

# New product development and firm value in mobile handset production<sup>†</sup>

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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 the 16 largest major handset manufacturers from 1992-2002, 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.

**JEL Codes:** O31, O33, L96.

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## **1. Introduction**

Wireless markets trigger the innovation of new technologies and products that are subsequently used and applied throughout the economy. The widespread adoption of new wireless technologies provides substantial growth opportunities for firms (Helpman and Trajtenberg, 1998; David and Wright, 2003), and the discussion on the “digital divide” suggests that economies depend on an advanced telecommunications infrastructure (including wireless) to prosper (Röller and Waverman, 2001). Given that there are potentially divergent public and private incentives for different types of innovations, it is important to consider the impact of the introduction of innovative products on firm value to identify a starting point for further studies on differences between socially desired and privately executed innovative activity.

This paper therefore takes a first look at patterns of successful, growth facilitating product innovations in cellular handsets. Handset producers adopt different innovation strategies (specifically imitation and “true” innovation) to create value. These competitive strategies determine which kinds of innovations are launched and how, i.e. whether consumers and other firms are offered new wireless technologies with incremental improvements or with drastically new technological features. These innovation strategies also determine the impact of new wireless technologies on economic growth. They also determine the extent to which a new service or technology penetrates the economy. For example, the success of SMS technology was made possible only by the introduction a series of drastic (e.g. technical SMS functionality) and incremental (e.g. auto-completion of words) innovations in a large number of wireless handsets.

In addition to being truly innovative or imitative, a handset encapsulating novel features can also contain features that make it more attractive to all consumers (vertical innovation) or only a subset of them (horizontal innovation). mobile handset industry. In the 1990s,

competition moved from vertical technological improvements such as decreased handset weight to horizontal innovations increasing customer segmentation and product differentiation to attract replacement demand for handsets (Koski and Kretschmer, 2007).<sup>1</sup>

Firm strategies on research and development and product introduction in this market therefore entail multiple decisions. Firms have to decide if they want to engage in vertical and/or horizontal innovation and whether, or to what extent, to imitate technological leaders or to expand the technological boundaries themselves. In this context, we can think of several empirical issues to address:

- i) First, *is truly innovative or imitative product introduction more conducive to increasing firm value?* A naïve view would state that true innovations create more value for the firm as something genuinely new is introduced (and valued) by the market. However, this view does not consider the cost of R&D for a truly new product. If these costs were high and second-movers could imitate an introduction quickly, the market would value imitative product introduction more highly since the same technology can be used for a fraction of the cost. Given that we consider only successful product introductions (i.e. ones that resulted in a product for the end consumer market) however, we would expect true innovation to increase firm value more than imitation.
- ii) The second question arising from the distinction between horizontal and vertical innovation is the following: *Will vertical innovation increase firm value more than horizontal innovations?* The answer to this question again depends crucially on the degree to which these types of innovations can be imitated. While it might seem intuitive that vertical innovations (which are valued by all consumers) should be more profitable than horizontal ones, it will also be the case that vertical innovations will

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<sup>1</sup> 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.

attract more imitative product introduction than horizontal innovation. In other words, a dominant design on vertical product characteristics might emerge, while products remain differentiated horizontally. Assessing the relative effect of these is the second empirical task we face.

iii) A third question we ask is: *Does the impact of product introduction on firm value change over time?* Given that a shift in innovative behavior can be observed in this market (Koski and Kretschmer, 2007), the hypothesized ranking of true innovation over imitative product introduction over no new products may change if continued innovation becomes more expensive and/or easier to imitate (Adner and Zemsky, 2006), so that imitation becomes more profitable compared to true innovation.

Various previous studies have found that R&D investments – typically measured very broadly – and new product announcements are positively related to firm valuation (see, e.g., Kelm et al, 1995; 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 innovative activity and firm value. Specifically, we use a sample of the 16 largest mobile handset manufacturers and their product introduction decisions during the years 1992-2002, and further match the data with their phones' characteristics and firm financial information to see how new product introductions relate to firm value. Using Tobin's Q, a standard measure of shareholder value in innovation studies (Hall, 1999), as our 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.

