New Media, Competition, and Growth: European Cities After Gutenberg

Jeremiah Dittmar*

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Abstract

This research studies how variations in competition and in media content characterized the use and impact of Gutenberg's printing press technology during the European Renaissance. The research constructs annual firm-level panel data on the publications produced by 7,000+ printing firms operating in over 300 European cities 1454-1600. Evidence on the timing of the premature deaths of firm owner-managers is used to isolate shocks to competition. Firms where owner-managers died experienced large negative shocks to output. However, at the city-level deaths of incumbent managers were associated with significant increases in entrance and with a positive and persistent impact on competition and city output. Variations in city supply induced by heterogeneous manager deaths are used to study the relationship between the diffusion of ideas in print and city growth. A uniquely strong relationship is observed between city growth and the ideas in the new business education literature.

Keywords: Information Technology, IO, Media, Growth, History, Business Education.

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

*Department of Economics, London School of Economics. Email: j.e.dittmar@lse.ac.uk. Online: www.jeremiahdittmar.com. Russ Gasdia, Skipper Seabold, Kevin McGee, Jess Chen, Josh Reese, and David Rinnert provided excellent research assistance. I thank Ralf Meisenzahl, Noam Yuchtman, Suresh Naidu, and participants at the Washington-area economic history workshop, Warwick, Chicago-Booth, and the LSE for comments and conversation. The research has been supported by the Deustche Bank Membership at the Institute for Advanced Study (Princeton, NJ) and National Science Foundation grant SES #1023380. The errors are mine. An earlier version circulated with the title "New Media, Firms, Ideas, and Growth."

1 Introduction

New media technologies are widely believed to have a profound impact on society. But the impact of innovation in media and information technologies depends on the nature of competition and the nature of content.

It is commonly suggested that recent innovations in information technology are in the process of delivering changes in media markets and knowledge transmission that compare to those delivered by the Gutenberg Revolution of the European Renaissance. The Gutenberg Revolution itself provides an unparalleled body of firm- and city-level evidence in which to study how variations in competition and content shape the impact of radical innovation in media technology.

Gutenberg's printing press with moveable metal type was one of the most important innovations in information technology in human history (Braudel 1979; Gilmore 1952). The Gutenberg Bible was published in 1454. By the early 1500s the price of books had fallen by over 95% and the variety of available media increased dramatically. The production and circulation of ideas was transformed. Roberts (1996, p. 220) suggests that the outcome was one, "dwarfing in scale anything which had occurred since the invention of writing." A leading interpretation of these transformations is that they reflect the impact of the printing press as itself an agent of change (Eisenstein 1980).

However, the Romerian meta-idea behind the Gutenberg Revolution was not simply the physical apparatus of the printing press with moveable metal type, but rather the use of the apparatus by for-profit firms.[1] Printing was one of the very first industries in which production was organized by firms. The printing firms of the European Renaissance executed a Schumpeterian "end run" around existing regulations and operated outside guild restrictions (Brady 2009, Barbier 2006, Nicholas 2003, Füssel 2005). The fact that this transformative information technology industry emerged in an overwhelmingly free market setting and outside any anti-trust regulation makes the development of printing particularly interesting for economics (Hirsch 1974).

Previous economic research has not documented how the nature of industrial organization and competition shaped the use and impact of print media during the European

[1]The Korean counterfactual is as intriguing as the Chinese. Printing with moveable metal type was invented in Korea long before Gutenberg. But printing in Korea developed in a radically different economic and institutional environment: printing in Korea was never capitalist enterprise. See Sohn (1998) and Park (1998). The Koreans also adopted a set of character simplifications (*Hangul*). These character simplifications were initially resisted by scholarly elites, but ultimately made language more amenable to printing. This fact calls into question the idea that the fixed complexity in inherited written language is in and of itself what accounts for the divergence in output and industrial organization in printing between China and Europe over the so-called early modern period.

Renaissance. Neither has previous research documented the content of print media or the channels through which the media impacted the broader economy. 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. But Dittmar (2011) does not document the most interesting and important sources of variation: variations in competition and content.[2]

This research uses firm-level data to document how variations in competition and content shaped the use and impact of innovation in media technology. The research constructs the first comprehensive firm-level database on the production of printed books across Renaissance Europe. 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. The research also constructs evidence on the timing of the deaths of heterogeneous firm owner-managers. The timing of the deaths of owner-managers is used to isolate plausibly exogenous shocks to competition and content at the city level.

The research delivers two big picture findings. The first finding is that negative shocks to incumbent firms generated lasting and positive increases in city-level competition. Quantitative and narrative evidence indicates that incumbents became enemies of free markets and suggests that shocks to firms were a significant part of a process "saving capitalism from capitalists." The second finding is that while many ideas circulated in print 1450-1600, the diffusion of the new business education literature was uniquely related to city growth. This literature included the first printed mathematics textbooks, accounting manuals, and guides to business practice.[3] Arguments in the social sciences going back to Werner Sombart suggest that the ideas in the business education literature had a transformative impact on the development of capitalism. No previous quantitative research has documented the diffusion of the business education literature or the relationship between the diffusion of this knowledge in print and growth.

The research delivers these big picture findings – and ties them together – by using firm-level data to study supply shocks and competitive dynamics at the firm and city level. 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 occasioned by manager deaths, (iii) city-level responses to heterogeneous firm-level shocks, and (iv)

[2]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. In related research, Baten and van Zanden (2008) find that the number of historic books produced at the level was associated with simulated national-level real wages 1500-1800. Dittmar and Seabold (2014) document how competition in media markets impacted the diffusion of the Protestant Reformation.

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

the relationship between the diffusion of knowledge in print and city population growth.

To identify shocks to firm and city level supply, the research constructs data on the timing of manager deaths. In a subset of firms, master printers died without grown sons able to assume management control. Many of these deaths were premature, in the sense that printers died during prime working age and/or when their own children were not yet grown. This paper will refer to all such deaths as "premature" as a short-hand.[4] These printer deaths led to management transitions in which widows and non-son heirs took control of firms. The data I construct identify 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.

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 shocks observed in their local competitors.[5] The research first estimates the output decline caused by the death of a manager for firms experiencing this loss. It then documents the significant increase in entry at the city level and the large, persistent increase in city output observed in the precise years and cities when managers died.

The key city-level finding is that shocks that were negative at the firm-level increased competition and *raised* total city supply. City supply increased through two channels: production by new entrants and increased production by incumbents. Across firms in a given city, the incumbents that expanded when a printer died were the ones with product lines most similar to the firm losing its manager.

The observed relationship between firm-level shocks and city-level industrial organization could only emerge in an environment in which transport costs limited inter-city trade. To document transport costs, the research analyzes new data recording book characteristics and prices for 2,000+ purchases made in 42 cities over the 1500s.[6] These data are used to document the price gradient associated with import distance controlling for observable book characteristics and the level of prices in a given city-year. The price

[4]This paper will refer to non-son heirs as "heirs." The fact that when printers 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 (further discussion below). 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. 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".

[5]The research thus contributes to the literature on media markets and the literature on the value of managers (e.g. Gentzkow, Shapiro, and Sinkinson 2011; Slovin and Sushka 2012; Johnson, Magee, and Nagarajan 1985; Pérez-González 2006).

[6]No previous economic research has constructed this sort of market evidence on the prices and characteristics of books during the Renaissance.

gradient estimates help explain the importance of within-city competition. They also support the view of historians that exposure to content was highly correlated with local production and that cities that printed books experienced local spillovers.

Finally, this research documents that cities with relatively more premature printer deaths developed thicker media markets, produced more books, and experienced higher population growth over longer time horizons. Across different types of content, the positive relationship between the local supply of business education content and city growth was unique in its magnitude and statistical significance. The correlation between local exposure to business education content and growth is a significant fact for economists thinking about upper tail human capital and the lessons of history. However, it reflects underlying determinants of both demand and supply. These include dimensions of city-level cultures and economic environments that we expect mattered for growth before and independent from innovations in the printed business education literature.

To make headway distentangling cause and effect, the research examines variations in supply induced by the deaths of heterogeneous printers. The deaths of printers who previously produced business education materials had a differential positive impact on both the city supply of business education books and city growth. Using printer deaths as a source of plausibly random variation, we find that a 10% increase in the supply of business education content was associated with a 1%-2% increase in population growth 1500-1600, a period when mean city growth was 30 percentage points. In contrast, the deaths of printers who were not business education producers had no impact on the supply of business education content. Deaths of printers who did not produce business education content did induce variations in the supply of other types of books. Induced variations in the supply of books outside the business education literature had a positive but quantatively very small and relatively imprecisely estimated impact on growth.

This research studies the relationship between firm-level shocks and competitive responses serves as a first stage in the analysis of growth, but also as unusually rich, stand-alone evidence on how shocks to firms may impact competition and collusion in a lightly regulated, high technology industry. The evidence on the supply of business education content highlights one channel through which increased competition in media markets may have delivered spillovers that impacted the diffusion of knowledge and urban dynamism over the transition to modern growth. More broadly, the research should be understood to provide a preliminary exploration of the ways competition may shape the use and effects of innovations in technology.

2 Historical Background

This section provides a condensed review of the history of printing in Europe. The key facts are as follows. First, printing was undertaken by profit-seeking firms. Second, competition took place almost entirely outside pre-existing guild regulations. Third, the industry was characterized by fixed costs. Fourth, competition was oligopolistic and incumbents made repeated attempts to establish anti-competitive agreements. Fifth, inter-city competition was limited by transport costs. Sixth, master printers had a valuable combination of skills and knowledge. Seventh, when printers died without sons able to assume control of their firms, this typically represented a big shock to both their firms and the local competitive environment.

1. Printing was a for-profit enterprise from the outset. The first movable type printing press enterprise was established in Mainz, Germany around 1447 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. 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), Nicholas (2003), and Hirsch (1974) 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] The subsequent development of guild regulation was limited, uneven, and broadly late in coming.[9]

[7]Dittmar (2011) 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 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

3. Printing was characterized by fixed costs at the firm-level and at the book-level. The big firm-level fixed cost was the cost of moveable metal type. The process and specific combination of alloys used to cast moveable metal type was the central technological break-through in printing and remained semi-secret until 1540 when the first blueprint guide was printed (Dittmar 2011). 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, printers typically required substantial wealth or financial backing. At the book level, the fixed costs included up front investments in cultivating and signing contracts with authors and in setting the type to print books.[11]

4. The characteristic form of competition was oligopolistic and incumbents repeatedly entered into anti-competitive agreements. In 1550, for example, the mean city producing books had 6.1 active book-producing firms and the median city had 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.[12] The anti-competitive agreements between firms were informal and formal (Pettegree 2011). Formal agreements set up syndicates on a semi-permanent basis or for a set number of years and/or involved contractually agreed price-fixing and quantity-setting policies. Section 4.1 provides details on syndicates. Section 5.3 shows that shocks to firms more deeply embedded in cross-firm networks had a bigger impact on the competitive environment than shocks to similar firms without such relationships.

5. The costs of inter-city trade shaped competition. Print media was heavy and costly to transport overland. It was also fragile and susceptible to 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 a few hundred miles (Edwards 1994). Due to the high level of transport costs, local producers were partially sheltered from import competition. As a result local production was strongly correlated (positively) with access

controlled. The results I report below are robust to controlling for the presence of local regulation of the book industry and to excluding England from the analysis.

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

[11] As an example, in 1483 the Ripoli press in Rome incurred a fixed cost of 3 Florins per quinterno for type setting Plato's *Dialogs*. In the 1480s a good scribe could charge 1 Florin per quinterno for copying services. However, the Ripoli print run for the *Dialogs* was 1,025 copies. The quinterno was a bundle of 5 sheets of paper that carried 20 pages of text when folded. See de la Mare (1985, p. 411). The surviving evidence on firm-level capital is limited, however in the early 1500s the agreements establishing the largest Venetian printing syndicates stipulated total capital contributions of over 30,000 Ducats (Nuovo 2013), equivalent to over 1,000 years of income for an unskilled worker and over 100 years of income for a highly paid university professor in Northern Italy.

[12] See sections 4.1 and 5.3 for further discussion and evidence on the distribution of firms across cities.

and (negatively) with prices. Section 6 assembles new evidence on book purchases to document the price-distance gradient that characterized the inter-city book trade.

6. Printing firms were family businesses to which the master printer brought a valuable and rare combination of skills, knowledge, and contacts. The printer was a capitalist worker-entrepreneur: "Almost all the printers were investors, organizers, and managers of their firms." (Brady 1998) In addition 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 perturbed city industrial organization. Febvre and Martin (1958) observe that the competitive environment was characterized by a propensity to "cut-throat" competition and a "struggle to keep competition at bay." Formal contractual agreements and informal arrangements were used to limit competition. In this environment, Parker (1996) observes, "It is difficult to overestimate the disruption caused by the death of a master printer." While widows were able to succeed their printer husbands as managers, women faced special constraints as firms managers as discussed below.

