The Impact of Copyright Policy Changes on Venture Capital Investment in Cloud Computing Companies

By Josh Lerner[1]

[1] Jacob H. Schiff Professor of Investment Banking at Harvard Business School, Harvard University, Cambridge, MA. The author wishes to thank the following employees of Analysis Group: Christopher Borek, Lau Christensen, Rebecca Kirk Fair, Peter Hess, and Greg Rafert. Funding for this research was provided by the Computers and Communication Industry Association, whose members can be found here: http://www.ccianet.org/index.asp?bid=11.

1. Introduction

This paper examines the effect of copyright policy changes on venture capital (VC) investment in cloud computing companies. To do this, we analyze the effect on venture investment in cloud computing firms of the U.S. Second Circuit Court of Appeals' August 2008 decision in *The Cartoon Network, et al. v. Cablevision*, which was widely seen as easing certain ambiguities surrounding the intellectual property standing of these firms in the U.S. Our findings suggest that decisions around the scope of copyrights can have significant impacts on investment and innovation. We find that VC investment in cloud computing firms increased significantly in the U.S. relative to the EU after the *Cablevision* decision. Our results suggest that the *Cablevision* decision led to additional incremental investment in U.S. cloud computing firms that ranged from $728 million to approximately $1.3 billion over the two-and-a-half years after the decision. When paired with the findings of the enhanced effects of VC investment relative to corporate investment, this may be the equivalent of $2 to $5 billion in traditional R&D investment.

2. Background

2.1. Academic Research Examining Impact of Policy on Venture Financing

To understand the impact of copyright policy changes on the willingness of venture capitalists to invest in cloud computing, we employ a difference-in-difference approach, hypothesizing that policy shifts affect investments in different geographies, sectors, and years in varying ways. While such analyses are widely employed in the economics literature, the closest analogy to our work is that of Goldfarb and Tucker (2011), which examines how the enactment of the EU Privacy and Electronic Communications Directive affected the performance of

advertisement campaigns in the European countries that enacted it, relative to other countries that had no such laws.

This topic is important due to the relationship between venture capital, innovation, and job growth. It might be thought that it would not be difficult to address the question of the impact of venture capital. For instance, one could look at regressions across industries and time, and examine whether, controlling for R&D spending, venture capital funding has an impact on various measures of innovation. But, even a simple model of the relationship between venture capital, R&D, and innovation suggests that this approach is likely to give misleading estimates.

Both venture funding and innovation could be positively related to a third unobserved factor such as the arrival of technological opportunities. Thus, there could be more innovation at times that there was more venture capital, not because the venture capital caused the innovation, but rather because the venture capitalists reacted to some fundamental technological shock which was sure to lead to more innovation. To date, only a handful of papers have attempted to address these challenging issues.

Hellmann and Puri (2000), for instance, examines a sample of 170 recently formed firms in Silicon Valley, including both venture-backed and non-venture-backed firms. Using questionnaire responses, they find empirical evidence that venture capital financing is related to product market strategies and outcomes of startups. They find that firms that are pursuing an "innovator strategy" (a classification based on the content analysis of survey responses) are significantly more likely and faster to obtain venture capital. The presence of a venture capitalist is also associated with a significant reduction in the time taken to bring a product to market, especially for innovators. Furthermore, firms are more likely to list obtaining venture capital as a significant milestone in the lifecycle of the company as compared to other financing events.

The results suggest significant interrelations between investor type and product market dimensions, and a role of venture capital in encouraging innovative companies. Given the small sample size and the limited data, they can only modestly address concerns about causality, and as a result, the possibility remains that more innovative firms select venture capital for financing, rather than venture capital causing firms to be more innovative.

Kortum and Lerner (2000), by way of contrast, examines whether these patterns can be discerned on an aggregate industry level, rather than on the firm level. The authors address concerns about causality in two ways. First, they exploit the major discontinuity in the recent history of the venture capital industry: in the late 1970s, the U.S. Department of Labor clarified the Employee Retirement Income Security Act, a policy shift that freed pensions to invest in venture capital. This shift led to a sharp increase in the funds committed to venture capital. This type of exogenous change should identify the role of venture capital, because it is unlikely to be related to the arrival of entrepreneurial opportunities. They exploit this shift in instrumental variable regressions. Second, they use R&D expenditures to control for the arrival of technological opportunities that are anticipated by economic actors at the time, but that are unobserved to econometricians. In the framework of a simple model, they show that the causality problem disappears if they estimate the impact of venture capital on the patent-R&D ratio, rather than on patenting itself.

Even after addressing these causality concerns, the results suggest that venture funding has a strong positive impact on innovation. The estimated coefficients vary according to the techniques employed, but on average a dollar of venture capital appears to be three to four times more potent in stimulating manufacturing industry patenting than a dollar of traditional corporate R&D. The estimates, therefore, suggest that venture capital, even though it averaged less than

three percent of corporate R&D from 1983 to 1992, is responsible for a much greater share—perhaps ten percent—of U.S. industrial innovations in this decade. Moreover, the venture-backed firms' patents are more frequently cited and litigated, which suggests that the results are not being driven by patenting for its own sake.

There also appears to be a strong relationship between venture capital and job creation. There are several ways to see this relationship. Perhaps the most straightforward way is to take a snapshot of the public markets. By late 2011, venture-backed firms that had gone public made up over 11 percent of the total number of public firms in existence in the U.S. Those public firms supported by venture funding employed six percent of the total public-company workforce—many of which were high-salaried, skilled positions in the technology sector.[2]

Puri and Zarutskie (2010), in a more academically rigorous analysis, looks at job creation by venture-backed firms. They highlight that many of the firms that receive venture backing for the first time have no revenues and very modest employment. They compare the evolution of venture-backed and non-venture-backed firms using the records of the U.S. Census's Longitudinal Business Database, which tracks both public and private entities. After venture financing, they find very rapid employment growth in venture-financed firms relative to non-venture-financed firms. While the venture-backed firms (and by construction, the matching entities) have an average of about 20 employees at the time of the initial financing, five years later the venture-financed firms have on average about 80 employees, while non-venture-financed firms have grown to around 30 employees. Beyond the fifth anniversary of the financing, they continue to see greater employment growth by venture-financed firms relative to non-venture-financed firms.

---

[2] Lerner, Josh, *The Architecture of Innovation*, Boston: Harvard Business School Press (*forthcoming*).

2.2. The Impact of the Litigation

The present analysis looks at venture investment around a key juncture in copyright policy in the United States: the 2008 appellate decision in *The Cartoon Network, et al. v. Cablevision*. It will compare venture capital investment in cloud computing in the U.S. against that in the EU (where the decision did not have bearing) both before and after the *Cablevision* decision by employing a differences-in-differences approach.

