transport costs for a

[37] This section follows closely Dittmar (2011).

[38] Contemporary accounts confirm that access to print media was limited outside printing centers. Platter (1839, p. 28-29) described the constraints on his education in the early 1500s in a town without a printing press: "In the school at St. Elizabeth, indeed, nine Bachelors of Arts read lectures at the same hour, and in the same room...neither had any one printed books...What was read had first to be dictated, then pointed and constructed, and at last explained; so that the Bacchants had to carry away thick books of notes when they went home."

[39] See Nieto (2003, p. 17), Edwards (1994, p. 8), Eisenstein (1980). Note, however, that the diffusion of pamphlet literatures such as the *flugschriften* (flying papers) of the German Reformation were important media for intercity idea transfers.

[40] Edwards (1994, p. 8) observes: "If, for example, there was an interest in Strasbourg for a work first published in Wittenberg, it was more common for a printer in Strasbourg to reprint the work than it was for the printer in Wittenberg to ship a large number of copies [500 kilometers] to Strasbourg."

shipment of 21 books from Lyon to Medina del Campo (930 kilometers as the crow flies) were equivalent to 30 days' wages for a skilled craftsman (Febvre and Martin 1958, p. 338). Similarly, in the 1550s the cost of shipping one pack-animal load of books from Rome to Lyon (750 kilometers as the crow flies) was approximately 50 days of laborers' wages for overland transport (Richardson 1999, p. 37).[41]

5.2 Documenting Transport Costs with New Price Data

To document the impact of transport costs on book prices this paper assembles data on book purchases made by Hernando Colón in 42 cities across Europe 1509-1540. The data are used to estimate the price gradient associated with distance between the city where a book was produced and the city where it was purchased, controlling for observed book characteristics and the overall level of book prices in the city and year where each individual purchase was made.

Figure 15 shows the map of the cities in which Hernando Colón bought books and the set of cities that produced books that were exported and purchased by Colon elsewhere. Figure 16 shows the distribution of distances between printing cities and point of purchase for imported books. Figure 17 presents summary statistics on the number of purchases and mean import distance for the ten cities in which Colón bought the most books.

Figure 18 uses regression analysis to document the price gradient associated with transporting a book from the point of production to the point of sale in another city. Column (2) documents that the elasticity of prices with respect to distance is 0.43 – controlling for any variation in prices by city-year and observable book characteristics. Here the identifying variation in prices is across books within a given city-year – controlling for book length, page size, format, and subject matter. The coefficient of 0.43 tells us that – other things equal – every time the distance between the point of production doubles the price increases by 35 percentage points. A book sold 400 kilometers from its printing city cost 35% more than the same book sold 200 kilometers from where it was printed – which in turn cost 35% more than a book sold at a distance of 100 kilometers from the printing city. Column (3) documents how this price-distance gradient declined over the mid-1500s. However, a caveat is in order: the parameter estimates on time-distance interactions are sensitive to the periods chosen: the price-distance gradient is relatively

[41] Archival holdings provide additional evidence on the limits on the trade in print media. Dittmar (2011) presents evidence on historic collections now housed at the Bayerische Staatsbibliothek in Munich and shows that the proportion of the editions produced in a given city and held in the Munich archives declines sharply (and non-linearly) in the distance between the printing city and the archive.

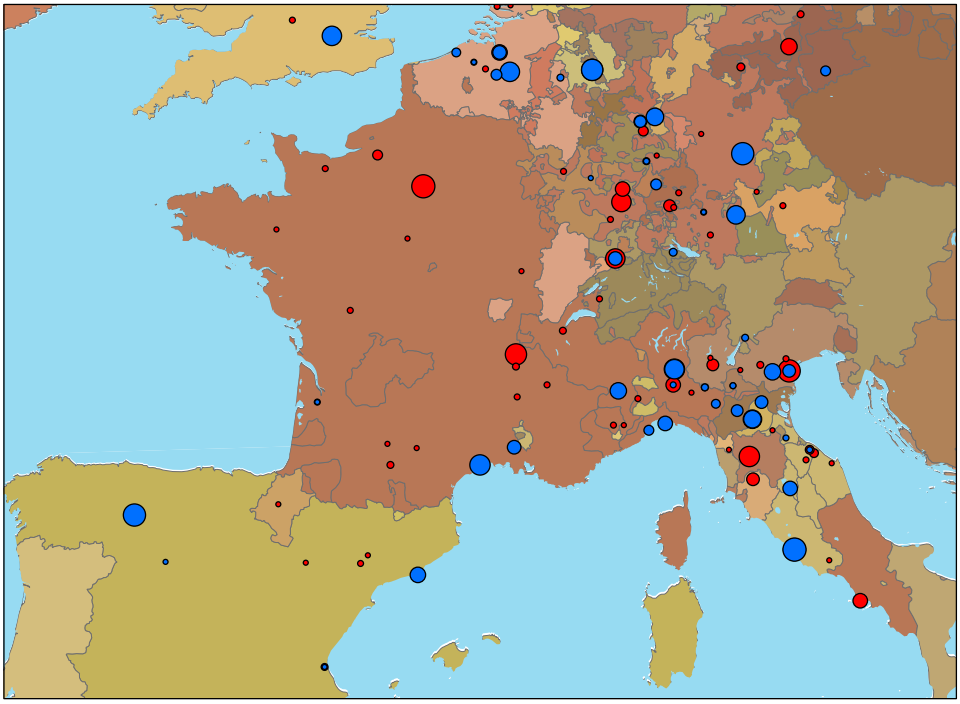

Figure 15: Cities in which Hernando Colón purchased books 1510-1539 (blue markers) and cities producing books that were exported and purchased by Colón elsewhere (red markers). City markers scaled to reflect the number of purchases (exports) at each location.

