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*Handset Subsidies - an Empirical Investigation**

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Handset subsidies – an empirical investigation*

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Abstract

Mobile phone companies compete on several dimensions. One is price, another is equipment subsidization. Using hedonic regressions for implicit subsidies and prices of handsets from the Portuguese market, at the handset level, we unveil stylized facts. Subsidies are used more intensively in new models and tend to vanish as the handset model ages. Large networks tend to decrease their subsidies when network size grows, the smaller network decreases subsidies when its size decreases. The three existing operators do subsidize in different ways. In particular, the largest network subsidizes less than the others. The characteristics that appear to be associated with handset subsidies also differ across companies, suggesting that they may be targeting distinct consumer groups. This is visible in characteristics associated with "leisure" features and services. Our results show that companies are heavily subsidizing handsets that support the new 3G technology (and its associated services). Subsidies are clearly larger for 3G phones, and prices are aligned with handsets for the same characteristics but without 3G support. Both findings point to a strategy of subsidizing handsets in order to induce a take-off of 3G services. The available evidence does not raise, for the moment, special regulatory concerns.

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1 Introduction.

Mobile phone companies compete on several dimensions. The most obvious one is price. Pricing strategies in telecommunications have been extensively discussed, as regulation of interconnection prices plays a central role in the determination of final prices paid by consumers. Other issues addressed in the literature on mobile telephony have been the allocation of radio spectrum, the diffusion of mobile services, the study of access pricing, interconnection and related regulation, network externalities and their impact on mobile pricing, etc. For a recent account of developments in mobile telephony markets see the overview by Gans et al. (2006).

However, companies also compete through equipment subsidization. New handsets are offered in the market at prices that are attractive to consumers, often bundled with calls packages, at the cost, to the consumer, of fidelity contracts over some time period. At the same time, independent sellers of mobile phone handsets are able to offer both “locked” and “unlocked” devices at different prices. These price differences may be between “unlocked” and “locked” phones, but also between distinct brands/operators. We identify empirically which elements determine the level of such subsidies, and how they differ across companies.

Understanding price-setting behaviour, handset offers and service innovation will help the design of suitable regulatory instruments, if they become necessary. The new European regulatory framework excludes mobile retail markets as possible markets to regulate as it is widely accepted that retail competition is fierce enough in most European countries to ensure efficient outcomes. However, mobile call termination appears to be a market where regulatory intervention might be necessary. Clearly, regulating mobile call termination will have an impact on retail activities. Understanding the retail market would enable us to pin down the possible consequences of such regulation on retail market outcomes.

The practice of mobile telephony operators of subsidizing handsets is common, in Portugal as well as in many other countries. For example, in Germany handsets were often sold for 1 euro as part of contracts lasting more than one year. In Spain, subsidies to handsets are also common. For example, Movistar, the mobile brand of the historical telecommunications operator holding a market share of 50 %, offers a free phone (Nokia 3220 or Motorola c390) or a discount (Sony Ericsson K700i for 19 euros, Sony Ericsson W800i for 39 euros) to new subscribers moving from a competitor. The street prices of these phones are, respectively, 129 euros (Nokia 3220), 101.49 euros (Motorola c390), 173.95 euros (Sony Ericsson K700i), 299.95 euros (Sony Ericsson W800i). Vodafone (market share of 30%) has the same type of offers, although with different phones: for free, Nokia 6030 (street price of 79 euros), Nokia 6101 (street price of 199 euros) and Sharp GX25 (street price of 129 euros), and for 9 euros, Motorola V360 (street price of 143 euros) and Sony Ericsson Z520i (street price of 190.95 euros).[1]

The very same strategy of equipment subsidy has been used in the introduction of 3G phones and services, and is now applied to 3.5G, the HSDPA technology (High Speed Downlink Packet Access). The three mobile operators in Portugal announced their offers of this technology in the first week of April 2006. The two larger networks set a price of 249.90 euros for a computer card for HSDPA, or a price of 199.90 under a loyalty contract of 12 months. All offers have a cost of 39,90 euros per month with 1 GB/month free download. For the third operator, the smallest one, only the loyalty option was made public, at a cost of 149.90 euros (meeting the same conditions as other operators on the per-month fee and free download capacity). Therefore, the implicit subsidy in the larger networks is of 50 euros, and it is larger (about 100 euros) in the smaller network.