In 2006, Cablevision announced the development of a Remote Storage Digital Video Recorder (RS-DVR). Similar in operation to a traditional recorder, the Cablevision RS-DVRs allow customers to record, pause, and replay television content on a hard drive. Unlike traditional DVRs, however, in which a consumer installs and uses an appliance in their own home, the Cablevision RS-DVR was located remotely, recording to and playing back from remote servers. When a consumer hit the "record" button on their remote, the RS-DVR would start to record, just as if that RS-DVR were right in their living room. In response, a consortium of U.S. television and copyright holders filed a complaint against Cablevision in May 2006 over alleged copyright infringement.

In March 2007, the District Court declared a summary judgment against Cablevision.[3] As the appellate court narrated:

> *[P]laintiffs successfully argued that Cablevision's proposed system would directly infringe their copyrights in three ways. First, by briefly storing data in the primary ingest buffer and other data buffers integral to the function of the RS-DVR, Cablevision would make copies of protected works and thereby directly infringe plaintiffs' exclusive right of reproduction under the Copyright Act. Second, by copying programs onto … hard disks …, Cablevision would again directly infringe the reproduction right. And third,*

[3] *Twentieth Century Fox Film Corp. v. Cablevision Sys. Corp.*, 478 F. Supp. 2d 607 (S.D.N.Y. 2007).

by transmitting the data ... to ... customers in response to a "playback" request, Cablevision would directly infringe plaintiffs' exclusive right of public performance.[4]

In August 2008, the District Court decision was reversed on appeal by the Second Circuit Court of Appeals.[5] The Circuit Court held that Cablevision's RS-DVR system did not infringe the plaintiffs' rights of reproduction and public performance on any of the three claimed grounds. The original decision was reversed, vacated, and sent back to be reconsidered by the lower court. In June 2009, the Supreme Court refused to hear the case, thereby effectively finalizing the Second Circuit's decision.

At the time of the decision, the ruling was viewed as an important one that would impact cloud computing. To cite two contemporaneous accounts:

- *The Cablevision ruling is good for IT companies moving into cloud computing, said Dow Lohnes PLLC attorney James Burger, who represents technology companies in IP and content licensing matters. If the court had found Cablevision guilty of direct infringement for giving its customers the RS-DVR data storage system, system operators storing consumers' legally acquired entertainment media in the internet cloud could have faced the same claims.*[6]
- *[A] rule holding Cablevision liable merely because it housed and maintained the servers in this case could imperil a wide variety of innovative business models that rely on the use of remote computing, ranging from examples like*

---

4 *Cartoon Network, LP v. CSC Holdings*, 536 F.3d 121 (2d Cir. 2008).
5 *Ibid.*
6 Standeford, Dugie, "US Cablevision Decision Has Implications for Cloud Computing, Online Advertising," *Intellectual Property Watch*, July 3, 2009, http://www.ip-watch.org/weblog/2009/07/03/us-cablevision-decision-has-implications-for-cloud-computing-online-advertising/.

Internet-enabled self-service photo processing and printing, to cloud computing services offered by companies like Amazon, Apple and Google.[7]

Thus, it is logical to hypothesize that the *Cablevision* decision would lead to increased venture investment in cloud computing in the U.S. relative to other counties where no comparable legal clarity has been established.[8] To the extent that U.S.-based firms also do business in the rest of the world, or EU firms do business in the U.S., such international activity will dampen the hypothesized effect. In the presence of such dampening influences, any estimates of the hypothesized effect, should one be found, are likely to be conservative.

A complication is introduced by the fact that the volume of venture capital activity varies considerably over time due to factors that are largely exogenous to the issues being studied here. To cite one notable example, the volume of venture investment fell by almost 90 percent between 2000 and 2002; this decline was driven primarily by the collapse in the public valuations for internet and telecommunications stocks in 2000, and the subsequent inability of venture funds to exit many of their investments at attractive prices. In other cases, funds have flowed to particular sectors, such as cleantech, potentially crowding out investment elsewhere. As a result, the bulk of our analyses examine VC investments in cloud computing as a share of all VC investments, though we also analyze the level of venture investment in cloud computing in a robustness check.

---

[7] Kwun, Michael, "Victory for DVRs in the Cloud," *Electronic Frontier Foundation*, August 4, 2008, https://www.eff.org/deeplinks/2008/08/victory-dvrs-cloud.

[8] While there have been several copyright cases against online video recording service providers in Europe, we are unaware of any that has resolved such substantial uncertainty with respect to reproduction and retransmission rights in favor of such service providers as the *Cablevision* decision has in the U.S.

3. Data

3.1. Venture Capital Funding Data

Our analysis focuses on how VC investment in cloud companies varies between the U.S. and EU, and over time. In order to examine these differences, we construct a dataset that draws on historical investment figures captured by VentureXpert.[9] VentureXpert is one of the two most widely-used databases of venture capital investments in the U.S.[10] It contains data on approximately 1.2 million global private companies and over 25,000 venture, buyout, and mezzanine funds.[11]

The dataset is seeded with all private equity investments in the Thomson database from the beginning of 1995 through the end of 2010 classified as "Venture Capital Deals"[12] involving a portfolio company with a business description including the term "cloud." These criteria yielded data on investments in 280 companies. Independent research identified an additional 216 cloud computing-related companies,[13] 59 of which received VC investment from 1995 through 2010

---

[9] More specifically, the Thomson ONE's Private Equity module powered by VentureXpert was used.

[10] Maats, Frederike, Metrick, Andrew, Hinkes, Brian, Yasuda, Ayako & Vershovski, Sofia, "On the Consistency and Reliability of Venture Capital Databases," (2009).

[11] "Private Equity Module: ThomsonONE.com Investment Banking," Thomson Reuters factsheet, 2011.

[12] Venture capital investments include start-up, seed, and early, expansion, and later stage deals.

