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No. 1174

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NEW PRODUCT DEVELOPMENT AND FIRM VALUE IN MOBILE HANDSET PRODUCTION

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ABSTRACT: We study the effect of new product introduction on firm value. Using a unique sample on mobile phone handset introduction by 16 major handset manufacturers over 10 years, we distinguish between imitative product introduction and truly innovative product introduction. We find that while most product introduction is imitative, both types of innovation increase firm value. However, truly innovative innovation is found to increase firm value by more than imitative introductions.

Keywords: Product innovation, mobile telephony, firm value.

1. Introduction

The markets for wireless technologies are the origin of new products that can be applied throughout the economy and of which widespread adoption provides substantial growth opportunities (Helpman and Trajtenberg, 1998; David and Wright, 2003). This paper aims at shedding light on the successful, growth facilitating product innovation patterns in the core wireless technology markets, i.e. in the production of cellular handsets. The handset producers adopt innovation strategies (imitation vs. truly innovative innovation) that are most profitable for them and create greatest value for a firm. These strategies arising from the competition dynamics in the core markets of wireless technology providers determine how drastic innovations are launched, i.e. whether consumers or other firms are offered new wireless technologies with incremental improvements or with drastically new technological features. These innovation strategies thus determine also the order of magnitude of economic growth that can be potentially derived from the diffusion of new wireless technologies.

The launch of new technically improved and attractively designed handset models is a major driver of competition for market share in the mobile handset industry. During the 1990s, competition moved from technological improvements aimed at decreasing handset weight and size towards increasing customer segmentation and product differentiation to attract replacement demand for handsets in the mature market areas. Koski and Kretschmer (2007) call this the switch from “vertical” to “horizontal” innovation as early innovations improved handset quality globally, i.e. for virtually all consumers, while later innovation segmented the market into different consumer types with differentiated preferences for newly introduced handset characteristics and features.¹

¹ Koski and Kretschmer (2007) also document an intricate pattern of imitation and differentiation – some features are copied rapidly by other handset producers and form part of the “dominant design”, while others remain sources of product differentiation.

Firm strategies on research and development and product introduction in this market entail several different decisions. Firms have to decide whether they want to engage in vertical and/or horizontal innovation and whether, or to what extent, to imitate technological leaders. All these decisions have to take the current technological and competitive landscape into account, i.e. if a technological advancement or a new product feature is likely to be copied quickly, the expected returns from R&D will be comparably small. Similarly, if a firm is entering an already crowded market segment with a me-too technology, it is unlikely to reap high benefits from this product introduction.

Various previous studies have shown that R&D investments and new product announcements are positively related to firm valuation (see, e.g., Kelm et. al, 19955; Chen et. al., 2002; Sharma and Lacey, 2004; Cho and Pucik, 2005; Connolly and Hirschey, 2005). Our paper aims to give a more nuanced picture of the relationship between product introduction and firm value. Specifically, we use a sample of the 16 major mobile handset manufacturers and their product introduction decisions during the years 1992-2002, and further match the data with their phones' characteristics and their financial information to see how new product introductions relate to firm value. Using Tobin's Q, a standard measure of shareholder value (see, e.g., Hall, 1999), as the dependent variable, we will also study how the competitive landscape affects the product introduction-firm value link to see whether being an innovation leader or imitating seems a more profitable strategy.

The paper is organized as follows. Section 2 illustrates product introduction patterns in the cellular handset industry during the period of 1992-2002 and introduces the key explanatory variables of our empirical exploration. Section 3 analyses the relationship between new product introductions and firm value. Section 4 concludes.

2. Product introduction patterns in the handset industry

Our data comprise information from 1826 new handset model introductions of 16 cellular handset manufacturers during the years 1992-2002 (see Annex 1 for the list of sample companies). The handset specific features (such as weight and talk times) are compiled from the EMC World Cellular Database and then merged with the manufacturer specific financial information extracted from Datastream. The sampled 16 companies represent the major players in the global mobile phone markets: their share of the all launched new handsets during 1992-2002 recorded to the EMC World Cellular database is 84%. While it is not possible to measure market share with our data, we cover the most important firms in the global handset market.