high over the second half of the 1530s.[42]

The estimated price-distance gradient is stable across the distribution of observed import distances. In particular, the estimate is not driven by the costs of transporting books over particularly long or short distances. Figure 19 uses quantile regression to document that the price gradient estimates are large, statistically significant, and relatively stable across the distribution of import distances. Figure 19 presents estimates of the relationship between residual prices conditional on non-distance observables and import distance, bootstrapping to estimate 500 iterations for each distance quantile τ.[43] To obtain a measure of the book-level residual price $\hat{\epsilon}_i$ for a book i purchased in city j at time t, I regress book prices on non-distance book-level observables X_i and city-year fixed effects θ_{jt}, where the X_i are the covariates in Figure 18.

$$\ln P_{ijt} = \alpha + \beta X_i + \theta_{jt} + \epsilon_i$$

I then examine the relationship between residual prices ($\hat{\epsilon}_i$) and log distance between the

[42]Distance is measured as great circle ("as the crow flies") distance, which is of course an imperfect (noisy) measure of the true, unobserved cost distance of transport.

[43]For each iteration 2,000 book purchase observations are drawn randomly with replacement.

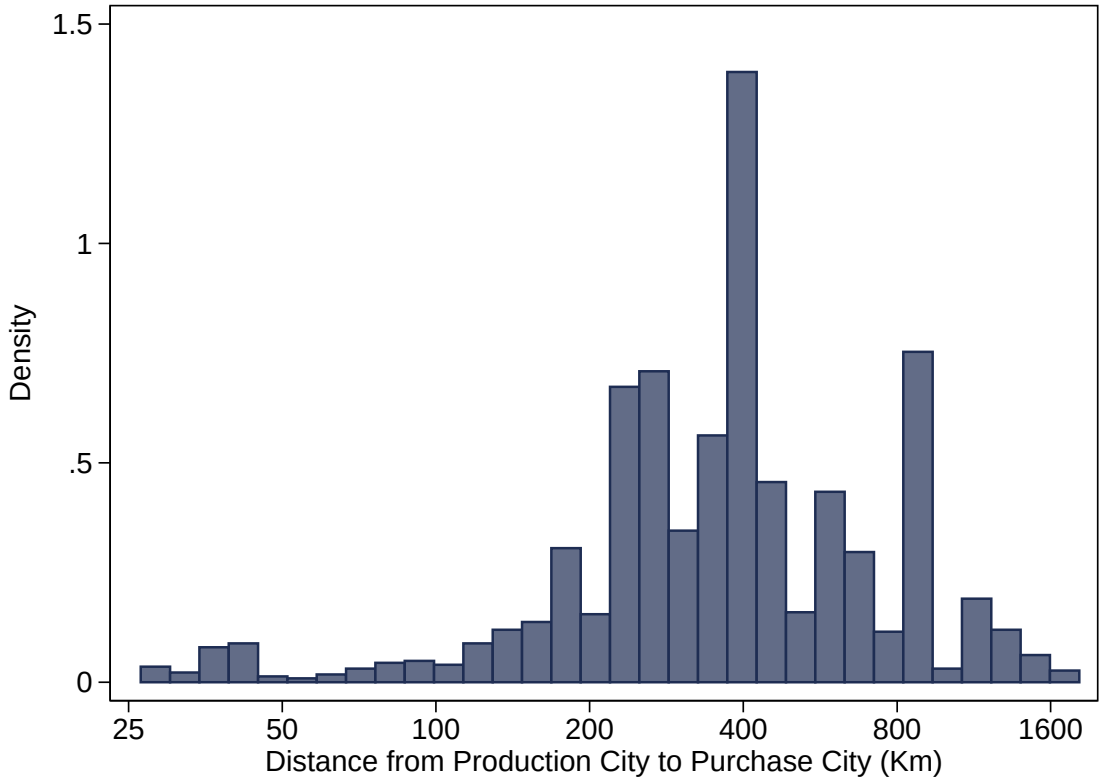

Figure 16: Distance between printing city and point of purchase for 1,707 book purchases.

City	Domestic Books	Imported Books	Mean Import Distance	Year of First Purchase	Year of Last Purchase
(1)	(2)	(3)	(4)	(5)	(6)
Rome	241	474	387	1512	1531
Nuremberg	20	248	386	1512	1522
Leon	0	226	1,030	1525	1536
Cologne	50	108	392	1522	1531
Montpellier	0	89	431	1525	1535
London	4	71	499	1522	1522
Leuven	8	63	289	1520	1531
Frankfurt	0	54	206	1522	1524
Milan	26	28	328	1530	1535
Bologna	22	22	245	1520	1530

Figure 17: Summary statistics on book purchases made by Hernando Colón in select European cities. This table presents data for the 10 cities in which Colón purchased the most books.