[13] This researched involved the review of numerous sources, including: Corbin, Kenneth, "15 Cloud Computing Firms to Watch: Security, Storage, Apps," *datamation.com,* April 26, 2011, last accessed October 3, 2011, http://itmanagement.earthweb.com/cloud-computing/15-Cloud-Computing-Firms-to-Watch-Security-Storage-Apps-3931826.htm; "The Top 20 Software as a Service (SaaS) Vendors," *clouds360.com,* last accessed October 3, 2011, http://www.clouds360.com/saas.php; "The Top 20 Infrastructure as a Service (IaaS) Vendors," *clouds360.com,* last accessed October 3, http://www.clouds360.com/iaas.php; "The Top 20 Platform as a Service (PaaS) Vendors," *clouds360.com,* last accessed October 3, http://www.clouds360.com/paas.php; Kirilov, Kiril, "Top 25 European Cloud Computing Rising Stars To Watch – Complete List," *cloudtweaks.com*, April 6, 2011, last accessed October 3, 2011, http://www.cloudtweaks.com/2011/04/top-25-european-cloud-computing-rising-stars-to-watch-complete-list/; Geelan, Jeremy, "The Top 150 Players in Cloud Computing: SYS-CON's Cloud Computing Journal Expands Again Its List of Most Active Players in the Cloud Ecosystem," *soacloud.utilizer.com*, October 29, 2009, last accessed October 3, 2011, http://soacloud.ulitzer.com/node/770174; "50 Top Cloud Computing Companies," *cloudtweaks.com,* July 30, 2010, last accessed October 3, 2011, http://www.cloudtweaks.com/2010/07/over-50-of-the-biggest-and-best-cloud-computing-companies; Depena, Ray, "Cloud Computing Companies to Watch in 2011," *Cloud Computing Journal*, Cloud Expo Blog Feed Post, February 4, 2010, last accessed October 3, 2011, http://cloudcomputing.sys-con.com/node/1662284; Singh, Basant Narayan, "Top 10 Cloud Computing Service

captured in VentureXpert. Seventy-nine companies were removed from the list of 339 (280 + 59) companies appearing in VentureXpert based upon review of their business descriptions, and 17 were removed for lack of any data on investment amount.[14] As a result, the final dataset contains data on VC investments in 243 cloud computing companies.

The unit of observation in the data extracted from VentureXpert is an investment by a particular venture capital fund into a particular portfolio company on a particular date. The dataset contains 2,009 observations on investments by 706 distinct funds into the 243 companies on 587 different dates. These data were then aggregated by calendar quarter of investment date by region (U.S., EU, and rest of world).

Appendix A summarizes these quarterly investment-level figures and other data discussed below, by quarter, for both the U.S. and EU. As Appendix A depicts, total VC investment in the identified U.S. cloud companies from the first quarter of 1995 to the end of 2010 amounted to $5.9 billion. This reflects average quarterly investment of $92.3 million over that time period. In the period immediately preceding the *Cablevision* ruling (Q1 2006 to Q2 2008), average quarterly investment in U.S. venture-backed cloud companies was $131.0 million, and subsequent to the ruling, that figure amounted to $184.7 million. Thus, average quarterly investment in U.S. cloud computing increased by approximately 41 percent after the *Cablevision* decision. Appendix A further depicts that VC investment in the identified EU cloud companies from the first quarter of 1995 to the end of 2010 amounted to $242.3 million. This reflects

---

Providers of 2009," *techno-pulse.com,* December 8, 2009, last accessed October 3, 2011, http://www.techno-pulse.com/2009/12/top-cloud-computing-service-providers.html; and, "List of Top 'Cloud Computing Solution Providers to Watch in 2009," *onCloudComputing.com*, July 1, 2009, last accessed October 3, 2011, http://www.oncloudcomputing.com/en/2009/07/list-of-top-cloud-computing-solution-providers-to-watch-in-2009/.

[14] Business descriptions from VentureXpert, Bloomberg, the company websites, and news stories were reviewed. Companies were excluded if cloud computing did not appear to be a primary part of their business or their business appeared to focus on pushing non-user-generated content to from the cloud to users (*e.g.*, security updates, games, licensed media content).

average quarterly investment of $3.8 million over that time period. In the period immediately preceding the *Cablevision* ruling (Q1 2006 to Q2 2008), the average quarterly investment in EU venture-backed cloud companies was $7.0 million, and subsequent to the ruling, that figure amounted to $8.9 million. Thus, average quarterly investment in EU cloud computing increased by approximately 27 percent, as compared with 41 percent in the U.S., after the *Cablevision* decision.

3.2. Supplemental Data

We augment the VC funding data with data on other factors that could influence investors' decisions to invest in cloud computing, specifically, and in other sectors more generally. Such factors include macroeconomic conditions reflected in gross domestic product (GDP) measures and the feasibility of cloud computing as measured by broadband penetration.

Our GDP data are quarterly growth rates of real, seasonally adjusted GDP as a percent change over the previous quarter from the OECD.[15] These data are available for the U.S. from Q1 1995 through Q2 2011, and for the EU (27 countries) from Q2 1995 through Q2 2011.

Data on broadband penetration, which is equal to the number of broadband subscriptions per 100 inhabitants, was obtained from the OECD for the U.S. and 21 of the 27 EU member states from Q2 2002 through Q4 2010.[16] To calculate an EU-specific measure of broadband penetration in each period, the broadband penetration rate of each EU member state was multiplied by its corresponding annual population to obtain the number of broadband subscribers. Next, the total number of EU broadband subscribers was obtained by summing over all EU member states; this total was then divided by the total EU population to obtain an EU-

[15] Data accessed through http://stats.oecd.org.
[16] Data accessed through http://stats.oecd.org.

specific measure of broadband penetration. Finally, quarterly broadband penetration rates were calculated by linearly interpolating the semi-annual series.

These supplemental data are also summarized in Appendix A. As the summary statistics show, quarterly GDP growth in the U.S over the period 1995 through 2010 was higher on average than in the EU (means of 0.6 and 0.5 percent, respectively) and more volatile than in the EU (standard deviations of 0.7 and 0.6 percent, respectively). In the period immediately preceding the *Cablevision* ruling (Q1 2006 to Q2 2008), quarterly GDP growth in the U.S. was lower on average and more volatile than in the EU (means of 0.4 and 0.7 percent, respectively; standard deviations of 0.5 and 0.4 percent, respectively). Subsequent to the ruling, quarterly GDP growth in the U.S. was higher on average than in the EU and more volatile (means of -0.1 and -0.3 percent, respectively; standard deviations of 1.2 and 1.1 percent, respectively).

