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**The Impact of the Internet on  
Retail Competition:  
Evidence from Technological  
Differences in Internet Access**

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# The Impact of the Internet on Retail Competition: Evidence from Technological Differences in Internet Access

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## Abstract

Does the internet increase competition? To address this question, I exploit two institutional details unique to Germany: (1) Some municipalities received glass fibre cables that cannot be upgraded to DSL; I use these municipalities as a treatment group with reduced online competition. (2) German law mandates resale price maintenance for books; I compare three retailing sectors, electronics (price competition), books (no price competition), and food (no online sales), to identify the effect of price competition: The effect of price competition is highly significant. Full broadband access reduces offline electronics retailers' producer rents by 1.5 percent per year from 1999 to 2007.

*Keywords: Internet, Market Structure, Retail Competition, Differences in Differences*

*JEL-Classification: D43, L81, L13*

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# 1 Introduction

Small search costs, no geographical differentiation, and low barriers to entry — the frictionless internet economy should force down prices and drive bricks-and-mortar retailers out of business. Yet, the internet economy has also spawned deliberate obfuscation, new forms of product differentiation, and an increased role for reputation — all factors that soften competition. In this paper, I attempt to quantify the balance of these effects on competition by studying changes in retail employment. Roughly, my argument runs as follows: If online retailers reduce the producer rents of offline retailers by  $x$  percent,  $x$  percent of retailers must leave the market, and  $x$  percent of the employees must find new jobs outside the industry.

For identification, I exploit that consumers have only limited broadband access in some regions of Germany, as Deutsche Telecom chose a bad technology in the early 90s. In these regions, I find that employment in electronics retailing expands relative to the rest of Germany; employment in food retailing does not. As employment in electronics and food retailing are affected by the same factors with the exception of online competition, I interpret the electronics-food employment growth differential as the impact of online competition: It is approximately 1.5 percent per year. To identify how much of this loss results from reduced margins as opposed to loss of market share, I exploit that legally mandated resale price maintenance prevents retail price competition in the German book trade. I repeat the analysis for book versus food retailing and get a much smaller effect of 0.15 percent per year. I conclude that online *price* competition has a large competitive effect, online competition per se does not.

Every year “Deutsche Telecom”, the erstwhile German telecommunication monopoly, replaces worn out cables with new ones, using the newest and best, available technology. In the early 90s, the best technology was thought to be glass fibre cables. When, beginning in July 1999, Deutsche Telecom rolled out a new broadband data transmission technology, Digital Subscriber Line (DSL), it realized that it could not upgrade the glass fibre cables to DSL. To provide DSL anyway, Deutsche Telecom essentially has to replace the glass fibre cables by

copper cables. It started the replacement in late 2003, but proceeded so slowly that towards the end of 2008 most areas still waited to get a DSL connection. In the glass fibre areas households use the internet less than in the rest of Germany, as data show (see Section 2.1). Retailers are less affected, as they often use a dedicated line, which is available even in glass fibre areas.

Deutsche Telecom does not publish data on the geographical distribution of the glass fibre cables, but it informs affected households whenever glass fibre cables prevent it from offering DSL. This information is provided by households when they register on a website called “www.kein-dsl.de” to receive localized information regarding broadband access in their region. From this website, I have obtained a data set containing all registrations from the start in February 2003 until September 2006 according to ZIP code. This data set allows me to split West Germany<sup>1</sup> into a control group with unlimited broadband access and a treatment group with broadband access limited by the glass fibre cables.

What differences between the treatment and control group do I expect? Online retailers reduce offline producer rents in two ways: They take away market share and they force down mark-ups. Because resale price maintenance is legally binding in Germany for on- and offline booksellers alike, internet booksellers may take away market share but cannot reduce mark-ups. In contrast, price competition is not regulated in electronics retailing, the only sector (excluding services such as travel and banking) that experienced a surge in online competition as early as books; hence, changes in producer rents result from both, lower mark-ups and loss in market share. Finally, there should be no changes in producer rents for food retailing, where online competition is virtually non-existent. Thus I can use the three retail sectors to separate the effect of online competition from other contemporaneous changes in the retail industry and I can disentangle the two channels by which online competition impacts on offline competition.

To proxy for changes in producer rents, I use changes in full time employment. Full time employment is a major component of fixed costs in retailing, and total

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<sup>1</sup>I restrict my analysis to West Germany; for a discussion of the reasons consider Section 2.1.

fixed costs in the market must equal producer rents in any long run equilibrium with free entry. Any reduction of producer rents must trigger an equivalent reduction in fixed costs, when loss-making firms leave the market or become more efficient. To proxy for changes in total fixed costs by just one component, I must control for changes in factor input proportions. Factor input proportions change if factor prices or technology change; in particular, the differential broadband access itself could affect factor input proportions differentially in the treatment and control group. But all these supply side changes affect food retailing in the same way as books and electronics. When I take the difference between books or electronics and food, I eliminate them.

To implement my identification strategy, I need data that have a high resolution in two dimensions: geographically down to the level of municipalities, and sectorally down to 5 digit industry classification level. German employment data fulfill these criteria since 1998 — before, the industry classification is too coarse; they are available in the form of the BA-Beschäftigtenpanel, a 1.97% sample of register data of all employed Germans. I use all available data, i.e., data from the first quarter of 1998 until the last quarter 2007.