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.Table 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

[13]These data are examined in detail below.

[14]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 Table 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

Table 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).

text string often contains complicated descriptive text in multiple languages as well as 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, 20,000+ 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 Consortium of European Research Libraries's (CERL) online Thesaurus of early modern printers.[17] For each name found,

[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 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 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.

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

the Thesaurus provides a set of variants and aliases (sometimes none, sometimes a dozen) used on the title pages of books printed by individual printers' firms. The 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. All 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.

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		

Table 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.

The measure of shocks in this research is the death of a firm owner-manager. In the baseline data, the timing of manager deaths is defined as the first year a book by a widow or heir appears. This measure identifies only deaths of managers whose firms do not immediately exit the market.[19] As a result, the baseline evidence on shocks derived from book-level inscriptions allows us to identify a local average treatment effect below. In addition to the baseline data the research constructs independent evidence on the timing of the deaths of German printers from historical sources (Benzing 1963, Reske

[18]Most female printers are designated as "the widow of" or "heirs of" (Parker 1996). A subset of female printers published under their own names. The research identifies named female printers in two independent ways: manually and using the www.genderchecker.com database. The research forms the firm-level panel by searching for the husband or other predecessor(s) of each female printer.

[19]The data from historical books do not enable us to distinguish between firms closed by deaths and exits caused by other factors also do not tell us about the within-year timing of death.

2007). In German subsample we are able to document the precise date of death for 448 of 970 master printers and discriminate between exits caused by deaths and exits caused by other factors.

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] For example, the subjects include include religion (35%), bibles (2%), educational books (5%), law books (7%), and science and mathematics (1%). The USTC subject codes are valuable, but do not identify books belonging to the business education literature which historians argue was an important conduit of useful knowledge.[21] These manuals were used in business education and as reference texts for active businessmen (Hoock 1998; Dittmar 2011). Preliminary data on merchants' manuals is coded from Jeannin and Hoock (1991, 1993, 2001). Jeannin and Hoock catalogue 1,151 merchants' manuals printed across Europe 1474-1600, but miss several hundred such publications. These additional missing data are recorded manually.[22] Merchants' manuals account for 0.5% of publications. The appendix provides summary statistics on all subject literatures.

The book-level unit of analysis in this paper is the book edition – defined as a given title produced by a given firm in a given place and year. For the purposes of this research 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 use this information in estimation.[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 the period 1509-1539, Colón set out to assemble a universal library that would contain all known books. Colón purchased several thousand books in 42 cities across Europe. Colón recorded the price paid for individual books in local currency and the

[20] A small number of books are assigned multiple subject codes. The USTC database is slowly being expanded, e.g. 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.

[22] First, the research identifies editions of known merchants' manuals missed by Jeannin and Hoock. Second, it identifies additional volumes by searching all publications by known authors of merchants' manuals. Third, it identifies potential merchants' manuals by "fuzzy string matching" frequently used language in titles of known manuals against unknown books in potentially relevant classification areas. Potential candidates are then researched individually to determine if they are merchants' manuals.

[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.

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 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 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. The median book in the data cost less than 1 days worth of wages for an unskilled urban laborer and several hundred shorter books and pamphlets cost approximately 1 hours' worth of unskilled wages. Details on the distribution of prices, distances between point of purchase and point of production, and the cities where books were produced and purchased are presented in section 6 below.

4 Competition and 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 2011, 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

[24] On the unique quality of the evidence in the notebooks see Dondi (2010).

[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."

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

additional constraints in managing workers and cultivating and signing contracts with authors (Driver 1998; Parker 1996; Postel-Lecocq 1998; Broomhall 2002).[27]

The death of a printer was a shock to the city-level competitive environment for two principal reasons. The first reason printer deaths were shocks to competition is 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. The magnitude of the price gradient associated with shipping books over even short distances is documented in section 6 (below).

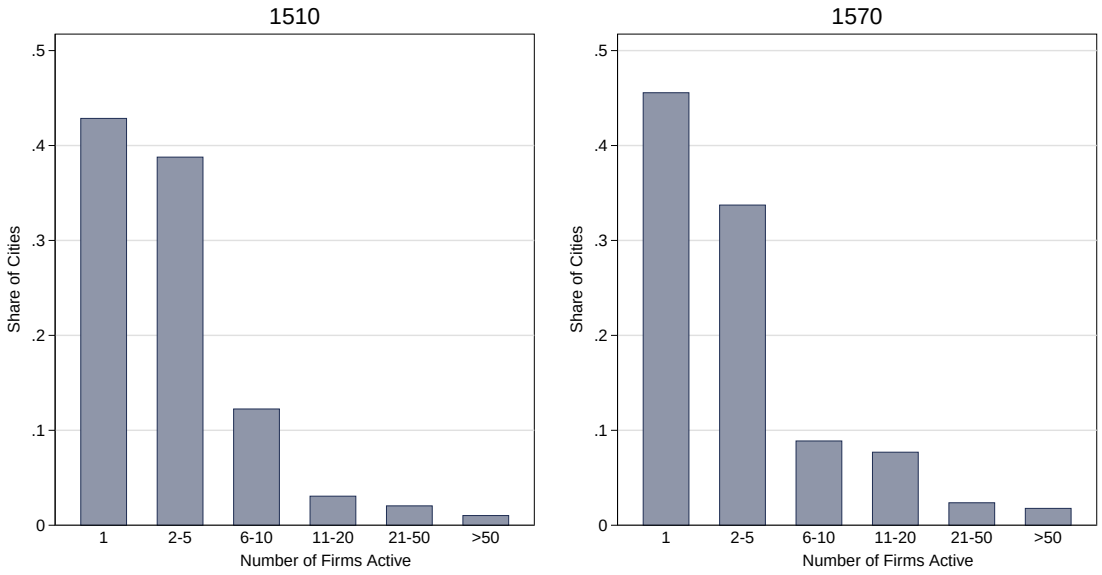

Figure 1: The distribution of the number of firms per city in cities publishing a book in 1510 (left panel) and 1570 (right panel).

The second reason printer deaths were shocks to competition is because deaths perturbed frequent but relatively fragile anti-competitive arrangements between incumbents. Informal agreements to limit competition were common (Pettegree 2011). Printers also formed a variety of formal anti-competitive syndicates, partnerships, and agreements that

[27]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).

frequently terminated when a party died. Evidence of anti-competitive arrangements is found across Europe. In the 1470s, the two largest firms in Venice were the firms owned by Nicholas Jenson (18% of Venetian publications in the 1470s) and Johannes de Colonia (15%). In 1480, Jenson and Colonia effected an agreement to produce together along with several lesser printers as "Johannes Colonia, Nicolas Jenson et Socii." The company lasted only one year due to the deaths of both leading partners (Nuovo 2013, p. 28). Similar examples are from the Giunti family of printers who came to prominence in Venice in the 1490s. In 1507, Luc'Antonio Giunti established a syndicate to produce law books under a five year contract with four fellow printers; such contractual associations between printers were typically set for a fixed duration of several years (Parent 1974, p. 139). On expiry, the initial five year contract was renewed to run to 1517. In 1517 Luc'Antonio entered into a formal business agreement with his nephew Giuntini Giunti that lasted until the nephew's premature death in 1521.[28] When Luc'Antonio himself died in 1538, his sons Tommaso and Giovanni Maria Giunti took over the firm. In 1539, Tommaso and Giovanni Maria set up a new law book syndicate which comprised, "the most powerful names in Venetian publishing," and which was renewed in 1550.[29] In 1571, leadership of the Giunti family business passed to Luc'Antonio the Younger. The business expanded under Luc'Antonio the Younger, who innovated by establishing a larger society (syndicate) with shareholders, but then entered into decline following his death. These examples from Northern Italy are not unique. In 1535, Johannes Oporinus formed a contractual partnership (*druckgemeinshaft*) in Basel with Thomas Platter, Balthasar Lasius, and Robert Winter (Reske 2007, p. 78). In Augsburg, Johan Otmar (active 1502-1516) collaborated with Erhard Ogelin and Johann Schönsperger. In Cologne, Eucharius Cevicornus cooperated with Johannes Prael, Hero Fuchs, Peter Quentel, and Johann Gymnich (Reske 2007, p. 430).

In addition to long-term business networks, we have archival evidence of price-fixing for specific products and anti-competitive strategic behavior. For example, in 1552 four Parisian printers (Vivant Gaultherot, Poncet Le Preux, Oudin Petit, and Jean Foucher) 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). In addition, there is 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

[28]The total capital contributions in the business agreement came to 32,153 Ducats, equivalent to over 1,000 years of wages for an unskilled worker. See Nuovo (2013), p. 53.

[29]The syndicate included Federico Torresani and Ottaviano and Giralomo Scoto. Nuovo (2013), p. 59.

books, Wechel used a quantity competition response strategy and unleashed, "a massive and systematic onslaught...aiming at little short of a monopoly...by putting into practice the commercial principle: if a competitor produces an edition, do the same."

In a world characterized by anti-competitive strategies, the death of a printer presented incumbents and potential entrants with new, ex ante profitable incentives. 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. In addition, I show that the impacts of deaths reflected firm heterogeneity. Deaths of printers specialized in a particular type of content (e.g. religious books or alternatively merchants' manuals) precipitated output expansions of that content.[30]

4.2 The Impact of 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 four key findings. First, the death of a manager was associated with a large and significant negative shock to output for their own firms. 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 that of the firm losing its manager and effectively non-existent for firms with entirely different product lines. Fourth, the deaths of managers with more extensive business networks induced larger competitive responses.

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

In years when firm managers died, their own 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 induced by the loss of a manager, controlling for variations in overall business conditions

[30] An alternative theory could be that the output response of surviving incumbents represented something like optimal investment under uncertainty. However, standard theories of demand uncertainty cannot explain a notable feature of the data: dramatically lower prices in years when a printer died. The appendix reports results showing that city-level prices were significantly lower in years when a printer died prematurely, even controlling for changes in quantities.

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 δ_{it} capture pre- and post-trends.[31]

Table 3 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 to within city-year variation we obtain an even stronger signal on manager deaths: a 32% decline (-0.4 log points) in output.

Figure 2 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 2 presents the parameter estimating the relationship between current firm-level output and leads of printer death variable, to document the assocation between output today and a manager's death tomorrow. The estimates for periods $t < 0$ can be taken as placebos and the decline in period $t = 0$ is the parameter estimate from Table 3 (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 towards the end of life.

4.2.2 The Impact of a Manager Death on Entrants

This section documents the significant increase in new entrants observed in the city-years with manager deaths. New entrants could either come from within a city or from other

[31] Specifications using count data models provide very similar results.

	All Firms		Firms with Transitions		
	Ln Titles	Ln Titles	Ln Titles	Ln Titles	Ln Titles
	(1)	(2)	(3)	(4)	(5)
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

Table 3: Printer deaths and own-firm output measured by titles 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. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

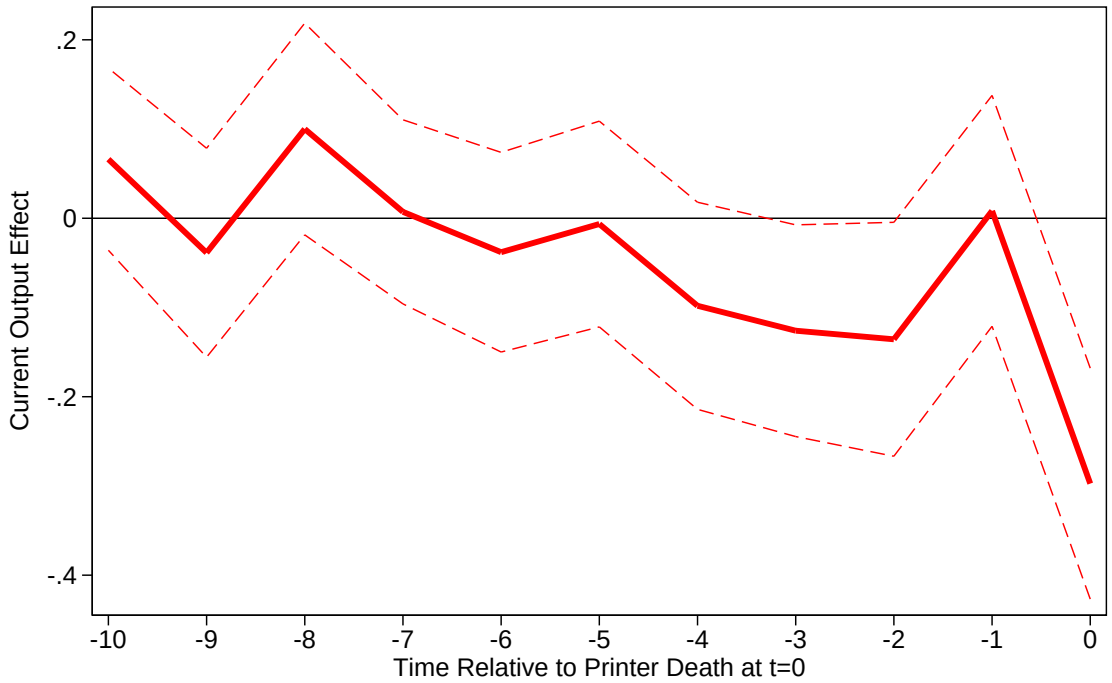

Figure 2: The relationship between premature printer deaths at time $t = 0$ and own-firm output in years up to and including the year of the shock. Years $t < 0$ are years before a premature printer death. Dashed lines represent the 95% confidence interval.

cities. Social historians emphasize the intercity mobility of printers.[32] In the database assembled here, 8% of printers made permanent inter-city moves.[33]

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

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

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.