4. Estimation and Results

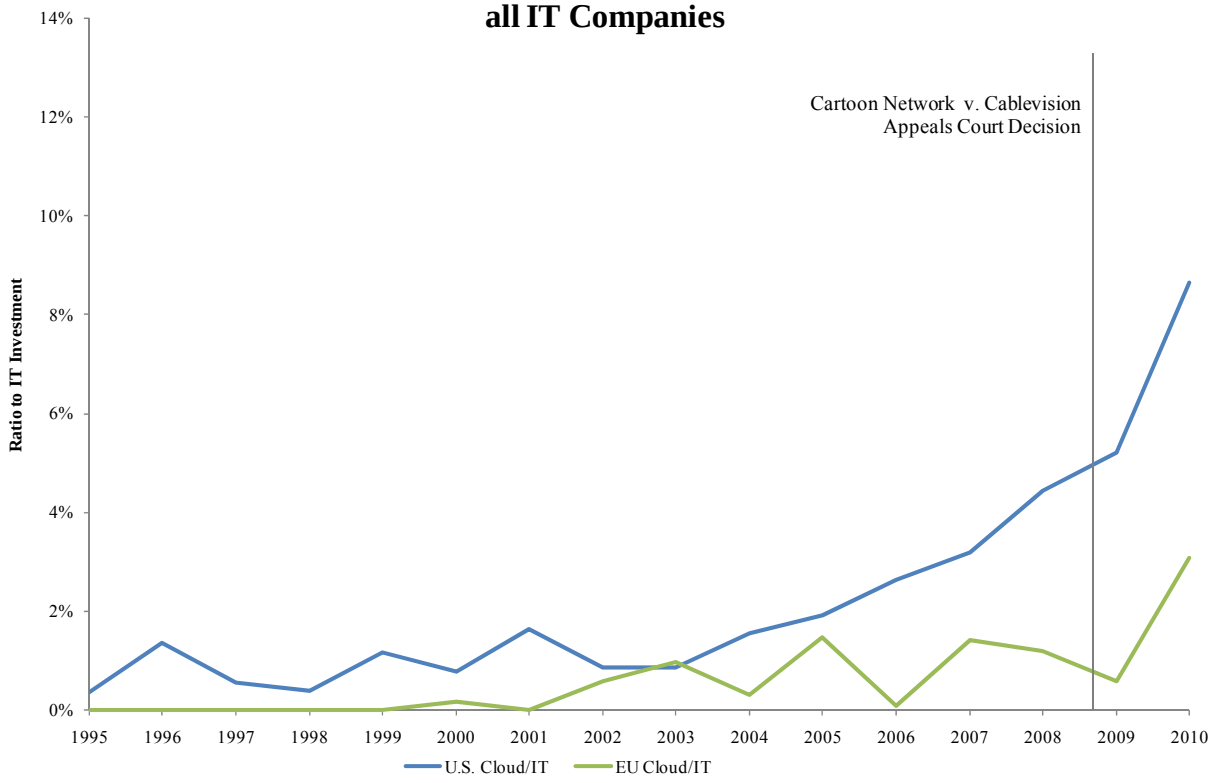
We have conducted multiple statistical analyses in order to determine whether investment in venture-backed U.S. cloud companies rose subsequent to the Q3 2008 *Cablevision* appeals court ruling. Each of these analyses are variants of difference-in-difference regression frameworks that rely on historical investment levels in both the U.S. and EU as controls in order to identify any statistically significant increase in U.S. cloud companies post *Cablevision*.

Our initial set of regression analyses are variants of the following regression model that accounts for the impact of a variety of factors on quarterly venture-backed investment in the identified cloud companies:

$$VC\ Ratio_{r,t} = \beta_0 + \beta_1(U.S.\ Indicator)_r + \beta_2(Q3\ 2008\ or\ After\ Dummy)_t + \beta_3(Effect\ of\ Cablevision\ on\ U.S.\ VC\ Investment)_{r,t} + \theta X_{r,t} + \varepsilon_{r,t}. \quad (1)$$

Specifically, the dependent variable, *VC Ratio*$_{r,t}$, is venture capital dollars invested in the cloud computing companies in region *r* at quarter *t* divided by venture capital dollars invested in information technology (IT) companies in region *r* at quarter *t*. We normalized our dependent variable this way to control for secular trends in the venture capital market, as discussed in Section 2.2 above. Figure 1 depicts *VC Ratio* for the U.S. and EU annually from 1995 through 2010.

Figure 1
Ratio of Investment in Cloud Computing Companies to Investment in all IT Companies



Source: Private Equity Investment data Jan 1995 - Dec 2010 from Thomson ONE.

The explanatory variable *U.S. Indicator* equals one for investment in U.S. cloud computing companies and zero for investment in EU cloud computing companies. The explanatory variable *Q3 2008 or After Dummy* equals zero for all quarters before the U.S. Appellate Court decision in the *Cablevision* case in August 2008 and one in Q3 2008 and all quarters thereafter. The explanatory variable, *Effect of the Cablevision Decision on U.S. VC Investment*, a dummy

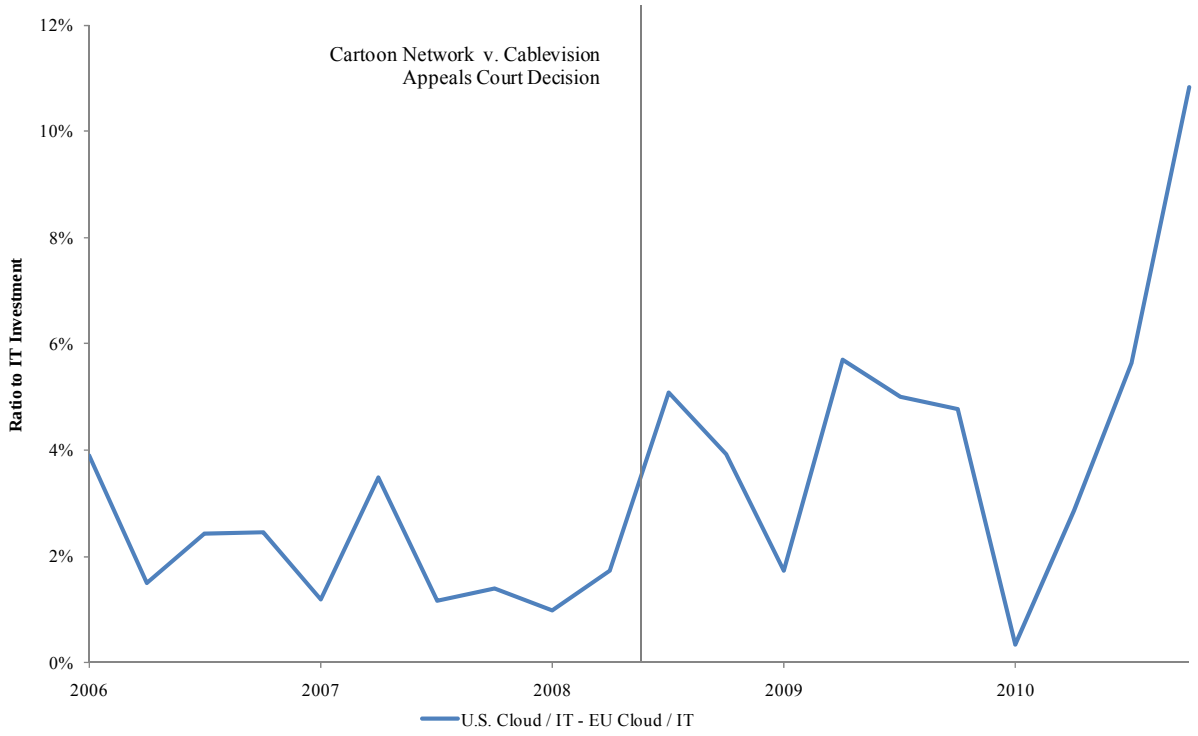
variable capturing the interaction between the *U.S. Indicator* and the *Q3 2008 Dummy*, equals one for investment in U.S. cloud computing companies in Q3 2008 and thereafter, and zero otherwise. $X_{r,t}$ is a vector of other explanatory variables including GDP growth and broadband penetration that may be associated with investment in cloud companies.