Consistent with the hypothesis that online competition reduces mark-ups, I find a large and highly significant effect for electronics: Each report of glass fibre cable problems per 10,000 inhabitants reduces employment growth in electronics relative to food by approximately 5 percentage points over the 34 quarters. The effect is significant at the 0.1 percent level. This estimate translates into a 1.5 percentage point difference in year-on-year employment growth between an area with 2.5 reports per 10,000 inhabitants, the mean affected area, and an area with full DSL access. Consistent with the hypothesis that it is not online competition per se, but *price* competition that reduces mark-ups, I find that the point estimate for books is one tenth the size of the effect for electronics. This point estimate is not significantly different from zero.

As a robustness check, I estimate differences-in-differences separately for each of the three sectors: I find that the difference between food and electronics

is almost completely driven by the employment growth differential in electronics retailing, which is again significant at the 0.1 percent level. I find no significant impact of glass fibre cables on employment growth in food retailing. This is consistent with the joint hypothesis that (1) the allocation of glass fibre cables is not correlated with any determinant of retail employment other than DSL access for consumers and (2) that DSL access does not impact on retail employment on the supply side, as retailers do not rely on DSL but on dedicated lines.

In a related paper Goldmanis, Hortacsu, Syverson, and Emre (2010) investigate the impact of the internet on market structure in several retail industries (including bookstores); in contrast to this paper, they rely on a structural approach to identify the effect of the internet. They find that small retailers exit while large retailers may even grow. Brown and Goolsbee (2002) identify the effect of the internet on life insurance prices by considering the price changes for different demographics that exhibit differential use of the internet. They find that life insurance prices drop more for those demographics that have better access to the internet. Another potential implication of increased competition on the internet that has been studied is reduced price dispersion: Yet, Baye, Morgan, and Scholten (2004) find that high price dispersion persists in online retailing. While I study the impact of online competition on bricks-and-mortar retailers, Ellison and Ellison (2009) study competition and margins in online electronics retailing. They present evidence in favour of large price elasticities online for some electronics goods, but also demonstrate that online retailers can sustain at least some rents.

## **2 Institutional Setting and Data**

### **2.1 Glass Fibre Cables and Broadband Infrastructure**

#### **Institutional Background**

Every year Deutsche Telecom replaces worn out cables by new ones, using the newest and best technology. In the early 90s, Deutsche Telecom considered glass

fibre cables the best technology and used them to replace old copper lines.<sup>2</sup> Because Germany had recently been reunited, Deutsche Telecom had to replace the outdated telecommunication infrastructure in the former GDR. Thus, in almost all larger East German municipalities at least some households received glass fibre cables. Some West German areas came up for renewal as well, and Deutsche Telecom laid glass fibre cables there, too.

In July 1999, Deutsche Telecom began to roll out a new broadband data transmission technology, Digital Subscriber Line (DSL). At this point, it realized that it was technologically impossible to offer DSL over the glass fibre cables it had recently deployed. Around this time, Deutsche Telecom must have decided to stop laying glass fibre cables; however, it has never publicly acknowledge such a decision and Mühlbauer (2001) claims that Deutsche Telecom continued to lay glass fibre cables as late as 2001. In the areas equipped with glass fibre cables, Deutsche Telecom can offer DSL only after replacing the glass fibre with copper cables. It started the replacement in late 2003, but it proceeds so slowly that towards the end of 2008 still most areas are waiting to get DSL. A potential substitute for DSL is third generation mobile telephony; it was introduced in 2005 but remained so expensive that in 2007 less than 10 percent of mobile phones were third generation (See Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V., 2009).

The areas with glass fibre cables, however, are not the only areas that lack DSL. In some, often rural, areas Deutsche Telecom does not upgrade copper lines because it anticipates that it will not be able to recoup the investment. For the purpose of this study, I do not want to use these areas that lack DSL for economic reasons as part of the treatment group because of obvious endogeneity problems.

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<sup>2</sup>For an overview and technical details see Mühlbauer (2001).

## **Broadband Data**

Deutsche Telecom does not publish data on the areas affected by the glass fibre problem<sup>3</sup>, but it informs households that try to order DSL, why it does not offer DSL; i.e., individual households know, whether there is a glass fibre problem or whether copper lines have not been upgraded. This information is aggregated by the website “www.kein-dsl.de”, which is the main data source for my study. On this website, households can register if they cannot get DSL; they may want to register because the administrator of the website will inform them when DSL or alternative broadband technologies become available in their area. In the process of this registration, the households submit their ZIP code and click a button if their problems result from glass fibre cables. There is a second button if they were told that DSL is not economically viable in their area.

I have obtained a dataset containing all registrations from the start of the website in February 2003 until September 2006 according to ZIP code. I get 5086 reports in 1001 ZIP codes. Figure 1 displays the geographical distribution of the glass fibre cables; the affected ZIP codes are shaded in dark grey.

As can be seen from Figure 1, the glass fibre problem affects large swathes of East Germany because Deutsche Telecom replaced most of the telecommunication infrastructure in East Germany precisely at the time it had adopted glass fibre cables as its preferred technology. Even though I find a varying degree of reports, there are very few municipalities that are entirely unaffected and these municipalities tend to be small and rural. Thus, there is no viable control group of municipalities with full DSL access in East Germany and I drop the East German municipalities from the sample and concentrate on the homogeneous West German sample.