	Cities that Produce Books		All Cities	
Regression Variables	Ln Price	Ln Price	Ln Price	Ln Price
(1)	(3)	(4)	(2)	(3)
Ln Distance	0.434***		0.383***	
	(0.078)		(0.090)	
Ln Distance x 1510s		0.813***		0.846***
		(0.115)		(0.149)
Ln Distance x 1520s		0.362***		0.384***
		(0.102)		(0.073)
Ln Distance x 1530s		0.342***		0.263*
		(0.094)		(0.134)
Ln Pages	0.232***	0.231***	0.227***	0.227***
	(0.046)	(0.046)	(0.037)	(0.037)
Ln Page Dimension	2.600***	2.702***	3.301***	3.400***
	(0.467)	(0.451)	(0.513)	(0.489)
Book Age	-0.00774**	-0.00790***	-0.00733***	-0.00735***
	(0.003)	(0.003)	(0.002)	(0.002)
Illuminated	0.330**	0.332***	0.348***	0.349***
	(0.123)	(0.123)	(0.094)	(0.095)
Bibles	0.361***	0.355***	0.320***	0.318***
	(0.113)	(0.108)	(0.091)	(0.087)
Literature	0.222	0.249*	0.136	0.157
	(0.145)	(0.140)	(0.123)	(0.120)
Orations	-0.633***	-0.636***	-0.687***	-0.679***
	(0.144)	(0.146)	(0.112)	(0.115)
Poetry	-0.550*	-0.486*	-0.570**	-0.513**
	(0.283)	(0.271)	(0.239)	(0.212)
Theology	0.315**	0.316**	0.280**	0.281**
	(0.130)	(0.132)	(0.114)	(0.113)
Languages	0.295***	0.278***	0.246***	0.242***
	(0.089)	(0.082)	(0.079)	(0.073)
Rights	0.308**	0.270**	0.123	0.0910
	(0.130)	(0.125)	(0.180)	(0.168)
Religion	0.348***	0.357***	0.123	0.135
	(0.112)	(0.114)	(0.139)	(0.141)
History & Legislation	0.248*	0.207	0.238*	0.220*
	(0.127)	(0.125)	(0.133)	(0.131)
City x Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	1117	1117	1542	1542

Figure 18: Price-distance gradient regressions. Ln Distance is measured as great circle (as the crow flies) distance between the printing city and the purchase city. Ln Pages and Ln Page Dimension are the natural logarithm of the number of pages and the surface area of pages, respectively. Book Age is the number years between the year of printing and the year of purchase. The Illuminatated indicator captures price variations associated with hand-painted illustrations. In addition to the subject codes shown, the regressions control for subject codes that have no significant association with price: e.g. Law, Philosophy, and Medicine. All regressions also control for book format (folio, quarto, octavo, other). Standard errors are clustered at the city-year level.

purchase city and the printing city (δ_i) using quantile regression to examine the price gradient over the distance quantiles $\tau \in (0.05, 0.95)$.