Table 1. Number of new models launched monthly by sample companies, 1992-2002

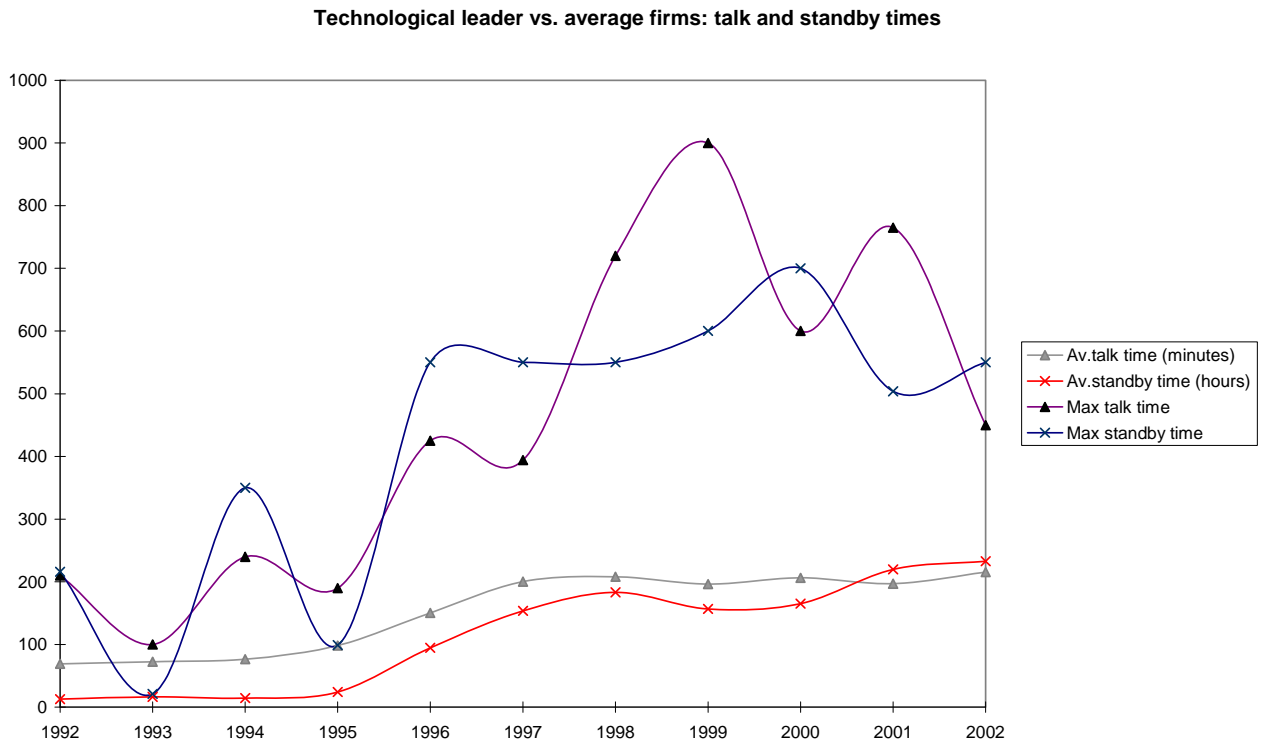
Number of new models launched monthly, 1992-2002	Frequency	% of new handsets launched by sample firms
0	1,512	71.59%
1	217	10.27%
2	145	6.87%
3	79	3.74%
4	39	1.85%
5	36	1.70%
6	21	0.99%
7	14	0.66%
8	15	0.71%
9	13	0.62%
10	5	0.24%
11	6	0.28%
12	1	0.05%
13	1	0.05%
14	2	0.09%
15	1	0.05%
16	1	0.05%
18	2	0.09%
24	1	0.05%
25	1	0.05%
Total	2,112	100.00%

Table 1 illustrates the number of new cellular phone models launched monthly by the companies in our sample. In about 70% of the monthly firm-level observations, there have been no new cellular handset introductions. Typically, a manufacturer introduces between one and three new handset models but during the peak growth years of the market for cellular telephony some companies took 10 to 25 new handset models to the market in a single month. In the empirical analysis, we measure the (monthly) number of new handset model introductions by a firm by the variable NEW_HSET. The L.NEW_HSET describes the lagged value of the variable.