I find single reports of glass fibre problems but no corresponding press reports for some major cities such as Stuttgart or Frankfurt. I conclude that these reports are most likely mistakes. To correct for these mistakes, I set all ZIP codes with

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<sup>3</sup>Deutsche Telecom does not release the data even though government reports have called for publication (See Bundesministeriums für Wirtschaft und Arbeit, 2005, p.52).



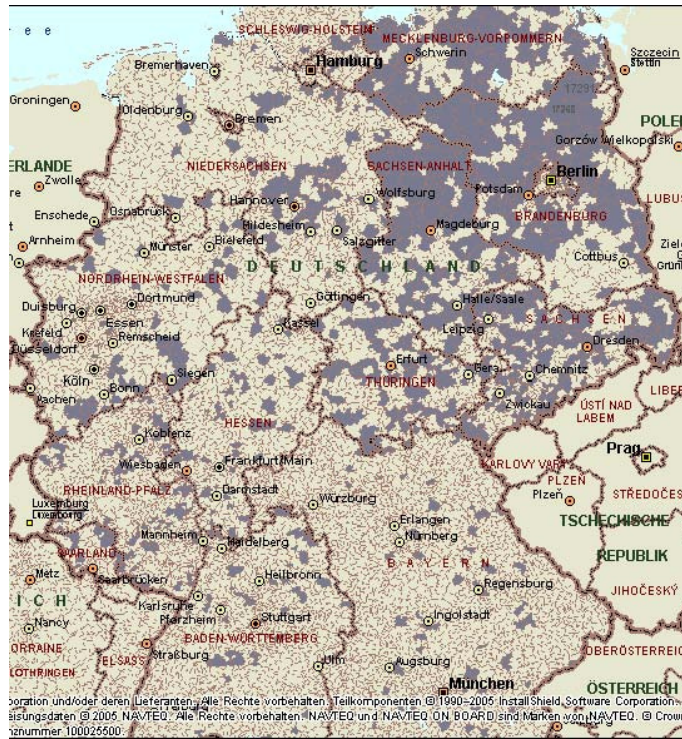


Figure 1: Geographical Distribution of Glass Fibre Cables in Germany, Source “www.kein-dsl.de”.

only one report to zero.

I use data from the German Socioeconomic Panel (GSOEP), a rich household panel data set,<sup>4</sup> to confirm that the glass fibre cables impact on internet use. In its 2003 questionnaire, the GSOEP includes a question on internet use. It is the only data source known to me that contains data on actual internet use (as opposed to mere internet availability) and that is available on ZIP code level. I find that the share of people using the internet at least once a day was 13.6 percent in the unaffected areas, but only 10.0 percent in the affected areas; i.e., glass fibre cables

<sup>4</sup>See Wagner, Frick, and Schupp (2007) for a description. While the basic panel data are available for off-site use, the ZIP codes of the households may only be accessed on-site at the DIW in Berlin. Because the data I use in the main section of the paper must only be used on the servers of the FDZ of the “Bundesagentur für Arbeit” in Nuremberg, it is impossible to combine the two data sources.

reduce daily internet use by 30 percent. The difference is significant at the 5 percent level.<sup>5</sup>

## 2.2 The German Retail Industry

### Institutional Background

The book trade in Germany offers a unique possibility to investigate the market share effect of online competition on offline retailers: Books were sold early in large quantities over the internet. Yet, for books, there is no retail price competition in Germany. For every book that is mainly sold on the German market (including foreign language publications that fulfill this criterion), the publishing house fixes a retail price that online as well as offline retailers must sell at. Until 2002, all participants in the book trade implemented this resale price maintenance with a collective contract, the so called *Sammelrevers*. When, in 2002, the European Commission classified this contract as a cartel that needed an explicit legal exemption, the German State passed a law to this end, the so called *Buchpreisbindungsgesetz*. As there is no price competition but strong online sales, book retailing can serve as a treatment group to measure the pure market share effect on producer surplus.

Consumer electronics and electric appliances, which I will subsume under the term electronics henceforth, serve as a treatment group with price competition. Retail prices for electronics are unregulated and electronics retailing over the internet flourished early on; electronics was the fourth category that “amazon.com” adopted in Germany (2001) (amazon.com, 2010), after books (1998), CD’s (1999), and DVD’s (2000). This fact reflects that the qualities of electric appliances and consumer electronics, like those of books, can well be communicated on a website; the additional benefit of physical inspection is small.

In addition to the two treatment groups, I need a control group to capture any differences in retailing between the areas with and without glass fibre cables that

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<sup>5</sup>I use robust standard errors clustered on ZIP code level.

Table 1: Development of Online Sales in Germany (2001–2003). *Source: GfK*

	2001	2002	2003
<i>Share in Online Sales (%)</i>			
Travel	25.5	21.8	24.1
Apparel/Shoes	12.1	14.3	13.8
Hard- and Software	11.0	12.6	10.5
Books/Maps/Newspapers	8.5	8.8	6.8
Consumer Electronics	6.6	6.6	8.3
CD's (Music)	4.5	5.5	5.1
Ticketing	3.6	3.9	4.0
Fast Moving Consumer Goods (incl. Food)	3.2	3.2	3.1
Electric Appliances	2.6	3.0	3.8
Toys	2.7	2.6	3.1
Sports Gear	1.8	2.1	1.8
DVD's	1.4	1.8	2.3
Telecommunication Equipment	1.1	1.4	1.8
Home Improvement/Gardening	1.3	1.4	1.4
Accessories	1.2	1.0	1.3
Home Textiles	1.0	1.0	0.8
Other	11.9	9.0	8.7
$\Sigma$	100.0	100.0	100.0
<i>Total Online Sales (Millions of €)</i>	4266	6347	8840