We find that new product introductions are positively related to firm value, and that the firms that are able to take a technological lead in innovation in the wireless markets are valued higher than others. Our data show that until the late 1990s, the mobile

manufacturers derived competitive advantage from technological leadership in terms of handset size, talk and standby times, but thereafter, as this advantage vanished, the firms needed to employ other, more horizontally oriented, innovation strategies.

The paper is organized as follows. Section 2 documents product introduction patterns in the cellular handset industry during the period of 1992-2002 and introduces the key explanatory variables of our empirical study. 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 Appendix A.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 16 companies in our sample represent the major players in the global mobile phone markets: their share of all new handsets launched between 1992 and 2002 recorded in the EMC World Cellular database is 84%. While it is not possible to measure market share with our data as we do not have sales figures for each model, we cover the most important firms in the global handset market.

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 (conditional on the firm introducing any new 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 our empirical analysis, we measure the log (monthly) number of new handset model introductions by a firm by the

variable NEW\_HSET. We also control for the handset models a firm has introduced in the recent past by the variable NEW\_HSET\_3MONTH that captures the log number of handset models the firms has launched in total during the three months prior to the month in question.<sup>2</sup>

Number of new models launched monthly, 1992-2002	Frequency	% of observations
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: Number of new models launched monthly by sample companies, 1992-2002

<sup>2</sup> Note that our measure of innovation reflects how market responds to a firm's new product introductions via changes in firm value but it may not capture the true impact of innovative activity on firm value: Suppose that a firm chose a strategy targeting towards the technological leadership but its R&D effort was unsuccessful so that no new handset was launched and firm value was hurt for that reason. This would generate an observation with zero values for TECH\_LEAD, plus lower Tobin's Q. In other words, our measure of vertical innovation cannot distinguish whether the imitation strategy of a firm was its strategic choice or a result of failed innovation.

Our aim is not only to explore how new product introductions as such are related to 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 at increasing the talk and standby<sup>3</sup> time of handsets, and in addition, improving convenience and portability by providing lighter new cellular phone models. As Figure 1 illustrates, technological leaders have greatly outperformed the average cellular handset provider in terms of the talk and standby times of the models they have launched.<sup>4</sup> After the mid-1990s, 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 a 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 a mean of about 100 grams.

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<sup>3</sup> Standby time is the time that the battery of a phone lasts when the phone is turned on but not in use.

<sup>4</sup> The development of average technological quality of new product introductions has been relatively smooth over time but we observe occasional dips in the maximum talk and standby times of the new handsets launched. These dips reflect the dynamics of product innovation in wireless markets: technological leaders in terms of talk and standby time are not necessarily followed immediately by other companies, possibly at least partly due to the trade-off that battery life-time sets between talk and standby times and inclusion of additional features.