Table 4 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.

4.2.3 The Impact of a Manager Death on Total City Output

To document the relationship between overall city production and the timing of manager deaths, this section uses an OLS estimation set-up. The appendix presents additional results obtained using a GMM dynamic panel estimator (Arellano and Bond 1991). Both OLS and GMM estimators both find printer deaths were associated with significant increases in book supply of 9%-10%.

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

[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.

	Linear Probability		Probit Marginal Effects	
	Entrant	Entrant	Entrant	Entrant
	(1)	(2)	(3)	(4)
Printer Death	0.12***	0.10***	0.13***	0.15***
	(0.03)	(0.03)	(0.03)	(0.04)
Ln Titles 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

Table 4: 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). Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

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.

Table 5 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

	Ln Titles	Ln Titles	Titles	Titles
	(1)	(2)	(3)	(4)
Printer Death	0.16***	0.10***	5.57***	2.81*
	(0.03)	(0.03)	(1.48)	(1.68)
Ln Titles Lagged	0.56***	0.17***		
	(0.02)	(0.01)		
Titles 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

Table 5: The relationship between book production and premature printers' deaths in annual city-level data. Book production is measured with the 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). Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

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 $\tau = t-8, t-7, \ldots, t+7, t+8$.

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

Figure 3 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 3 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 3 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 persistent innovations in city-level supply.

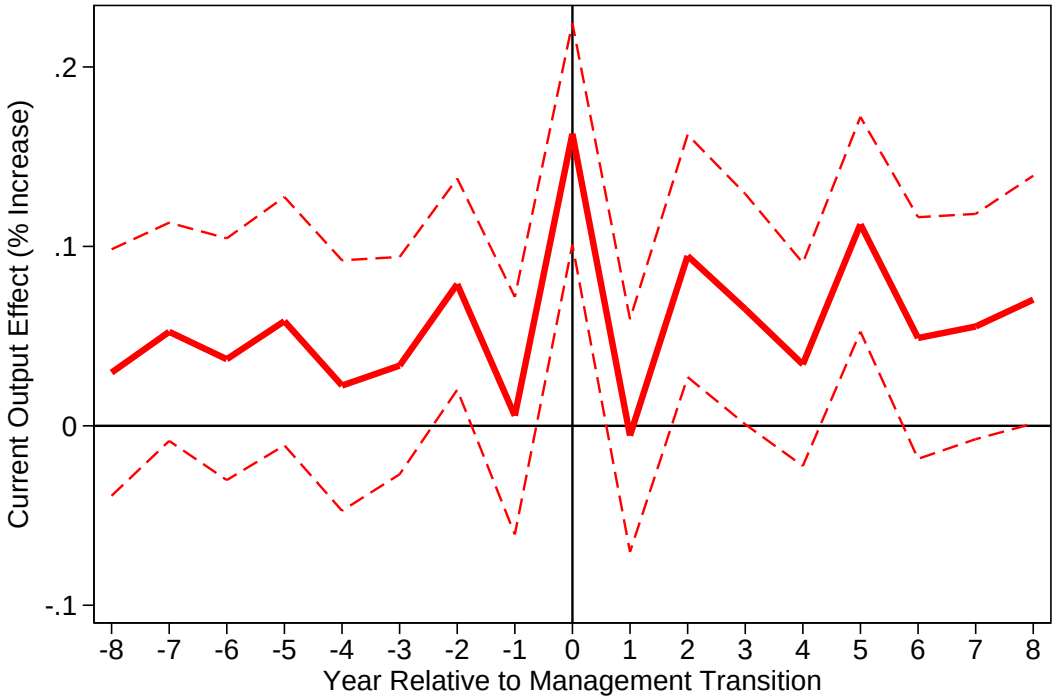

Figure 3: Placebo regression estimates of the city-level response of book titles to premature printer deaths over different time leads and lags. This figure plots the estimated slope parameters $\hat{\alpha}_\tau$ that relate growth in output at time τ to printer deaths at time $t = 0$. Heteroskedasticity-robust standard errors clustered at the city level.

4.2.4 The Impact of Heterogeneous Manager Deaths

Printing firms were not all the same. It is natural to wonder how their differences mattered for the transmission and impact of shocks. This section presents evidence on a key dimension of firm heterogeneity: product line specialization.

Firm-level heterogeneity in product specialization mattered for the transmission of shocks. Across incumbent firms the output response to a manager's death was largest for firms that were specialized in the same product lines as the firm losing its manager.[34] This heterogeneity will be used to study the differential impact of the deaths of different types of printers on the supply of content, and the relationship between induced variations in supply and city growth (section 5).

To document how product line specialization shaped the transmission and impact shocks, I develop an index of exposure to manager deaths that measures the proximity between firms in the product space. To index the proximity between firms, the research

[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 and do not report these results here.

classifies individual titles in 38 subject categories and measures the extent to which incumbents with surviving managers were producing a similar mix of subjects to firms losing managers in the same city.[35] The index is constructed as follows. For a firm i in city j which does not lose its manager, $s^n_{ij,t-1}$ is the share of output in the n^{th} subject in the previous year. For firms experiencing manager deaths, denote output shares in the year before the death with $s^n_{Dj,t-1}$. When these firms experience no deaths, $s^n_{Dj,t-1} = 0$. The index of a given firm's exposure to the death of heterogeneous printers is:

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

This index takes values from 0 to 1. If an incumbent firm produces books in entirely different subject areas from a firm experiencing a manager death, the incumbent's exposure to this shock is 0. If the incumbent firm and the firm experiencing a manager death are entirely specialized in the same subject area, the incumbent's exposure to this shock is 1. When the firms are diversified and have some subject varieties in common, the index takes intermediate values that increase in product line similarity.

To document the role of firm-level heterogeneity in the transmission of shocks, I estimate a regression in which variations in firm-level output are explained by city-level printer deaths unadjusted for heterogeneity, the exposure index measure of these shocks which varies across firms, and firm and year or firm-cross-decade controls. The regression is estimated for firm-years in which no "own deaths" occur, so the variation studied is entirely from the deaths of competitors.

$$\ln titles_{ij,t} = \alpha death_{j,t} + \beta exposure_{ij,t} + \delta_t + \theta_i + \nu_{i,t} \tag{5}$$

Table 6 shows that the output response to premature printer deaths was overwhelmingly accounted for by firms with similar product specializations. Table 6 estimates equation (5) and shows in columns (3) and (4) that the entire city-level output impact of about 10% is explained by the exposure index for firm-level heterogeneity which captures the differential impact of the death of a manager death in one firm across surviving competitors.

[35] The subject categories range from "Art and architecture", "Academic Dissertations", and "Bibles" to "Merchants' Manuals", "Jurisprudence", and "Poetry". The appendix provides summary statistics on the share of titles in each subject.

	Ln Titles	Ln Titles	Ln Titles	Ln Titles
	(1)	(2)	(3)	(4)
Exposure Index	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

Table 6: Estimates of the differential impact of printer deaths across heterogeneous firms. The "Exposure 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. "Printer Death" captures variation in printer deaths without adjustment for firm-level heterogeneity. See text for details. Standard errors clustered at the firm level in columns (2) and (3) and at the firm-decade level in columns (4) and (5). Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

5 Print Media, Human Capital, and Growth

Print media was a channel for the diffusion of knowledge. The knowledge that diffused in print was important for the accumulation of specialized human capital and in high-skill economic activities. This section provides evidence on the value of knowledge transmitted in the business education literature. It documents that the diffusion of the business education literature has a uniquely large and significant relationship with city population growth when compared to other literatures. This finding provides quantitative support for arguments on the importance of upper tail human capital and business education in the development of historical capitalism.[36] Finally, this section examines printer deaths as a possible source of variation in supply.

[36]Dittmar (2011) observed that the historical evidence suggests that business education literature contributed significantly to upper tail human capital formation. That research hypothesized that the role of print media in producing specialized human capital via business education may be a key explanation for the fact that cities that adopted printing early enjoyed a growth advantage over otherwise similar cities that did not. The current research presents quantitative evidence on this hypothesis. The question of how human capital relates to city growth in history has also been examined by Squicciarini and Voigtländer (2014), who construct a proxy measure for upper tail knowledge using purchases in France of the *Encyclopédie* of the 1700s. Squicciarini and Voigtländer argue that upper tail knowledge was associated with city growth starting with the industrial revolution of the late 1700s.

5.1 Business Education in Print

Qualitative evidence documents a surge in the development and diffusion in print of knowledge-based innovations during the Renaissance (Eisenstein 1980). The key economic innovations involved accounting, applied mathematics, and new forms of business practice that were valuable to merchants and bankers (Hoock 2008, Mills 1994). A classic debate centers on the question of whether the diffusion of double entry bookkeeping by itself had a sudden and revolutionary impact on the development of capitalism (e.g. Yamey 1949). However, the innovations in business education extended to a range of skills and knowledge beyond double entry bookkeeping, including basic numeracy, applied "commercial mathematics", business letter writing, contract design, and the use of "day books" to track inventory and transactions. In addition, we can identify the adoption or non-adoption of double entry book-keeping in only a small number of firms. For these reasons, this research examines data on the diffusion of the broader set of "merchants' manuals" that were used to transmit a class of knowledge (Hoock and Jeannin 1991).

Historical evidence suggests that the new forms of business knowledge were valuable (Goldthwaite 1972, Dittmar 2011). Braudel (1979) observes that historic accounting manuals were master works and that the knowledge they contained should not be underestimated. Price data are not available for large numbers of merchants' manuals.[37] However, surviving business records from one of the most important European printing firms provide a unique window onto pricing for upper tail knowledge. The accounts of the Antwerp firm of Christopher Plantin from 1564-1565 show that: (i) business education materials were distinguished by high prices and high mark-ups over costs and (ii) that authors' fees for business education content were extremely high.[38]

Table 7 shows that Plantin charged a price mark-up of 2.6 over marginal cost for an accounting manual by Pierre Savonne. The mark-up for this accounting text implies an elasticity of demand of -0.4 and is exceeded in the accounts only by the mark-up charged on a Hebrew-language bible. Table 7 also shows that Savonne's accounting manual was exceeded in price only by the Hebrew bible and the Vesalius-Valverda human anatomy text. The Vesalius-Valverda text contains a remarkable set of anatomical illustrations that made it one of the most expensive medical books of its time. Table 8 shows that the

[37]The Colón data record only a few purchases of arithmetics and merchants' law books. In the regression analysis below, the residual prices for these publications are positive.