We use data on prices and services available on handsets from the Portuguese

[1]Prices obtained from several sources, e.g. Phonehouse, Pixmania and Expansys, web sites consulted on 24 April 2006.

market. The available data is a collection of information from leaflets that advertise the offers of different mobile operators. The value of such offers, for a given handset, tends to change over time, as new technological developments take place.

We contribute to filling this gap by empirically looking into the dynamics of equipment subsidization in a mobile telephony market with three operators, VODAFONE - a pan-european operator, TMN - the mobile phone subsidiary of the incumbent operator and OPTIMUS - the most recent entrant in Portugal (1998).

We unveil different subsidizing strategies, as each firm follows a different pattern of subsidization. A common feature to all is the current subsidies to 3G phones, and the irrelevance of technical characteristics related to connectivity for subsidy values. Also interesting is the network effect associated with each company's customer base. For the largest one, it means the ability to subsidize less, while for the smallest network an increase in subscribers seems to induce a larger subsidy.

The paper is organized in the following way. Section 2 presents the main testable hypothesis. Section 3 describes the empirical approach and the data. Section 4 reports the main results and its implications. Section 5 concludes.

2 The testable hypotheses

Equipment subsidy practices have not received much attention in regulatory practice. Since such handset subsidies are usually bundled with some contractual lock-in of consumers (either through contract length or locked equipment, or both), there is the potential for anti-competitive effects. Subsidization of mobile handsets is usually associated with Subscriber Identity Module (SIM) card locking.

Unlocking the card usually has a cost, which is around 90-100 euros.[2]

On the other hand, handset subsidies promote the move of consumers from old technologies to new ones, benefiting from new services. In industries where network externalities are present, coordination devices may be required for consumers to switch to better technologies. This would be a beneficial effect.

According to the Oftel (2002) review, there may be economic reasons to allow for a SIM locking policy. Given the uncertainty about how this feature affects consumers, Oftel opted for a "soft" regulatory policy - raising consumers' awareness of SIM-locking. Oftel (2002) considers the relationship between handset prices and SIM-locking to be unclear, based on the argument that even if SIM-locking was not allowed companies would face an incentive to subsidize handsets.

When competing for new customers (both those taking out a mobile subscription or buying a prepaid package for the first time and those switching between operators) and when retaining their existing ones, mobile operators compete for the revenue streams these customers are expected to generate. They attract customers by offering a selection of tariff packages, combining various tariff components (handset price, connection fee and monthly subscription charges for post-paid customers, charges for making calls and using value-added services such as SMS, voice mail retrieval or various information services). Customers choose the most appropriate tariff package, given their preferences and anticipated usage.

These tariff packages often include considerable handset subsidies or rebates in order to reduce the upfront cost to the customer and to encourage new subscribers to try out mobile services. This practice is common in markets where customers need hardware in order to use services - heavily subsidized satellite dishes and receivers and discounted game consoles are but two examples.

Innovation is important in competing for customers. Mobile users have en-

[2]According to information provided by the two largest companies operating in Portugal in mobile telephony.

joyed continuous improvement in the quality of existing offers and the introduction of new services such as commercial GPRS, Remote Access and WapWeb. Some of these innovations, e.g. SMS, have been extremely successful; others (e.g. WAP) have not generated the expected customer interest and take-up has been slow. The constant need to innovate is an important characteristic of the mobile market, and new developments such as GPRS expand the capabilities of mobile phones in numerous ways; the move towards 3rd Generation services is widely regarded as a step change in functionality and quality.