Our aim is not only to explore how the new product introductions as such are related to the firm value but also how different innovation strategies and performance affect firm valuation. Particularly during the 1990s, the cellular phone manufacturers competed on vertical innovation (Koski and Kretschmer, 2007): technological development was largely targeted on increasing the talk and standby² time of the handsets, and in addition, accelerating the convenience of portability by providing lighter new cellular phone models. As Figure 1 shows, technological leaders have greatly outperformed the average cellular handset providers in terms of the talk and standby times of the models they have launched. After the mid-1990s, the new handset models had an average talk time of less than 3.5 hours and standby time greater than 9 days, while the best performing new handsets provided 15 hours of talk time and stand by time lasting for almost a month. There has been also substantial weight variation during the sample years: the average weight of new mobile handsets decreased from several hundred grams to the mean of about 100 grams.

² Standby time is the time that the battery of a phone lasts when the phone is turned on but not in use.

Figure 1. Technological leaders vs. average firms: talk and standby times



We use the variable TECH_LEAD to capture the (relative) vertical innovation performance of the firm. The variable is calculated by adding up three dummy variables that take value 1 if the handset models a firm introduced during the sample year: i) have greater talk time, ii) have greater standby time and iii) are lighter, on average, than the handset models introduced in the same year, and 0 otherwise. This constructed variable thus takes values between 0 and 3 – 0 indicates that a firm is a complete imitator in vertical innovation (i.e. the average new handset models on the market outperform the focal firm’s new handsets in all three dimensions), and 3 indicates that the firm belongs to the vertical innovation leaders (i.e. its new handsets have been superior to the average models in regard to their standby and talk times and weight).

Successful (horizontal) product differentiation may soften competition and thus generate supranormal returns and relate positively to firm value. Unfortunately, we do not have

sufficient data concerning the sample firms' horizontal innovation patterns such as the availability of the games and design features (e.g. clamshells) for the empirical estimations. However, as the inclusion of the additional features to the given handset model decreases its talk and standby time, we can use the dispersion in the talk and standby times of the firm's new handset models at a given time as indicator of its horizontal innovation strategy. The intuition here is that if that if all new handset models of the firm at a given time were homogeneous in terms of the additional features, the firm would produce new handsets with equal (maximum possible for a firm) talk and standby times. Thus, higher variation in talk and standby times also implies more differentiated products. Therefore, we use the variables CV_TALK and CV_STANDBY to measure the coefficient of variation (i.e. mean divided by standard deviation) in the talk and standby times, respectively, of the firm's new handset models in a given year. Since there is a tradeoff between talk and standby times and the handset size as well, we use the variable SIZE to control for the average size (i.e. *log of handset height*weight*length*) of the handsets the firm has launched that year.

Also, the firm's product mix and market strategy may influence its valuation. Competition between different technological standards has characterized the markets for cellular telephony throughout the sample time. The cellular telephone manufacturers have launched different mixes of new phones for analogous and digital standards GSM, CDMA, TDMA and PHSPDC network connections. These standard choices also reflect the manufacturers' geographical market strategies as the regional differences in the standard choices for the mobile telephony networks have been substantial (see, e.g., Koski, 2006). We control for the firm's product mix strategy in terms of technological standards by the variable CV_STANDARD. This variable is the number of new GSM, CMDA, TDMA, PHSPDC and analogue handset models the firm has launched at a given year. The variable gets value 0 if the firm has produced new handsets using only one technological standard, and higher values

