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Valuation of Innovation: The Case of iPhone*

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Abstract

We study the value of innovation in a case study of one of the most visible innovative products in recent years, Apple's iPhone. The value effects of news announcements, patent publications, and trademarks relating to iPhone are taken into account. Our estimate of the lower bound on the value of iPhone is fairly high, 30 billion U.S. (event-day) dollars or 10% to 13% of the firm's market cap (at the end of 2009). We find that patentable technology explains about 25% of the total value, which derives from market reactions to publication of patent applications rather than grants. We also observe a weak negative reaction among Apple's rivals to news about iPhone. Apple appears to capture most of the value within the iPhone supply chain.

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1. Introduction

Valuation of innovation and intellectual property, and determinants of that valuation challenge corporate managers and technology policy makers. One method of valuing innovation employs stock market information by observing either market values of innovating firms, or idiosyncratic stock return related to innovation-related events. In large samples, this valuation effort is often hampered by noise that is present in stock returns. In this study, we tackle the challenges in measurement of the value of innovations and intellectual property by conducting a careful in-depth case study of a single technology product: We consider the value effects of Apple's iPhone, associated patent documents and trademarks on Apple itself, its horizontal rivals, and the firms within the global supply chain of iPhone.

The high-profile entry by Apple into the cellular phone market in 2007 presents a fruitful case to use stock market reactions to value new product innovations and intellectual property for a number of reasons. First, Apple is highly visible both in product and stock markets, which allows us to study the value of a market entry from a viewpoint that differs markedly from that of small technology entrants, which are seldom publicly traded. Specifically, Apple's stock has high trading volume, which should reduce concerns of thin trading that tends to plague innovation valuation studies. The depth of trading in Apple's stock and the keen analyst following that the company attracts should reduce pricing errors in the stock.[1] Second, stock market reactions are likely to be more informative with drastic innovations, as identification of an innovation is easier than in the case of incremental innovations (Sorescu and Spanjol 2008). Undoubtedly, iPhone falls into the drastic innovation category. Third, the cellular phone industry is very patent intensive. It is characterized by cumulative innovation, strong

[1] Apple and its product innovations are also followed actively by the internet community, which should improve information dissemination related to the company's new products.

network effects and a high degree of standardization. These features tend to create high implicit barriers to entry, thus leading to market concentration, which should further make stock market reactions to a firm's innovative efforts more pronounced (see, e.g., Doukas and Switzer 1992). The market dominated by a limited number of large companies also facilitates the study of the effects of iPhone on Apple's horizontal rivals as they are relatively easy to identify. Finally, the high patent intensity of the cellular phone industry makes extensive patenting a pre-requisite for entering the industry.[2] Hence, Apple has faced a need to patent their iPhone-related innovations actively.[3] This helps us separate the value of intellectual property from other components of innovation value.

Innovative activity may be tracked through news announcements and rumors, and publications of patent documents, but the two methods are seldom studied together.[4] In this paper, we measure Apple's stock reactions to publications of both news and patent documents related to iPhone. Using the two sources should not only give a more accurate estimate of the value of iPhone but also shed light on the determinants of that value: The value of an innovation can be viewed as stemming from both investments in developing "hard" technologies embodied in the firm's intellectual property, and from the firm's managerial ability to take advantage of its own and its rivals' R&D efforts ("soft technologies") (Bloom and Van Reenen 2010). The soft technologies would thus capture the firm's knowhow in operations, management, marketing, assimilating external information, etc. One could view stock market reactions to news reflecting value effects

[2] For example, the news coverage of the purchase of Motorola by Google highlighted that the deal gave Google a portfolio of 17,000 patents which are seen as important in defending against law suits within the industry (see e.g. *The Wall Street Journal*, August 16, 2011).
[3] In the launch event of iPhone, January 9, 2007, Steve Jobs, the CEO of Apple, emphasizes several times that the technology is patented, e.g., "We have filed for over 200 patents for all the inventions in iPhone and we intend to protect them".
[4] A prominent exception is Lerner (2006) who uses both news and patent document announcements to identify financial innovations and their determinants.

related to both soft and hard technology value but the reactions to patent applications arising to a larger extent from the value of hard technology.[5]

Given that iPhone has, at least in the eyes of consumers, transformed cellular phone market, one could expect that a significant fraction of iPhone's value comes from new hard technologies. However, the intellectual property environment in the cellular phone industry is also characterized by less precise property rights than, say in the pharmaceutical industry (see, e.g., Bessen and Maurer 2008). This easily results in "a patent thicket" and hence almost unavoidable patent infringement, which should reduce the value of patents.[6] New cellular phone products also constitute prime examples of cumulative innovation where new innovations are built on previous ones. In such an environment the value of new product may reflect the value of intellectual property over previous innovations rather than the intellectual property of the new product (Green and Scotchmer 1995). Moreover, Apple is known for its brand management and marketing, and the introduction of iPhone created a possibility for leveraging economies of scale between it and Apple's existing products (e.g., Mac and iPod) which competent corporate management would be able to realize. Similarly, for competent corporate management, product pre-announcements – which form an essential part of our study – would constitute an important strategic communication tool, especially in a network industry where consumers' decisions to wait for an upcoming product introduction play a major strategic role (Dranove and Gandal 2003 and Sorescu, et al. 2007). Finally, competent management should know not only how to exploit the firm's own innovative efforts but also how to absorb and assimilate the efforts by others (Cohen and Levinthal 1990 and

[5] Naturally the patent-related value effects are not exclusive to hard technology. One can for example posit that firms with high managerial abilities have more value in their patents as well.

[6] Shapiro (2001) defines a patent thicket as "a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology". According to *Economists* (21 October, 2010), Apple's iPhone is indeed at the center of one the greatest patent controversies in the history.

Zahra and George 2002). Hence it is conceivable that also marketing and management skills of Apple significantly contribute to iPhone's value.[7]

Our methodology builds on a long line of literature of using the event study methodology in valuation of innovations (see, e.g., Chaney, et al. 1991 for an early example, and Girotra, et al. 2007, and Sood and Tellis 2009 for recent ones). As mentioned above, valuation based on stock market reactions is known to be sensitive to a number of issues. Those issues include identification of an innovation and dates relevant to it, estimation period, trading volume and market structure (see, e.g., Doukas and Switzer 1992, MacKinlay 1997, Tkac 1999). Following Girotra, et al. (2007) who study the value of R&D portfolios in the pharmaceutical industry, we use the methodology suggested by Tkac (1999) to distinguish significant events among a large number of news announcements, using the daily trading volume as an indicator of significance. Similar to Chen, et al. (2005), we also extend our analysis to Apple's rivals in the cellular phone industry. Besides studying the effects on the competitors, we also consider stock market reactions to iPhone related events among the firms within the supply chain of iPhone. Although we are not aware of previous studies using the event study methodology to evaluate economic consequences of a new product within a global supply chain, accounting data has been used to study value capture within the supply chain of similar new products (see, e.g., Linden, et al. 2009 for the case of Apple's iPod and Ali-Yrkkö, et al. for the Nokia's N95 smartphone).

We also use the event-study approach to study intellectual property valuation, following Austin's (1993) seminal paper. We estimate the value of iPhone-related patents to Apple, after which we explore the determinants of that value. The effects of patenting activity on rival firms are also considered, using daily stock returns. Furthermore, we

[7] We think management ability broadly, including absorptive capacity and ability to realize potential organizational synergies from various product lines.

consider trademark filings. Besides estimating returns on granted patents, which has been the main focus of previous literature, we use the publication of a patent application as an event date, as most of the new information embodied in patent documents becomes public at that point.[8] This method allows us to study the market value of individual patents, and it should be seen as complementary to the popular method of estimating the market value of patents on a more aggregate level (see, e.g., Bloom and van Reenen 2002, Hall, et al. 2005). Here, our paper comes close to the literature that studies the stock market reactions to patent litigation decisions and settlements, stemming from Cutler and Summers (1988).

We find the value of iPhone to be fairly high, at minimum 30 billion U.S. dollars.[9] The patentable technologies explain about 25% of the total value. This effect arises from patent applications rather than grants. More specifically, our estimates of the value of iPhone based on the news announcements vary from $19.7 billion to $24.2 billion, depending on the estimation method. Accounting for abnormal reactions to patent application publications contributes another $6.9 billion (publication date) dollars to the value of the product whereas we find no value effect when patents are granted. Given the Apple market capitalization of $190.6 billion at the end of 2009, the news announcement-based value of iPhone would be between 10% and 13% of the total market capitalization, with the patent application publications contributing another 4% of the market capitalization.

[8] The prior literature has not considered patent applications partially because pending patent applications filed prior to November 29, 2000 were not published in the U.S. and thus the distinction between grants and applications was a moot issue e.g. in Austin (1993).

[9] At the end of Section 4 we discuss the reasons for why we think that $30 billion establishes a lower bound on the estimate of the value of iPhone to Apple. For example, we use a tight filter in selecting the news events to consider, which is likely to leave some value effects unobserved. Also, all our valuation figures are measured in event day dollars. Compounding of those values to the present day would obviously increase the value.