are unrelated to internet access of consumers. My control group is food retailing: In food retailing competition is unregulated, but the online market share is negligible due to technological problems. Food retailing's share in online sales over the years 2001–2003 was so small that it does not merit a separate category in Table 1. In 2001, the market share of online retailers in food retailing was less than 0.15 percent (Source: Riehm, 2004), while online retailers had a 3 percent share in book retailing in 2001, and almost 1 percent in the consumer electronics retailing industry (Source: Riehm, 2004).

Even though I have chosen the three sectors to disentangle the market share and margin effects of online competition, I obtain a comprehensive analysis of retailing. The three sectors comprise an important share of bricks-and-mortar

retailing — 37 percent of retail employment in 2007.<sup>6</sup> Electronics and books are among the most important sectors of online retailing — they represent almost 20 percent of online sales in the years 2001–2003 (see Table 1).

Most of the other retail industries that feature in Table 1 cannot serve as an additional treatment group, albeit for different reasons: Travel and ticketing are services. Bricks-and-mortar retailers of CD's and DVD's, or newspapers suffer additionally because they cannot offer downloads. Retailers of computers and telecommunication presumably sell more if their consumers have broadband access; a direct impact of broadband availability on producer rents that I cannot separate from the competitive changes I want to isolate.

The numbers in Table 1 suggest the apparel retail industry as an additional treatment group and home furniture as an additional control group. Apparel represented a large share of online retailing early on and does not suffer from any of the deficiencies that rule out the other important online retail industries as a treatment group. Home furniture, on the other hand, is absent from Table 1 — most likely it represents less than 1 percent of online sales. Most likely this is due to technological problems that make furniture unsuited to online sales. I present regression results for the apparel and home furniture retail industries in Section 4.2, as a robustness check.

## **Employment Data**

To quantify the producer rents lost by bricks-and-mortar retailers, I would ideally use data on sales and margins. As these data are not publicly available, I exploit — in the spirit of Bresnahan and Reiss (1991) — the zero profit condition that must hold in any free entry equilibrium: If retailers suffer a permanent loss of producer rents, they can no longer recover their fixed costs. Most likely, some retailers exit the market, but maybe some become more efficient and learn to operate with lower fixed costs. Whatever the exact adjustments are, after some time, total market

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<sup>6</sup>This percentage is calculated from the *BA-Beschäftigtenpanel*, the data set I use for my analysis. For Details see Section 2.2 below.

fixed costs must shrink by the same amount total producer rents shrink; hence, I can use changes in total fixed cost as a measure of changes in total producer rents.

I have to measure changes in fixed costs with a high resolution in two dimensions to implement my identification strategy: (1) geographically down to the level of municipalities, and (2) for industries on 5 digit industry classification level. As only employment data are available with this resolution, I use changes in fulltime employment as a proxy for changes in fixed cost. Fulltime employment is an important part of fixed costs in retailing. Changes in fulltime employment proxy for changes in fixed costs as long as I control for differential trends in the labor intensity of retailing between the treatment and control areas. Typically the labor intensity changes if labor costs or other factor prices like rents change, or if technology changes; the latter being of particular importance for my investigation, as internet availability could directly impact on the labor intensity. Yet, all these supply side effects should impact on food, books, and electronics retailing in the same way. As I measure the development in books and electronics retailing against the yardstick of food retailing, I eliminate them.

As data source I use the “BA-Beschäftigtenpanel”, which is provided by the research data center of the “Bundesagentur für Arbeit”, the German Federal Employment Agency. The BA Beschäftigten Panel is a 1.92 percent sample of the official employment registry data of all people employed in Germany. The data are quarterly and include information on the municipality in which the employee works and a five digit industry code for the employer. The five digit code is available starting from the first quarter of 1998 up to the fourth quarter 2007. I use only fulltime employment because I want to measure fixed costs and I restrict my sample to people working in the ten former West German states and Berlin, for the reasons given in Section 2.2. For West Germany each cohort contains more than 400,000 employees. To identify employees that work in the three retail sectors, I use the five digit codes that I describe in detail in Appendix A. My measures of retail employment do neither include internet retailing nor mail or phone order. For employees in these retail industries, there are three separate five digit codes

for so called *Versandhandel*.

### 3 Theoretical Background and Hypotheses

Online retailing affects offline producer rents either because it reduces offline market share or because it reduces offline margins. While the market share effect is straightforward, the effect of online competition on margins merits a short explanation. Ellison and Ellison (2005) sum up the three most important reasons why online competition erodes margins: (1) There is no geographical product differentiation on the internet, which reduces total product differentiation; this leads to lower margins in models such as Hotelling (1929). (2) The internet reduces search costs. While arbitrarily small search costs are enough to support the monopoly price in the model of Diamond (1972), in models with heterogenous consumers (Stahl, 1989) the margin decreases with decreasing search costs. (3) Fixed costs are lower online than offline (Ellison and Ellison, 2005, p. 148); hence more entry occurs. Still, authors dispute the size of the competitive effect, as online and offline retailers alike try to increase non-geographical product differentiation, and may engage in obfuscation to increase search costs (See Ellison, 2005; Ellison and Wolitzky, 2008; Wilson, 2008).