In a recent paper, Koski and Kretschmer (2006) address the issue of how standards emerge in the mobile phone industry in a non-mandated way. In particular, they look at cellular handset features and design. Koski and Kretschmer (2006) find that the two decades from 1980 to 2000 were characterized by weight and size competition for handsets, and that since then companies have competed on "(increasing) customer segmentation and product differentiation" (p. 23).[3]

Mobile phone companies invest considerably in customer acquisition. Since a link between contractual switching costs and loyalty (lower churn rates) seems to exist (Caruana, 2004), handset subsidies associated with contractual lock-in have an important role in business strategies.

In terms of business strategies, Birke and Swann (2006) show that network size plays an important role fin determining value to consumers of on-net and off-net calls, hinting that operators that initially gain a larger subscriber' base will have an advantage over rivals. Subsidizing handsets can be a strategy for firms to gain a lead in the 3G market. The significant role found by Birke and Swann (2006) contrasts with initial findings of Valletti and Cave (1998) for the UK mobile telecommunications market.

Evidence of network externalities is always relevant from a regulatory per-

[3]The data in Koski and Kretschmer (2006) span from 1992 to 2003 and therefore does not cover our period of analysis, as detailed below.

spective, as they have been used in arguments related to termination charges and asymmetric regulation (Competition Commission, 2003; OFCOM, 2004).

A main issue is the role of SIM-locked handsets and why a consumer would choose an unlocked handset. The obvious reason is the lack of mobility across networks that a locked handset implies. The SIM-locked phones and their subscription contracts imply increased switching costs to consumers, precluding them from taking advantage of price or quality differences (in calls) between operators. However, these price differences must be unanticipated by consumers, otherwise they would select the SIM-locked, subsidized, handset of the most favorable network. Alternatively, the consumer may expect to stop using the mobile phone prior to the end of the contract.

Therefore, since all networks often offer the same handset, with subsidization, it is not obvious why someone would choose an "unlocked phone", especially since number portability is ensured by regulation.

A different interpretation of handset subsidization is as a tool to discriminate between groups of consumers. Tech-savvy consumers are early adopters and may be especially profitable. The gains to the telecom operator are not on the equipment but on the sale of services. As long as tech-savvy consumers are also more intensive consumers of services, they will be relatively more profitable. As the handset ages, it becomes less fashionable and the propensity of such consumer groups to acquire it decreases. In line with this argument, the gain from subsidizing such handsets decreases with the time in the market.

This argument has, in fact, two different testable implications. First, age of the model should encourage handset subsidies to disappear (converge to zero). Second, the price of the handset itself, whether SIM-locked or unlocked, should also decrease over time.

Our main testable hypotheses are the following. Over the product life-cycle, there are two conflicting effects on the price difference between the “unlocked” handset and the “locked” one. On the one hand, as the model ages, fewer consumers are willing to pay the “switching cost” involved in taking an “unlocked” phone. To induce consumers to buy it, mobile phone operators have to offer a higher subsidy to equipment acquisition. This suggests an increasing difference between “unlocked” and “locked”-handset prices over the product’s life-cycle. On the other hand, profitability of attracting consumers through equipment subsidization falls as the model ages. Thus, the incentive of companies to subsidize equipment decreases over the life cycle. This effect suggests a decreasing price difference between “free” and “locked” handsets over the life-cyle.

The second testable hypothesis relates to technical characteristics of the handsets. Handsets with more and better characteristics should make consumers more valuable to the operator as they generate more traffic. The price difference between “unlocked” and “locked” phones should increase with the number of new characteristics.

A third testable hypothesis is related to the size of each network. The larger the customer base of a telecommunications operator, the higher the value the consumer places on belonging to the network. Accordingly, the equipment subsidy required to attract the consumer is lower than in the case of a network with a smaller size. These hypotheses will be tested using the methodology described in the next section.