We find that the shares of some of Apple's rivals in the cellular phone industry react negatively to the news about iPhone. Within the global supply chain of iPhone, we find no systematic value effects besides a positive effect on Apple. Only when the launch event is considered on its own, we detect a positive average abnormal return of 6.8% among suppliers, which is statistically significant at the one percent level. Taken together our findings suggest that marketing and management abilities and efforts might play an important role in explaining the value of iPhone.

In the next section we describe our data, and in Section 3 we explain our valuation methods. The results are presented in Section 4, and conclusions in Section 5.

2. Data

We study the valuation effects of news related to iPhone from the first hints of the product until December 31, 2009. We employ various data sources in this study. Our main source for news announcements is Lexis-Nexis, with Bloomberg and Google being used as secondary sources. There, we search for all rumors and news that are related to iPhone. In total, we find 74 days on which news announcements related to iPhone occur. The earliest of these announcement dates back to December 15, 1999, when Apple registered iPhone.org website. The first group of news with more precise information came in 2004, as Apple's partnership with Motorola on a product called ROKR became public. The official announcement of iPhone was made by Steve Jobs on January 9, 2007. Out of the 74 announcements, 31 take place prior to that date. Table 1 indicates the breakdown of our events. A full list of all news items analyzed is provided in Appendix 1.

Another potential source of information on an upcoming product is patent documents and trademark filings. Indeed, a key rationale for patent system is to enhance

information disclosure (see, e.g., Kultti, et al. 2006), and disclosure requirements related to patent documents are inherently rooted in patent laws (see, e.g., 35 United States Constitution (U.S.C.) §112 and §122). Furthermore, patents can only be granted to new and non-obvious inventions (e.g., 35 U.S.C. §102 and §103), and thus the information disclosed in a patent application should be new to the market almost by definition.[10] In the United States, like in other countries, the average lag from the filing of a patent application to a patent grant is several years but pending applications are often made public 18 months after the earliest filing date.[11] We therefore consider both the dates when patent applications are published and the dates when patents are issued.

We use the United States Patent and Trademark Office (USPTO) patent database to identify those patent filings made by Apple that are related to a cellular phone product. Generally, it is not easy to identify patents associated with a certain type of innovation without Type I or II errors (see, e.g., Bessen and Hunt 2007 and Hall, et al. 2009 for discussion on how to identify software and financial patents, respectively). In our case, the challenge is to distinguish Apple's patent applications concerning iPhone from Apple's applications that are related to their other product lines. Following, e.g., Bessen and Hunt (2007), we use a search algorithm based on keywords rather than, e.g., the USPTO patent classification system to identify the patent documents related to iPhone.[12] Whenever it is unclear whether the patent is related to cellular phones, we download the

[10] In theory, the situation is somewhat more complicated, especially in the United States, where the first-to-invent rule was used to determine the novelty criterion until the passage of the America Invents Act of 2011. Hence only an information leakage prior to (12 months of) filing the patent application constitutes a novelty bar. However, as firms usually strive to keep their R&D information secret, especially when they aim at filing patents, information disclosed in patent applications should generally be new to the market.

[11] More specifically, the 18 months publication rule applies to all U.S. patent applications filed on or after 29 November, 2000, subject to some exceptions such as design patents and the cases in which an applicant waives her right to seek patent protection outside the United States.

[12] We first studied several applications clearly related to iPhone in detail to identify appropriate keywords. This suggested the following keyword search algorithm: (((((portable OR (mobile AND device)) OR cellular) OR telecom) OR (wireless AND device)) OR ringtone).

full patent application that includes information such as pictures of the invention to be patented, to study the application area further.

We find patent documents for a total of 213 iPhone related inventions, which are listed in Appendix 2.[13] For most of Apple's patents related to iPhone, we are able to identify an application publication date, and thus we can use both application and grant dates. There are 44 patents that are granted with no prior publication, and they are therefore included in our analysis of granted patents but not in the analysis of patent applications. The sample includes 47 applications published prior to the product pre-announcement on January 9, 2007. The earliest publication date is February 7, 2002. Since many of the patent applications share common publication dates, we end up with a total of 97 unique patent application publication dates. Following similar procedure, we identify 72 unique patent issue dates.

We also identify dates related to trademark filings on iPhone in various countries. The trademark filings occur relatively early, with the first filing in Singapore taking place on October 18, 2002, and filings in the UK and Australia following within the same year. In total, we find six trademark filings, all of them occurring prior to the product pre-announcement on January 9, 2007. [14]

Given the high degree of concentration of the cellular phone industry, it is relatively easy to identify the main horizontal rivals of Apple. In contrast, identification of firms within the global supply chain of Apple is less straightforward. We use various internet sources including teardown reports from www.isuppli.com, and announcements

[13] The unity of invention requirement maintains that one patent application can only refer to one invention (see, e.g., 35 U.S.C. §121). Our figure is a sum of all iPhone related granted (utility and design) patents and published (utility) patent applications that were still pending as of 31 December, 2009. In other words, those patents for which we have both an issued patent and a published patent application are counted just once. Albeit being in line with Apple's own estimate (cf. footnote 3), our figure is likely to slightly underestimate the number of iPhone related patent applications.

[14] In the U.S., a trademark for iPhone was filed in 1996 by Infogear Technology, Corp., a company that was later acquired by Cisco Systems in 2000. Apple and Cisco settled a trademark infringement lawsuit in 2010. We do not consider these events.

of supply contracts from both Lexis-Nexis and Bloomberg to compile a set of firms connected to iPhone, mainly consisting of hardware manufacturers and cellular service providers. These firms are listed in Appendix 3.[15]

For stock return and trading volume data, we use the Center for Research in Security Prices (CRSP) as our primary database. However, many important firms in the cellular phone industry and iPhone supply chain are not traded in the U.S. exchanges. Therefore, we use Datastream as an alternative data source for stock returns.

3. Measurement of event-related value changes

In order to establish the dollar value of iPhone to Apple, we complete a number of event studies that explore the abnormal stock returns that various information releases cause on Apple's stock. As mentioned above, we identify 74 different days on which news releases or speculation regarding iPhone occur. We use the event study methodology (see MacKinlay, 1997 for a survey) to study the valuation effect of these announcements. Our primary event study method is based on the market model, as shown in equation (1):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}, \qquad (1)$$

where R_{it} and R_{mt} are the period-t stock returns for firm i and the market, respectively, and α_i and β_i are parameters estimated within the estimation period. Finally, ε_{it} is the zero mean disturbance term. As the market model generates expected returns for the stock, we then measure abnormal returns within the event window following equation (2):

[15] Naturally, iPhone may have affected firms outside cellular phone market and its supply chain. The analysis of the effects of iPhone on such firms, e.g., vertical rivals, is however beyond the scope of this study.

$$AR_{it} = R_{it} - \alpha_i - \beta_i R_{mt}. \qquad (2)$$

Since the market model parameter estimates are sensitive to our choice of estimation period, we vary the estimation period to test the robustness of our findings. Our first choice is to use an estimation period outside the main time period of iPhone events for Apple, as significant events may cause bias in market model parameter estimation. One could also posit that an earlier estimation period allows us to estimate the relation between Apple's stock and the market portfolio without iPhone. We therefore use the daily returns from 2003 and 2004 to estimate the alpha and the beta in equation (1). The CRSP value-weighted market index serves as a proxy for R_m in all those of our tests that employ a market portfolio.

The beta for Apple with the two year estimation period is 1.3104, and the alpha is 0.0022. However, the parameters for Apple have somewhat varied during our sample period, as witnessed by Figure 1, where we use a rolling 250-day window to calculate the market model beta for Apple. To ensure that our choice of estimation window does not significantly affect our findings, we use the more standard estimation window of (-250,-10) as an alternative setting.

A constant-mean-return model is an alternative way to observe the effect of an event on asset returns (MacKinlay 1997). In the constant-mean-return model, the expected returns are assumed to equal the observed mean return during the estimation period. We use this method both with the fixed estimation period of years 2003-2004, and with (-250,-10) estimation period as additional alternative metrics on the value of each event.

In order to minimize potential biases caused by contaminating events, we use the tightest possible event window by observing abnormal returns only on the day of each event ($t = 0$). In this effort, we make three assumptions. First, we assume that the events bring genuinely new information to the market, so that we do not need to account for possible information leakage prior to the event. Second, we assume that the market on Apple's stock is deep and efficient enough that new information will be embedded in the stock price within a single trading day. An exception to the rule of using the publication date as the event day is made for those news announcements that became public after 4:00 p.m. Eastern time. NASDAQ reports closing prices for the day to the CRSP database based on the Market Hours, which end at 4:00 p.m. Eastern Time. Therefore, any market reaction to announcements that occur after that time should be reflected in the following day's CRSP stock return. For that reason, we use $t = +1$ as the event day for those events. Out of the total of 74 news events, five fall into this category. Third, we assume that there are no systematic patterns of contaminating events occurring on the event dates that we consider. We check, by using both Lexis-Nexis and Bloomberg, each event date in order to exclude days with obvious contaminating events. While one-day abnormal returns are our main metric for the value effect of each event, we also analyze abnormal returns for days surrounding each event, in order to reduce concerns regarding the assumptions about no information leakage and fast information assimilation, discussed above. To the extent the assumptions fail to hold, our estimates are biased downwards.