In my data, changes in full time employment in electronics retailing should reflect both channels, changes in full time employment in book retailing should reflect only the change in market share, while full time employment in food retailing should not be affected.

**Hypothesis 1** *The difference in full time employment growth between areas with limited and those with unlimited DSL access after DSL was introduced (second quarter 99) is*

(a) *larger for electronics retailing than for food retailing (margin and market share effect),*

(b) *larger for electronics retailing than for book retailing (margin effect),*

*(c) larger for book retailing than for food retailing (market share effect).*

Theory does not make precise predictions as to the size of the margin effect: Producer rents could drop arbitrarily close to zero if Bertrand competition prevails on the internet. The effects driving (a) and (b) of Hypothesis 1 could both be large.

Theory does, however, make a precise prediction concerning the market share effect: A one percent loss in market share translates into a one percent loss of producer rent. I use this insight for a back-of-the-envelope calculation of the order of magnitude of the effect that we can expect for book and electronics retailing. From the information in Table 1, I can calculate that online sales of books (electronics) have increased by almost 30 percent (67 percent) in each year between 2001 and 2003. Using the online market share of 3 percent (1 percent) in 2001 (and ignoring total market growth, which was very low anyway), I can calculate that online sellers have taken 1 (0.7) percent in market share per year from offline retailers, reducing producer rents and ultimately fixed costs, i.e., employment, by the same percentage. As this effect is the total effect of the internet, it is an upper bound on the effect we should observe for the glass fibre areas, which have reduced internet access. Thus, we are looking for a small market share effect that drives part (c) of Hypothesis 1.

The triple differences approach allows me to test an implication of my identifying assumption that the deployment of glass fibre cables is independent of any factor that influences retail employment growth. If areas with glass fibre cables differ only with regard to broadband availability and if retail technology is not affected by broadband availability, there cannot be an employment growth differential between the two areas for food retailing, as food retailing is not influenced by broadband availability for consumers. From this insight, I obtain a secondary hypothesis:

**Hypothesis 2** *For the food retail industry, the difference in full time employment growth between areas with limited and those with unlimited DSL access after DSL was introduced (second quarter 99) is not different from zero.*

## 4 Results

### 4.1 Graphical Analysis

In this section, I present time series of the employment data for the three retail sectors; each sector is split into areas with full and with limited DSL access. To create the two areas, I set all ZIP codes with only one report to zero and aggregate the ZIP codes to municipality level, using data from “Deutsche Post” (German postal service). Reports from ZIP codes that belong to more than one municipality are divided up equally between the municipalities. Then I aggregate employment over municipalities without a report and those with a positive number of reports.

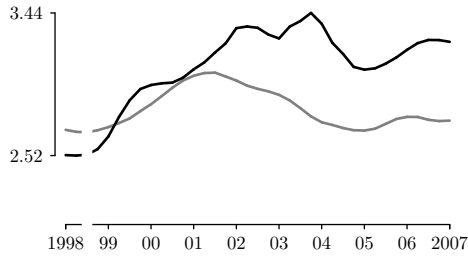
In Figure 2, all available data for the two groups and the three sectors are plotted. The quarterly data run from 1998–2007. The first data point is for the last quarter of 1998, as I have taken rolling four quarter averages, to adjust for seasonal variation. For each sector, each data point represents the employment share of the sector in the four quarters up to and including the date, i.e., a four quarter rolling average of employment in the respective retail sector divided by the four quarter rolling average of total employment. Each data point is scaled relative to the lowest value in the data such that vertical distances reflect percentage changes. A break in the lines marks the date after which Deutsche Telekom started to roll out DSL in a select few major cities (second quarter 1999).

We can read some descriptive statistics off Figure 2: The labels on the ordinates give the employment share of the respective sector. Around 21 out of every 1000 employees sell food, three sell electronics, but only a little more than one sells books. The grey lines, representing areas with full internet access, are smoother than the black lines, representing areas with a glass fibre problem. This additional noise reflects the fact that there are only 2810 municipalities with a glass fibre problem, but 9530 municipalities without.

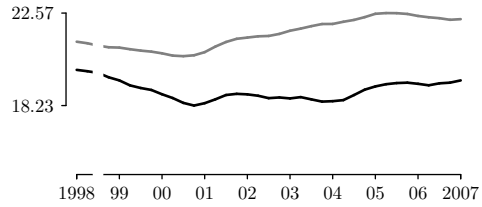
If we inspect the growth trends, we find a development for the electronics trade that differs from the other sectors. In electronics, the relative employment in both areas moves in lockstep until 2001 — there is an upward trend. After



Employment Share Electronics Retailing  
(per 1000 Employees)



Employment Share Food Retailing  
(per 1000 Employees)



Employment Share Book Retailing  
(per 1000 Employees)

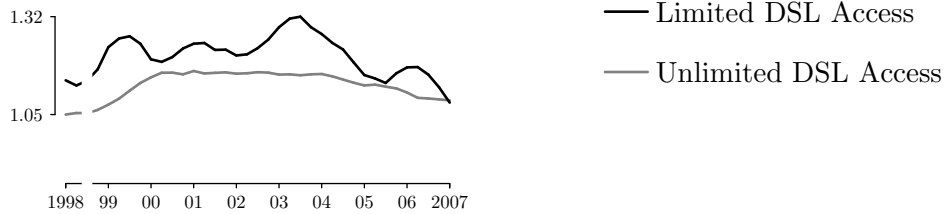


Figure 2:

2001, however, only the areas with limited internet access hold the high level of employment, while employment drops off in the areas with full internet access. This difference continues to grow until 2007. There is no such break for food or book retailing. In book retailing, the employment share in the areas with limited DSL access hovers above the share in the areas with full access during the whole period. In food retailing, the employment share in the areas with limited DSL access remains below the share in the areas with full access in all periods.