3 Methodology and Data

To test the hypotheses presented above we make use of hedonic regressions. Our unit of analysis is the subsidy offered by a company in a particular handset. For each Portuguese mobile phone operator, we compute the implicit subsidy of each handset. This subsidy is given by the difference between the “unlocked” phone price and the "locked" phone price.

To explore our data (described below), we consider a simple empirical specification, where the "subsidy" is explained by several elements: brand value, product characteristics, age of the handset, and so on. A complete list of included variables is described in Table 1.

There is no direct information on the cost of handsets to operators. Therefore, we rely on indirect information. All data used come from leaflets of a company selling phones, both "unlocked" and "locked", in association with each of the three Portuguese mobile phone operators. The leaflets describe in detail the main characteristics of each phone and its price.

The price of the "unlocked" phone should reflect market conditions, while the price of "locked phones" results from agreements with operators.

This is, of course, a very crude source of information. It allows us, however, to follow the pricing strategies of operators across time (monthly data) and across phone models.

Table 1 reports the variables used and their definition. One of the variables used is the age of the model in months (also squared, to account for non-linear effects), starting with the month when the model first appeared. We have then a set of variables describing characteristics and features of the phone. The description in Table 1 is self-explanatory for most variables. The least obvious one is CONNECT, which allows for an extra valuation to be placed on the simultaneous presence of Bluetooth and Infra-red communication possibilities. We consider explicitly this interaction term, as it is the only one highlighted by communication strategies and company advertising.

Since we do not have monthly information on network size, we use quarterly data for the total number of subscribers of each network, TOTSUBS, and for the number of new subscribers of each network, NEWSUBS. This too is a crude

Table 1: Variable definitions

Variable	Definition
SUBS	Implicit subsidy in handset price;
PRICE	Price of the handset;
AGE	number of months of the model in the sample;
AGE2	age squared
TOTSUBS	number of consumers associated with each operator in the quarter;
NEWSUBS	number of new consumers of the operator in the quarter;
AUTSB	hours of stand-by allowed by the battery;
AUTCONV	hours of conversation allowed by the battery;
COVERS	dummy variable, 1 if it has removable covers;
WAP	dummy variable, 1 if it has WAP, 0 otherwise;
GPRS	dummy variable, 1 if it has GPRS, 0 otherwise;
IR	dummy variable, 1 if it has infra-red capabilities, 0 otherwise;
HANDS-FREE	dummy variable, 1 if it has hands-free capabilities, 0 otherwise;
MMS	dummy variable, 1 if it has multimedia message, 0 otherwise;
COLORSCR	dummy variable, 1 if it has color display, 0 otherwise;
BLTOOTH	dummy variable, 1 if it has Bluetooth technology, 0 otherwise;
POLI	dummy variable, 1 if it supports polyphonic rings, 0 otherwise;
GAMES	dummy variable, 1 if it supports games, 0 otherwise;
CAM	dummy variable, 1 if it has built-in photographic camera, 0 otherwise;
RADIO	dummy variable, 1 if it has radio capabilities, 0 otherwise;
CONNECT	dummy variable, 1 if it has bluetooth and infra-red, 0 otherwise;
CARKIT	dummy variable, 1 if it is ready for use with a car kit, 0 otherwise;
VIDEO	dummy variable, 1 if it has video reproducing ability, 0 otherwise;
3G	dummy variable, 1 if it is a 3G phone, 0 otherwise;
TIME	time trend: 1 in the first month, 2 in the second month, etc...
TIME3G	product of TIME and 3G
XMAS	dummy variable, 1 if December, 0 otherwise;
AUGUST	dummy variable, 1 if August; 0 otherwise.