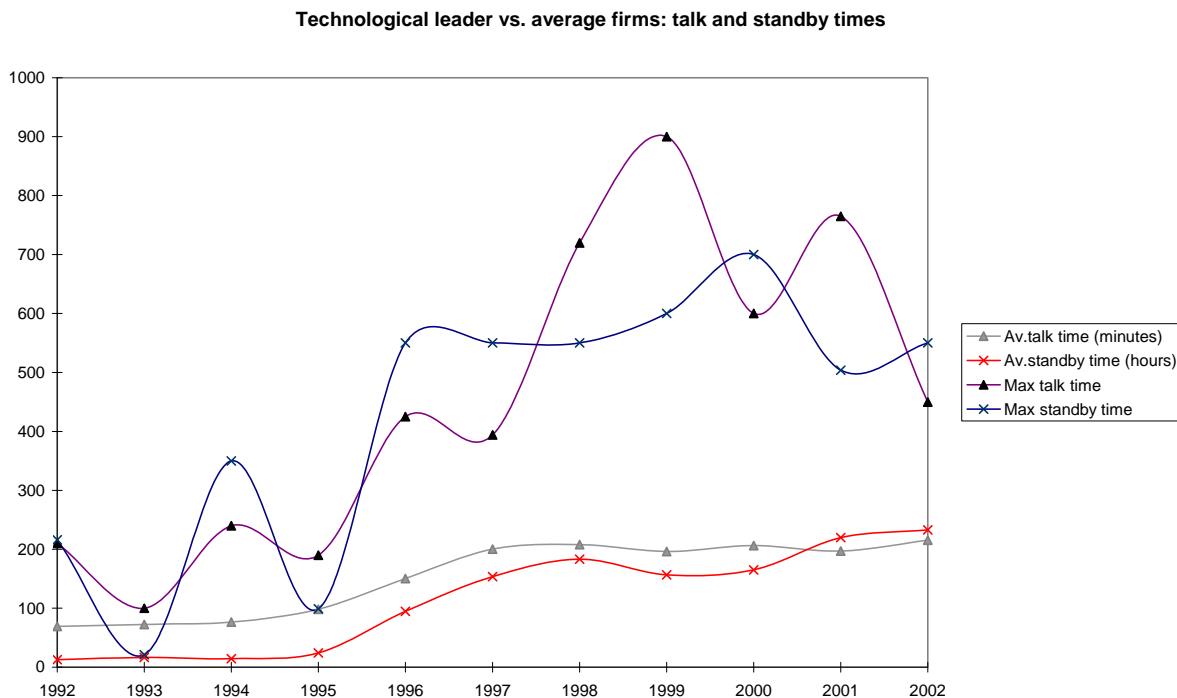


Figure 1: Technological leaders vs. average firms: talk and standby times of new product introductions

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 is a vertical innovation leader (i.e. its new handsets are 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 abnormal 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 additional features in a 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 a proxy for its horizontal innovation strategy. The intuition is that if all new handset models of the firm at a given time were homogeneous in terms of the additional features offered, the firm would produce new handsets with equal (maximum possible for a firm) talk and standby times. Introducing handsets with different talk and standby times implies that the firm chose different combinations of features, form factors and battery power for their existing handsets, addressing different consumer groups with different types of handsets. 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 handset size as well (as handset size is to a large extent determined by battery size), we use the variable SIZE to control for the average size (i.e. *log of handset height\*depth\*length*) of the handsets the firm has launched that year.

Further, the firm's product mix and market strategy may also affect 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 STANDARD. This variable measures the number of different *standards* for which new handsets were launched in a given time period. The variable gets value 0 if the firm has produced new handsets for just a single 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 measure of Tobin's Q to measure firm value:

$$(1) \quad [(common\ shares\ outstanding) * (price) + book\ value\ total\ assets - common\ equity] / book\ value\ total\ assets$$

Figure 2 shows the monthly averages of the 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 during the years 1992-2002 is about 2 for the manufacturers introducing new handset models, while it is about 1.4 for firms with no new mobile handsets. A t-test indicates that this difference is statistically significant at the 0.001 level, providing preliminary evidence on the positive relationship between the cellular phone manufacturers' market value and new handset model introductions. Note in Figure 1 that mobile handset manufacturers also benefitted from the dot.com bubble around 2000, where valuations for any "new economy" firms increased significantly.