Figure 2 suggests that the data are consistent with both our hypotheses: Online price competition dampens employment growth in electronics retailing, but not in book or food retailing. In the data, the roll out of DSL impacts on employment

after roughly three years, a plausible delay given that DSL was not rolled out at once all over Germany and given that a reduction in margins takes some time to translate into a reduction of fixed costs.

## **4.2 Regression Analysis**

### **Regression Equations**

To exploit the two dimensions of treatment versus control (full versus limited access, books or electronics versus food), I implement a triple differences approach: As the first (log-) difference, I calculate the growth rates of sectoral employment between the last year of my sample (2007) and the four quarters before the introduction of DSL (second quarter 1999), separately for each area in the treatment and the control group. This yields a total of three employment growth rates for each area. Thereby, I eliminate all differences in levels that persisted before the treatment. The second difference is the difference between the employment growth rates for either books or electronics minus the growth rate for food. This yields two excess growth rates for each area, one for books and one for electronics. Thereby, I eliminate all employment growth trends that are common to the whole retail industry, but differ over treatment and control groups; e.g., trends resulting from differential changes in factor prices, such as wages or rents. I take the third difference, when I regress this pair of variables (excess growth for books and electronics) on my measure of the size of the glass fibre problem. The resulting coefficients measure excess employment growth trends for the treatment over the control group that are unique to book or electronics retailing and that align with the strength of the treatment, i.e., the size of the glass fibre problem. I interpret this excess growth as the causal effect of online competition on offline employment in electronics and book retailing.

To measure employment growth rates after the introduction of DSL, I take log differences. To be able to calculate log differences, I need geographical units that have at least one observation in each retail industry. As a first step, I match the

report data to municipalities, as described above (Section 4.1). Because many municipalities are very small (there are 12340 municipalities in West Germany), I must further aggregate the data if I want to avoid a large number of missing values when calculating log differences. If I use the next geographical level (the county), however, I lose most of the variation in the data, as affected communities are spread out over all counties.

As a solution, I construct composite geographic areas of the same size, into which I aggregate municipalities according to the magnitude of the glass fibre problem first and according to location only second. Thus, I do not lose the variation in the degree of the glass fibre problem.<sup>7</sup> To determine the optimal aggregation level, I use a trial and error procedure which results in 102 units with a size of about 3750 observations each (roughly equivalent to 675,000 inhabitants). This is the smallest aggregation level such that I get no missing values for food and electronics retailing. For book retailing, there are still some missing values, which I cannot eliminate without reducing the number of observations too much.

I calculate employment growth from the introduction of DSL (second quarter of 1999) until the end of my data (fourth quarter of 2007). I denote the first date by time 0 and the second by time 1. To correct for seasonal variation, I average employment  $y$  in each geographical unit  $i$  over four quarters at each of the two points in time; i.e., I calculate the geometric means for each sector  $S \in \{e, b, f\}$ , i.e., electronics ( $e$ ), books ( $b$ ), and food ( $f$ ):

$$y_{i0}^S = \frac{1}{4} \left( \ln(y_{i98Q3}^S) + \ln(y_{i98Q4}^S) + \ln(y_{i99Q1}^S) + \ln(y_{i99Q2}^S) \right),$$

$$y_{i1}^S = \frac{1}{4} \left( \ln(y_{i07Q1}^S) + \ln(y_{i07Q2}^S) + \ln(y_{i07Q3}^S) + \ln(y_{i07Q4}^S) \right).$$

Then I take the difference

$$\Delta y_i^S = y_{i1}^S - y_{i0}^S$$

to obtain growth rates. I report summary statistics for all variables in Table B-1 in

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<sup>7</sup>For a detailed account of the aggregation process see Appendix A.

## Appendix B.

For electronics and book retailing, I run a regression of the log differences of employment in the sector minus the log difference for food retailing on a constant and on reports per head ( $rph_i$ ):

$$\Delta y_i^e - \Delta y_i^f = \beta_0 + \beta_1 rph_i + \varepsilon_i \quad (1)$$

$$\Delta y_i^b - \Delta y_i^f = \beta_0 + \beta_1 rph_i + \varepsilon_i \quad (2)$$

$$\Delta y_i^e - \Delta y_i^b = \beta_0 + \beta_1 rph_i + \varepsilon_i \quad (3)$$

I estimate equations (1), (2), and (3) with OLS and calculate robust standard errors.