$$\hat{\epsilon}_i = \phi(\tau) \ln \delta_i + \nu_i$$

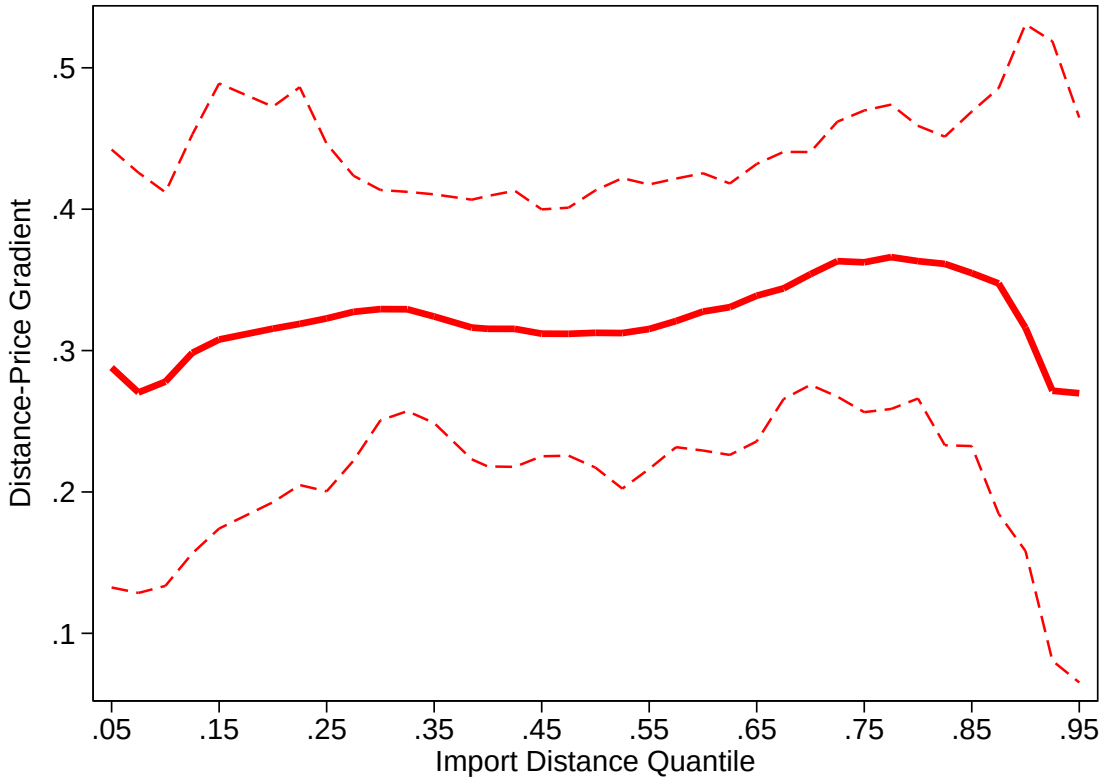

Figure 19: The price-distance gradient over distance quantiles. The figure reports the mean, 5th, and 95th percentile of quantile regression estimates $\phi(\tau)$ for each quantile. The mean and 5th and 95th percentiles are obtained bootstrapping and estimating the price-distance gradient 500 times for each distance quantile.

6 Print Media and Growth

This section documents the relationship between the diffusion of print media and growth at the city level. It first documents that book supply was associated with city growth and that, across types of content, merchants' manuals had a uniquely large and significant relationship with growth. It then examines printer deaths as a source of arguably exogenous variation in book supply.

6.1 The Association Between Print Media and City Growth

The basic set up here examines the relationship between city growth and (i) the cumulative stock of books produced locally and (ii) the current flow of book production. The set up echoes the framework commonly used to estimate returns to education[44]:

$$\Delta Y_{i,t} = \underbrace{\alpha_0 \Delta BOOKS_{i,t}}_{flow} + \underbrace{\alpha_1 BOOKS_{i,t}}_{stock} + \alpha_2 Y_{i,t} + \gamma X_{i,t} + \epsilon_{i,t} \quad (7)$$

The principal measure of growth ($\Delta Y_{i,t}$) used here is city population growth. Population growth reflects local changes in productivity in contemporary economies with labor mobility (Glaeser et al. 1999). Historically, population growth was largely drive by rural-to-urban migration (Dittmar 2010).[45]

Figure 20 documents the associations between city growth and the quantity of books produced locally.[46] Column (2) restricts to the set of cities printing 1450-1500 and finds a 7% increase in growth 1500-1600 associated with books printed 1500-1600. Column (3) examines all cities, controls for pre-1500 printing with a binary indicator capturing whether or not each city printed 1450-1500, and finds a similar correlation. These correlations between current book production and growth naturally raise the question of which subject literatures were more or less correlated with economic development.

Figure 21 documents the fact that the association between city growth and the local supply of merchants' manuals was uniquely large, positive, and statistically significant. Figure 21 presents estimates from a regression which documents the relationship between city growth 1500-1600 and the production of books in 38 subject areas. The measure of book production for each subject is a binary variable recording whether or not this content was produced in a given city. Figure 21 thus presents estimates of analogues to $\hat{\alpha}_1$ in (7) for all subject literatures. The regression controls for pre-1500 book in each individual subject (these estimates are almost all not statistically significant). The regression also controls for initial city population, port location, the presence of historic universities, navigable rivers, latitude, longitude, the interaction of latitude and longitude, and country fixed effects.

[44] The dependent variable is classically GDP or wages and the econometrician documents the relationship between variations in these outcomes and variations in stocks and flows of education or schooling. See for instance Krueger & Lindahl (2001).

[45] A substantial literature uses city population growth as a measure of economic dynamism in early modern (1450-1800) Europe. See Acemoglu, Johnson, and Robinson (2005), DeLong and Shleifer (1999), Dittmar (2011) for discussion.

[46] The next section presents evidence that local production mattered for the availability and price of books.

	Dependent Variable is Ln City Growth 1500-1600	
Regression Variables	Cities that Print pre-1500	All Cities
(1)	(2)	(3)
Ln Books 1501-1600	0.07**	0.07***
	(0.03)	(0.02)
Ln Books 1450-1500	-0.01	
	(0.03)	
Print 1450-1500 Indicator		0.00
		(0.00)
Observations	126	485

Figure 20: City level growth and the production of books. City growth 1500-1600 is $ln(POP_{1600}/POP_{1500})$. Standard errors clustered at the country level. The regression controls for pre-1500 books. The regression also controls for initial city population, port location, the presence of historic universities, navigable rivers, latitude, longitude, the interaction of latitude and longitude, and country fixed effects. Column (2) restricts to all cities with positive book production 1450-1500 and 1501-1600. Column (3), controls for positive book production pre-1500. Standard errors clustered at the country level.