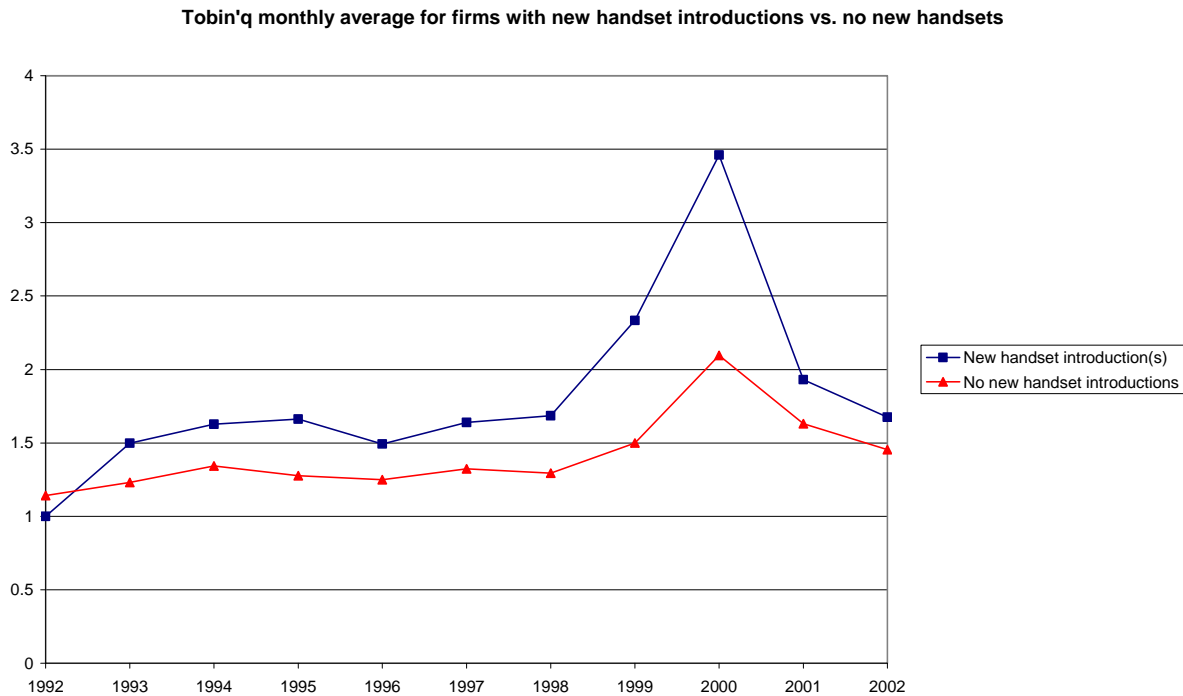


Figure 2: Tobin's Q monthly averages for firms with/without new handset introductions.

### 3.2. Econometric model and findings

While our descriptive observations above are suggestive of a positive relationship between innovation and market value, we cannot accept this as evidence for a positive impact of innovation on firm value. In particular, it could well be that a firm introducing new handsets is simply larger and thus generates higher value in a market with significant economies of scale or network effects. To isolate the relationship between (imitative and innovative) product launch and firm value therefore, our correlation has to be subjected to a more stringent econometric test. Further, 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 a fixed effects model, which allows us to control for possibly omitted firm-specific variables affecting the firm value, to investigate the relationship between

innovation and firm value among the major cellular phone manufactures. We use the following baseline model in our estimations to explain variation in the firm value of the mobile handset manufacturers during the years 1992-2002:

(2)

$$\begin{aligned} \text{Log}(\text{Tobin's } sQ_{it}) = & \alpha_0 + \alpha_1 \text{NEW\_HSET}_{it} + \alpha_2 \text{NEW\_HSET\_3MONTH}_{it} \\ & + \alpha_3 \text{TECH\_LEAD}_{it} + \alpha_4 \text{SIZE}_{it} + \alpha_5 \text{CV\_STANDBY}_{it} + \alpha_6 \text{CV\_TALK}_{it} + \alpha_7 \text{CV\_STANDARD}_{it} \\ & + \alpha_8 \text{SALES\_GROWTH}_{it} + \alpha_9 \text{DEBT}_{it} + \alpha_{10} \text{PROFITABILITY}_{it} \\ & + \sum_{t=1.1992}^{12.2002} \alpha_t dm + \sum_{y=1992}^{2002} \alpha_y dy + \sum_{i=1}^{16} \alpha_i di + u_i + \varepsilon_{it} \end{aligned}$$

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* and *dy* control, respectively, for month and year effects. In addition to the standard error term,  $\varepsilon_{it}$ , the model includes a firm-specific, time-constant 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:<sup>5</sup>

*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 simply captures the annual sales growth of the company.

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<sup>5</sup> We do not report the coefficients for year, month and firm dummies. Results 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 clearly also affect 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.<sup>6</sup> To test the strength of the relationship between current profitability and firm valuation, we define PROFITABILITY as  $(\text{net income} / \text{sales})$  and include it in our model.