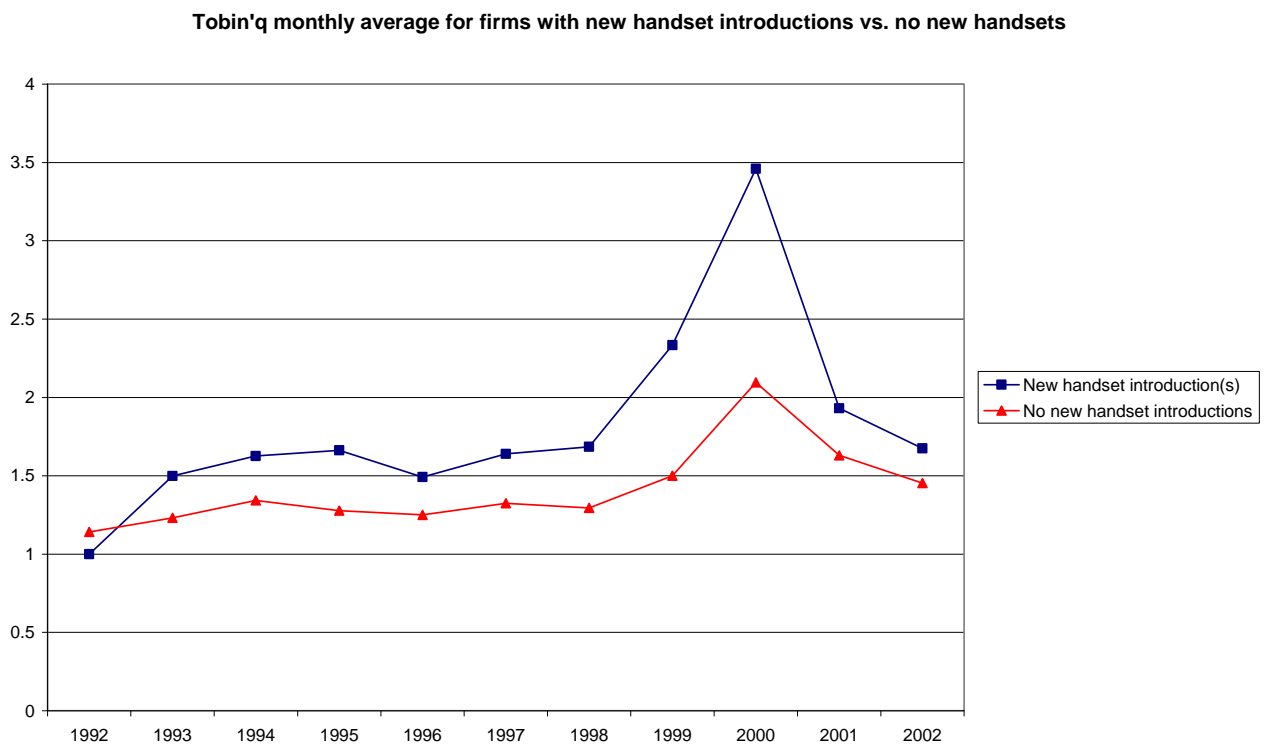
the greater the mix of phones using different technological standards (i.e. value 5 means that the firm has launched new cellular phone models compatible with all 4 digital standards and with one or more analogue standards)

3. Product introductions and firm value

3.1 Descriptive analysis

We use the following approximation of the theoretical Tobin's Q measure to measure firm value: $(\text{common shares outstanding} * \text{prices} + \text{book value total assets} - \text{common equity}) / \text{book value total assets}$. Figure 2 compares the monthly averages of Tobin's Q values of firms which introduced new cellular handset models to those of the firms that launched no new handset models during the observed month. The average Tobin's Q over all observed months

Figure 2. Tobin's Q monthly averages: firms with new handset introductions vs. no new handsets



during the years 1992-2002 is about 2 for the manufacturers introducing new handset models, whereas the corresponding number is about 1.4 for firms with no new mobile handsets. The t-test further indicates that this difference is statistically significant, providing preliminary evidence on the positive relationship between the cellular phone manufacturers' market value and new handset model introductions.