In an effort to focus on the set of events that bring significant new information to the market, Tkac (1999) suggests using trading volume as an indicator. Her model indicates that extraordinary events induce an increase in the volume of the firm's stock trading (measured as the ratio of daily market volume to market capitalization), relative

to the trading volume for the entire market (measured as the ratio of daily market volume for the market to total market capitalization). Thus, she motivates the use of a model similar to the market model for returns, presented in our equation (1), to identify significant events for a firm. Girotra, et al. (2007) apply this method in their study of R&D value in the pharmaceutical industry. We follow the work of Tkac (1999), and identify event days with abnormal trading volume for Apple by estimating the following equation:

$$V_{it} = \gamma_i + \delta_i V_{mt} + \lambda_i D_t + \varepsilon_{it}, \qquad (3)$$

where V_{it} is the natural log of the ratio of trading volume over market capitalization for Apple on day t, V_{mt} is a similar measure for the market on day t, and D_t is a dummy variable that takes the value of one for the event day.[16] We run a separate regression for each event. As trading volume of Apple has undergone significant and persistent shifts during our study period (see Figure 2), it is preferable to use an estimation period that is near the event. Thus, we include days (-250,+1) in each regression. An event is determined to have significant abnormal volume if λ_i is statistically significant at the 5% level or higher. In order to account for heteroskedasticity present in daily trading volume data, we use robust standard errors.

As a robustness check, we also use internet activity related to iPhone to gauge the informative value of our events. We first extract data from Google trends with a search word "iPhone". Then, following Da, et al. (2011) who use Google trends to measure

[16] Relative daily market volume for both Apple and the total market exhibit skewness, which is why we use the natural log of the relative trading volume in this specification and our tests. However, in Figure 2, we report abnormal trading volume in number of shares.

investor attention to stocks, we construct an index to capture abnormal internet activity as follows:

$$ASVI_t = \log(SVI_t) - \log[\text{Mean}(SVI_{t-1}, ..., SVI_{t-60})]. \quad (4)$$

In (4), $ASVI_t$ is the Abnormal Search Volume Index for day *t*. In contrast to Da, et al. (2011), who utilize weekly data, we use daily data. Also, they specify normal internet activity as the median SVI for weeks -1 to -8, whereas we use the mean for days -1 to -60. Our use of mean instead of median is dictated by numerous days with zero values, particularly in the early part of our study period, resulting in the median value of zero for several events.

4. Results

4.1 Stock market reactions to news announcements

We begin by exploring stock returns related to all iPhone news. On the first row of Table 2, we report the abnormal mean return for Apple on all 74 news event days. The average one-day abnormal return for Apple is 0.47%, which is statistically significant at the 10% level. We compare the Apple returns to those of their main competitors. Out of them, CRSP returns are available for Ericsson, Motorola, Nokia, and Research In Motion (RIM). On the event days, Nokia also posts a moderate average abnormal gain of 0.29%, whereas Motorola (-0.07%), RIM (-0.19%), and Ericsson (-0.37%) tend to lose value on event days related to iPhone. None of the competitors' average reactions is statistically significant at the conventional levels.

We then employ equation (3) to identify events that bring new information to the market. Our tests indicate that 22 of our 74 news events are associated with abnormal trading volume. Further, when we use equation (4), we find that the ASVI measure for these 22 events is higher than that for the remaining 52 events that do not exhibit abnormal relative trading volume. The difference is statistically significant at the 10% level. We next take the events that generate abnormal trading volume under a closer examination. Their average abnormal returns are displayed by the second row of Table 2. The effect measured in Apple's stock reaction is now stronger, with the mean abnormal return of 1.93% on day t=0, which is statistically significant at the 1% level. Except for Nokia's slightly positive average reaction at 0.20%, all other competitors exhibit negative abnormal mean returns in this sample of events, varying from -0.20% for Motorola to -0.39% for RIM. But again, none of the competitor average returns on day t=0 differs from zero at the conventional levels of statistical significance.

In Figure 3, we observe average abnormal returns for days surrounding each event. Compared to the relatively large abnormal return on day t=0 for Apple, all other days within the (-2,+2) window exhibit only modest average effects. This finding increases our confidence on our event day identification strategy. We further repeat the same analysis to include Apple's competitors in Figure 4. Besides Nokia, Samsung and HTC, all of the competitors exhibit slightly negative abnormal returns on day t=0.[17]

Next, we compare our findings across different estimation periods and methods. The results are reported in Table 3. The table indicates that variation across models and estimation periods is negligible. The average abnormal return related to the event days varies from the minimum of 1.81% using the constant-mean-return model with an estimation period that immediately precedes the event, to the maximum of 1.93%, which

[17] In this graph, we utilize Datastream returns for firms, denoted by an asterisk (*), that are not traded in the United States. Since all three of them trade on exchanges that close prior to the U.S. trading hours, we use the one-day lag returns for them in all of our analysis.

result is obtained from the market model with a fixed estimation period. Adding the Fama-French factors[18] to our market model reduces the average event day abnormal return by one basis point.

4.2. Value of patents

We complete a similar analysis for days on which patent documents related to iPhone have been made public. As described in Section 2, we identify 97 unique patent application publication days. In Table 4, we report average abnormal returns for both Apple, and those of its competitors that are traded in the U.S. stock market. The results are based on the market model, with years 2003 and 2004 serving as the estimation period. Panel A of Table 4 shows the average abnormal returns across all 97 days. The abnormal return is slightly positive for Apple, but falls far short of statistical significance. Similarly, the competitors do not appear to exhibit any signs of systematic abnormal performance around patent application publication dates for Apple.

We then focus on the patent application publication days that are connected with abnormal trading volume. We find that 31 of the 97 dates fall into that category. When we check the dates of abnormal volume for potential event contamination, we find that nine of the 31 days coincide with corporate information releases (such as quarterly earnings announcements, high-level managerial changes, and an adoption of a stock option expensing rule in accounting). Thus, we are left with 22 days on which patent applications are published, and which are free of contamination. On those days, the Apple average abnormal return is 1.13%. The effect is statistically significant, with the *p*-value of 5.5%.

[18] We obtain daily returns for the Fama-French SMB and HML factors from Kenneth French's website at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

Next, we repeat the abnormal return analysis for the 72 days when patents are granted. This includes patents both with and without prior publications of corresponding patent applications. Since patents without prior publications are likely to be less valuable[19], and since information about the (more valuable) patents with prior publications becomes public when the corresponding applications are published, it is unlikely that the grant of the patent would bring significant new information to the market. This prediction is confirmed by our data, as the average reaction to the patent grants is small: For all 71 patent grants, the daily average abnormal stock reaction is -0.11%. Out of those 71 days, 13 exhibit abnormal trading volume, and on those days, the abnormal return is 0.35%. Based on the evidence that patent grants do not appear to bring new information to the market in a significant manner, we exclude them from further analysis.

We explore the determinants of value reaction to patent applications by regressing the abnormal returns related to a patent application event on patent characteristics. The results are reported in Table 5. In the first five columns of Table 5, we include abnormal reactions on all 97 patent event days. When the patent characteristics are considered individually in the first three columns, only the number of claims exhibits a weakly significant (negative) connection with abnormal returns. However, when all patent characteristics are included in a single regression in column (4), more results emerge. The number of backward citations (defined as log(1+# of backward citations)) is positively related to the abnormal return, whereas claims and forward citations seem to

[19] These patents fall into two categories: 1) The publication requirement for patent applications does not apply to inventions that are only patented domestically. Apple may have decided to waive the possibility of international patenting, perhaps because the invention was not patentable outside the United States or perhaps because the invention was not significant enough to warrant a costly international application process. 2) They deal with design patents which arguably have weaker protection than utility patents. See also footnote 12.

affect abnormal returns negatively[20]. The abnormal reactions seem to become smaller through time, as the time trend variable enters with a negative and significant sign. In column (5), we add a control variable for the 22 patents whose application publication generated abnormal trading volume in Apple stock. The variable enters with a positive and significant coefficient, while leaving the rest of the findings intact. In column (6), we include only events with abnormal trading volume. Even in that subset of patent applications, the number of claims and the time trend variable enter with a negative and significant sign. Neither forward citations nor backward citations are significant determinants of abnormal returns in that subset.[21]

4.3. Value of trademarks

As described in Section 2, we find six days on which Apple filed a trademark for iPhone. The first two (in Singapore and UK) occur on subsequent trading days, on October 18 and October 21, 2002. The filing in Singapore exhibits abnormal trading volume, while the filing in the UK fails to do so. Filing in Australia on December 3, 2002 also fails to generate abnormal trading volume. The filing in Canada on October 14, 2004 is met with a very large abnormal trading volume. Furthermore, Apple stock return on that day exceeds 14%, making it the best day during the entire decade for the stock. However, the filing coincides with a very favorable quarterly earnings announcement, which renders the Canadian trademark filing irrelevant for our analysis. Finally, trademark filings to New Zealand and the US in September 2006 fail to generate abnormal trading volume, which leaves us with only a single trademark filing event with

[20] Forward citations are adjusted for citation truncation by using the lag weights implied by Hall, et al (2002) for computers and communications industry. Using the weights from Hall, et al. (2007) for electronics industry yields similar results.