6.2 Printer Deaths and Induced Book Supply

This subsection estimates the impact of print media on city growth using premature printer deaths as an instrument for supply. There are two key findings. First, variation in the level and the relative number (rate) of premature manager deaths were both associated with variation in book production and growth. Second, the deaths of printers of merchants' manuals had a differential positive impact on the production of business education content and city growth. This finding reflects the fact that printer deaths transmitted heterogeneous shocks to media markets, and provides support for the view that the diffusion of business education played a significant role in commercial and urban dynamism. This section also presents evidence documenting that (i) there were relatively small numbers of firms in most cities, (ii) across cities there was substantial variation in the premature death rates, and (iii) this variation was not related to observable determinants of growth. I discuss these data and threats to identification below.

Figure 22 shows that variation in books induced by premature manager deaths was associated with growth through a specific channel: the diffusion of practical knowledge. Figure 22 documents that manager deaths predict both aggregate city level book output and city level output of merchants' manuals. Columns (2) and (3) consider all books. Here I find that an additional management transition due to a death is associated with approximately 500 books, but that this have a vanishingly small (though positive and statistically significant) association with growth. Columns (4) and (5) show that printer

Type of Books	Regression Coefficient	Coefficient P-Value
(1)	(2)	(3)
Merchants' Manuals	0.284	0.000 ***
Science & mathematics	0.171	0.100 *
Any Books	0.167	0.277
History & chronicles	0.165	0.009 ***
Book trade (including booksellers' lists)	0.163	0.250
Military handbooks	0.158	0.074 *
Political tracts	0.139	0.194
Discourses on government & political theory	0.130	0.092 *
News books (sensational literature, events and conflicts in foreign places)	0.128	0.363
Marriage & the debate on women	0.114	0.075 *
Educational books (ABCs, how to write letters, grammars, educational theory)	0.106	0.190
Art & architecture	0.099	0.280
Astrology & cosmography	0.095	0.243
Heraldic works & genealogies	0.085	0.242
Ordinances, edicts & proclamations	0.066	0.626
Poetry (not including Emblem books)	0.049	0.688
Literature	0.044	0.714
Philosophy & morality	0.037	0.540
Witchcraft, demonology & occult writings	0.024	0.805
Adages, aphorisms, emblem books, jests & proverbs	0.022	0.784
Dictionaries, vocabularies, phrase books & instruction in foreign languages	0.015	0.750
Bibles (including parts)	0.007	0.929
Culinary arts (cookery, table manners, household management)	0.004	0.970
Games & recreations (texts on chess, tennis, card games)	-0.003	0.981
Medical texts	-0.008	0.959
Calendars, almanacs & prognostications	-0.022	0.690
Music	-0.046	0.458
Drama	-0.061	0.673
Jurisprudence (legal texts books, handbooks, commentaries,etc.) excluding edicts	-0.075	0.528
Funeral orations	-0.081	0.223
Linguistics & philology	-0.100	0.460
Economics (treatises on the economy, regulation of guilds)	-0.109	0.205
Dialectics & rhetoric	-0.117	0.265
Classical authors	-0.140	0.407
Travel, topography, maps & navigational manuals	-0.154	0.097 *
Agriculture, viticulture, texts on hunting & veterinary science	-0.156	0.078 *
Academic dissertations	-0.182	0.019 **
Religious	-0.211	0.116
Courtesy, civil conversation, etiquette & sumptuary	-0.361	0.001 ***

Figure 21: City level growth 1500-1600 and the production of books across 38 subject areas. City growth measured as $\ln(POP_{1600}/POP_{1500})$. This table reports parameter estimating the association between the local supply of types of print media and city growth, where local supply is recorded with indicators for books produced in each subject field. The regression controls for pre-1500 book in each individual subject, initial city population, port location, the presence of historic universities, navigable rivers, latitude, longitude, the interaction of latitude and longitude, and country fixed effects. There are 485 cities in the regression. These comprise all cities for which population is observed 1500 and 1600 in Bairoch, Batou, and Chèvre (1988). Standard errors clustered at the country level.

deaths predict the production merchant manuals and that 1 death is associated with 1 additional merchants' manual being printed 1500-1600 and a 1% increase in growth 1500-1600.

	All Books		Merchants' Manuals	
	First Stage	Second Stage	First Stage	Second Stage
	All	Ln City	Merchants'	Ln City
Regression	Books	Growth	Manuals	Growth
(1)	(2)	(3)	(4)	(5)
Printer Deaths	537.47***		1.08**	
	(27.61)		(0.43)	
Books		0.00**		0.01***
		(0.00)		(0.00)
F Statistic on IV	232.15		8.51	
Observations	413	413	413	413

Figure 22: Printer deaths, the production of merchant manuals in levels, and city growth 1500-1600. City growth 1500-1600 is $ln(POP_{1600}/POP_{1500})$. The variable "Printer Deaths" is an integer count of premature printer deaths in a given city 1500-1600. The regression controls for pre-1500 books. The regression also controls for initial city population, port location, the presence of historic universities, navigable rivers, latitude, longitude, the interaction of latitude and longitude, and country fixed effects. Standard errors clustered at the country level.

Figure 23 shows that when we examine output in logarithms, the "return" to is estimated at 8% and the return to merchants' manuals as 9%. This result implies that the first books and merchants' manuals are the ones with the biggest impact on growth – as picked up by the curvature of the log-transformed data.