### **Regression Results: Electronics, Books, and Food**

In Table 2, I present the coefficient estimates for the triple differences regressions. For the difference between electronics and food retailing (column 1), the coefficient on reports per head is 0.0494, which is significant at the 0.1 percent level; i.e., excess employment growth over areas with unlimited DSL increases significantly more with the number of reports in electronics retailing than in food retailing. This is consistent with part (a) of Hypothesis 1. The excess growth difference between electronics and book retailing (column 2) is significant (5 percent level) as well. This is consistent with part (b) of Hypothesis 1. The coefficient for book minus food retailing (column 3) is less than a tenth in size than the one for electronics and not significantly different from zero. Thus, concerning part (c) of Hypothesis 1, I cannot reject the null hypothesis that there is no difference between book and food retailing, but I show below that at least the size of the point estimate is plausible. We expected the market share effect to be small and there is too much noise in the data to reject the null hypothesis.

In a back of the envelope calculation, I can demonstrate that the size point estimate for books versus food retailing is plausible. I use the point estimates to compare an area with full DSL access with an area with the mean number of re-

Table 2: Impact of Glass Fibre Reports per Head on Differential Employment Growth in Electronics, Book and Food Retailing; OLS Estimates for the Quarters Q2 1999–Q4 2007

	Electronics–Food	Electronics–Books	Books–Food
	(1)	(2)	(3)
Reports per Head	0.0494 (0.0111)***	0.0463 (0.0223)*	0.0042 (0.0233)
Constant	0.0066 (0.0498)	0.0104 (0.0892)	0.0283 (0.0770)
N. obs.	102	84	84
$R^2$	0.0302	0.0121	0.0001

Notes: An observation in the regression is one composite geographical region. The dependent variable is logged differences of employment in one sector minus logged differences in the other sector. Robust standard errors in parenthesis.

\* significant at 5%; \*\* significant at 1%; \*\*\* significant at 0.1%;

ports per 10000 inhabitants (2.5) to calculate that full availability of DSL reduces year on year employment growth by 0.15 percentage points in book retailing. This number is 15 percent of the effect that I predict in Section 3, based on a simple market share calculation. The point estimate suggests that limited broadband access causes 15 percent of the total effect of the internet that we should expect. This number seems broadly plausible, as the limited broadband access does not affect everybody in the area and as basic internet access is still available.

A similar calculation yields a rough idea of the size of the margin effect for electronics: Again, I compare an area with full DSL access with an area with the mean number of reports per 10000 inhabitants (2.5) to calculate that full availability of DSL reduces year on year employment growth in the electronics retailing industry by 1.5 percentage points. In Section 3, I predict an employment reduction of 0.67 percentage points a year for electronics due to the full market share effect. Taking the 15 percent of this effect estimated for books as a benchmark, I calculate a market share effect of 0.1 percentage points for electronics retailing. I attribute the remaining 1.4 percentage points of fixed cost reduction to margins

reduced by increased price competition.

Table 3: Impact of Glass Fibre Reports per Head on Employment Growth in Books, Electronics and Food Retailing; OLS Estimates for the time Q2 1999–Q4 2007

	Electronics	Books	Food
	(1)	(2)	(3)
Reports per Head	0.0382 (0.0117)***	−0.0056 (0.0177)	−0.0112 (0.0066)
Constant	0.0750 (0.0457)	0.0676 (0.0751)	0.0685 (0.0184)***
N. obs.	102	84	102
$R^2$	0.0215	0.0003	0.0116

Notes: An observation in the regression is one composite geographical region. The dependent variable is logged differences of employment in the respective sector. Robust standard errors in parenthesis.

\* significant at 5%; \*\* significant at 1%; \*\*\* significant at 0.1%;

In Table 3, I present differences-in-differences estimates for all three retail sectors separately. The results show that the main result is driven by the development in electronics retailing and not by the development in food retailing that acts as a control group. In column (1), I report the regression result for electronics retailing: the coefficient is 0.0382 and it is significant at the 0.1 percent level. This suggests that almost 80 percent of the differential effect reported in Table 3 derives from the development in the electronics sector.

The insignificant coefficient for food retailing is consistent with Hypothesis 2. The coefficient on reports per head for food retailing is small, −0.0112, and it is not significantly different from zero; hence, there is no evidence in favor of differential food employment growth between areas with full DSL access and areas with limited DSL access. This is exactly what we would expect to see if the distribution of glass fibre cables is orthogonal to any influence on retail employment growth and if there are no supply side effects of broadband availability on employment.

### **Additional Sectors: Apparel and Home Furniture**

In this section, I present regression results for two additional retail industries, apparel (*a*) and home furniture (*h*), as a robustness check. I argue that the apparel retailing industry is an additional treatment group with price competition; hence, an adjusted version of Hypothesis 1 should hold. Furthermore, I argue that the home furniture retail industry is an additional control group without online competition; hence, Hypothesis 2 should hold. I find that the results are consistent with the respective hypotheses.

As there is full price competition and sizeable online sales in the apparel retail industry, I expect the same hypotheses to apply to it as to the electronics retail industry. Yet, I expect a quantitatively smaller effect for three reasons: (1) In Table 1, apparel features as an important component of online sales. But apparel comprises such a large share of online sales because the apparel retail industry is large and not because online retailers hold a large market share: the market share of online retailers was only 0.5 percent in 2001, half that of online retailers in the electronics retail industry (Source: Riehm, 2004). (2) Online sales took off later for apparel than for books and electronics. While electronics were introduced by “amazon.com” in Germany in 2001 (amazon.com, 2010), the apparel shop opened seven years later. (3) Apparel retailing relies more on physical inspection. Contrary to books and electronics, clothing, when ordered online, is typically tried on and sent back if it does not fit. I expect this behavior to impose additional costs on online retailers and to soften online competition.