[38]The accounts record wholesale prices and marginal costs for books in production. In some instances, total and/or marginal costs are available by category (e.g. paper, labor, authors' fees). Where available, cost figures cover paper, compositors' and pressmen's wages, and illustrations. The accounts do not record costs for proof-readers, sales staff, equipment, candles, or heating fuel. See Voet (1969).

author fees for Pierre Savonne's accounting manual comprised 45% of total costs while no other book has author's fees or costs of content above 7% of total costs.[39]

Book	Subject Class	Price in Wages	Mark-Up over Cost
(1)	(2)	(3)	(4)
Biblia Hebraica	Bibles	5.9	2.8
Savonne: Instruction et manière de tenir livres de raison	Accounting	4.0	2.6
Biblia Latina	Bibles	2.4	2.3
Pindarus: Olympia, Pythia, Nemea, Isthmia	Classical	0.8	2.0
Isaac: Grammatica Hebraica	Educational	0.7	1.8
Orta: Aromatum, et simplicium aliquot medicamentorum…	Medicine	0.5	1.7
Porta: Magiae naturalis, sive de miraculis rerum naturalium	Science	0.3	1.7
Diogenes Laertius: De vita et moribus philosophorum	Classical	0.8	1.4
Estienne: Promptuarium Latinae linguae	Educational	0.9	1.3
Junius: Nomenclator	Dictionary	1.6	1.2
Valerius Maximus: Dictorum factorumque memorabilium	Classical	1.0	1.1
Erasmus: Colloquia	Medicine	0.6	1.0
Estienne: De landtwinninghe ende hoeve	Agriculture	0.5	1.0
Virgil: Opera	Classical	0.4	1.0
Lucanus: Marcus Annaeus Lucanus opera emendatus	Classical	0.2	1.0
Reynaert de Vos: Een seer ghenouchlicke historie	Literature	0.2	1.0
Vesalius-Valverda: Vivae imagines partium corporis humani	Medicine	6.6	0.9
Le Nouveau Testament de Nostre Seigneur	Bibles	0.9	0.8
Hunnaeus: Dialectica, seu generalia logices praecepta omnia	Dialectics	0.7	0.8
Lancellotti: Institutionum juris canonici	Jurisprudence	0.6	0.8
Cornelius Valerius: Physicae, seu de naturae philosophia…	Science	0.2	0.7
Valerius Flaccus: Locis innumerabilibus	Classical	0.2	0.5

Table 7: Prices and mark-ups for books produced by Christopher Plantin 1564-1565. Prices in wages are nominal book prices (in *stuiver*) deflated by the daily wage in Antwerp. Data from Voet (1969).

5.2 The Association Between Ideas in Print and City Growth

This section disaggregates book production to document the relationship between urban dynamism and specific bodies of knowledge and ideas in print. The analysis examines city growth as a measure of economic dynamism in pre-industrial Europe motivated by the literature on historical growth (Acemoglu, Johnson, and Robinson 2005, DeLong and Shleifer 1999). Historically, population growth was largely driven by rural-to-urban migration and reflected productivity differentials, including those associated with differences in local knowledge (Dittmar 2011).[40]

[39] A portion of the author fee to Savonne was paid in printed books. For the purposes of this calculation these volumes are valued at the per unit sales price as quoted in the Plantin accounts.

[40] Population growth reflects local changes in productivity in contemporary economies with labor mobility (Glaeser et al. 1999).

Book	Subject Class	Wage Bill	Paper Input	Text Review	Illus-tration	Author & Content
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Vesalius-Valverda, Vivae imagin	Medicine	0.06	0.12	0.00	0.77	0.01
Savonne, Instruction et manière…	Accounting	0.13	0.40	0.02	0.00	0.45
J. Sambucus, Emblemata	Emblems	0.06	0.24	0.00	0.70	0.00
Hadrianus Junius, Nomenclator	Dictionary	0.33	0.49	0.11	0.00	0.07
J.B. Porta, Magia Naturalis	Science	0.34	0.51	0.00	0.00	0.00
ABC avec la civilité puerile	Education	0.47	0.53	0.00	0.00	0.00
Index seu specimen characterum…	Book List	0.83	0.17	0.00	0.00	0.00
Valerius Flaccus	Classical	0.46	0.54	0.00	0.00	0.00
Horatius	Classical	0.39	0.61	0.00	0.00	0.00
Index librorum…	Book List	0.53	0.47	0.00	0.00	0.00

Table 8: Cost shares for books produced by Christopher Plantin 1564-1565. Cost shares shown for J.B. Porta's *Magia Naturalis* and Vesalius-Valverda *Vivae imagines* sum to less than 1 because both books also had translation costs. Data from Voet (1969).

Consider first a simple model that examines the relationship between city growth ($\Delta Y_{i,t}$) and the local production of different subject literatures in the current and previous period while making no causal claims.[41]:

$$\Delta Y_{i,t} = \sum_{j}^{J} \alpha_j books_{i,t} + \sum_{j}^{J} \beta_j books_{i,t-1} + \theta Y_{i,t} + \gamma X_{i,t} + \epsilon_{i,t} \tag{6}$$

Here the measure of exposure to media content (*books*) is an indicator capturing whether a given city i produced content in 38 different subject categories indexed with j. The estimates control 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.

Table 9 documents the relationship between city growth and local supply of different types of print media and shows that the local supply of merchants' manuals had a uniquely large, positive, and statistically significant relationship with growth. Figure 9 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. The two literatures with the largest positive conditional association with growth are the business education literature (merchants' manuals) and the science and mathematics literature. The three literatures with the largest negative conditional association with growth are the literatures on (i) courtesy, etiquette, and sumptuary

[41]The set up loosely echoes frameworks used to estimate returns to education (e.g. Krueger and Lindahl 2001) and research using publications as measures of knowledge in contemporary settings (Adams 1990).

Type of Books	Coefficient	P-Value
(1)	(2)	(3)
Merchants' Manuals	0.28	0.00 ***
Science & mathematics	0.17	0.10 *
Any Books	0.17	0.28
History & chronicles	0.17	0.01 ***
Book trade (including booksellers' lists)	0.16	0.25
Military handbooks	0.16	0.07 *
Political tracts	0.14	0.19
Discourses on government & political theory	0.13	0.09 *
News books (sensational literature, events and conflicts in foreign places)	0.13	0.36
Marriage & the debate on women	0.11	0.08 *
Educational books (ABCs, how to write letters, grammars, educational theory)	0.11	0.19
Art & architecture	0.10	0.28
Astrology & cosmography	0.09	0.24
Heraldic works & genealogies	0.09	0.24
Ordinances, edicts & proclamations	0.07	0.63
Poetry (not including Emblem books)	0.05	0.69
Literature	0.04	0.71
Philosophy & morality	0.04	0.54
Witchcraft, demonology & occult writings	0.02	0.81
Adages, aphorisms, emblem books, jests & proverbs	0.02	0.78
Dictionaries, vocabularies, phrase books & instruction in foreign languages	0.01	0.75
Bibles (including parts)	0.01	0.93
Culinary arts (cookery, table manners, household management)	0.00	0.97
Games & recreations (texts on chess, tennis, card games)	0.00	0.98
Medical texts	-0.01	0.96
Calendars, almanacs & prognostications	-0.02	0.69
Music	-0.05	0.46
Drama	-0.06	0.67
Jurisprudence (legal texts books, handbooks, commentaries,etc.) excluding edicts	-0.08	0.53
Funeral orations	-0.08	0.22
Linguistics & philology	-0.10	0.46
Economics (treatises on the economy, regulation of guilds)	-0.11	0.21
Dialectics & rhetoric	-0.12	0.27
Classical authors	-0.14	0.41
Travel, topography, maps & navigational manuals	-0.15	0.10 *
Agriculture, viticulture, texts on hunting & veterinary science	-0.16	0.08 *
Academic dissertations	-0.18	0.02 **
Religious	-0.21	0.12
Courtesy, civil conversation, etiquette & sumptuary	-0.36	0.00 ***

Table 9: 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. 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. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

regulations on conspicuous consumption, (ii) religion, and (iii) academic dissertations. The estimates control for pre-1500 books in each individual subject (these estimates are almost all not statistically significant), initial city population, port location, the presence of historic universities, navigable rivers, latitude, longitude, the interaction of latitude and longitude, and country fixed effects.

These results suggest the importance of disaggregating the ideas in print and raise the question of whether the estimated coefficients reflect unobservables that matter for city growth. For example, the observed relationship between merchants' manuals and growth may reflect variations in the underlying city-level business environment and in demand for content as much as the impact of the knowledge contained in books per se.

To provide direct evidence on the variation in the data and to motivate the next section, Figure 4 presents the correlation between residual city growth and city-level supply of merchants' manuals. Residual growth is obtained by regressing growth on non-media market determinants of urban dynamism: initial population, port location, presence of historic universities, navigable river, latitude, longitude, and country fixed effects.

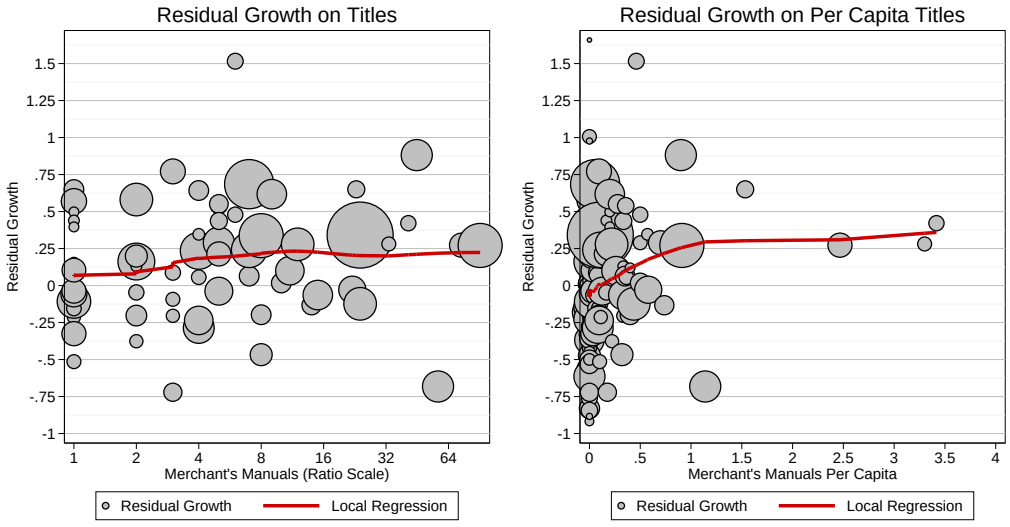

Figure 4: Residual growth and merchants' manuals. Residual growth is the residual from a regression of city growth on non-media market determinants of growth: initial city population, port location, the presence of historic universities, navigable rivers, latitude, longitude, the interaction of latitude and longitude, and country fixed effects. Titles are city-level titles produced 1500-1600. Per capita titles are obtained by dividing by initial 1500 population. Markers scaled to reflect city population in 1500.

5.3 Printer Deaths, Book Supply, and Growth

This section examines printer deaths as a possible source of exogenous variation in supply. The key finding is that the deaths of printers who produced merchants' manuals had a positive relationship with subsequent production of business education content, while the deaths of other printers did not, and that these variations in supply predict growth. The deaths of business education printers induced some variation in other types of content, but these were not associated with growth. Moreover, the deaths of other types of printers were associated with output increases in other subject areas, but these variations in output had a comparatively small and weak relationship to city growth. I discuss the details of these results and questions relating to causal inference below.

Consider a first stage model examining variations in the supply of business education content with a baseline estimating equation:

$$manuals_i = \alpha_0 + \alpha_1 deaths_i + \alpha_x X_i + \epsilon_i \tag{7}$$

This model is estimated below examining two measures of business education content: the number of manuals published 1500-1600 and the log of the number of manuals printer ($\ln[manuals + 1]$). In all specifications, the controls X include city population in 1500, pre-1500 printing, port location, the presence of historic universities, navigable rivers, latitude, longitude, and country fixed effects. The preferred specifications also control for whether a given city produced any business education content. To focus on variation in exposure to shocks and output within sub-groups of ex ante highly comparable cities, control group fixed effects are also introduced. Cities are assigned to control groups based on the similarity of their printing industries along three key dimensions over the period 1454-1499, before any deaths are observed for business education printers. Control groups are defined such that all cities in a given group (1) belong to the same output quantile, (2) are above (below) average science producers, and (2) are above (below) average education producers. Table 10 presents the characteristics that define control groups and documents the within-group variation in the exposure to printer deaths.[42]

Panel A of Table 13 documents the relationship between merchant manuals and printer deaths. Columns 1 and 6 document variations in supply associated with a printer deaths of any type. Columns 2-5 and 7-10 document that the relationship between variations in supply and deaths was driven by the deaths of printers running firms that published business education content, as opposed to other printer deaths.[43] Columns 4-5

[42]The results below are robust to dropping the control groups with no variation in merchant deaths and to reclassifying to construct coarser groups with variation in all cells.