Figure 24 shows that printer deaths had a larger impact in cities and years when there were fewer competing firms. Figure 24 weights printer deaths by the inverse of the number of firms operating at the time of a manager's death to capture the differential impact of manager deaths in cities and periods where there were relatively few (many) competitors. When printer deaths are weighted in this manner, the estimated impact of printer deaths operating through total book production rises to 9%. The estimated impact of weighted deaths operating through the merchant manual channel rises to 20%, however this estimate is only significant at the 10% level.

Figure 25 shows that the deaths of printers who produced merchant manuals had a much larger impact on the production of merchant manuals and on growth than the deaths of printers who never produced merchant manuals. Columns (2) and (3) replicate the results for all printers from Figure 22. Columns (4) and (5) present similar results

	All Books		Merchants' Manuals	
Regression	First Stage Ln of All Books	Second Stage Ln City Growth	First Stage Ln Merchants' Manuals	Second Stage Ln City Growth
(1)	(2)	(3)	(4)	(5)
Printer Deaths	0.14***		0.05**	
	(0.04)		(0.02)	
Ln Books		0.08***		0.09**
		(0.01)		(0.04)
F Statistic on IV	13.18		11.72	
Observations	329	329	74	74

Figure 23: Printer deaths, the production of merchant manuals in logs, and city growth 1500-1600. City growth 1500-1600 is $ln(POP_{1600}/POP_{1500})$. The variable "Printer Deaths " is an integer count of premature printer deaths in a given city 1500-1600. Controls and standard error clustering as in Figure 22.

	All Books		Merchants' Manuals	
	First Stage Ln of All Books	Second Stage Ln City Growth	First Stage Ln Merchants' Manuals	Second Stage Ln City Growth
	(1)	(2)	(3)	(4)
Printer Death / Firm	2.08***		0.72*	
	(0.26)		(0.41)	
Ln Books		0.09***		0.20*
		(0.03)		(0.11)
F Statistic on IV	56.14		4.07	
Observations	329	329	74	74

Figure 24: Weighted printer deaths, the production of merchant manuals in logs, and city growth 1500-1600. City growth 1500-1600 is $ln(POP_{1600}/POP_{1500})$. The variable "Printer Death / Firm" normalizes each premature printer death by number of firms currently active in the relevant city 1500-1600. Controls and standard error clustering as in Figure 22.

restricting to deaths of printers who produced merchants' manuals. The death of a printer of merchant manuals is associated with 70% more merchant manuals than the baseline where any printer is considered and the first stage F statistic rises from 8.5 to 20.5. The IV estimates also suggest the impact of merchants' manuals (in levels) rises from 1% to 7%. One possible explanation for this increase is that the measure of merchant manuals is observed with error and that instrumenting using the deaths of printers of merchant manuals provides a cleaner measure of true, unobserved output of useful knowledge and local exposure to this knowledge.

	All Printer Deaths		Merchant Manual Printer Deaths	
Regression	First Stage Merchants' Manuals	Second Stage Ln City Growth	First Stage Merchants' Manuals	Second Stage Ln City Growth
(1)	(2)	(3)	(4)	(5)
Printer Deaths	1.08**		1.72***	
	(0.43)		(0.43)	
Merchant Manuals		0.01***		0.07***
		(0.00)		(0.02)
F Statistic	8.51		20.54	
Observations	413	413	413	413

Figure 25: The differential impact of the deaths of printer who produced merchant manuals. The production of books (merchant manuals) is in levels. City growth 1500-1600 is $ln(POP_{1600}/POP_{1500})$. The variable "Printer Deaths" is an integer count of the relevant type of premature printer deaths in a given city 1500-1600. Controls and standard error clustering as in Figure 22.

To understand the association between premature printer deaths and book supply, it is important to observe that most cities had relatively few printing firms active at any time, premature manager deaths were relatively uncommon, and there was considerable variation in the number of premature deaths per firm across cities. Figure 26 shows that there was considerable variation in the number of premature deaths for cities with similar numbers of firms. Figure 27 shows that across cities approximately 6% of firms experienced a premature death.[47] Historical evidence suggests that selection by widows choosing whether or not to take over firms in "better" or "worse" cities was unlikely (Postel-Lecocq 1988). However, this possibility cannot be ruled out ex ante.

Finally, several further points should be made about these results. First, the best interpretation for the relationship between merchant manuals and growth may not be the literal one in which we imagine randomly distributing books in Renaissance Europe. In a broader sense, what these results are capturing are variations in the flows, availability, and access-costs associated with valuable knowledge. Second, even a 1 percentage point growth increase is a big number. The mean growth rate for cities in the sample 0.27 log points (31 percentage points) 1500-1600. Third, the identifying assumption here is that printer deaths impact city-level growth only through their impact on the quantity of books produced at the city-level. It is unlikely that premature printer deaths impacted city growth through channels besides their impact on city-level supply of books. But the identification rests on the assumption that observed printer deaths are not themselves

[47] This figure presents data for cities with at least 8 firms for illustration only. For cities with fewer than 8 firms active 1450-1600, the dispersion in death rates increases. Almost all of these cities had only 1 printer active at any point in time and hence drop out of the estimates documenting the competitive response to premature printer deaths.