[21] When we compare the two subsets of applications (with and without abnormal trading volume), we find that the applications associated with abnormal trading volume have on average more claims, and forward and backward citations, but the differences are not statistically significant.

abnormal trading volume to analyze. On the day of the first trademark filing (Singapore on October 18, 2002), the abnormal return for Apple stock is 0.78%, using the same fixed estimation period as above, but the reaction is statistically insignificant. We therefore do not further consider the trademark filing events in what follows.

4.4. Value effects within the supply chain

To study value capture and economic consequences of the launch of iPhone within its global supply chain, we follow our methodology and measure market reactions to iPhone related news announcements among the firms within the iPhone supply chain (see Sections 2 for the identification of firms). In contrast to the one-day event window, we use a two-day window of (0,1) as both the supplier and the service provider sets include firms that are not traded within U.S. trading hours. Also, these firms are smaller than Apple and their connection to iPhone is less direct than that of Apple. The two-day event window allows more time for information assimilation.

We set up a hedonic regression, where the dependent variable is the abnormal return for each firm and each event. With role-specific dummies for Apple, its suppliers, and service providers, we intend to measure any systematic value created by the product across the supply chain. Apple's competitors serve as the omitted control group in the regression. The results are reported in Table 6. They suggest that besides the positive value effect on Apple, no other systematic value effects exist. We consider the market reactions both before and after the product pre-announcement on January 9, 2007, and both events with and without abnormal trading volume are considered separately (in unreported results). When the product pre-announcement is considered on its own, we do detect a positive average abnormal return of 6.8% among suppliers, which is statistically significant at the one percent level.

5. Market value of changes

In order to estimate the value of iPhone to Apple, we follow Chaney, et al. (1991) and others by observing the market capitalization of Apple on the day prior to each event, and multiplying that figure by the abnormal return related to each event day. For a total value of the product, we then sum up these values across all events. We perform this calculation using each of our abnormal return metrics, focusing only on the events that are determined to be significant based on the trading volume data (see Section 4.1 for the identification of these events).

The results are reported in Table 7, with values in thousands of (event-day) dollars. Our estimates based on the news announcements vary from $20.0 billion to $24.4 billion, based on different methods of estimation. Our results further indicate that accounting for abnormal reactions to patent application publications contributes another $7.8 billion to the value of the product.[22] Given the Apple market capitalization of $190.6 billion at the end of 2009, the news announcement-based value of iPhone would be between 10% and 13% of the total market capitalization, with the patent application publications contributing another 4% of the market capitalization.

We believe that our estimate of the value of iPhone to Apple is likely to establish a lower bound on the value estimate. First, we report all our figures in event day dollars, which ignores the time value of money between each event and December 31, 2009.[23] Second, the development of iPhone took several years, and some news about the product may have leaked to the market before it was reported in news. Similarly, information

[22] Two of our patent application publication event dates coincides with a news announcement date. We have counted those as news days and excluded them from the market value of patent application publications calculation. Since one of the two events is connected with a positive value effect, and the other event is connected with almost equal negative value effect, their inclusion has a negligible effect on the total value.

[23] Our first news event with abnormal trading volume occurs on January 7, 2005, so for that event, we ignore almost five years of time value of money.

about an invention underlying a patent application may leak before the application is published. Any building anticipation of the product during the time between our events would further generate a downward bias to estimates that rely on discrete events, such as ours. Third, by excluding patent application publication dates with contaminating data releases, we reduce our estimate of the value of patent applications by over $10 billion. It is likely that events such as quarterly earnings announcements have a larger impact on Apple's stock than publication of patent applications. However, given that such patent publications can be assumed to have a positive value, that value is ignored in our estimates, as we exclude days with contaminating events completely from our analysis. If we assume that the effect of patent application publications on those days is similar to the average effect among other 22 patent application publication events (= 1.13%), the value of patent applications increases by approximately $632 million. Similarly, we are overlooking patent grant events and trademark filings as we failed to find statistically significant systematic evidence of market reaction to those events. Thus, we are assuming the economic effect of those events to be zero.

When we contrast our estimates to the accounting information on Apple we find that the company's quarterly 8k filing for the fiscal quarter ending on September 25, 2010, the company's net sales related to "iPhone and related products and services" equal $8.822 billion, which is about 43% of their total sales for the same quarter. This reaffirms that our estimate of the value of iPhone to Apple at 14-17% of the firm's market capitalization is a conservative estimate. Obviously, any current sales figures would ignore future growth potential (in case it differs relative to company's other product lines), and synergy effects across product lines.

6. Conclusions

In order to provide new insights to valuation of innovation, we take advantage of a unique case – the launch of Apple's iPhone - in which a major firm expanded its product portfolio to enter into a market that is characterized by significant barriers to entry. We study the stock market reactions to news announcements and rumors related to iPhone from the first hints of the product until December 31, 2009. Moreover, we also study the stock market reactions to the publications of various intellectual property documents related to iPhone. We consider the value effects of these events on Apple, its horizontal rivals, and the firms within the global supply chain of iPhone.

We find the lower bound for the market valuation of iPhone to be high, at roughly 30 billion U.S. dollars, with patentable technology explaining about 25% of the total value. According to our estimates, Apple itself appears to capture most of the value within the global supply chain of iPhone. This evidence suggests that Apple's management and marketing abilities and efforts contribute significantly to the value of iPhone.

In this paper, we also complement the existing intellectual property valuation literature by studying stock market reactions to trademark filings, issued patents and the publication of patent applications using daily stock market data. We find that the publication of patent applications release valuable new information to the market, and that the number of claims is negatively correlated with patent value, perhaps reflecting an increased concern for infringement litigation.

Our results predominantly indicate private value of iPhone to Apple. While we fail to find consistent significant effects on Apple's rivals and firms in the iPhone supply chain (save for the day of the product pre-announcement on January 9. 2007) such effects may nevertheless exist. For example, the introduction of iPhone has probably involved

complex and offsetting effects on rivals: it has certainly reduced the market share of some established cellular phone manufacturers (a “business-stealing effect”) but it has also probably increased the total size of the market and created technological spillovers, which have mitigated the business stealing effects. Furthermore, as this is an industry with imprecise and overlapping intellectual property rights, it is not surprising that Apple as an entrant has been at the center of extensive litigation concerning iPhone related intellectual property. The legal costs of intellectual property infringement suits and associated damage or settlement payments could be factored into the stock market reactions, and could explain the negative correlation between the patent value and the number of claims in our data. Our findings lend support to a business stealing effect that has been diluted by other considerations: We find that shares of Apple’s rivals typically encounter a negative but weak reaction to news about iPhone. Naturally, the estimations of full social value of iPhone should also incorporate consumer surplus besides industry and supply chain effects.

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Appendix 1. News Announcements

Date	Event
15 December 1999	Apple registers iPhone.org
11 September 2002	Cell phones mentioned in Jobs' interview at Apple Expo
26 July 2004	Motorola and Apple announce iTunes& Motorola cell phones partnership
07 January 2005	Motorola executive previews iTunes phone
01 September 2005	Hint at Motorola and Apple launching the "ROKR"
03 September 2005	More information that Apple will reveal the iPhone leaks out (referring to ROKR)
08 September 2005	Last night the ROKR and iPod nano was revealed
09 September 2005	The ROKR receives bad reviews
22 September 2005	Hint at Apple creating their own "iphone"
14 February 2006	More speculating concerning Apple creating their own Apple iPhone
22 March 2006	Apple Computer expected to unveil a Apple branded iPhone within 12 months
29 March 2006	More rumors regarding the unveiling of Apple iPhone emerge
29 March 2006	Another article regarding rumors of Apple iPhone launch
02 April 2006	Apple may have run into problems
18 May 2006	Some believe the rumors are only rumors
21 July 2006	Apple exec drops major hint regarding iPhone
31 July 2006	Code suggesting the existence of an iPod phone is found
09 September 2006	iphone.org belongs to Apple
11 August 2006	Steve Jobs allegedly talks about iPhone to his inner circles
11 September 2006	Analyst predicts the iPhone announcement will happen within 4 - 6 months
13 September 2006	French newspaper prints fake iPhone picture
26 September 2006	Apple and Cingular teaming up?
18 October 2006	More iPhone predictions
18 October 2006	Brian Cooley expects iPhone to be in stores in early February
27 October 2006	Apple + new patent = iPhone speculation