Figure 2 also illustrates that the stock market value of the cellular handset manufacturers rapidly increased at the end of the 1990s when the global market for the cellular handsets witnessed a fast expansion as the demand for the cellular handsets were strongly growing. The underlying reason for this growth pattern, however, relates rather to the "dot-com boom", the general overvaluation of the IT stocks in the end of the 1990s. In 2001, when the share prices of many IT companies crashed, we also observe a sharp decline in the share values of the stocks of the major cellular handset manufacturers. As the sample cellular handset manufacturers had a viable business models, unlike many newly established dot-com companies, the stock market valuation of the handset manufacturers was not collapsing but just returning to the level it was before the period of general overvaluation of the IT stocks.

3.2. Econometric model and findings

Our main interest is in the relationship between product launch (imitative and innovative) and firm value. At the same time, there are a number of control variables we need to consider because they are expected to have an impact on firm value in their own right. We chose to use the random effects model as our interest is to use information from the 16 sampled companies to draw inferences regarding all firms in the industry³. We use the following econometric

³ The disadvantage of the random effect model compared to the fixed effect model is that former one does not allow, unlike the latter one, correlation between the explanatory variables and the unobserved effect, α_0 . We therefore also estimated the fixed effect model for the equation. The results of the fixed effect model (that are available from the authors) are very similar to the ones of the random effects model and do not change any of our conclusions.

model in our estimations aiming at explaining variation in the firm value of the mobile handset manufacturers during the years 1992-2002:

$$\begin{aligned} \text{Log}(\text{Tobin's } Q_{it}) = & \alpha_0 + \alpha_1 \text{NEW_HSET}_{it} + \alpha_2 \text{L1.NEW_HSET}_{it} + \alpha_3 \text{TECH_LEAD}_{it} \\ & + \alpha_4 \text{SIZE}_{it} + \alpha_5 \text{CV_STANDBY}_{it} + \alpha_6 \text{CV_TALK}_{it} + \alpha_7 \text{CV_STANDARD}_{it} \\ & + \alpha_8 \text{SALES_GROWTH}_{it} + \alpha_9 \text{DEBT}_{it} + \alpha_{10} \text{PROFITABILITY}_{it} \\ & + \sum_{t=1.1992}^{12.2002} \alpha_t \text{dm} + \sum_{y=1992}^{2002} \alpha_y \text{dy} + \sum_{i=1}^{16} \alpha_i \text{di} + u_i + \varepsilon_{it} \end{aligned}$$

The subscripts i and t denote, respectively, firm- and month-specific observations from January 1992 to December 2002 among the sampled 16 companies. The dummy variables dm , dy and di control, respectively, for fixed month, year, and firm effects. In addition to t the standard error term, ε_{it} , the model includes firm-specific, time-constant random heterogeneity term, u_i .

In addition to the major explanatory variables of interest describing the firms' innovation performance and strategies, we use the following covariates:⁴

Sales growth may raise investors' expectations about a firm's future returns and thus affect its market valuation. Growing firms are expected to perform well in the future in two ways: First, higher sales simply enable them to reap higher profits. Second, fast-growing firms may gain market share on their rivals, giving them a stronger position in the market. However, as most of the products in our sample are multiproduct firms, we cannot account for this second potential effect – increasing sales may come from other product lines than mobile handsets. The variable *SALES_GROWTH* therefore captures the annual sales growth of the company.

⁴ We do not report the coefficients for year, month and firm dummies. Results on these are available on request.

Firm's financial leverage is also expected to have an effect on firm value. On the one hand, higher financial leverage may indicate a higher likelihood of financial distress and bankruptcy. On the other hand, financial leverage may also indicate that an investor's share of total equity stretches further. Although it is an empirical question which of the effects dominates, we need to control for these effects. We do this by including the variable DEBT, defined by $(\text{Total Assets} - \text{Total Equity}) / \text{Total Assets}$, in our regressions.