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 fixed effects model with standard errors robust to heteroscedasticity and intra-group correlation. In Table 2, we report our preferred model in column (1) and report several robustness checks in columns (2) to (6). Our baseline model (column (1)) 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 prior three months, matter. 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

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<sup>6</sup> See Kretschmer and Schneider (2008) for a model of firm value in emerging network industries.

after their introduction, which would imply that the model's success is already well-known shortly after introduction. We substantiate this claim in columns (2) and (3), where we use only NEW\_HSET and NEW\_HSET\_3MONTH, respectively, and find that NEW\_HSET remain significant while NEW\_HSET\_3MONTH remains insignificant, suggesting that they are picking up different effects (and that immediate product introduction is indeed what matters).

**TABLE 2: Estimation Results for Tobin's Q**

Dependent variable	(1) ln(Tobin's Q)	(2) ln(Tobin's Q)	(3) ln(Tobin's Q)	(4) ln(Tobin's Q)	(5) ln(Tobin's Q)	(6) ln(Tobin's Q)
<b>NEW_HSET</b>	0.002 (1.980)	0.002 (2.000)		0.002 (1.870)	0.002 (1.31)	0.002 (2.600)
<b>NEW_HSET_3</b>	-0.000 (-0.150)		-0.000 (-0.190)	0.001 (1.130)	0.000 (-0.210)	0.000 (-0.009)
<b>TECH_LEAD</b>	0.058 (3.030)	0.058 (3.000)	0.058 (3.030)	0.042 (2.250)	-0.001 (-0.030)	0.037 (1.810)
<b>TECH_LEAD_SALES_GROWTH</b>						
<b>TECH_LEAD_2000</b>						0.193 (3.980)
<b>SIZE</b>	0.098 (1.410)	0.098 (1.410)	0.098 (1.400)	0.323 (3.070)	0.290 (2.420)	0.117 (1.840)
<b>CV_STANDBY</b>	0.011 (0.370)	0.011 (0.370)	0.011 (0.350)	0.053 (1.620)	0.000 (-0.010)	0.034 (1.260)
<b>CV_TALK</b>	0.003 (0.100)	0.003 (0.100)	0.003 (0.110)	0.016 (0.390)	0.032 (1.100)	-0.005 (-0.160)
<b>STANDARD</b>	0.073 (1.440)	0.073 (1.440)	0.076 (1.480)	-0.190 (-2.380)	0.011 (0.230)	0.058 (1.160)
<b>SALES_GROWTH</b>	-0.054 (-1.000)	-0.053 (-1.000)	-0.053 (-1.000)	0.051 (1.380)	-0.371 (-2.070)	-0.029 (-0.630)
<b>PROFITS</b>	0.092 (0.430)	0.092 (0.430)	0.092 (0.430)	-0.537 (-1.180)	0.819 (2.540)	0.050 (0.240)
<b>DEPT</b>	-0.779 (-2.170)	-0.779 (-2.170)	-0.781 (-2.190)	-0.846 (-5.080)	-0.329 (-1.880)	-0.730 (-2.03)
<b>Constant</b>	-2.501 (-2.300)	-2.501 (-2.300)	-2.501 (-2.300)	-4.470 (-3.420)	-3.286 (-2.380)	-2.224 (-2.7006)
<b>YearDummies</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Monthly Dummies</b>	Yes	Yes	Yes	Yes	Yes	Yes
<b>Observations</b>	1284	1284	1284	480	804	1284

<b>R<sup>2</sup> within</b>	0.55	0.55	0.55	0.65	0.46	0.57
<b>R<sup>2</sup> between</b>	0.38	0.38	0.38	0.08	0.00	0.43
<b>R<sup>2</sup> overall</b>	0.42	0.42	0.42	0.20	0.11	0.44

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NOTES:

- (1) is the preferred regression.
- (2) is the preferred regression with NEW\_HSET\_3 omitted.
- (3) is the preferred regression with NEW\_HSET omitted.
- (4) is the preferred regression for early time period (<1998).
- (5) is the preferred regression for late time period (> 1998).
- (6) is the preferred regression with TECH\_LEAD x YEAR 2000 dummy interacted.