[43]In the data there are four such deaths that occur before the firm publishes the firm's first business

City	Print Media Output 1454-1499				Cities & Shocks 1500-1600		
Control	Mean	Output	High	High	Total	Merchant	Other
Group	Titles	Quantile	Science	Education	Cities	Death	Death
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	0.0	1	No	No	133	6	22
2	1.4	2	No	No	13	0	6
3	2.0	2	No	Yes	2	0	0
4	10.4	3	No	No	26	5	15
5	21.3	3	No	Yes	12	4	9
6	16.5	3	Yes	No	4	0	1
7	30.0	3	Yes	Yes	2	0	1
8	413.9	4	No	No	17	9	12
9	421.2	4	No	Yes	13	6	8
10	266.8	4	Yes	No	12	5	9
11	602.2	4	Yes	Yes	5	2	4

Table 10: The construction of control groups based on 1454-1499 media output. Column 7 records the number of cities experiencing the death of a printer whose firm produced business education content. Column 8 records the number of cities experiencing the death of printer whose firm did not produce business education.

and 9-10 control for whether a city ever printing business education materials and for control group indicators. The specifications studying the count of titles indicate that the death of a merchant printer was associated with an additional 11+ titles. The specifications studying the log of titles indicated that merchant printer deaths were associated with an approximately 1 log point increase in business education content – an increase of over 100%. These results are robust across specifications. They hold even when the identifying variation in printer deaths is variation within tight control groups of ex ante similar cities.[44] Below I discuss questions about the exclusion restriction, showing that (i) deaths of business education printers do not appear to have impacted growth through other media market channels, (ii) deaths of other types of printers do not have similar effects, and (iii) business education output increased significantly in the precise city-years in which deaths of business education printers are observed and not before.

The first stage results are used to isolate plausibly exogenous variation in supply and to estimate the relationship between growth and the business education literature. The reduced form estimating equation is:

$$\ln(POP_{t+1}/POP_t) = \beta_0 + \beta_1 manuals_{it} + \beta_x X_{it} + \nu_{it} \tag{8}$$

Panel B of Table 13 presents 2SLS estimates of the relationship between growth and

education publication. The results are robust to controlling for this feature of the data.

[44]The results are quantitatively very similar in a sample restricted to cities that did produce merchants' manuals.

the business education literature. Columns 1-5 show that when printer deaths are used as an IV for supply we estimate that an additional merchants' manual was associated with an increase in population growth of 0.7%-2.5% . Columns 6-10 present estimates examining variations in growth induced by variations in the log of business education publications. The estimated elasticities of growth with respect to this media output fall between 0.1 and 0.2 and are highly significant. To interpret these magnitudes, consider that the mean city experienced 30% population growth 1500-1600.

These results raise three key questions about the variations in shocks, output, and growth and the plausibility of causal inference. First, it is natural to wonder whether shocks that occurred relatively early are associated with larger output effects in the first stage. We might be concerned if shocks in the late 1500s were associated with the same output variations as earlier shocks. Were this the case, that might suggest that variation in output is driven by the fact that cities with shocks are propitious places, rather than by variations in competition engendered by shocks. Second, it is natural to wonder whether the timing of the relationship between shocks and supply is consistent with a causal interpretation. We would like to test in high frequency data whether the supply of business content increased in the wake of merchant printer deaths or, to the contrary, before these deaths. Third, it is natural to wonder what the output and growth effects were when other types of printers died.

To address the first question, we can document that cities where shocks occured relatively early experienced larger output increases. To show this I estimate regressions that document the relationship between business education supply and a measure of time since a printers' death. The baseline specification is:

$$manuals_i = \alpha_0 + \alpha_1 deaths_i + \alpha_2(deaths_i \cdot periods_i) + \alpha_x X_i + \epsilon_i \tag{9}$$

Here $periods_i$ measures the time between a manager death and 1600, α_1 captures any timing-invariant relationship between shocks and output, and α_2 captures variations in output associated with the timing of the shock.

Table 12 shows that variations in titles are explained by time since shocks as opposed to simply the characteristic of being exposed to shocks at some point. Table 12 presents estimates using 25-year windows as the measure of time since exposure to shocks.[45] Columns 1-4 show that an additional 25 years post-shock was associated with a 0.5 log point increase in merchant manuals, under the maintained assumption that the relationship between time "treated" and output is linear. Column 5 estimates a flexible

[45]Using decades yields similar results. Using annual level data generates quantatively similar but less precisely estimated results.

Panel A: First Stage - Dependent Variable is Measure of Merchants' Manuals										
	Titles	Titles	Titles	Titles	Titles	Ln Titles	Ln Titles	Ln Titles	Ln Titles	Ln Titles
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Death Any	1.034**					0.067***				
	(0.372)					(0.016)				
Death Merchant		14.180***	13.730***	12.036***	11.645***		1.777***	1.721***	1.048***	1.027***
		(2.983)	(2.962)	(3.501)	(3.237)		(0.166)	(0.181)	(0.198)	(0.184)
Death Non-Merchant			1.612	1.365	1.350			0.200**	0.102	0.097
			(0.985)	(1.045)	(1.025)			(0.084)	(0.067)	(0.070)
Ever Manuals				2.827*	2.733**				1.123***	1.114***
				(1.608)	(1.171)				(0.093)	(0.069)
Control Groups					Yes					Yes
Observations	239	239	239	239	239	239	239	239	239	239
R Square	0.581	0.391	0.395	0.402	0.441	0.556	0.687	0.693	0.813	0.832
Panel B: Second Stage - Dependent Variable is Ln City Growth										
	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth
Manuals	0.007***	0.025**	0.023**	0.012**	0.016**					
	(0.002)	(0.011)	(0.010)	(0.006)	(0.007)					
Ln Manuals						0.109***	0.197***	0.185***	0.140**	0.177**
						(0.021)	(0.063)	(0.058)	(0.055)	(0.065)
Ever Manuals				0.252**	0.225*				0.129	0.070
				(0.108)	(0.119)				(0.118)	(0.131)
Control Groups					Yes					Yes
Observations	239	239	239	239	239	239	239	239	239	239
R Square	0.279	0.179	0.199	0.313	0.312	0.323	0.331	0.336	0.345	0.360
IV: Printer Death	Any	Merchant	Merchant	Merchant	Merchant	Any	Merchant	Merchant	Merchant	Merchant
F Statistic on IV	7.7	22.6	21.5	11.8	12.9	18.6	115.3	90.4	28.0	31.2

Table 11: Panel A presents first stage regressions documenting the city-level relationship between the supply of merchants' manuals and printer deaths. The dependent variable in columns 1-5 is the number of manuals produced 1500-1600. The dependent variable in columns 6-10 is the log of manuals ($\ln[manuals + 1]$). "Deaths Any" is an indicator for any printer deaths 1500-1600. "Death Merchant" is an indicator for deaths of printers whose firms ever produced merchants' manuals. "Death Non-Merchant" is an indicator for deaths of printers whose firms did not. "Ever Manuals" is an indicator for cities that ever produced business education content. Control group fixed effects are as discussed in the text. Panel B presents 2SLS estimates of the impact of merchant manual supply on growth. The dependent variable is: $ln(POP_{1600}/POP_{1500})$. All regressions control for population in 1500, pre-1500 printing, port location, the presence of historic universities, navigable rivers, latitude, longitude, and country fixed effects. Standard errors clustered at the country level. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

specification with a set of interactions that allow printer deaths in different time periods to have independent, non-linear effects on supply. Using the timing of shocks in the first stage, the 2SLS estimates of the growth impact of business education content are highly significant and quantitatively large, although somewhat smaller than the estimates above which did not account for the timing of shocks.

To address the second question – whether shocks to firms producing business education content precipated or followed the variations in supply – it is useful to study the relationship between shocks and the supply at the city-year level. City-year level allow us to test whether output is elevated after deaths as opposed to before, in the spirit of Granger-causality. Consider a regression examining the probability a merchant manual is printed in a city-year it:

$$P(merchant_{it} > 0) = \sum_{\tau=0}^{m} \beta_\tau death_{i,t-\tau} + \sum_{\tau=1}^{q} \gamma_\tau death_{i,t+\tau} + \theta_i + \delta_t + \epsilon_{it} \qquad (10)$$

The parameters of interest are the β's and γ's, which capture the relationship between output and lags and leads of indicators for the death of a manager in a firm that produced business education content. The θ_i and δ_t are city and year fixed effects, respectively.

Figure 5 presents the regression estimates graphically to highlight the key result: the probability of getting a merchants manual dramatically increases in the city-years in which a death of a business education printer is observed. Before the death the probability is under 0.05 higher than the time-invariant city mean and statistically insignificant. In the year of the death the conditional probability more than doubles to 0.1 and is statistically significantly different from zero at the 95% level. The following years (t = 1, t = 2) also have elevated production of business education. The point estimates on future deaths are positive at $t = -1$ is consistent with the fact that on average cities saw deaths in periods when firms producing merchant content were active and as a result when production was high relative to the time invariant city fixed effect. Complete regression estimates and alternate specifications are presented in the appendix.

To address the third question – whether the deaths of non-merchant printers had similar supply and output effects – Table 13 presents 2SLS estimates of the relationship between (i) non-merchant deaths and non-business output and (ii) between these induced variations in supply and growth. The key finding is that the deaths of non-merchant printers did induce variations in non-business book supply, but these induced variations in supply were associated with quantitatively relatively small and statistically insignificant variations in city growth.

Panel A: First Stage - Dependent Variable is Measure of Merchants' Manuals					
	Ln Titles	Ln Titles	Ln Titles	Ln Titles	Ln Titles
	(1)	(2)	(3)	(4)	(5)
Death Merchant	0.603	0.572	-0.096	-0.092	
	(0.427)	(0.384)	(0.370)	(0.391)	
Death Merchant x Periods	0.564**	0.555***	0.553***	0.550***	
	(0.197)	(0.186)	(0.179)	(0.182)	
Death Merchant x Period 1575-1599					0.600**
					(0.251)
Death Merchant x Period 1550-1574					0.895***
					(0.232)
Death Merchant x Period 1525-1549					1.489***
					(0.430)
Death Merchant x Period 1500-1524					2.574***
					(0.430)
Death Non-Merchant		0.181*	0.083	0.071	0.076
		(0.103)	(0.057)	(0.067)	(0.069)
Ever Manuals			1.122***	1.108***	1.109***
			(0.090)	(0.071)	(0.063)
Control Groups				Yes	Yes
Observations	239	239	239	239	239
R Square	0.721	0.726	0.845	0.863	0.866
Panel B: Second Stage - Dependent Variable is Ln City Growth					
	Ln Growth	Ln Growth	Ln Growth	Ln Growth	Ln Growth
Ln Manuals	0.169***	0.155***	0.071*	0.103**	0.112***
	(0.051)	(0.045)	(0.041)	(0.040)	(0.036)
Death Non-Merchant		0.090	0.086	0.079	0.078
		(0.067)	(0.066)	(0.075)	(0.074)
Ever Manuals			0.237	0.183	0.169
			(0.150)	(0.153)	(0.144)
Control Groups				Yes	Yes
Observations	239	239	239	239	239
R Square	0.333	0.337	0.348	0.366	0.366
F Statistic on IV	69.2	59.7	19.5	22.4	18.2

Table 12: Panel A presents first stage regressions documenting the relationship between the deaths of merchant printers and the supply of merchants manuals measured as: $\ln[manuals + 1]$. "Death Merchant" is an indicator taking the value of 1 for cities where deaths of business education printers is observed. "Periods" is a measure of 25-year periods elapsed since the first (only) merchant printer death, and takes the value of 1 for cities with printer deaths 1575-1599, 2 for cities with merchant deaths 1550-1574, and so on. Column 5 uses interactions between deaths and time period indicators. Panel B presents 2SLS estimates of the impact of non-merchant supply on city growth. In Panel B the dependent variable is: $ln(POP_{1600}/POP_{1500})$. All regressions control for city population in 1500, pre-1500 printing, port location, the presence of historic universities, navigable rivers, latitude, longitude, and country fixed effects. Control groups fixed effects are described in the text. The IV for "Ln Manuals" are "Death Merchant" and "Death Merchant" interactions. Standard errors clustered at the country level. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

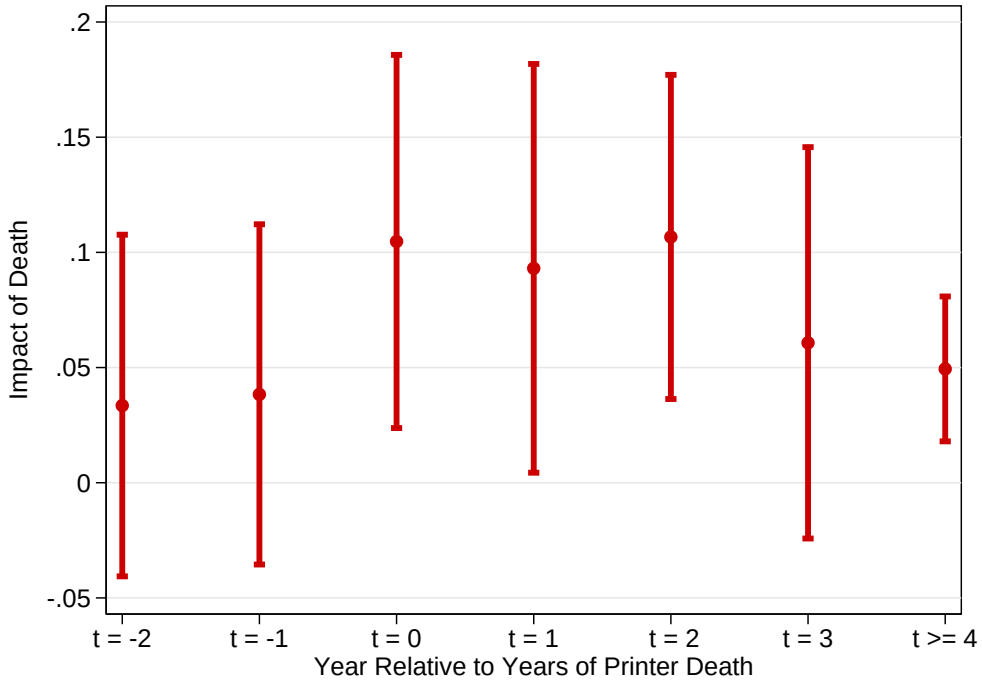

Figure 5: Regression estimates of the relationship between deaths of business education printers and the city-level supply of business education media. This graph presents parameter estimates of regressions in which the outcome is the probability of a merchant manual being printed in a given city-year. The explanatory variables are leads and lags of an indicator capturing whether the city experienced the death of a business education printer at time $t = 0$. The estimating model controls for city and year fixed effects. Vertical bands represent +/- 1.96 times the standard error of each point estimate. Standard errors are clustered at the city-decade level. Similar results obtain without clustering or clustering at city level.