This difference-in-difference model is designed to estimate parameter β_3, the effect of the *Cablevision* decision on investment in U.S. cloud computing, controlling for trends in the U.S. relative to EU (captured by *U.S. Indicator*), and trends in cloud computing generally (captured by *Q3 2008 or After Dummy*) absent the policy.

The annual series plotted in Figure 1 shows a long-term upward trend in VC investment in cloud computing companies, particularly in the U.S., beginning well before the *Cablevision* decision. In order to focus more narrowly on the time period surrounding the *Cablevision* decision, our analyses focus on investment levels from 2006 to 2010. Doing so eliminates long-term investment trends prior to 2006 from influencing the results. Figure 2, which depicts the quarterly difference between investment in U.S. and EU venture-backed firms, suggests that investment in U.S. venture backed cloud companies was not systematically increasing, relative to EU firms, in the time period immediately preceding the 2008 *Cablevision* ruling, an observation that is confirmed more rigorously in Section 4.1.2 below.

Our first set of regression results are presented below in Table 1, and show that investment in venture-backed cloud computing companies is significantly higher in the U.S. than in the EU after the *Cablevision* decision. The difference-in-difference framework shows that this result holds after controlling for both differences in levels of investment in U.S.- vs. EU-based cloud computing companies and differences in investment in cloud computing companies before vs. during and after Q3 2008, the quarter of the appellate court ruling in the *Cablevision* case.

Figure 2
Difference in the Ratio of Investment in Cloud Computing Companies to Investment in all IT Companies in the U.S. and EU



Source: Private Equity Investment data Jan 2006 - Dec 2010 from Thomson ONE.

More specifically, results for Model 1 presented in Table 1 can be interpreted as follows.

- The constant term, $\beta_0 = 0.0117$, is an estimate that VC investment in cloud computing in the EU as a percentage of VC investment in IT in the EU averaged approximately 1.17 percent prior to Q3 2008. The standard error of this estimate indicates that it is statistically significant at the 99 percent confidence level.[17]
- The coefficient $\beta_1 = 0.0202$ on the *U.S. Indicator* variable is an estimate that VC investment in cloud computing in the U.S. as a percentage of VC investment in IT in the U.S. averaged approximately 2.02 percent higher than the corresponding share in the EU, or 3.19 percent of VC investment in IT in the U.S. prior to Q3 2008.[18] The standard error of the β_1 estimate indicates that it is statistically significant at the 99 percent confidence level.

[17] Robust standard errors are used throughout.
[18] $\beta_0 + \beta_1 = 0.0117 + 0.0202 = 0.0319$.

Table 1
Cloud Computing Regression Results: U.S. vs. EU[1,2]
Dependent Variable: Ratio of Cloud Computing VC Dollars to Total IT VC Dollars

	Model	
Independent Variables	(1)	(2)
U.S. Indicator	0.0202***	0.0129***
	(0.0048)	*(0.0045)*
2008 Dummy[3]	0.0059	-0.0094
	(0.0080)	*(0.0090)*
Effect of Cablevision on U.S. VC Investment	0.0257**	0.0256**
	(0.0114)	*(0.0095)*
Percent Change in GDP		0.0093***
		(0.0030)
Broadband Penetration Rate		0.3754***
		(0.0900)
Constant	0.0117***	-0.0629***
	(0.0038)	*(0.0167)*
Observations	40	40
Adjusted R-Squared	0.544	0.699
Implied Increase in U.S. Cloud VC Investment ($ Millions)	**$730**	**$728**
Length of Time Period	1Q 2006 - 4Q 2010	1Q 2006 - 4Q 2010

Notes:
[1] Robust standard errors are provided under the point estimates in italics.
[2] *** indicates significance at a 1 percent level, ** indicates significance at a 5 percent level, and * indicates significance at a 10 percent level.
[3] Decision by Appellate Court (judgment of District Court is reversed) (8/4/2008). The 2008 Dummy variable is set equal to one for all quarters after 2Q 2008.

- The coefficient $\beta_2 = 0.0059$ on the *Q3 2008 Dummy* is an estimate that VC investment in cloud computing in the EU as a percentage of VC investment in IT in the EU averaged approximately 0.59 percent higher beginning in Q3 2008 than it did prior to Q3 2008, or 1.76 percent of VC investment in IT in the EU in that latter time period.[19]
- The coefficient $\beta_3 = 0.0257$ on the *Effect of Cablevision on U.S. VC Investment* interaction dummy is an estimate that the rise in average VC investment in cloud

[19] $\beta_0 + \beta_2 = 0.0117 + 0.0059 = 0.0176$.

computing in the U.S. as a percentage of VC investment in IT in the U.S. from the period Q1 2006 through Q2 2008 to the period Q3 2008 through Q4 2010 was approximately 2.57 percent greater than the corresponding rise in cloud computing investment in the EU, or approximately 3.16 percent overall.[20] This estimate of β_3, statistically significant at the 95 percent confidence level, implies an approximately $730 million increased VC investment in U.S. cloud computing companies after the *Cablevision* decision.

Model 2 is similar to Model 1, except that it incorporates variables that control for GDP growth and broadband penetration. As shown in column 2 of Table 1, the coefficients on these variables have the expected positive sign and are statistically significant. Interpretation of the other variables remains the same, and as shown in the table, the magnitude and significance of the *Effect of Cablevision on U.S. VC Investment* is almost identical to the magnitude and significance of the *Effect of Cablevision on U.S. VC Investment* in Model 1. The implied increase in U.S. VC investment of approximately $728 million is nearly identical as well.

To investigate the potential impact of outliers on our analysis, we ran Models 1 and 2 using a difference-in-difference quantile regression analysis. Quantile regression analysis allows one to estimate the relationship between a set of independent variables and a specific quantile, or percentile, of the response variable. One advantage of such an analysis is that the influence of large outliers is mitigated. Thus, for our context, it allows us to determine the extent to which our results are sensitive to quarters with very large or very small values of the dependent variable, *VC Ratio*. Results for median (quantile) difference-in-difference regressions are presented in Table 2.