11 November 2006	Two phones?
15 November 2006	More iPhone speculation
21 November 2006	Apple stock reaches new high
24 November 2006	More speculating concerning two Apple iPhone devices
30 November 2006	Apple seeks patent protection for an iPhone
07 December 2006	iPhone predicted to not be released until later
07 December 2006	Kevin Rose predicts
11 December 2006	Jesse Tortora says production of "iPhone slim" has started
11 December 2006	Forbes estimates iPhone sales
14 December 2006	Rebecca Runkle claims to have inside information
15 December 2006	Shares of Skyworks Solutions Inc. Sky rocket
16 December 2006	Jajah working with Apple?
17 December 2006	Cisco owns the name "iPhone"
18 December 2006	Cisco's linksys release "iPhone"
08 January 2007	Apple updates website
09 January 2007	**iPhone announcement**
11 January 2007	More joint products with Cingular Wireless?
11 January 2007	Telefonica in talks with Apple
06 February 2007	Hint: iPhone may be available on the 15th of june
12 April 2007	iPhone will be released at the end of June
25 May 2007	Media report: iPhone will be released on the 20th of June
03 June 2007	Commercials show iPhone release date
11 June 2007	Jobs unveils more of OS X leopard
18 June 2007	Apple updates iPhone before release
25 June 2007	Pictures of iPhone accessories leaked
29 June 2007	iPhones now in stores
05 July 2007	Web development page for iPhone
05 July 2007	A patent suggests that there may be an iPhone nano
10 July 2007	A cheaper version of the iPhone?
09 September 2007	Apple expected to annouce UK distributor
18 September 2007	Apple announed UK iPhone release date
19 September 2007	iPhone for Germany announced
20 September 2007	iPhone for France announced

17 October 2007	Apple announces Software Development Kit (SDK)
17 October 2007	Apple will release an unlcoked iPhone in France
31 October 2007	iPhone named invention of the year by Time Magazine
09 November 2007	iPhone released in Germany and Britain
20 November 2007	Rumor: Apple planning iPhone 3G release
28 November 2007	Apple plans 3G iPhone
18 December 2007	iPhone launching in Japan?
03 January 2008	More speculation concerning MacWorld
05 February 2008	New iPhone and iPod announced
08 February 2008	New Apple event?
27 February 2008	Apple sets date for announcements
06 March 2008	Apple releases iPhone SDK
06 May 2008	Hint: iPhone 3G release early?
14 May 2008	iPhone 3G coming to England?
20 May 2008	Apple announces iPhone 3G release date
27 May 2008	Teliasonera announce iPhone deal
09 June 2008	Apple unveils iPhone 3G
09 June 2008	Apple announces iPhone 3G release in several countries
11 July 2008	Apple launches iPhone 3G in 22 countries
17 September 2008	Apple may begin to produce own chips
22 December 2008	iPhone nano?
03 February 2009	iPhone 4G rumor
13 February 2009	New product rumors
26 March 2009	Apple to unveil new iPhone?
09 April 2009	More iPhone rumors
16 April 2009	Apple patents suggest iPhone specs
27 April 2009	Apple and Verizon creating two new products
13 May 2009	No new iPhone at WWDC?
19 May 2009	Fishy rumor regarding new iPhone launch date
26 March 2009	New iPhones and iPod nano?
26 March 2009	6 new iPhones?
06 June 2009	New iPhones to be unveiled in 2 days?
08 June 2009	Apple unveils new iPhone
19 June 2009	New iPhone goes on sale
02 July 2009	New Apple patents

Appendix 2: Patents related to iPhone

Patent number	Publication date	Filing date	Application Publication date
US6054955 (A)	25-Apr-00	8/23/93	
US5998972 (A)	7-Dec-99	30-Apr-98	
US6222347 (B1)	24-Apr-01	30-Apr-98	
US6400321 (B1)	4-Jun-02	17-Jul-00	
US6496149 (B1)	17-Dec-02	1-Feb-01	
US6583676 (B2)	24-Jun-03	20-Jun-01	26-Dec-02
US6704710 (B2)	9-Mar-04	12-Oct-01	7-Feb-02
US6711245 (B1)	23-Mar-04	15-Mar-02	
US7003260 (B1)	21-Feb-06	15-Mar-02	
US6934812 (B1)	23-Aug-05	5-Apr-02	
US20030167318 (A1)		5-Apr-02	4-Sep-03
US7054981 (B2)	30-May-06	24-Jun-02	17-Jun-04
US7765326 (B2)	27-Jul-10	21-Oct-02	24-Apr-03
US7166791 (B2)	23-Jan-07	28-Oct-02	25-Mar-04
US6867738 (B2)	15-Mar-05	3-Dec-02	26-Jun-03
US7318196 (B2)	8-Jan-08	24-Feb-03	10-Jul-03
US7627343 (B2)	1-Dec-09	25-Apr-03	11.-Nov-04
US7669134 (B1)	23-Feb-10	2-May-03	
US7346705 (B2)	18-Mar-08	2-Jun-03	4-Mar-04
US7499040 (B2)	3-Mar-09	18-Aug-03	10-Mar-05
US7281214 (B2)	9-Oct-07	3-Sep-03	2-Dec-04
US7495659 (B2)	24-Feb-09	25-Nov-03	26-May-05
US7343561 (B1)	11-Mar-08	19-Dec-03	
US7372473 (B2)	13-May-08	10-Feb-04	19-Aug-04
US7127394 (B2)	24-Oct-06	18-Feb-04	19-Aug-04
US7441062 (B2)	21-Oct-08	27-Apr-04	27-Oct-05
US7663607 (B2)	16-Feb-10	6-May-04	11-May-06
US7515431 (B1)	7-Apr-09	2-Jul-04	
US7397164 (B1)	8-Jul-08	6-Aug-04	
US7511722 (B1)	31-Mar-09	27-Aug-04	
US7680849 (B2)	16-Mar-10	25-Oct-04	11-May-06
US7735012 (B2)	8-Jun-10	4-Nov-04	4-May-06
US7688306 (B2)	30-Mar-10	12-Nov-04	26-Jan-06
US7541776 (B2)	2-Jun-09	10-Dec-04	15-Jun-06
US7339580 (B2)	4-Mar-08	17-Dec-04	19-May-05
US7525216 (B2)	28-Apr-09	7-Jan-05	13-Jul-06
US7417869 (B1)	26-Aug-08	13-Jan-05	
US7573159 (B1)	11-Aug-09	9-Mar-05	
US7428709 (B2)	23-Sep-08	13-Apr-05	19-Oct-06
US7800592 (B2)	21-Sep-10	26-Apr-05	7-Sep-06
US7719830 (B2)	18-May-10	9-May-05	9-Nov-06

US7234026 (B2)	19-Jun-07	17-May-05	29-Sep-05
USRE40153 (E1)	18-Mar-08	27-May-05	
US7351925 (B2)	1-Apr-08	10-Jun-05	20-Oct-05
US7523146 (B2)	21-Apr-09	21-Jun-05	21-Dec-06
US7352567 (B2)	1-Apr-08	9-Aug-05	15-Feb-07
US7590772 (B2)	15-Sep-09	22-Aug-05	5-Apr-07
US7580255 (B2)	25-Aug-09	24-Aug-05	1-Mar-07
US7430679 (B2)	30-Sep-08	31-Aug-05	22-Mar-07
US7580833 (B2)	25-Aug-09	7-Sep-05	8-Mar-07
US7614008 (B2)	3-Nov-09	16-Sep-05	9-Mar-06
US7728823 (B2)	1-Jun-10	21-Sep-05	30-Mar-06
US7522236 (B2)	21-Apr-09	23-Sep-05	29-Mar-07
US7560637 (B1)	14-Jul-09	28-Sep-05	
US7244129 (B2)	17-Jul-07	30-Sep-05	5-Apr-07
US7653883 (B2)	26-Jan-10	30-Sep-05	20-Jul-06
US7221570 (B2)	22-May-07	8-Nov-05	16-Mar-06
US7702279 (B2)	20-Apr-10	20-Dec-05	19-Jul-07
US7650137 (B2)	19-Jan-10	23-Dec-05	28-Jun-07
US7657849 (B2)	2-Feb-10	23-Dec-05	28-Jun-07
US7574177 (B2)	11-Aug-09	4-Jan-06	6-Sep-07
US7673238 (B2)	2-Mar-10	5-Jan-06	5-Jul-07
USRE40993 (E1)	24-Nov-09	13-Jan-06	
US7546083 (B2)	9-Jun-09	24-Jan-06	26-Jul-07
US7634263 (B2)	15-Dec-09	30-Jan-06	2-Aug-07
US7554812 (B2)	30-Jun-09	10-Feb-06	12-Apr-07
US7705830 (B2)	27-Apr-10	10-Feb-06	15-Jun-06
US7451250 (B2)	11-Nov-08	27-Feb-06	29-Jun-06
US7348967 (B2)	25-Mar-08	21-Mar-06	18-Jan-07
US7632114 (B2)	15-Dec-09	30-Mar-06	4-Oct-07
US7487346 (B2)	3-Feb-09	7-Apr-06	8-Mar-07
US7643895 (B2)	5-Jan-10	22-May-06	22-Nov-07
US7634605 (B2)	15-Dec-09	22-May-06	1-Feb-07
US7643895 (B2)	5-Jan-10	22-May-06	22-Nov-07
US7408403 (B2)	5-Aug-08	9-Jun-06	8-Nov-07
US7656393 (B2)	2-Feb-10	23-Jun-06	26-Oct-06
US7305506 (B1)	4-Dec-07	27-Jun-06	
US7415563 (B1)	19-Aug-08	27-Jun-06	
US7293122 (B1)	6-Nov-07	30-Jun-06	
US7619618 (B2)	17-Nov-09	3-Jul-06	26-Oct-06
US7509588 (B2)	24-Mar-09	24-Jul-06	5-Jul-07
US7574672 (B2)	11-Aug-09	24-Jul-06	5-Jul-07
US7596761 (B2)	29-Sep-09	24-Jul-06	5-Jul-07
US7694231 (B2)	6-Apr-10	24-Jul-06	5-Jul-07
US7558697 (B2)	7-Jul-09	3-Aug-06	14-Feb-08
US7724532 (B2)	25-May-10	7-Aug-06	30-Nov-06