These findings underline the significant relationship between upper tail knowledge and growth and strongly suggest that supply side variations in knowledge may have contributed to growth. While our conclusions are necessarily tentative, several further pieces of evidence provide reason to be skeptical that selection is what explains the results. First, there was considerable variation in the number of premature deaths per firm across cities, overwhelmingly due to chance differences in health in an era in which early death was comparatively frequent. Second, a notable set of cities with strong growth and dynamic business communities experienced no deaths of business education printers. Cities with no deaths of business education printers include: London, Geneva, Leiden, Zürich, Bologna, Copenhagen, and Valladolid. Third, across cities where business education printers died the timing of the first and/or only such death varied remarkably and was uncorrelated with other ex ante measures of economic dynamism. Examples of cities and dates of these deaths are: Augsburg 1513, Lyon 1527, Antwerp 1534, Erfurt 1537, Frankfurt 1542, Paris 1548, Barcelona 1551, Amsterdam 1565, Toulouse 1593,

Panel A: First Stage - Dependent Variable is Measure of Non-Business Book Supply				
	Titles	Titles	Ln Titles	Ln Titles
	(1)	(2)	(3)	(4)
Death Non-Merchant	468.588	491.065	1.333***	1.411***
	(418.509)	(348.937)	(0.169)	(0.184)
Death Merchant	3600.603**	3161.113**	0.670*	0.482
	(1624.185)	(1467.768)	(0.340)	(0.326)
Ever Manuals	529.623	447.048	1.446***	1.448***
	(407.788)	(304.627)	(0.213)	(0.198)
Control Groups		Yes		Yes
Observations	239	239	239	239
R Square	0.317	0.373	0.696	0.719
Panel B: Second Stage - Dependent Variable is Ln City Growth				
	Ln Growth	Ln Growth	Ln Growth	Ln Growth
Titles Non-Merchant	0.0002	0.0002		
	(0.0002)	(0.0002)		
Ln Titles Non-Merchant			0.0658	0.0589
			(0.0439)	(0.0478)
Death Merchant	-0.5270	-0.3530	0.1025	0.1538*
	(0.9716)	(0.7838)	(0.0759)	(0.0760)
Ever Manuals	0.1870	0.1921**	0.1910	0.1825
	(0.1207)	(0.0788)	(0.1244)	(0.1146)
Control Groups		Yes		Yes
Observations	239	239	239	239
F Statistic on IV	1.3	2.0	62.1	58.7

Table 13: 2SLS estimates of the relationship between deaths of printers who did not produce business education content, the city-level supply of non-business content, and growth. Deaths of non-business printers are the IV for non-business content. Specifications, controls, and standard errors are as in Table 13 above.

Madrid 1594. Fourth, firms that produced business content were multi-product firms for whom the business education market was a relatively small component of total revenues and profits. For this reason, local demand for specialized business education content was not likely to be a significant factor determining whether or not to a widow or heir would take over such a firm over and above general market demand for books. Business education titles comprised about 4% of titles for the average firm that produced this content. In the case of the Plantin firm for which accounts survive, business education content generated about 4% of sales revenue in 1565.

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 as-

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

6 The Cost of Inter-City Trade

If trade was not costly, the death of a printer in a given city would not have a differential impact on competition in that particular city. If trade was not costly, the relationship between local production and access to ideas in print would be expected to break down.

A large body of narrative evidence indicates that transport costs were extremely high, but previously no systematic quantitative evidence on either book prices or transports costs have been assembled. This section reviews evidence on transport costs from the historical literature and presents a newly constructed on prices from book purchases in the 1500s. These data allow us to document the price gradient associated with transport between city of production and city of purchase controlling for the overall level of prices in a given city-year and individual book characteristics. The estimated price gradient provides support for the salience of within-city competition, the historical observation that exposure to the media was highly correlated with local production (Edwards 1994), and a causal interpretation of the relation between supply shocks to local production and city growth.

Print media were costly to transport because books were heavy, fragile, and sensitive to water damage (Barbier 2006; Febvre and Martin 1958; Richardson 1999; Dittmar 2011). The inter-city trade in books was extensive (Pettegree 2011) but significantly limited. Outside printing cities, information on the range of available media was incomplete and many books were not offered for sale – implying extremely high shadow prices (Flood 1998, p. 55). Transport costs were sufficiently high that print media often spread through reprinting rather than inter-city trade (Edwards 1994, p. 8).

To quantitatively document the impact of transport costs on book prices this paper examines data on book purchases made by Hernando Colón in 41 cities across Europe 1509-1539. Figure 6 shows the distribution of book prices in terms of the prevailing historical wage for laborers.[46] The appendix reports additional summary statistics on

[46]To compute prices of books in laborer days, all prices are converted into gold ducats using the

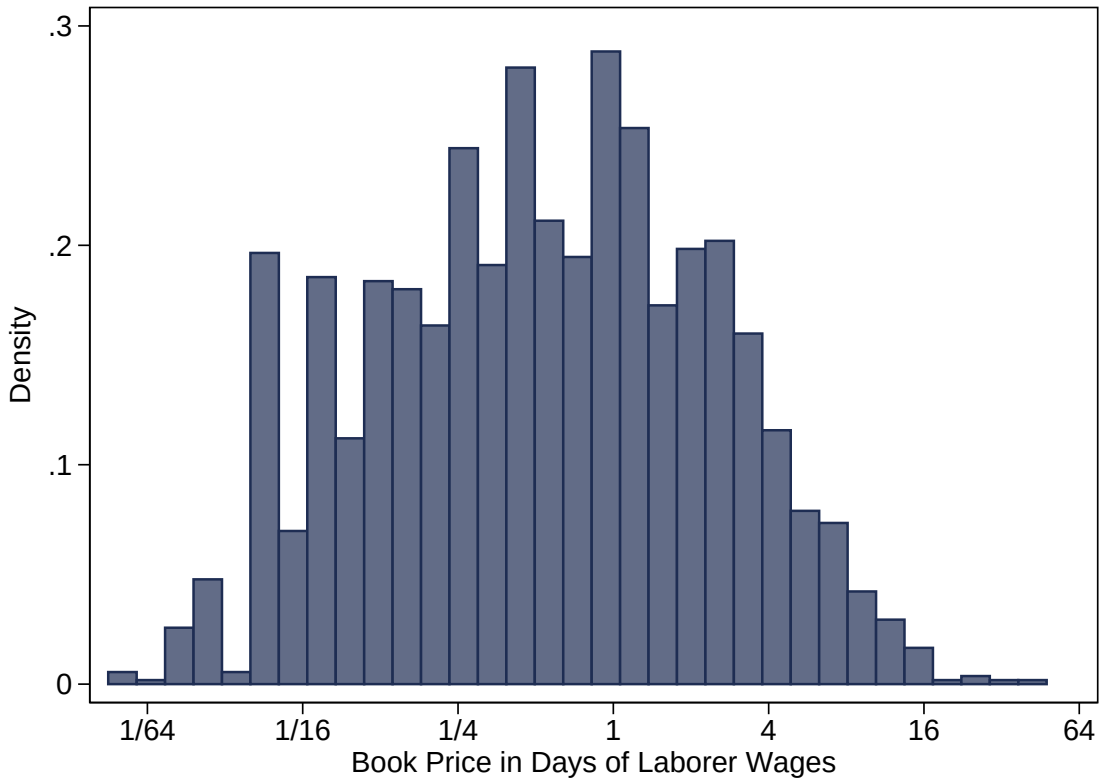

Figure 6: Distribution of book prices recorded by Hernando Colon 1509-1539.

import distances and book-level characteristics and provides a map showing the cities where Colón bought books and the set of cities that produced books that were exported and purchased by Colón elsewhere.

Table 14 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, controlling for the overall level of prices in each city-year and observable book characteristics. The baseline elasticity of prices with respect to distance is 0.38, as reported in column (2). The coefficient of 0.38 tells us that every time the distance between purchase city and production city doubles the price increases by 30 percentage points, other things equal.[47] This elasticity is estimated in a model:

$$\ln price_{ijt} = \alpha \ln distance_i + \theta_{jt} + \beta X_i + \epsilon_{it}$$

historical exchange rate. Ducat values are converted into silver equivalents using the fact that over this period the ducat and the florin traded at par and the silver content of the florin from the Global Income and Price History database. The silver prices of books are deflated by silver laborers' wages. I take as the European laborers' wage the mean of wages in Antwerp, Amsterdam, Paris, Strasbourg, Florence, Milan, Naples, Valencia, Madrid, Augsburg, Leipzig, and Vienna as recorded in Allen (2012).

[47] Distance is measured as great circle ("as the crow flies") distance.

where variations in the price of book i purchased in city j are explained by the distance between printing city and purchase city ($distance_i$), city-year fixed effects θ_{jt} and book characteristics X_i. The book-level characteristics controlled for include the number of pages in a book, format (folio, quarto, octavo), the physical size of pages, the subject matter, the presence of illustrations, and the age of the book defined as years between print date and purchase date. The relationship between distance and price varied systematically with the length of books, although not with other observed features. Column (3) shows that there was a negative differential price gradient for longer books. Equivalently column (4) shows that the positive relationship between price and distance was much stronger for pamphlets (booklets of 32 pages or less). In contrast, the estimated price-distance gradients reported here are stable across the distribution of observed import distances. Quantile regression results documenting the stability of price gradient estimates across import distances are reported in the appendix. It is relatively less likely that unobserved book characteristics vary with small differences in import distance. However, for a causal interpretation the necessary identifying assumption is clearly that there are not unobserved variations in book characteristics associated with distance and price.

7 Conclusions

During the Renaissance the economic and intellectual landscape of Europe was transformed. The transformations were shaped by the diffusion of the moveable type printing press. This technology was adopted by firms competing in new media markets. Historic and econometric evidence indicate that incumbents pursued anti-competitive strategies. Evidence from firm-level data strongly suggests that negative shocks to incumbents had positive impacts on competition, output, and the diffusion of knowledge in print. This research studies how print media was a channel for the diffusion of innovations in business education. Historians argue that the knowledge-based innovations in business education played a key role in the development of capitalism, but previous research has not quantified the diffusion of these ideas. The diffusion of the business education education literature was strongly associated with growth at the local level. More pointedly, the evidence suggests that variations in media market competition may have played a role in determining local access to these ideas and, through this channel, the long run development of market economies. Future research may examine how historical evidence on information technology and competition in the media shaped the diffusion of other bodies of knowledge and ideas.