---

[20] $\beta_2 + \beta_3 = 0.0059 + 0.0257 = 0.0316$.

Table 2
Cloud Computing Quantile Regression Results: U.S. vs. EU[1,2]
Dependent Variable: Ratio of Cloud Computing VC Dollars to Total IT VC Dollars

	Model	
Independent Variables	(3)	(4)
U.S. Indicator	0.0204*	0.0099
	(0.0105)	*(0.0066)*
2008 Dummy[3]	-0.0014	-0.0174
	(0.0085)	*(0.0149)*
Effect of Cablevision on U.S. VC Investment	0.0335**	0.0318*
	(0.0138)	*(0.0160)*
Percent Change in GDP		0.0058
		(0.0061)
Broadband Penetration Rate		0.3594***
		(0.0792)
Constant	0.0112	-0.0556***
	(0.0075)	*(0.0142)*
Observations	40	40
Implied Increase in U.S. Cloud VC Investment ($ Millions)	**$952**	**$904**
Length of Time Period	1Q 2006 - 4Q 2010	1Q 2006 - 4Q 2010

Notes:
[1] Robust standard errors are provided under the point estimates in italics.
[2] *** indicates significance at a 1 percent level, ** indicates significance at a 5 percent level, and * indicates significance at a 10 percent level.
[3] Decision by Appellate Court (judgment of District Court is reversed) (8/4/2008). The 2008 Dummy variable is set equal to one for all quarters after 2Q 2008.

Results for Model 3, the quantile regression version of Model 1, are presented in Table 2. These results are similar to those presented in Table 1 and imply that the rise in median (as opposed to average) VC investment in cloud computing in the U.S., as a percentage of VC investment in IT in the U.S. from the period Q1 2006 through Q2 2008 to the period Q3 2008 through Q4 2010, was approximately 3.4 percent greater than the corresponding rise in cloud computing investment in the EU. This estimate, which is statistically significant at the 95 percent

confidence level, implies an approximately $952 million increase in VC investment in U.S. cloud computing companies after the *Cablevision* decision.

Results for Model 4, the quantile regression version of Model 2, are also presented in Table 2, and are similar to those for Model 3 with an implied increase in U.S. cloud computing investment of approximately $904 million.

4.1. Additional Sensitivity Analyses and Robustness Checks

4.1.1. Alternative Control Group Specifications

We have also estimated a difference-in-difference model comparing investment in the U.S. to investment in the rest of the world (ROW) in order to examine whether the results are sensitive to the use of EU companies as a control group. Specifically, we have conducted analyses analogous to Model 1 using ROW investment (rather than investment in the EU) as a benchmark. These results are presented in Table 3 and are qualitatively similar, finding that the surge in investment in U.S. venture-backed cloud computing companies amounted to $779 million.

As an alternative approach to examining the robustness of our findings, we have examined the extent to which investment levels increased subsequent to the *Cablevision* ruling for a broad set of internet companies, rather than just the cloud companies included in the above analyses. We anticipate that there will be no effects for this set of internet companies since the Cablevision ruling should only affect cloud computing companies. The results associated with Models 6 and 7, presented in Table 4, are analogous to Models 1 and 2 except that they are run on the "internet-specific" companies rather than the cloud companies.[21]

---

[21] VentureXpert categorized 8,510 companies as being internet-specific. This list includes companies described as "internet communications," "e-commerce technology," "computer hardware," "internet software," "internet programming," "internet ecommerce," "internet content," and "internet services."

Table 3
Cloud Computing Regression Results: U.S. vs. Rest of World[1,2]
Dependent Variable: Ratio of Cloud Computing VC Dollars to Total IT VC Dollars

	Model
Independent Variables	(5)
U.S. Indicator	0.0257***
	(0.0045)
2008 Dummy[3]	0.0042
	(0.0044)
Effect of Cablevision on U.S. VC Investment	0.0274***
	(0.0092)
Constant	0.0062*
	(0.0034)
Observations	40
Adjusted R-Squared	0.706
Implied Increase in U.S. Cloud VC Investment ($ Millions)	**$779**
Length of Time Period	1Q 2006 - 4Q 2010

Notes:
[1] Robust standard errors are provided under the point estimates in italics.
[2] *** indicates significance at a 1 percent level, ** indicates significance at a 5 percent level, and * indicates significance at a 10 percent level.
[3] Decision by Appellate Court (judgment of District Court is reversed) (8/4/2008). The 2008 Dummy variable is set equal to one for all quarters after 2Q 2008.

As the results in Table 4 show, investment levels in U.S. internet-specific companies either actually *decrease* in the U.S. following the Cablevision decision (Model 6), or are not statistically different in the time periods before and after the *Cablevision* ruling (Model 7). This suggests that the findings described above are specific to cloud companies, in particular, and do not reflect general trends associated with venture-backed investment in internet-specific companies.

Table 4
Cloud Computing Regression Results: U.S. vs. EU[1,2]
Dependent Variable: Ratio of Internet-Specific VC Dollars to Total IT VC Dollars

	Model	
Independent Variables	(6)	(7)
U.S. Indicator	0.1094***	0.0806***
	(0.0274)	*(0.0282)*
2008 Dummy[3]	0.1185**	0.0501
	(0.0446)	*(0.0574)*
Effect of Cablevision on U.S. VC Investment	-0.0857*	-0.0793
	(0.0491)	*(0.0501)*
Percent Change in GDP		0.0152
		(0.0147)
Broadband Penetration Rate		1.2995***
		(0.4465)
Constant	0.2030***	-0.0441
	(0.0238)	*(0.0804)*
Observations	40	40
Adjusted R-Squared	0.303	0.370
Length of Time Period	1Q 2006 - 4Q 2010	1Q 2006 - 4Q 2010

Notes:
[1] Robust standard errors are provided under the point estimates in italics.
[2] *** indicates significance at a 1 percent level, ** indicates significance at a 5 percent level, and * indicates significance at a 10 percent level.
[3] Decision by Appellate Court (judgment of District Court is reversed) (8/4/2008). The 2008 Dummy variable is set equal to one for all quarters after 2Q 2008.

4.1.2. Stationarity[22]

One assumption made in our regression analyses is that the data are stationary; that is that the data series do not depend on time and thus, that the mean, variance, and covariance of the data do not vary with time. To examine the extent to which increased U.S. investment subsequent to the *Cablevision* decision reflects an ongoing trend, perhaps attributable to factors not reflected in any of the data we collected, we have conducted a variety of tests. First, we ran a

[22] A stationary time series is one whose statistical properties such as mean, variance, and autocorrelation, are all constant over time. Most statistical methods are based on this assumption, and violations of stationarity can lead to biased point estimates.

simple ordinary least squares regression on the difference between U.S. and EU investment levels against a time trend; this revealed that U.S. investment levels relative to EU investment levels were falling on average, but not significantly, during the Q1 2006 to Q3 2008 time period.