Table 2: Market share of mobile phone operators - subscribers

	TMN	VODAFONE	OPTIMUS
2000	44.0%	37.2%	21.0%
2001	47.6%	35.6%	26.3%
2002	46.2%	31.7%	22.1%
2003	46.4%	31.7%	21.9%
2004	46.7%	33.6%	19.7%
2005, Q2	46.6%	33.5%	19.9%
2005, Q3	45.7%	34.3%	19.9%

measure and one that is prone to endogeneity issues (a successful model attracts more subscribers). Still, the lack of suitable instruments precludes, at the moment, the use of more sophisticated econometric approaches. The "natural" instrument, lagged variables, produces essentially the same qualitative results.

We include two extra dummy controls to take into account the possible specificities of two particular months: August and December. Around Christmas (December) we usually observe several promotional campaigns. Price and subsidies defined by mobile telephony companies may, therefore, be quite distinct from the ones followed in other months of the year. In a somewhat similar way, the month of August can also be a special case. Since August is the vacation period for most of the Portuguese population, companies typically offer special deals during this period.

4 Evidence on determinants of handset subsidies

Our analysis is performed at the handset model level. Still, it is useful to provide a minimum background on the mobile market under review. The Portuguese telephony market comprises three licensed operators: TMN, VODAFONE and OPTIMUS. Their market share evolution in the recent past is reported in Table 2.

Asymmetries in network size have been relatively stable. Regulatory intervention has occurred mainly through interconnection prices, though 2004 shows a slight reduction in OPTIMUS market share.

Table 3 describes the role of each variable on the handset subsidies set by a mobile phone company. We have grouped variables according to their type, in terms of characteristics to consumers. We use a simple classification of positive (+), negative (–) or null (o) average effect of the characteristic indicated to the subsidies to handsets of each company (in column). The null effect corresponds to statistically insignificant estimated coefficients, while the positive and negative effects are the signs of statistically significant individual coefficients. The estimates that form the basis for this table are reported in detail in Table 6 in Appendix.

We can see that higher performance in functional characteristics of a handset are associated with more significant subsidies. In contrast, technical characteristics, mostly pertaining to connectivity, are essentially irrelevant.

More curious are the effects associated with "leisure" characteristics. Handsets with the possibility of changing covers are less subsidized than others, the same holds weakly for radio reception capabilities and color screen. On the other hand, handsets with an ability to play games and presence of a camera are more subsidized. It is also noteworthy that companies follow different subsidization patterns, with VODAFONE being the one less inclined to subsidize handsets with "leisure" characteristics. This is in accordance with a strategy aimed mainly at business subscribers, rendering less relevant "leisure" characteristics as a way of attracting subscribers.

Characteristics that are associated with higher subsidies by all companies fall in the "vertical innovations" terminology of Koski and Kretschmer (2006), while those that are differently subsidized by each company (in the "leisure" group) are most likely horizontal differentiation features.

Table 3: What determines handset subsidies?

	TMN	VODAFONE	OPTIMUS
Functional characteristics			
Stand-by time battery	*o*	*o*	*o*
Conversation time battery	+	*o*	*o*
MMS	*o*	*o*	*o*
3G	+	+	+
Hands-free	+	+	+
Technical characteristics			
GPRS	*o*	*o*	*o*
Infra-red	*o*	*o*	*o*
Bluetooth	*o*	*o*	*o*
Car Kit	*o*	*o*	*o*
Connectivity	*o*	*o*	*o*
Leisure			
Covers	–	–	–
Color screen	*o*	–	*o*
Polyphonic rings	*o*	*o*	*o*
Games	+	*o*	*o*
Camera	+	*o*	+
Radio	*o*	–	–
Video	*o*	*o*	*o*
Network effects			
Total subscribers	–	*o*	+
New (quarter) subscribers	*o*	*o*	*o*
Time effects			
Age of model	–	*o*	*o*
General time trend	*o*	*o*	–
3G time trend	*o*	*o*	–
XMAS	*o*	*o*	*o*
AUGUST	*o*	*o*	*o*

Taking our hypotheses against the results, we see that network size is a determinant of subsidy levels, though not quite as expected. For the largest network, TMN, it has a negative sign, as expected. The largest network does not need to subsidize as much. As TMN grows larger, it subsidizes less. On the other hand, for the middle-sized network, VODAFONE, the effect is statistically non-significant, while for for the smaller network, OPTIMUS, we find a positive effect: as market share shrinks, it subsidizes less. Simple theoretical models do not account for this feature of the data. Moreover, since in the literature there is no model that we know of that considers the subsidization of handsets in the context of three networks of different sizes, we leave this result as a stylized fact calling for further work.