	Ln Price	Ln Price	Ln Price
	(1)	(2)	(3)
Ln Distance to Producing City	0.38***	0.72***	0.18**
	(0.09)	(0.22)	(0.08)
Ln Distance x Ln Pages		-0.10**	
		(0.04)	
Ln Distance x Pamphlet			0.24***
			(0.07)
Ln Pages	0.23***	0.85***	0.00
	(0.04)	(0.28)	(0.04)
Pamphlet			-2.34***
			(0.44)
Ln Page Dimension	3.30***	3.28***	3.25***
	(0.51)	(0.50)	(0.48)
Book Age	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)
Illuminated	0.35***	0.34***	0.33***
	(0.09)	(0.10)	(0.10)
Bibles	0.32***	0.32***	0.27***
	(0.09)	(0.10)	(0.09)
Additional Controls	Yes	Yes	Yes
City x Year Fixed Effects	Yes	Yes	Yes
Observations	1542	1542	1542

Table 14: Price-distance gradient regressions. Ln Price is the log of purchase price in gold ducats. Ln Distance is measured as the logarithm of 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. Pamphlet is an indicator for items with 32 or fewer pages. Book Age is the number years between the year of printing and the year of purchase. Illuminated is an indicator for books with illuminations. Bibles is an indicator for bibles. All regressions include fixed effects for book subjects: e.g. Law, Philosophy, Theology, Religion (Non-Theological), Orations, Poetry, Languages, and Medicine. All regressions include fixed effects for book format (folio, quarto, and octavo). Standard errors are clustered at the city-year level. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

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A Subject Matter of Publications

The publications examined in this research are classified in 38 subject categories. Table A summarizes the distribution of titles across these subject categories. Table A presents the within-firm correlation between output shares in different subject areas.

Subject Classification	Share of Titles
(1)	(2)
Academic dissertations	2.6%
Adages, aphorisms, emblem books, jests & proverbs	0.7%
Agriculture, viticulture, hunting & veterinary science	0.3%
Art & architecture	0.3%
Astrology & cosmography	0.8%
Bibles (including parts)	2.3%
Book trade (including booksellers' lists)	0.1%
Calendars, almanacs & prognostications	1.4%
Classical authors	6.1%
Courtesy, civil conversation, etiquette & sumptuary	0.2%
Culinary arts (cookery, manners, household management)	0.1%
Dialectics & rhetoric	0.8%
Dictionaries, vocabularies, foreign language instruction	0.7%
Discourses on government & political theory	0.4%
Drama	1.5%
Economics (treatises, regulation of guilds)	0.7%
Educational books (ABCs, how to write letters, grammars)	4.8%
Funeral orations	1.3%
Games & recreations (texts on chess, tennis, card games)	0.1%
Heraldic works & genealogies	0.1%
History & chronicles	2.9%
Jurisprudence (legal texts books, handbooks, etc.)	6.7%
Linguistics & philology	0.2%
Literature	3.7%
Marriage & the debate on women	0.7%
Medical texts	3.6%
Merchants' Manuals	0.5%
Military handbooks	0.3%
Music	4.5%
News books (sensational literature, events, wars)	2.2%
Ordinances, edicts & proclamations	5.4%
Philosophy & morality	1.4%
Poetry (not including Emblem books)	4.6%
Political tracts	2.0%
Religious	34.6%
Science & mathematics	0.9%
Travel, topography, maps & navigational manuals	0.7%
Witchcraft, demonology & occult writings	0.2%

Table 15: The share of publications (titles) in different subject categories 1450-1600.

	1 Academic	2 Adages	3 Agriculture	4 Art & Arch.	5 Astrology	6 Bibles	7 Book Trade	8 Calendars	9 Classics	10 Courtesy	11 Cooking	12 Dialectics	13 Dictionaries	14 Government	15 Drama	16 Economics	17 Education	18 Funerary	19 Games	20 Heraldry	21 History	22 Jurisprudence	23 Linguistics	24 Literature	25 Marriage	26 Medicine	27 Military	28 Music	29 News	30 Ordinances	31 Philosophy	32 Poetry	33 Politics	34 Religion	35 Science	36 Travel	37 Witchcraft	38 Merchants
1 Academic	1.0																																					
2 Adages		1.0																																				
3 Agriculture			1.0																																			
4 Art & Architecture				1.0																																		
5 Astrology					1.0																																	
6 Bibles						1.0																																
7 Book Trade							1.0																															
8 Calendars								1.0																														
9 Classics		0.6							1.0																													
10 Courtesy										1.0																												
11 Cooking											1.0																											
12 Dialectics									0.7			1.0																										
13 Dictionaries													1.0																									
14 Government														1.0																								
15 Drama															1.0																							
16 Economics																1.0																						
17 Education		0.7							0.7			0.5	0.5				1.0																					
18 Funerary																		1.0																				
19 Games																			1.0																			
20 Heraldry																				1.0																		
21 History		0.6							0.7					0.5			0.5				1.0																	
22 Jurisprudence																						1.0																
23 Linguistics																							1.0															
24 Literature																					0.6			1.0														
25 Marriage																		0.8							1.0													
26 Medicine																					0.5					1.0												
27 Military																											1.0											
28 Music																												1.0										
29 News																													1.0									
30 Ordinances																0.5														1.0								
31 Philosophy																															1.0							
32 Poetry															0.5						0.6			0.7	0.5							1.0						
33 Politics																														0.5			1.0					
34 Religion						0.6											0.5				0.5											0.5		1.0				
35 Science					0.6																					0.6									1.0			
36 Travel																																				1.0		
37 Witchcraft																																					1.0	
38 Merchants																																			0.5			1.0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38

Table 16: The within-firm correlation between output in different subject areas. This table only shows correlations with value of 0.5 or above.

B The Size of Print Runs

This research takes the book title defined as the unit of analysis. Print runs – the number of individual copies printed of each title – varied across books and time. Surviving evidence on print runs from printers' accounts is fragmentary. However, the available

evidence sheds light on the broad patterns in the data. Figure B presents data on the size of print runs for 393 titles printed in 73 different European cities.

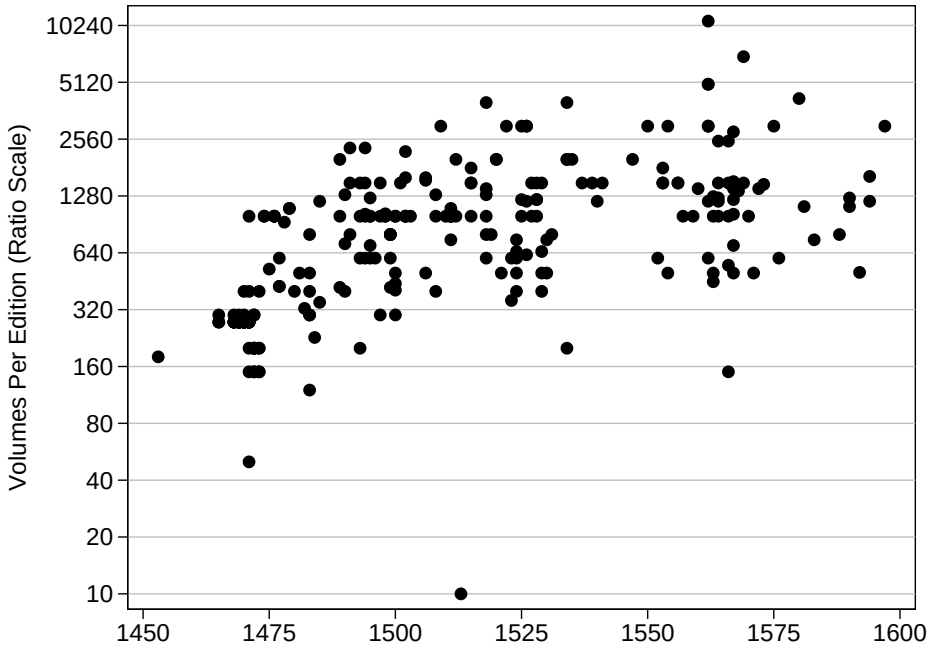

Figure 7: The size of print runs for 393 titles printed in 73 different European cities. Data from Neddermeyer (1998).

C GMM Estimates of Output Effects

In the main body of the paper, OLS regressions are used to as baseline estimators to document the relationship between shocks to firms and city-level supply. To address potential dynamic panel bias, this appendix 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:

$$\Delta \ln(titles)_{j,t} = \alpha \Delta \ln(titles)_{j,t-1} + \beta \Delta death_{j,t} + \Delta \nu_{j,t} \tag{11}$$

Table 17 presents Arellano-Bond estimates of the impact of printer deaths on city-level output. Columns (2) and (4) provide baseline specifications but exhibit implausibly large p-values for Hansen's J-statistic testing over-identification. Columns (3) and (5) collapse the instrument matrix 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.

	Data 1454-1600		Data 1500-1600	
	Ln Titles	Ln Titles	Ln Titles	Ln Titles
	(1)	(2)	(3)	(4)
Ln Titles at time t-1	0.06*	0.18***	0.09**	0.20***
	(0.03)	(0.03)	(0.03)	(0.03)
Ln Titles 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

Table 17: 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. See text for details. Heteroskedasticity-robust standard errors. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".

D Book Prices and Transport Costs

This section provides supporting evidence on the book purchases made by Hernando Colón. The evidence documents the locations of cities in the data, the characteristics of the purchased books, and the relative stability of the price-distance relationship across different import distances.

Figure 8 shows the map of the cities in which Colón bought books and the set of cities that produced books that were exported and purchased by Colon elsewhere. Table 18 presents summary statistics on the imported books purchased by Colón with recorded price data. Figure 9 summarizes the distribution of import distances.

OLS regressions are used to obtain baseline estimates of the price-distance gradient relating book prices to import distances and are reported in the main body of the paper.

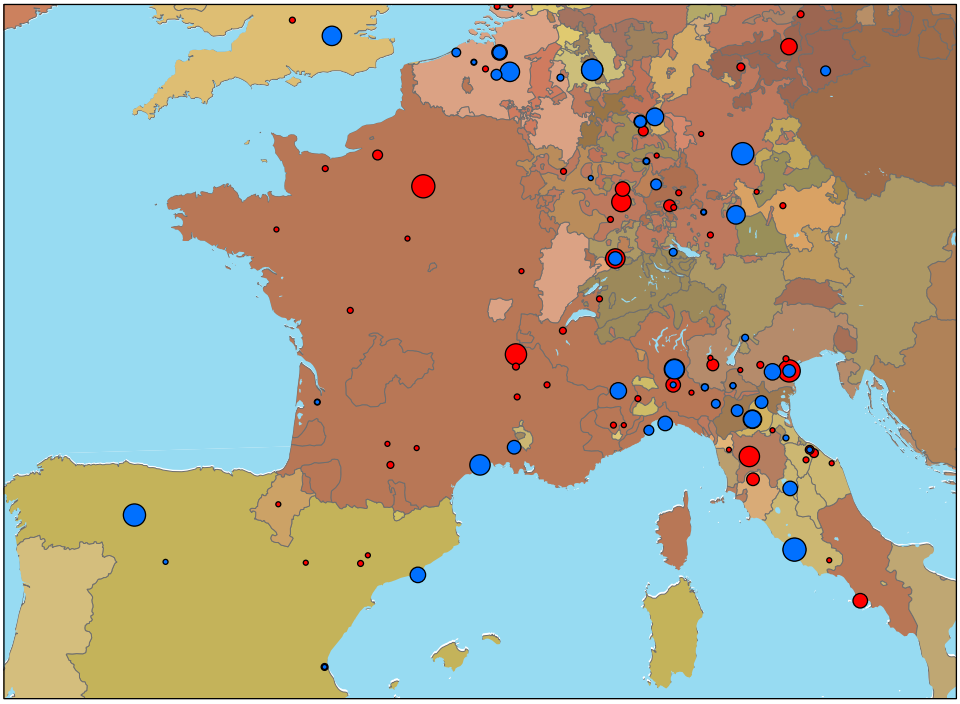

Figure 8: Cities in which Hernando Colón purchased books 1510-1539 (blue markers) and cities producing books that were exported and purchased by Colón elsewhere (red markers). City markers scaled to reflect the number of purchases (exports) at each location.

This section presents quantile regression estimates to document that the estimated price-distance gradient is relatively stable across the distribution of observed import distances. Figure 10 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.[48] 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 14.

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

I then examine the relationship between residual prices ($\hat{\epsilon}_i$) and log distance between the purchase city and the printing city (δ_i) using quantile regression to examine the price gradient over the distance quantiles $\tau \in (0.05, 0.95)$.