To more formally test for stationarity in our time series data, we conducted three well-known tests on our data from Q1 2006 through Q4 2010: the Dickey-Fuller, Phillips-Perron, and Kwiatkowski–Phillips–Schmidt–Shin tests. Using each test, we found no evidence of non-stationarity. As such, our data appear to be stationary, and thus, it is not necessary to adjust our regression equations or data.

4.1.3. Autocorrelation

We also tested for the presence of autocorrelation in our regression analyses by conducting a test proposed by Jeffrey Wooldridge for panel data.[23] After correcting for autocorrelation, the estimate of the effect of Cablevision remains significant and positive, and the implied increase in U.S. cloud VC investment actually increases from that of Models 1 and 2.

4.1.4. Investment Levels (vs. Ratios)

We ran additional sensitivities based on an alternate specification of the dependent variable. Specifically, we ran regressions analogous to Models 1 and 2 where the dependent variable was the total quarterly investment (in the U.S. or EU) measured in dollars, rather than measured in terms of a ratio relative to total IT spending. The total other IT venture capital investment and total other venture capital investment in a given region were controlled for by their inclusion as separate independent variables in the regression analysis. These regressions yielded results, presented in Table 5, comparable to those of Models 1 and 2.

---

[23] Wooldridge, J.M, *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press (2002), pp. 282-283.

In Model 8, the analog to Model 1, U.S. investment was, on average, $119.1 million higher each quarter after the Cablevision ruling (after controlling for EU differences), totaling $1.2 billion over the 2.5 subsequent years. The corresponding figures for Model 9, the Model 2 analog, which incorporates controls for GDP changes and broadband penetration, imply $126.8 million higher investment on a quarterly basis and $1.3 billion in total for the 2.5 years.

Table 5
Cloud Computing Regression Results: U.S. vs. EU[1,2]
Dependent Variable: Cloud Computing VC Dollars

	Model	
Independent Variables	(8)	(9)
IT U.S. Minus Cloud VC Investment	0.0532	0.0590**
	(0.0327)	*(0.0267)*
Total VC Investment Minus IT Minus Cloud VC Investment	0.0087	-0.0004
	(0.0106)	*(0.0115)*
U.S. Indicator	-71.1660	-87.7535
	(108.5990)	*(84.7400)*
2008 Dummy[3]	7.2783	-24.2030
	(8.8634)	*(26.8703)*
Effect of Cablevision on U.S. VC Investment	119.1098*	126.8498**
	(59.3409)	*(51.4516)*
Percent Change in GDP		20.6457**
		(9.2363)
Broadband Penetration Rate		713.7737*
		(376.2864)
Constant	-37.2162	-170.5333**
	(22.5880)	*(71.7582)*
Observations	40	40
Adjusted R-Squared	0.750	0.803
Implied Increase in U.S. Cloud VC Investment ($ Millions)	**$1,191**	**$1,268**
Length of Time Period	1Q 2006 - 4Q 2010	1Q 2006 - 4Q 2010

Notes:
[1] Robust standard errors are provided under the point estimates in italics.
[2] *** indicates significance at a 1 percent level, ** indicates significance at a 5 percent level, and * indicates significance at a 10 percent level.
[3] Decision by Appellate Court (judgment of District Court is reversed) (8/4/2008). The 2008 Dummy variable is set equal to one for all quarters after 2Q 2008.

4.1.5. Cloud Company Identification

We have also tested the sensitivity of our results to the list of cloud computing companies included in our dataset. Our results are robust to the use of a smaller set of companies, that is, one that includes those with "cloud" in their VentureXpert business descriptions but does not include additions based on review of third party cloud computing company lists.

Our research also revealed specific types of service companies that rely on cloud computing technologies. These include companies described as software-as-a-service (SaaS), hardware-as-a-service (HaaS), and/or platform-as-a-service (PaaS). The *Cablevision* decision is likely only to have an indirect effect on these computing companies as they generally are much less likely to be directly associated with third-party copyrighted material. As one would expect, including these "as-a-service" companies in our data sample renders the effects associated with the 2008 *Cablevision* ruling statistically insignificant.

5. Conclusions

In this paper we set out to examine the effect of copyright policy changes on venture capital investment in cloud computing companies by analyzing the effect of the Second Circuit Court of Appeals' decision in *The Cartoon Network, et al. v. Cablevision* on VC investment in U.S-based cloud computing companies. To that end, we constructed a dataset on VC investment in cloud computing companies and estimated multiple difference-in-difference regression models designed to test for a statistically significant increase in U.S. cloud companies post *Cablevision*.

Our findings suggest that decisions around copyright scope can have significant impacts on investment and innovation. We have tested a number of models and consistently find that the U.S. Second Circuit Court of Appeals' decision led to additional incremental investment in U.S. cloud computing companies compared to the EU experience. As shown in the figure in Appendix

B, estimates of increased VC investment in U.S. cloud computing from our seven models range from $728 million to approximately $1.3 billion, with an average of $936 million. When paired with the findings of the enhanced effects of VC investment relative to corporate investment, this may be the equivalent of $2 to $5 billion in traditional R&D investment.

References

"50 Top Cloud Computing Companies," *cloudtweaks.com*, July 30, 2010, last accessed October 3, 2011, http://www.cloudtweaks.com/2010/07/over-50-of-the-biggest-and-best-cloud-computing-companies.

Cartoon Network, LP, LLLP v. CSC Holdings, Inc., 536 F.3d 121 (2d Cir. 2008).

"Cloud Computing – SaaS, PaaS, IaaS Market, Mobile Cloud Computing, M&A, Investments, and Future Forecast – Worldwide," *Renub Research,* September 2010, last accessed October 3, 2011, http://www.slideshare.net/renubresearch/cloud-computing-market-worldwide.

Corbin, Kenneth, "15 Cloud Computing Firms to Watch: Security, Storage, Apps," *datamation.com,* April 26, 2011, last accessed October 3, 2011, http://itmanagement.earthweb.com/cloud-computing/15-Cloud-Computing-Firms-to-Watch-Security-Storage-Apps-3931826.htm.

Depena, Ray, "Cloud Computing Companies to Watch in 2011," *Cloud Computing Journal*, Cloud Expo Blog Feed Post, February 4, 2010, last accessed October 3, 2011, http://cloudcomputing.sys-con.com/node/1662284.