US7671804 (B2)	2-Mar-10	5-Sep-06	6-Mar-08
US7558894 (B1)	7-Jul-09	11-Sep-06	16-Jul-09
US7729791 (B2)	1-Jun-10	11-Sep-06	29-May-08
US7751198 (B2)	6-Jul-10	11-Sep-06	13-Mar-08
US20080076495 (A1)		11-Sep-06	27-Mar-08
US20080086494 (A1)		11-Sep-06	10-Apr-08
US20080229335 (A1)		11-Sep-06	18-Sep-08
US7441058 (B1)	21-Oct-08	11-Sep-06	
US7673083 (B2)	2-Mar-10	11-Sep-06	27-Dec-07
US7639187 (B2)	29-Dec-09	25-Sep-06	27-Mar-08
US7514900 (B2)	7-Apr-09	6-Oct-06	10-Apr-08
US20080062127 (A1)		12-Oct-06	13-Mar-08
US20080062137 (A1)		12-Oct-06	13-Mar-08
US7667148 (B2)	23-Feb-10	13-Oct-06	6-Nov-08
US7478037 (B2)	13-Jan-09	13-Oct-06	8-Feb-07
US7633076 (B2)	15-Dec-09	24-Oct-06	5-Apr-07
US7602378 (B2)	13-Oct-09	26-Oct-06	23-Oct-08
US7447033 (B2)	4-Nov-08	1-Nov-06	1-May-08
US7480145 (B2)	20-Jan-09	1-Nov-06	1-May-08
US7688267 (B2)	30-Mar-10	6-Nov-06	8-May-08
US7728316 (B2)	1-Jun-10	15-Nov-06	19-Apr-07
US7630707 (B2)	8-Dec-09	27-Nov-06	29-May-08
US7667124 (B2)	23-Feb-10	29-Nov-06	29-Mar-07
US7521625 (B2)	21-Apr-09	7-Dec-06	19-Apr-07
US7710394 (B2)	4-May-10	13-Dec-06	12-Apr-07
US7623077 (B2)	24-Nov-09	15-Dec-06	19-Jun-08
US7623078 (B2)	24-Nov-09	15-Dec-06	19-Jun-08
US20080158168 (A1)		3-Jan-07	3-Jul-08
US20080158174 (A1)		3-Jan-07	3-Jul-08
US20080162920 (A1)		3-Jan-07	3-Jul-08
US20080162967 (A1)		3-Jan-07	3-Jul-08
US7840912 (B2)	23-Nov-10	3-Jan-07	2-Aug-07
US7643011 (B2)	5-Jan-10	3-Jan-07	3-Jul-08
US7692638 (B2)	6-Apr-10	3-Jan-07	3-Jul-08
US7643010 (B2)	5-Jan-10	3-Jan-07	3-Jul-08
US7595759 (B2)	29-Sep-09	4-Jan-07	10-Jul-08
US7688574 (B2)	30-Mar-10	5-Jan-07	10-Jul-08
US7728558 (B2)	1-Jun-10	5-Jan-07	10-Jul-08
US20080166009 (A1)		5-Jan-07	10-Jul-08
US7672142 (B2)	2-Mar-10	5-Jan-07	10-Jul-08
US7589536 (B2)	15-Sep-09	5-Jan-07	10-Jul-08
USD580387 (S1)	11-Nov-08	5-Jan-07	
US7688574 (B2)	30-Mar-10	5-Jan-07	10-Jul-08
US7729131 (B2)	1-Jun-10	5-Jan-07	10-Jul-08

USD558756 (S1); USD558757 (S1); USD558758 (S1)	1-Jan-08	5-Jan-07	
US7430675 (B2)	30-Sep-08	16-Feb-07	21-Aug-08
US7589629 (B2)	15-Sep-09	28-Feb-07	28-Aug-08
US7548161 (B2)	16-Jun-09	2-Mar-07	28-Jun-07
US7551486 (B2)	23-Jun-09	30-Mar-07	15-Nov-07
US7333092 (B2)	19-Feb-08	5-Jun-07	18-Oct-07
US7612725 (B2)	3-Nov-09	21-Jun-07	25-Dec-08
USD618204 (S1)	22-Jun-10	27-Jun-07	
US7671756 (B2)	2-Mar-10	28-Jun-07	10-Jul-08
USD581922 (S1)	2-Dec-08	30-Jul-07	
USD586800 (S1)	17-Feb-09	30-Jul-07	
USD593087 (S1)	26-May-09	30-Jul-07	
US7671559 (B2)	2-Mar-10	31-Jul-07	5-Feb-09
US7590783 (B2)	15-Sep-09	15-Aug-07	7-Feb-08
US7711864 (B2)	4-May-10	31-Aug-07	5-Mar-09
USD602014 (S1)	13-Oct-09	31-Aug-07	
USD602486 (S1)	20-Oct-09	31-Aug-07	
20080122796 (A1)		5-Sep-07	29-May-08
USD604297 (S1)	17-Nov-09	5-Sep-07	
USD613735 (S1)	13-Apr-10	5-Sep-07	
US20090082951 (A1)		26-Sep-07	26-Mar-09
US7510405 (B1)	31-Mar-09	26-Sep-07	26-Mar-09
US20090088204 (A1)		1-Oct-07	2-Apr-09
US7452220 (B2)	18-Nov-08	31-Oct-07	28-Feb-08
US20090143007 (A1)		30-Nov-07	4-Jun-09
US20090149153 (A1)		5-Dec-07	11-Jun-09
US7551142 (B1)	23-Jun-09	13-Dec-07	18-Jun-09
US7469381 (B2)	23-Dec-08	14-Dec-07	10-Jul-08
US20090157289 (A1)		18-Dec-07	18-Jun-09
US7705795 (B2)	27-Apr-10	18-Dec-07	18-Jun-09
US20090182492 (A1)		10-Jan-08	16-Jul-09
US20090200648 (A1)		8-Feb-08	13-Aug-09
US20090201246 (A1)		11-Feb-08	13-Aug-09
US7715187 (B2)	11-May-10	12-Feb-08	13-Nov-08
US20090215497 (A1)		21-Feb-08	27-Aug-09
US20090216531 (A1)		22-Feb-08	27-Aug-09
US20090226091 (A1)		4-Mar-08	10-Sep-09
US20090175509 (A1)		6-Mar-08	9-Jul-09
USD602015 (S1)	13-Oct-09	7-Apr-08	
US7479949 (B2)	20-Jan-09	11-Apr-08	24-Jul-08
USD600241 (S1)	15-Sep-09	18-Apr-08	
USD615083 (S1)	4-May-10	5-Jun-08	
USD602016 (S1)	13-Oct-09	6-Jun-08	
US20090096573 (A1)		13-Aug-08	16-Apr-09

US20100039530 (A1)		18-Aug-08	18-Feb-10
US20100046766 (A1)		20-Aug-08	25-Feb-10
US20100048241 (A1)		21-Aug-08	25-Feb-10
US7675746 (B2)	9-Mar-10	31-Aug-08	8-Jan-09
US7627128 (B2)	1-Dec-09	3-Sep-08	16-Jul-09
USD602017 (S1)	13-Oct-09	5-Sep-08	
US7697281 (B2)	13-Apr-10	5-Sep-08	11-Mar-10
USD599342 (S1)	1-Sep-09	6-Sep-08	
US20100060803 (A1)		8-Sep-08	11-Mar-10
US20090083850 (A1)		9-Sep-08	26-Mar-09
US20090305730 (A1)		9-Sep-08	10-Dec-09
US7587540 (B2)	8-Sep-09	12-Sep-08	1-Jan-09
US7702833 (B2)	20-Apr-10	12-Sep-08	8-Jan-09
US20090303242 (A1)		18-Sep-08	10-Dec-09
US20100069054 (A1)		18-Sep-08	18-Mar-10
US20100075712 (A1)		19-Sep-08	25-Mar-10
US20090303231 (A1)		29-Sep-08	10-Dec-09
US20100079387 (A1)		30-Sep-08	1-Apr-10
USD618677 (S1)	29-Jun-10	18-Nov-08	
US20100146445 (A1)		8-Dec-08	10-Jun-10
USD601558 (S1)	6-Oct-09	13-Feb-09	
US20090254753 (A1)		4-Mar-09	8-Oct-09
US7746032 (B2)	29-Jun-10	9-Mar-09	9-Jul-09
US20100162109 (A1)		23-Mar-09	24-Jun-10
US7643789 (B2)	5-Jan-10	27-Mar-09	23-Jul-09
USD613736 (S1)	13-Apr-10	12-May-09	
US7541939 (B2)	2-Jun-09	15-Mar-07	18-Sep-08
USD617792 (S1)	15-Jun-10	3-Aug-09	
US7218226 (B2)	15-May-07	1-Mar-04	1-Sep-05
US7581119 (B2)	25-Aug-09	7-Jan-05	19-Jan-06
US20060026521 (A1)		30-Jul-04	2-Feb-06
US20060026535 (A1)		18-Jan-05	2-Feb-06
US20060026536 (A1)		31-Jan-05	2-Feb-06
US20060033724 (A1)		16-Sep-05	16-Feb-06
US7656623 (B2)	2-Feb-10	10-Nov-05	23-Mar-06
US20060085653 (A1)		8-Oct-04	20-Apr-06
US7844914 (B2)	30-Nov-10	16-Sep-05	20-Apr-06