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

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

Variable	Mean	Standard Deviation
(1)	(2)	(3)
Ln Price (Ducats)	-3.08	1.39
Ln Distance to Producing City	5.86	0.73
Ln Pages	3.19	1.62
Ln Page Dimension	3.07	0.25
Pamphlet	0.51	0.50
Book Age	12.16	11.88
Illuminated	0.07	0.26
Format Quarto	0.53	0.50
Format Octavo	0.24	0.43
Format Folio	0.23	0.42
Format Other	0.01	0.07
Law	0.07	0.26
Bibles	0.04	0.20
Philosophy	0.09	0.28
Literature	0.05	0.21
Orations	0.04	0.18
Poetry	0.16	0.37
Theology	0.09	0.28
Medecine	0.05	0.21
Languages	0.07	0.25
Rights	0.06	0.23
Religion	0.11	0.31
History & Legislation	0.03	0.16
Observations	1,542	

Table 18: Summary statistics on imported books purchased by Hernando Colón in European cities. Imported books are books purchased in a city other than the one in which they were printed.

E Price Responses to Premature Manager Deaths

The main body of this paper emphasizes how shocks to firms were associated with variations in quantities supplied. This subsection provides supporting evidence on the relationship between output, firm-level shocks, and book prices. It 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

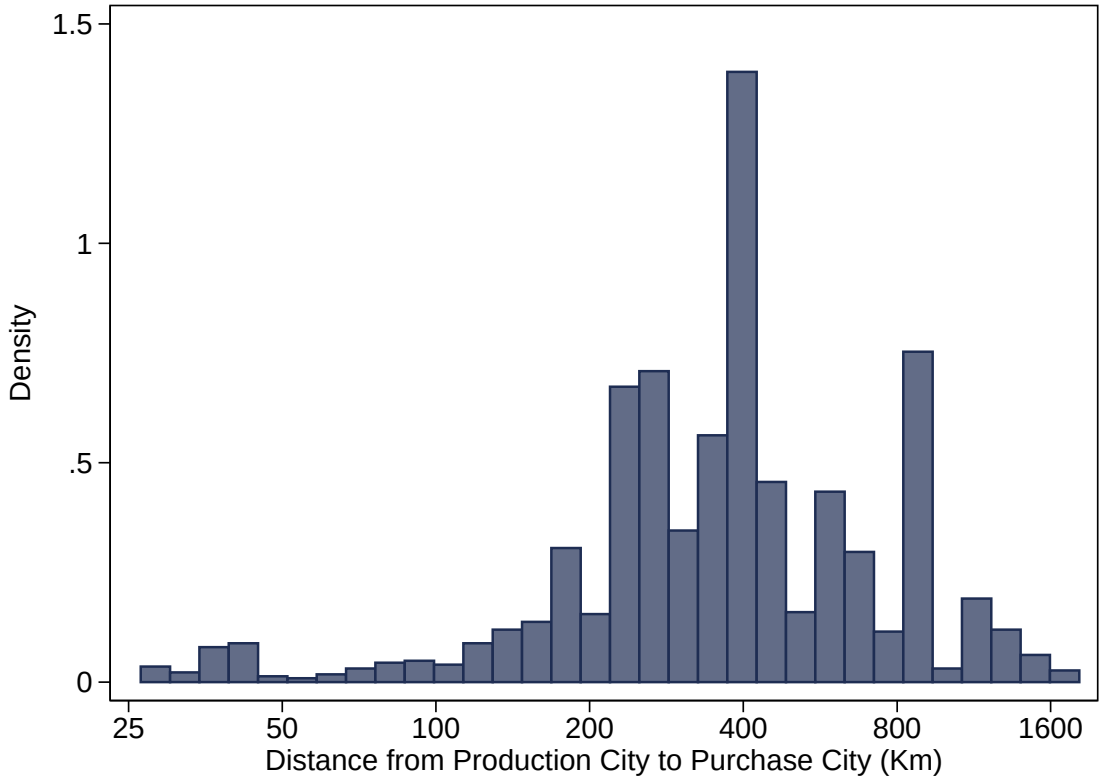

Figure 9: Distance between printing city and point of purchase for purchases of 1,707 imported books in the Colón purchasing data.

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 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

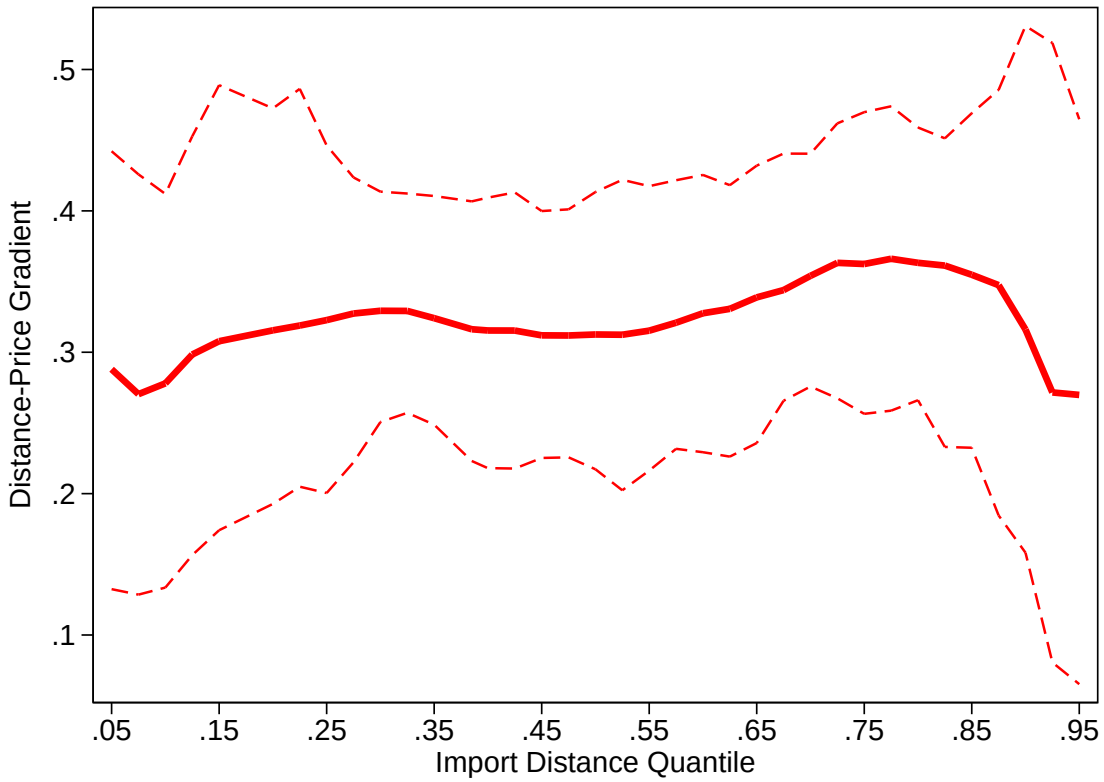

Figure 10: The price-distance gradient over distance quantiles. The figure reports the mean, 5th, and 95th percentile of quantile regression estimates $\phi(\tau)$ for each quantile. The mean and 5th and 95th percentiles are obtained bootstrapping and estimating the price-distance gradient 500 times for each distance quantile.

sale.

Table 19 documents that increases in aggregate, city-level output were associated with very large and highly significant price declines.[49] 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.[50] Finally, columns (6) and (7) show that the association

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

[50] 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), Pe-

	Ln Price	Ln Price	Ln Price	Ln Price	Ln Price	Ln Price
	(1)	(2)	(3)	(4)	(5)	(6)
Ln Titles	-0.635***	-1.491***			-0.626***	-0.691**
	(0.147)	(0.400)			(0.149)	(0.296)
Ln Titles Lagged	0.589**	0.322			0.605**	0.526***
	(0.253)	(0.323)			(0.241)	(0.062)
Printer Death			-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

Table 19: The relationship between book prices, city-level book production, and city-level management transitions. The regressions include the complete set of book-level controls used above to control for heterogeneity across books. 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).

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 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 may be seen as suggestive of predatory pricing. However, it is also possible that price movements reflect attempts to liquidate or reduce inventories or otherwise increase short-term cash flows by lowering prices on the part of firms losing managers.

F The Rate of Premature Deaths Across Cities

The rate of premature deaths per firm exhibited significant variation across cities, but was approximately stable across cities with relatively large and relatively small printing industries. Figure F shows that across cities approximately 6% of firms experienced a premature death and that this rate is stable across cities with few and many firms.[51]

rugia (1530), Venice (1530).

[51]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

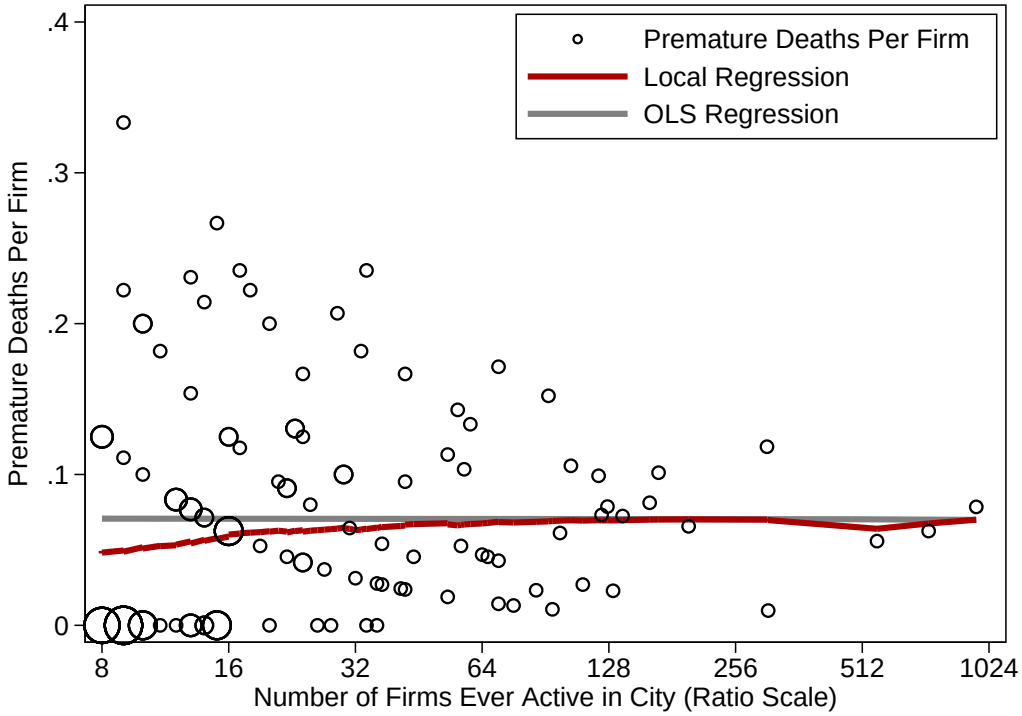

Figure 11: The relative number of premature printer deaths versus the cumulative number of firms active at the city level. Markers scaled to reflect the number of cities.

G Output Responses to Deaths of Business Education Printers

To document the timing of the relationship between shocks to firms producing business education content and variations in supply, this research studies the relationship between premature printer deaths and the supply of business education content at the city-year level.

The main body of the text graphs parameter estimates from a regression examining the relationship between the probability a merchant manual is printed in a city-year it and leads and lags of indicators for the deaths of business education printers:

$$P(merchant_{it} > 0) = \sum_{\tau=0}^{m} \beta_\tau death_{i,t-\tau} + \sum_{\tau=1}^{q} \gamma_\tau death_{i,t+\tau} + \theta_i + \delta_t + \epsilon_{it} \qquad (12)$$

The parameters of interest are the β's and γ's. The θ_i and δ_t control for city fixed effects and year fixed effects.

response to premature printer deaths.

Table 20 presents estimates of these regressions and documents the sharp increase in business education content supply observed in the precise years when business education printers died. Column 3 corresponds to the graph in the main body of the text.

	Manual Printed	Manual Printed	Manual Printed
	(1)	(2)	(3)
Deaths at t = +2	0.033	0.034	0.034
	(0.038)	(0.038)	(0.038)
Deaths at t = +1	0.041	0.042	0.038
	(0.038)	(0.038)	(0.038)
Deaths at t = 0	0.090**	0.111***	0.105**
	(0.041)	(0.041)	(0.041)
Deaths at t = -1	0.075*	0.096**	0.093**
	(0.044)	(0.045)	(0.045)
Deaths at t = -2	0.090***	0.111***	0.107***
	(0.034)	(0.036)	(0.036)
Deaths at t = -3			0.061
			(0.043)
Deaths at t <= -3		0.054***	
		(0.016)	
Deaths at t <= -4			0.049***
			(0.016)
Observations	15395	15395	14933
R Square	0.231	0.233	0.235

Table 20: Linear probability model analysis of the supply of business education content. The outcome is an indicator recording whether business education content is supplied in a city-year. Regressions examine variations in supply associated with the timing of the deaths of business education printers, conditional on city fixed effects and decade fixed effects. Standard errors clustered at the city-decade level. Significance at the 99%, 95%, and 90% confidence level denoted "***", "**", and "*".