Our regressions also indicate that leading vertical innovators (TECH\_LEAD = 1) have higher 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 weight and battery life time during the sample years. Estimating the model using split samples (early: < 1998 reported in column (4) , late: > 1998 reported in column (5)) shows that the variable TECH\_LEAD is statistically significant in the early sample while it is not in the later sample. This suggests that the competitive advantage cellular manufacturers have derived from technological leadership in terms of handset weight, talk and standby times had disappeared 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.<sup>7</sup> As a final robustness check we interact TECH\_LEAD with the year 2000 dummy to see if much of the value increased for technological leaders is explained by the spike in 2000 at the weight of the dot.com boom. We find that although size and significance of the coefficient on

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<sup>7</sup> 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.

TECH\_LEAD decrease, the linear term remains marginally significant at the 10% level, indicating that the effect existed in the other time periods as well.

Our measure of differences in firms' horizontal innovation and product mix strategies (CV\_STANDBY and CV\_TALK) does 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. Particularly, as the variables CV\_STANDBY AND CV\_TALK do not allow us to investigate inter-firm differentiation strategies (i.e. how differentiated a firm's products are from the other firm's products) but rather the relationship between intra-firm product differentiation or heterogeneity of a firm's product portfolio and firm value, our variables capture firms' product differentiation strategies only partially. More accurate information on the firms' horizontal innovation choices would be needed for drawing more precise conclusions on the relationship between firm value and its horizontal innovation strategies. We leave this interesting extension for future work.

#### **4. Conclusions**

Our paper illustrates that new product introduction results 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.

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 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). At a broad level, our study also suggests that innovations that are imitated quickly (mostly horizontal innovations in our dataset) create less value for the firm than vertical ones that are difficult to imitate. Interestingly, from a social planner's perspective, it may be precisely the innovations that can be widely copied by competitors and other firms in the economy that are most beneficial, while tightly protected innovations will diffuse in the economy at a much slower rate, if at all. This result ties in with the sizable literature on spillovers that find a divergence between private and public incentives for poorly protected innovations (which reflect in lower impact on firm value in our study). However, it is interesting to note that although imitation seems easy and quick in this industry, some firms still do thrive for drastic product innovation, which subsequently creates significant consumer value through imitation from direct competitors. Thus, while we do not have a counterfactual scenario to consider, innovation still appears rapid in this industry and technological opportunities are still seized, if only for a brief period of time.

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

firm-specific effects in our estimations, 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) average sales price and volume. Clearly, this may be an even better indicator of a new product's success and its subsequent 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.

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## Appendix: Description of the data

### Appendix A.1: Manufacturers included in the sample

Nokia (Finland); Ericsson (Sweden); Motorola (USA); Alcatel (France); Fujitsu (Japan);  
 Hyundai (South Korea); JRC (Japan); Maxon (Korea); Mitsubishi (Japan); NEC (Japan);  
 Philips (Netherlands); Samsung (Japan); Sanyo (Japan); Sharp (Japan); Toshiba (Japan);  
 Sony (Japan).

### Appendix A.2: Variable descriptions

Description of variable	Variable name	Mean (S.D.)
<b>Dependent variable:</b>		
Tobin's Q following eq. (1)	TOBINSQ	0.40 (0.45)
<b>Explanatory variables:</b>		
Log(# handsets launched by firm in the current month)	NEW_HSET	-3.57 (3.86)
Log(# handsets launched by firm in the previous 3 months)	NEW_HSET_3MONTH	-2.26 (4.10)
Sum of dummy variables for handsets launched by firm in current year with: i) greater average talk time, ii) greater average standby time and iii) lower average weight than all handset models introduced that year.	TECH_LEAD	1.57 (0.79)
Log(average size of handsets launched by firm in current year).	SIZE	11.87 (0.29)
Log(coefficient of variation of standby time of handsets launched by firm in current year).	CV_STANDBY	-0.97 (0.64)
Log(coefficient of variation of talk time of handsets launched by firm in current year).	CV_TALK	-1.26 (0.74)
Log(# handsets using different standards launched by firm in current year).	STANDARD	0.85 (0.54)
$(Sales_t - Sales_{t-1})/Sales_{t-1}$ (by year)	SALES_GROWTH	0.08 (0.32)
$(Total Assets - Total Equity)/Total Assets$ (by year)	DEBT	-0.36 (0.21)
$Net\ income_t/Sales_t$ (by year)	PROFITABILITY	0.09 (0.32)