Firm profitability will also have an effect on firm value. However, in a market characterized by high growth like the mobile handset industry, the link between current profits and overall firm value may be tenuous.⁵ We define PROFITABILITY as $(\text{net income} / \text{sales})$.

As mentioned above, we include annual dummies to account for global shifts in the market, monthly dummies to account for seasonality, and firm dummies to control for differences between the firms in our sample.

We estimated a random-effects model with standard errors robust to heteroscedasticity and serial correlation. Our estimated model, reported in Table 2, suggests that the relationship between the number of new mobile handset models the firm has launched and its market value is positive and statistically significant. It seems that the market reacts rapidly to the new handset introductions as only the current month's new products, not the ones launched during the previous months, matter. That is, the one-period lag of the number of handsets introduced is insignificant in our regressions.⁶ This is consistent with the intuition that investors view a new handset more as an indicator of future innovativeness rather than a proxy for expected sales in the near future. Another interpretation would be that most sales of new handsets take place in the first few months after their introduction, which would imply that the model's success is already well-known shortly after introduction.

⁵ See Kretschmer and Schneider (2008) for a model of firm value in emerging network industries.

⁶ Experimenting with longer lags gives qualitatively similar results.

Table 2. Estimation results of random effects model for firm value (Dep. Var.: Tobin's Q).

Log(Tobin's Q)	Robust Coefficient	T-value
NEW_HSET	0.002	2.01
L1.NEW_HSET	0.001	0.66
TECH_LEAD	0.058	2.98
SIZE	0.099	1.4
CV_STANDBY	0.011	0.37
CV_TALK	0.003	0.1
CV_STANDARD	0.073	1.43
SALES_GROWTH	-0.053	-0.99
DEBT	-0.778	-2.16
PROFITABILITY	0.093	0.43
Year dummies	Yes	
Monthly dummies	Yes	
Firm dummies	Yes	
Constant	-1.283	-1.38
Number of observations	1284	
R-square within	0.54	
between	1.00	
overall	0.85	

Our regressions also indicate that leading vertical innovators have greater market value than technological imitators. In other words, controlling for the total number of new handsets introduced in a given month, the handsets' positioning relative to the market average plays an important role in determining firm value. This appears intuitive as true innovators not only may be able to generate higher margins from their technologically superior handsets (reaching or expanding the current technological frontier), but they are also building intellectual capital that increases the value of the company. It is especially important to send such signals of future profitability in markets where future growth counts for much more than current performance. Thus, an indication that a firm is able to take a technological lead in the market will be especially valuable, a result which is borne out in our empirical specification. This finding also reflects the significance of competition over handset size and battery life time during the sample years. Estimating the model using split samples (early: prior to 1998, late:

1998 and after) shows that the variable TECH_LEAD is highly statistically significant in the early sample while it does not explain variation in firm value significantly later in the industry. This suggests that the competitive advantage that cellular manufacturers have derived from the technological leadership in terms of handset size, talk and standby times had vanished by the late 1990s, and the firms thereafter needed to employ other, more horizontally oriented, innovation strategies. This is in line with the observations in Koski and Kretschmer (2007), who find a shift from vertical to horizontal innovation strategies around that time.⁷ The results above shed some light on why this was the case.

Differences in the firms' horizontal innovation and product mix strategies do not, however, explain the variation in firm values significantly. Note that imitation in the handset production is substantial: innovative and successful handset features are copied rapidly by the competitors, reducing returns from such horizontal innovation efforts. This could be one of the reasons why the coefficients on CV_STANDBY and CV_TALK are not statistically significant – in other words, a heterogeneous product portfolio is no indication that the firm will be able to occupy a profitable market niche for long as it is likely to be imitated quickly. It is also possible that these variables measure firms' product differentiation strategies too imprecisely. More accurate information on the firms' horizontal innovation choices would be needed for making general conclusions on the relationship between firm value and its horizontal innovation strategies. We leave this interesting extension for future work.