Appendix 3: Suppliers, Service Providers, and Competitors

Suppliers

Balda AG
Broadcom Corp.
Catcher Technology Company Limited
Compeq Manufacturing Company Limited
Everlight Electronics Company Limited
Infineon Technologies AG
Marvell Technology Group Limited
National Semiconductor Corp.
Quanta Computer Inc
Sharp Corp.
Toshiba Corporation
Wintek Corporation

Service Providers

Deutsche Telekom AG
America Movil Sab De CV
AT&T Inc
France Telecom
NTT Docomo Inc
Singapore Telecommunications Limited
Sprint Nextel Corp
Telefonica SA
Teliasonera AB
U.S. Cellular Corp
Verizon Communications Inc

Competitors

Ericsson Telephone AB
HTC Corp.
LG Corp.
LG Electronics Inc
Motorola Inc
Nokia Corporation
Samsung Electronics
Research in Motion Limited

Figure 1
AAPL market model beta

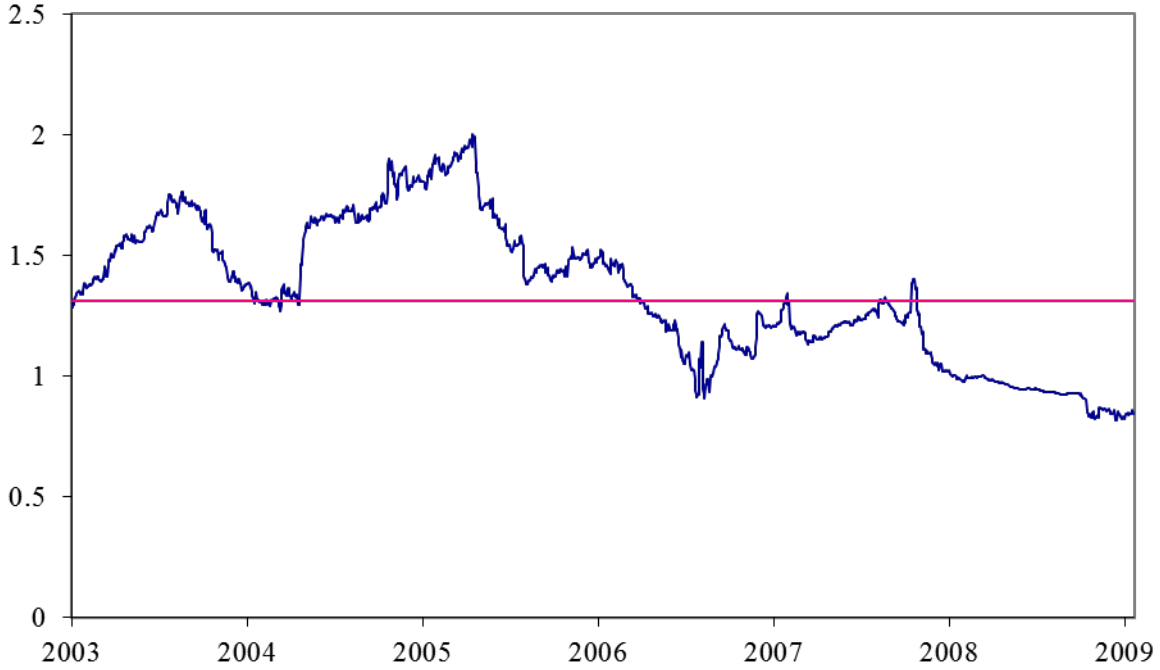

Figure 2
Apple, Inc. abnormal daily trading volume

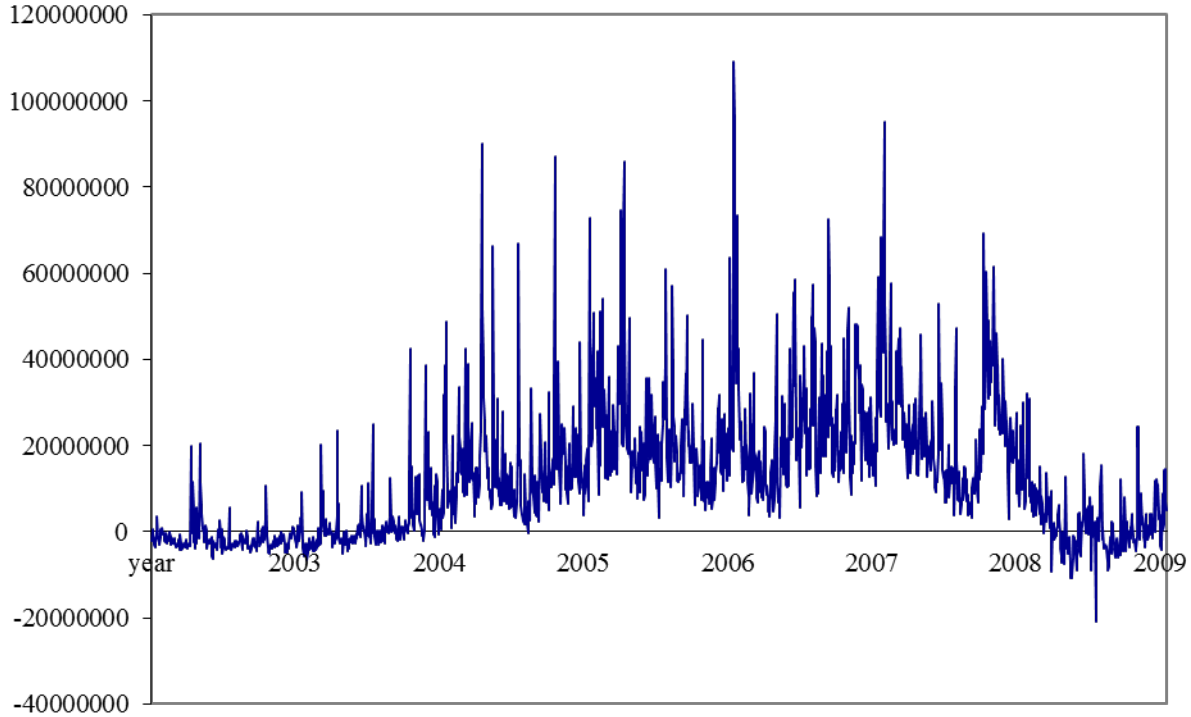

Figure 3
Average AAPL abnormal return on events with significant volume

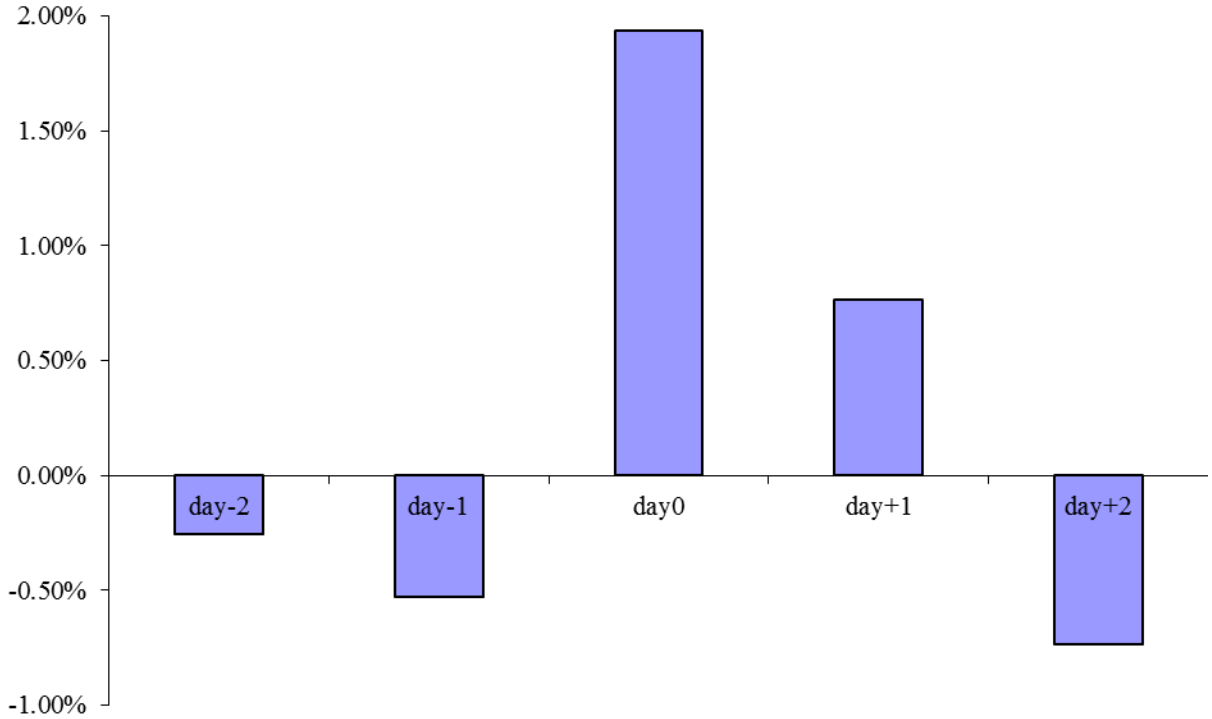

Figure 4
Average abnormal return for Apple and its competitors on events with significant volume