Using a simple (and limited) model of handset subsidies (see appendix) a possible explanation is proposed. An increase in valuation differences between on-net and off-net calls leads to a positive association between network size and handset subsidies for the smaller network. As to the larger network, an ambiguous effect results. These two implications are compatible with our findings. However, a full exploration of this explanation can only be made accounting explicitly for the role of on-net and off-net prices, which is beyond the scope of the paper.

From Table 3, we see that new subscribers do not seem to be of relevance. Thus, our interpretation emphasizes the role of network externalities as increasing the value of subscribing to a given network, which in turn allows the largest network to subsidize less and, everything else constant, forces the smallest one to subsidize more handsets.

As to the model age effect, if anything we have evidence that subsidies decrease as the model becomes older. The effect is only statistically significant for TMN, being insignificant for the remaining networks.[4]

[4] This holds true in the pooled data regression (results available from the author upon request).

Regarding time effects, we see a general tendency for subsidies to a particular handset to decline over time, although VODAFONE seems to have a more stable subsidy policy (that is, decreasing prices of handsets are accompanied by smaller subsidies). For the largest network, it is essentially the age of the handset (in months after introduction) that drives subsidies' decrease. For the smallest network, lower subsidies have been occurring over time, both in 2G and 3G phones.

All three mobile phone companies are subsidizing 3G handsets considerably. The smallest network was the one introducing the largest subsidy, while the other two networks had a very similar behaviour. With 3G handset models, and others, alike, subsidies tend to decrease over time. This effect is more pronounced in the smallest network, as it started with a higher subsidy for 3G handsets.

Curiously, the pooled regression obtains no statistically significant difference between networks. If anything, the coefficients suggest higher subsidies provided by the smallest networks.

Given the somewhat surprising effects associated with some of the handset characteristics, we also report hedonic price regressions for handsets, again by operator and pooled across companies. These results are reported in Table 8.

The first comment is that the same stylized facts found in the subsidies equations emerge in the price equations, as well.

Given the existence of new technological developments, we expect prices of handsets to decrease over time, an effect distinct from ageing of the model. The same model of handset should have a lower price if introduced later. Thus, in addition to the "age" of the model, we also include a general time trend in the analysis.

Technological evolution in mobile phones/handsets occurs at a relatively fast pace, be it due to the new technical features introduced in the handset, lower production costs or marketing strategies (such as removable covers, extended keyboards, etc.). Prices of existing handsets tend to fall over time due to both lower production costs and the release of new models. Subsidies tend to decrease over time as well, as older models become less of a motive to induce consumers' switching. Although pointing in the same direction, the two time trends are conceptually distinct. One relates to technological developments, affecting handset prices directly. The second one is a behavioural effect, resulting from firms' conduct. We can disentangle one effect from the other, looking at subsidies and absolute prices independently.

The launching of the 3G models and the operators' need to induce consumer's switching from one generation of mobile phones (and services) to another may have changed firms' behavior regarding handsets subsidies. In particular, operators have stated several times that they would stop subsidizing the 2G models. Therefore, subsidies to handsets may have a different time trend according to whether they are 2G or 3G, In particular, we expect subsidies to be greater for 3G.