Geelan, Jeremy, "The Top 150 Players in Cloud Computing: SYS-CON's Cloud Computing Journal Expands Again Its List of Most Active Players in the Cloud Ecosystem," *soacloud.utilizer.com*, October 29, 2009, last accessed October 3, 2011, http://soacloud.ulitzer.com/node/770174.

Goldfard, Avi & Tucker, Catherine, "Privacy and Innovation," *NBER Working Paper Series*, no.17124 (2011).

Hellman, Thomas & Puri, Manju, "The Interaction between Product Market and Financing Strategy: The Role of Venture Capital," *The Review of Financial Studies* 13, no. 4 (2000): 959-984.

Kirilov, Kiril, "Top 25 European Cloud Computing Rising Stars To Watch – Complete List," *cloudtweaks.com*, April 6, 2011, last accessed October 3, 2011, http://www.cloudtweaks.com/2011/04/top-25-european-cloud-computing-rising-stars-to-watch-complete-list/.

Kortum, Samuel & Lerner, Josh, "Assessing the Contribution of Venture Capital to Innovation," *The RAND Journal of Economics* 31, no. 4 (Winter, 2000): 674-692.

Kwun, Michael, "Victory for DVRs in the Cloud," *Electronic Frontier Foundation*, August 4, 2008, https://www.eff.org/deeplinks/2008/08/victory-dvrs-cloud.

Lerner, Josh, *The Architecture of Innovation*. Boston: Harvard Business School Press *(forthcoming*).

"List of Top 'Cloud Computing Solution Providers to Watch in 2009," *onCloudComputing.com*, July 1, 2009, last accessed October 3, 2011, http://www.oncloudcomputing.com/en/2009/07/list-of-top-cloud-computing-solution-providers-to-watch-in-2009/.

Maats, Frederike, Metrick, Andrew, Hinkes, Brian, Yasuda, Ayako & Vershovski, Sofia, "On the Consistency and Reliability of Venture Capital Databases" (2009).

"OECD Stat Extracts," *Organization for Economic Co-operation and Development*, http://stats.oecd.org.

"Private Equity Module: ThomsonONE.com Investment Banking," *thomsonreuters.com,* last accessed October 17, 2011, http://thomsonreuters.com/content/financial/pdf/i_and_a/thomsononecom_ib_pe.pdf.

Puri, Manju & Zarutskie, Rebecca, "On the Lifecycle Dynamics of Venture-Capital-and-Non-Venture-Capital-Financed Firms," *EFA 2007 Ljubljana Meetings Paper; US Census Bureau Center for Economic Studies Paper No. CES-WP-08-13.* (June 2010).

Singh, Basant Narayan, "Top 10 Cloud Computing Service Providers of 2009," *techno-pulse.com,* December 8, 2009, last accessed October 3, 2011, http://www.techno-pulse.com/2009/12/top-cloud-computing-service-providers.html.

Standeford, Dugie, "US Cablevision Decision Has Implications for Cloud Computing, Online Advertising," *Intellectual Property Watch*, July 3, 2009, http://www.ip-watch.org/weblog/2009/07/03/us-cablevision-decision-has-implications-for-cloud-computing-online-advertising/.

"The Top 20 Infrastructure as a Service (IaaS) Vendors," *clouds360.com,* last accessed October 3, http://www.clouds360.com/iaas.php.

"The Top 20 Platform as a Service (PaaS) Vendors," *clouds360.com,* last accessed October 3, http://www.clouds360.com/paas.php.

"The Top 20 Software as a Service (SaaS) Vendors," *clouds360.com,* last accessed October 3, 2011, http://www.clouds360.com/saas.php.

"Thomson ONE's Private Equity module powered by VentureXpert," *ThomsonOne*.

Twentieth Century Fox Film Corp. v. Cablevision Systems Corp., 478 F. Supp. 2d 607 (S.D.N.Y. 2007).

Wooldridge, J.M, *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press (2002).

Appendix A
Summary Statistics for Investment Levels and Regression Variables

	Q1 1995 - Q4 2010						Pre Cablevision: Q1 2006 - Q2 2008						Post Cablevision: Q3 2008 - Q4 2010					
	Mean	Std Dev	Min	Med	Max	Total	Mean	Std Dev	Min	Med	Max	Total	Mean	Std Dev	Min	Med	Max	Total
VC Investment in U.S. Cloud ($ Millions)[1]	$92.3	$88.0	$0.0	$71.8	$406.5	$5,906.3	$131.0	$39.9	$72.9	$125.8	$191.1	$1,309.7	$184.7	$84.9	$58.8	$176.6	$369.4	$1,847.1
VC Investment in U.S. Cloud as % of VC Investment in U.S. IT[1]	2.2%	2.3%	0.0%	1.6%	11.5%		3.2%	0.9%	1.8%	3.0%	4.6%		6.3%	2.4%	3.1%	6.1%	11.5%	
VC Investment in EU Cloud ($ Millions)[1]	$3.8	$7.4	$0.0	$0.0	$34.0	$242.3	$7.0	$7.7	$0.0	$4.5	$20.5	$69.9	$8.9	$11.5	$0.0	$3.7	$34.0	$88.7
VC Investment in EU Cloud as % of VC Investment in E.U. IT[1]	0.7%	1.4%	0.0%	0.0%	6.4%		1.2%	1.2%	0.0%	0.9%	3.6%		1.8%	2.2%	0.0%	0.8%	6.4%	
Real U.S. GDP Growth Rate Prior Quarter[2]	0.6%	0.7%	-2.3%	0.7%	2.0%		0.4%	0.5%	-0.4%	0.4%	1.3%		-0.1%	1.2%	-2.3%	0.5%	1.0%	
Real EU GDP Growth Rate Prior Quarter[2]	0.5%	0.6%	-2.6%	0.5%	1.2%		0.7%	0.4%	-0.3%	0.7%	1.0%		-0.3%	1.1%	-2.6%	0.3%	1.0%	
U.S. Broadband Penetration Rate[3]	17.7%	7.4%	5.4%	18.6%	27.7%		20.7%	2.6%	16.6%	20.8%	23.9%		26.1%	0.8%	24.7%	25.9%	27.7%	
EU Broadband Penetration Rate[3]	15.0%	8.4%	2.0%	15.8%	26.0%		18.2%	3.0%	13.5%	18.5%	22.2%		24.6%	1.0%	22.8%	24.9%	26.0%	

Notes and Sources:
[1] Thomson ONE Private Equity data, Jan 1995 to Dec 2010.
[2] OECD real GDP growth from the previous quarter.
[3] OECD broadband penetration rate.

Appendix B
Implied Increase in U.S. Cloud VC Investment ($ Millions)