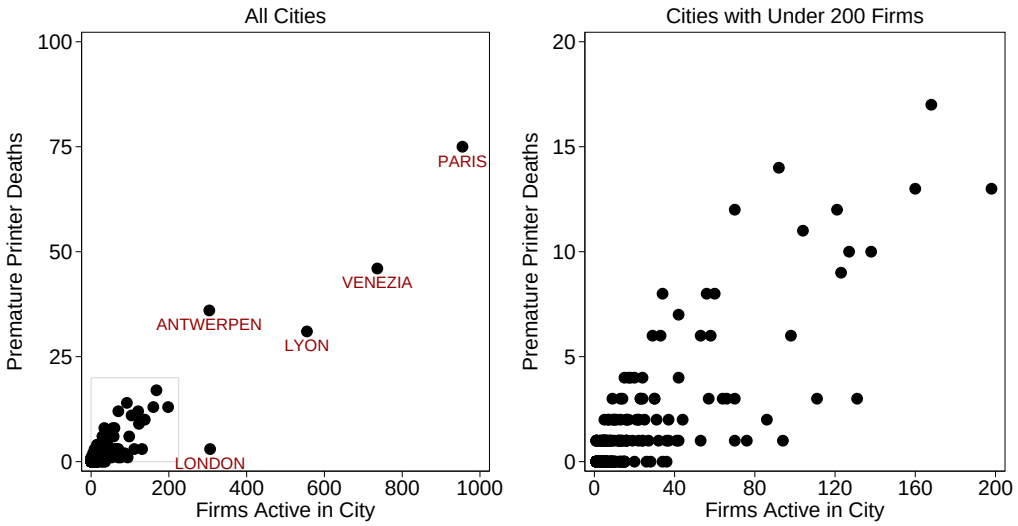

Figure 26: The cumulative number of premature printer deaths versus the cumulative number of firms active at the city level.

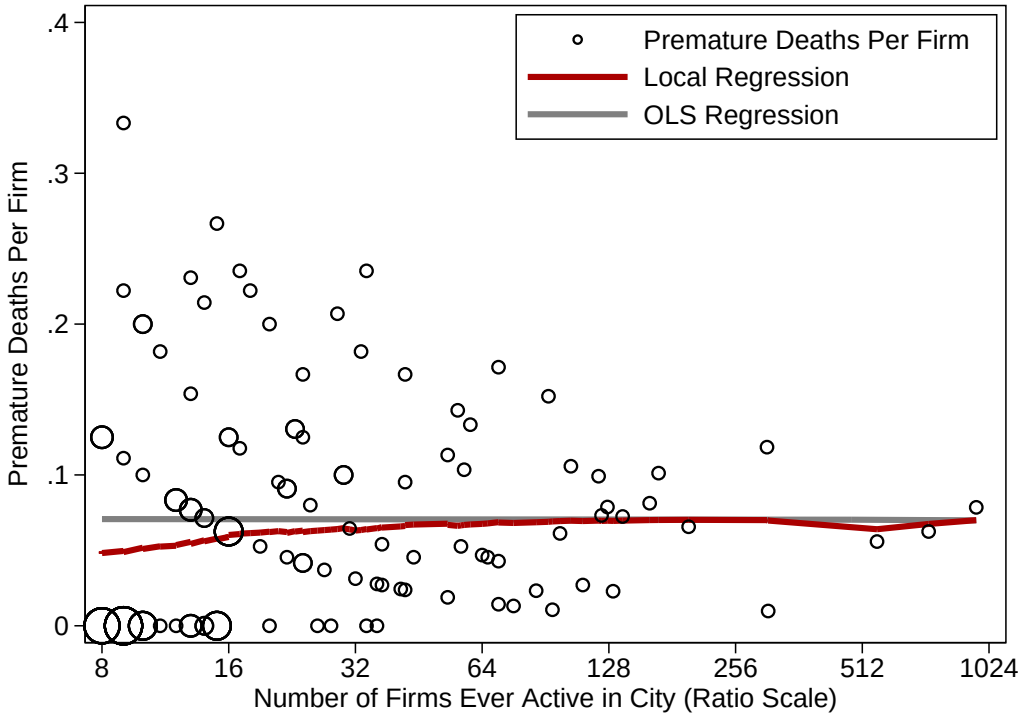

Figure 27: The relative number of premature printer deaths versus the cumulative number of firms active at the city level. Markers scaled to reflect the number of cities.

positively correlated with factors that drove variations in growth through other, non-media market channels.

7 Conclusions

The print media revolution radically transformed the ways ideas circulated and human capital was accumulated in Europe. This paper produces the first comprehensive, firm-level panel dataset on the universe of book titles printed by firms across Europe 1450-1600. The research identifies the timing of printer deaths as delivering exogenous variations in book supply at the firm and the city level. The firm-level impact is a measure of both the value of managers and the constraints on the often female entrepreneurs who succeeded them. At the city level, firm-level shocks increased competition among oligopolistic content producers and generated positive local spillovers. The data reveal that the variations in book supply induced by manager deaths were persistent. More specifically, this research documents that product line heterogeneity of firms mattered in the transmission of shocks. When a manager died in a particular city, the firms that responded to the death were the firms that were serving similar segments of the market. While the death of printers in general was associated with induced book supply and growth, using the heterogeneity across firms with and without manager deaths this paper finds that the publication of books that were used in business education was especially strongly associated with growth.