In the case of home furniture the same hypotheses should hold as for food. Table 1 does not list furniture as a separate category; it must comprise a share of online sales below one percent. Presumably for furniture the same advantages of physical inspection hold as for apparel, but the transport costs are so high that trying out and sending back unwanted furniture is not an option.

In Table 4, I report the triple differences result for apparel. It is in line with the hypothesis. I find a differential in growth rates for apparel relative to food that is positive and significant at the 0.1 percent level. The size of the point estimate

is, however, only a third compared to electronics; this amounts approximately to a producer rent loss of one percent per year. For home furniture, I find no significant difference in absolute growth rates — i.e., again I find no evidence for differential employment growth trends between the treatment and control areas.

Table 4: Impact of Glass Fibre Reports per Head on Employment Growth in Apparel and Furniture Retailing; OLS Estimates for the Quarters Q2 1999–Q4 2007

	Apparel–Food	Furniture
	(1)	(2)
Reports per Head	0.0167 (0.0057)***	−0.0204 (0.0128)
Constant	−0.1082 (0.0326)***	−0.1331 (0.0390)***
N. obs.	102	102
$R^2$	0.0084	0.0085

Notes: An observation in the regression is one composite geographical region. The dependent variable is logged differences of employment in the apparel retail industry minus logged differences in the food retail industry in column (1) and logged differences of employment in furniture in column (3). Robust standard errors in parenthesis.

\* significant at 5%; \*\* significant at 1%; \*\*\* significant at 0.1%;

## 5 Conclusion

In this paper, I have compared the development of bricks-and-mortar retailing in areas with full DSL access to areas with only limited DSL access. I find a large and significant effect for electronics relative to food; the effect for books, where there is no price competition, relative to food is much smaller and not significant. This is consistent with theories that predict that online competition reduces offline margins. Online retailers can force down offline prices if online prices are lower. Thus my results indicate that price competition on the internet is fierce and that counter strategies employed by online retailers, such as obfuscation and product differentiation, cannot prevent the erosion of margins.



## **Appendix A Data**

### **Industry Codes**

I use the code 52472 (“retailing of books and trade publications”) to identify employees in book retailing (retailing of newspapers and magazines does not fall in that category). I identify electronics retailing with the codes 52451 (“retailing of consumer electronics”) and 52452 (“retailing of electric appliances”). Computers and telecommunication gear is an extra category. I include the following codes in my measure of food retailing: 52111 (“retailing of food, tobacco, and beverages (not specialized)”), 52111 (“general retailing with a focus on food, tobacco, and beverages (not specialized)”), 52210 (“retailing of fruit, vegetables, and potatoes”), 52230 (“retailing of meat”), 52241 (“retailing of bread”), 52242 (“retailing of pastry”), 52272 (“retailing of dairy products”); These definitions do not include specialized retailing of non-alcoholic beverages, vines, spirits, and coffee, for which there are separate categories. There are three extra categories for *Versandhandel*, which include mail or phone order as well as internet retailing.

In my measure of employment in the apparel retailing industry, I include the codes 52421 (“retailing of apparel (not specialized)”), 52422 (“retailing of men’s wear”), 52423 (“retailing of women’s wear”), and 52424 (“retailing of children’s wear”). To identify employees in the furniture retailing industry, I use the codes 52441 (“retailing of home furniture”), 52442 (“retailing of lighting fixtures”), 52443 (“retailing of household articles”), 52444 (“retailing of glassware and pottery”), 52445 and 52447 (“retailing of home textiles”), 52446 (“retailing of wares made of wood or cork and basketry”).

### **Aggregation**

I start the aggregation process by excluding the few large cities that I do not need to put together with other municipalities because each of them has more than 3750 employees in the sample. Then I split the sample in two groups — municipali-

ties with reports and those without. The municipalities with reports I sort by the number of reports of glass fibre cables. Municipalities with the same number of reports are sorted according to the official numbering of German municipalities, which ensures that municipalities in the same counties first and states second are close to each other in the ranking. Then I start from the top (highest number of reports) to construct the first composite area. I add municipalities until there are more than 3750 observations; then I start the next composite area until I reach 7500 observations, and so on. For each unit  $i$ , I add population and number of reports to generate reports per head ( $rph_i$ ) as a measure of the severeness of the glass fibre problem. For the municipalities without a glass fibre problem, I repeat the process with the only difference that I sort only according to the official numbering.

## Appendix B Tables

Table B-1: Summary Statistics

	N.Obs.	Mean	Sd. Dev.	Min.	Max.
$\Delta y^h - \Delta y^b$	84	0.030	0.675	-1.495	2.268
$\Delta y^h - \Delta y^e$	102	0.026	0.493	-1.446	1.239
$\Delta y^h - \Delta y^a$	102	-0.102	0.316	-1.125	0.788
$\Delta y^h - \Delta y^f$	102	-0.205	0.433	-1.093	1.376
$\Delta y^f$	102	0.064	0.180	-0.323	0.483
$\Delta y^b$	84	0.065	0.659	-1.281	2.11
$\Delta y^e$	102	0.090	0.453	-1.118	1.099
$\Delta y^a$	102	-0.038	0.294	-1.091	0.581
$\Delta y^h$	102	-0.141	0.384	-0.943	1.268
Reports/Head	102	0.386	1.738	0	14.746

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