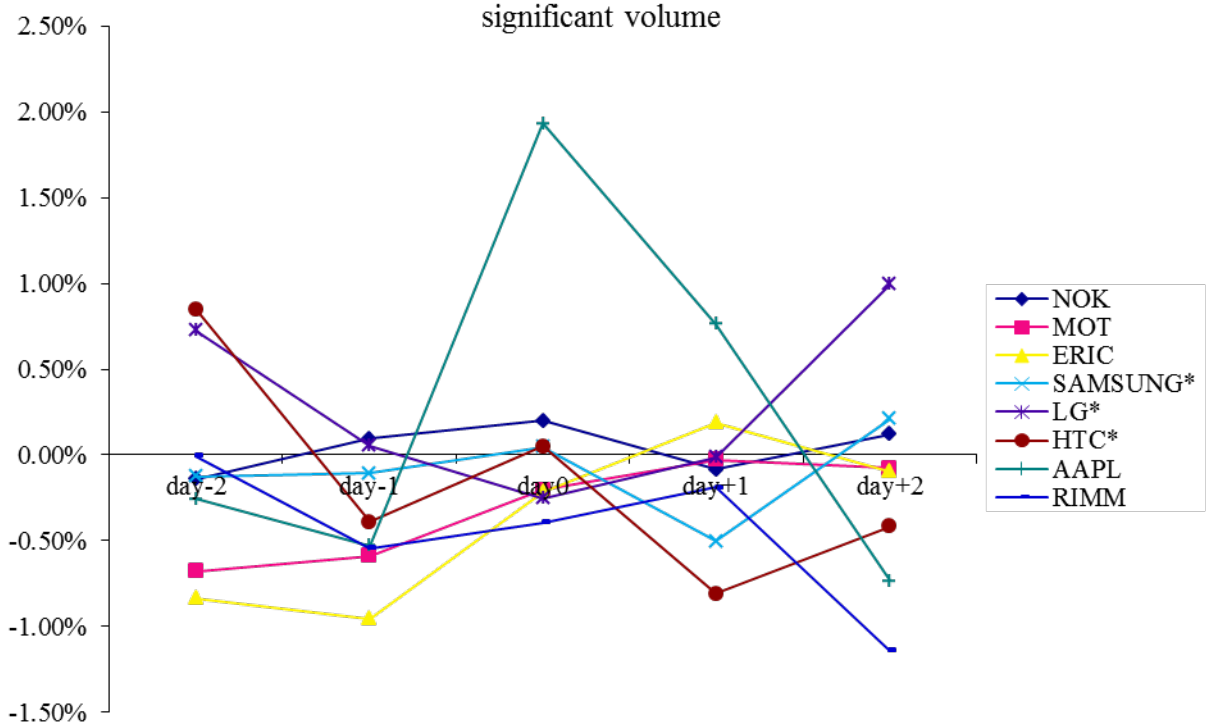

Table 1
News announcement events

The table reports the number of events related to iPhone introduction, identified from Lexis-Nexis. The first column reports all news, and the second column those that generate abnormal trading volume, measured as in Tkac (1999).

	total	**abnormal volume**
Dec 15, 1999 - Jan 9, 2007	31	13
Jan 10, 2007 - Dec 31, 2009	43	8
	74	21

Table 2
Abnormal returns related to news events for Apple and its competitors

The table reports the average one-day abnormal returns to Apple and those of its rivals that are available in the CRSP database. The asterisks indicate statistical significance at one percent (***), and ten percent (*) levels, respectively.

Average abnormal mean return (t=0)	**AAPL**	**NOK**	**MOT**	**ERIC**	**RIMM**
all events (n=74)	0.47%*	0.29%	-0.07%	-0.37%	-0.19%
abnormal volume events (n=22)	1.93%***	0.20%	-0.20%	-0.22%	-0.39%

Table 3
One-day average abnormal returns around news events for Apple

The table reports the average daily abnormal returns for Apple. The model and the estimation window used in estimating expected returns is indicated on each respective row. The asterisks indicate statistical significance at one percent (***), five percent (**), and ten percent (*) levels, respectively.

	day-2	**day-1**	**day0**	**day+1**	**day+2**
Market model, 2003-2004 estimation period	-0.26%	-0.53%	1.93%***	0.77%	-0.74%
Market model, (-250,-10) estimation period	-0.23%*	-0.55%	1.92%***	0.79%	-0.75%**
Fama-French, 2003-2004 estimation period	-0.11%	-0.57%	1.92%***	0.74%	-0.80%*
Mean return model, (-250,-10) est. period	-0.14%	-0.48%	1.81%***	0.44%	-0.73%**
Mean return model, 2003-2004 est. period	-0.11%	-0.38%	1.86%***	0.48%	-0.86%

Table 4
Daily abnormal returns around patent events

The table reports the average daily abnormal returns for Apple and those of its rivals that are available in the CRSP database. The estimates are based on the market model with years 2003 and 2004 serving as the estimation window. The asterisk indicates statistical significance at the ten percent (*) level.

Panel A: All patent application publication days (n=97)

	aapl	nok	mot	eric	rimm
day-1	0.01%	0.27%	-0.20%	0.31%	-0.03%
day0	0.02%	0.20%	-0.31%	-0.37%	-0.49%
day+1	-0.36%	0.05%	-0.27%	-0.16%	-0.03%

Panel B: Patent application publications with signif. trading volume and no contamination (n=22)

	aapl	nok	mot	eric	rimm
day-1	0.29%	0.08%	-0.17%	0.68%	-0.78%
day0	1.13%*	0.11%	0.37%	-0.50%	-0.93%
day+1	-0.03%	0.13%	-0.53%	-0.09%	-0.42%

Table 5
Determinants of value reaction to patent application publications

The table reports estimates of regressions, where the abnormal return for Apple is the dependent variable. Backward and Forward citations are defined as log(1+# of citations), respectively. Time trend is log(# of days between application publication and the end of 2008). Claims is log(1+# of claims), and Signif. volume is an indicator variable that takes the value of one for events with abnormal volume. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Backward citations	0.0018			0.0042**	0.0038*	0.0038
	(0.002)			(0.002)	(0.002)	(0.004)
Forward citations		-0.0012		-0.0053**	-0.0054**	-0.005
		(0.002)		(0.002)	(0.002)	(0.004)
Time trend				-0.0087**	-0.0079**	-0.0242**
				(0.003)	(0.003)	(0.010)
Claims			-0.0089*	-0.0122**	-0.0116**	-0.0165*
			(0.005)	(0.005)	(0.005)	(0.008)
Signif. Volume					0.0127*	
					(0.006)	
Constant	-0.0049	0.0022	0.0292*	0.0966***	0.0875**	0.2251**
	(0.004)	(0.004)	(0.016)	(0.035)	(0.033)	(0.091)
Observations	97	97	97	97	97	22
Adjusted R^2	0.008	-0.005	0.021	0.075	0.104	0.155

Table 6
Value effects within the supply chain

The table reports estimates of hedonic regressions, where the abnormal return of each firm in the supply change is explained by whether the firm is a cellular service provider or a supplier linked to iPhone. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

	before pre-announcement	**pre-announcement**	**After pre-announcement**
Apple	0.0289***	0.1609***	0.0195***
	(0.003)	(0.008)	(0.004)
Service provider	0.0019	0.0195	-0.0034
	(0.003)	(0.012)	(0.005)
Supplier	0.0012	0.0638***	0.0033
	(0.003)	(0.019)	(0.005)
Constant	-0.0044	-0.0370***	0.0011
	(0.003)	(0.008)	(0.004)
Observations	31	31	31
Adjusted R^2	0.354	0.371	0.078

Table 7
Market value of iPhone

The table reports estimates of the market value of iPhone. In estimation, we use the abnormal return upon each event, and multiply it by the market capitalization on the day prior to the event. Models used are indicated on each respective row.

Model used	**Events used**	**Total value**
Market model	news with significant volume	$ 24,373,869
Market model with Fama-French factors	news with significant volume	$ 23,940,622
Mean return model	news with significant volume	$ 19,986,256
Mean return with fixed est. period	news with significant volume	$ 20,590,347
Market model	patent apps with sign. vol.	$ 7,801,417

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