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A Databases of Print Media

This appendix documents that the USTC is more comprehensive than the nearest substitute database, the HPB (Heritage of the Printed Book) database maintained by the Consortium of European Research Libraries (CERL). The USTC is designed to be a comprehensive database of all known printed books produced in Europe 1450-1600. The CERL provides data on all books printed in Europe 1450-1800 that are held by member libraries. Because of the distribution and organization of library collections, this means that the CERL undercounts a greater or lesser proportion of known books depending on time and place.

Figure A documents the CERL shortfall by comparing the number of books recorded at the level of contemporary countries. It shows that the USTC systematically records a greater number of observations.

B Size of Print Runs

This paper takes the book title defined as the unit of analysis. Print runs (the number of individual copies printed of each title) varied. Figure B presents data on the size of print runs for 393 titles printed in 73 different European cities.

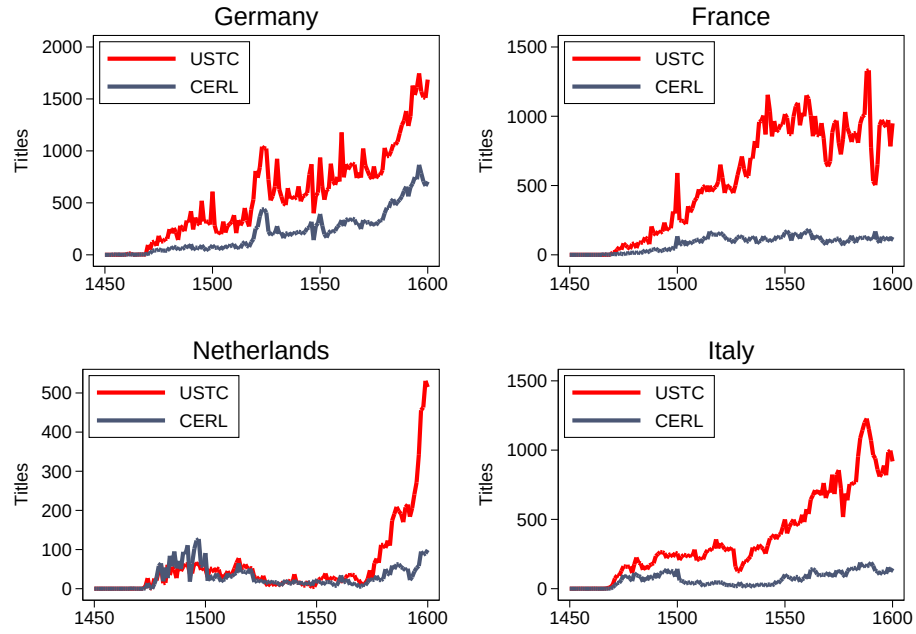

Figure 28: Comparison of number of titles printed in Germany, France, the Netherlands, and Italy as recorded in the USTC and the CERL data.

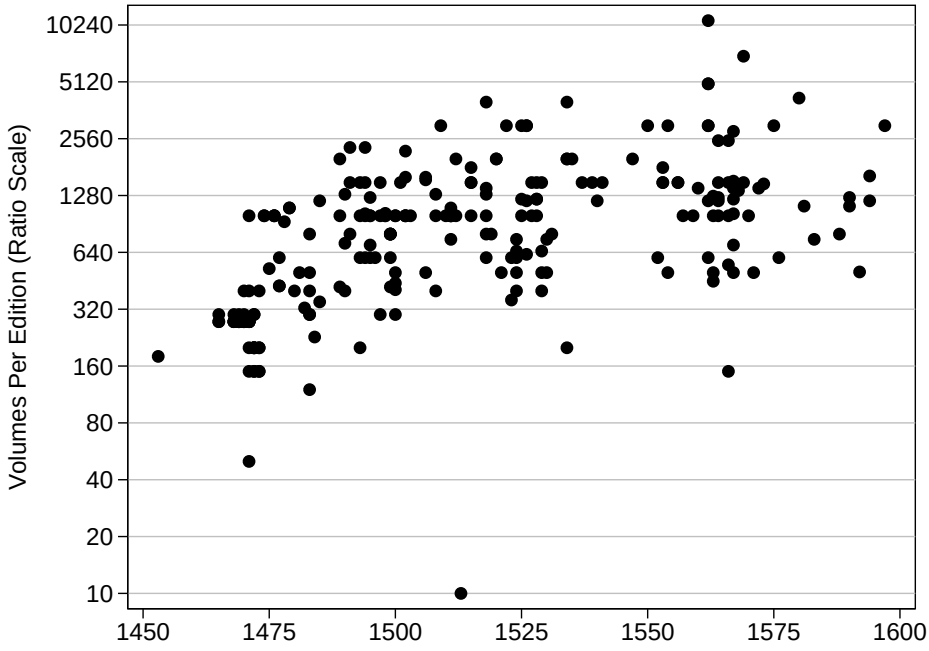

Figure 29: The size of print runs for 393 titles printed in 73 different European cities.