⁷ This is also consistent with Adner and Zemsky (2006) stating that in mature markets, when technological quality is already relatively high, users' marginal utilities from technological improvements decrease and firms' profits from vertical innovation shrink.

4. Conclusions

Our paper illustrates that new product introductions result in greater firm value in a technologically dynamic market in which technologies evolve and improve constantly. While this is not unexpected, our paper is the first (to our knowledge) to explicitly consider different competitive positions of a firm's new product portfolio. In a market with rapid technological progress and intense competition like the mobile handset market, following a strategy of technological leadership is risky as the advantage gained may be ephemeral if imitation is easy and quick. Our results suggest, however, that mobile phone manufacturers that launch new cellular handset models that are closer to the technological edge do create more value for their shareholders than other companies. That is, taking a technological lead is seen as an indicator for long-term viability and profitability, even though a current successful product may be copied or imitated fairly easily.

Our paper has a number of limitations: First, our firms are multiproduct firms whose value may be influenced by other important factors than handset introduction. By allowing for time-varying firm effects, we hope to strip out some of these effects, but there will always be some unexplained variation in the value of such complex firms. Second, our measure of technological leadership is imperfect. We plan to include data on horizontal product features (which play a more important role in later stages of the industry) in future research. However, even when using more narrow definitions of technological leadership or consider isolated dimensions, we find qualitatively similar results to the ones reported in our paper. Finally, we do not have data on a handset's (or a handset portfolio's) sales price. Clearly, this may be an even better indicator of a new product's impact on firm value, but we do not have this data available. Despite these shortcomings, we believe that our paper illustrates that technological

leadership played an important role in the early stages of the mobile handset market, thus lending some empirical support to first-mover strategies in technologically dynamic markets.

The innovation dynamics revealed by our data hint that there are clear incentives for firms in the mobile handset industry to aim at reaching or keeping technological leadership via innovation. This tendency pushing firms to strive for more drastic technological improvements benefits a world-wide market of end-users. It may also have long-term aggregate growth impacts as the business users and government service providers adopt new communication solutions that enable them to create more efficient work environments via wireless communications (such as transmitting real-time information via wireless systems to improve patient care in the hospitals).

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Appendix 1. Description of the data

Manufacturers included in the sample:

Nokia; Ericsson; Motorola; Alcatel; Fujitsu; Hyundai; JRC; Maxon; Mitsubishi;
NEC; Philips; Samsung; Sanyo; Sharp; Toshiba; Sony.

Description of the variables:

Description of variable	Variable name	Mean	Standard deviation
Dependent variable:			
(common shares outstanding * prices + book value total assets - common equity) / book value total assets	TOBINSQ	0.40	0.45
Explanatory variables:			
Log Number of new mobile handsets firm has introduced during the current month.	NEW_HSET	-3.57	3.86
Log Number of new mobile handsets firm has introduced during the previous month.	L1.NEW_HSET	-4.02	3.78
The sum of three dummy variables that get value 1 if handset models firm has introduced during sample year: i) have greater talk time, ii) have greater standby time and iii) are lighter, on average, than all handset models introduced during the year, and 0 otherwise.	TECH_LEAD	1.57	0.79
Log average size of new handset models firm has launched during the year.	SIZE	11.87	0.29
Log coefficient of variation of standby time of new handset models firm has launched during the year.	CV_STANDBY	-0.97	0.64
Log coefficient of variation of talk time of new handset models firm has launched during the year.	CV_TALK	-1.26	0.74
Log number of new handset models using different standards firm has launched during the year.	STANDARD	0.85	0.54
(Sales at year t-Sales at year (t-1))/Sales at year (t-1)	SALES_GROWTH	0.08	0.32
(Total Assets - Total Equity) / Total Assets, annual data	DEBT	-0.36	0.21
Firm's net income divided by its sales, annual data	PROFITABILITY	0.09	0.32