As to time evolution, we expect 2G models to show decreasing subsidies. The trend associated with 3G models is somewhat less clear cut. Due to introductory pricing, as suggested by operators' statements, we may expect a decline over time: higher subsidies in the first periods, which are then phased out. Nevertheless, the level of subsidies should be higher than for 2G models. However, if the switch to 3G models occurs at a slow pace, operators may opt to increase subsidies in the initial periods, and then resume the trend of mature products (decreasing subsidies). To our knowledge, there is no hard evidence on the extent of consumers' switching to 3G models.

A final comment on the role of handset characteristics is in order. Not all characteristics are positively associated with handset subsidies. Actually, for most of them we find no correlation. In particular, technical characteristics associated with connectivity are non-significant for all companies. Functional characteristics, on the other hand, do have an influence on subsidies, in particular being a 3G phone and having hands-free capability. This holds for the three companies operating in the Portuguese market.

We find, however, differences across companies in how “leisure” features of phones influence subsidies. Each company follows a different strategy, by picking distinct features. Such differences may be linked to targeting of distinct groups of consumers. We do not have sufficient information to probe further into the issue, which is left for future research.

Table 4 reports the main effects associated with prices.

A first observation is the considerable number of negative associations of phone characteristics with prices, calling for some comments. The second observation is that characteristics associated with prices and subsidies are quite different.

The negative associations between phone features and prices can have two distinct justifications. The first one is purely statistical – collinearities amongst variables may produce this set of results. The second one is that hedonic regressions detect equilibrium relationships in a market where different groups of consumers co-exist, with preferences over distinct characteristics. For example, “leisure” characteristics probably appeal more to a younger population, with lower purchasing power, leading to a majority of negative signs associated with these characteristics, as prices of phones with them will tend to be lower, in equilibrium.

Examination of sample correlations between pairs of variables (Tables 10 – 18 in the Appendix) in general shows low correlations. The exception is the variable COVERS, which has a negative and relatively high correlation with most technical characteristics. This gives some support to the statistical argument as an explanation for this negative association. The same explanation does not hold,

Table 4: What determines handset prices?

	TMN	VODAFONE	OPTIMUS
Functional characteristics			
Stand-by battery time	+	*o*	+
Conversation battery time	–	–	–
MMS	*o*	*o*	*o*
3G	*o*	*o*	+
Hands-free	+	*o*	*o*
Technical characteristics			
WAP	+	*o*	*o*
GPRS	–	+	–
Infra-red	*o*	*o*	+
Bluetooth	+	+	+
Car Kit	–	–	–
Connectivity	+	+	+
Leisure			
Covers	–	–	–
Color screen	–	–	–
Polyphonic rings	*o*	+	+
Games	*o*	*o*	+
Camera	+	+	+
Radio	–	–	–
Video	–	–	–
Network effects			
Total subscribers	–	*o*	*o*
New (quarter) subscribers	*o*	+	*o*
Time effects			
Age of model	–	–	*o*
General time trend	*o*	*o*	–
3G time trend	*o*	*o*	+
XMAS	–	*o*	*o*
AUGUST	*o*	*o*	*o*

however, for the remaining variables. Therefore, we rely on the second explanation: the mix of consumers and associated pricing strategies may be underlying the observed associations.

It is curious to note that prices of 3G phones are set comparable to handsets of previous generations of mobile technology by TMN and Vodafone, the two largest networks, as the associated coefficient is statistically insignificant. This shows that companies are willing to encourage take-off of 3G features through subsidization of equipment. The high effect associated with 3G phones in the subsidization equation is explained by the intention to keep prices of phones attractive, at roughly the same level of phones intended for 2G and 2.5G technologies.

5 Concluding remarks

Using hedonic regressions for implicit subsidies and prices, at the handset level, we unveil some stylized facts about the features of handset subsidies. Overall, we summarize our findings in two simple statements: handset subsidies are a relevant competitive tool used by mobile phone operators; handset subsidies are used more intensively in new models and tend to vanish as the handset model ages. This effect is empirically different from a general time trend towards lower handset prices. Larger networks tend to reduce their subsidies when network size grows, the smaller network tends to decrease (increase) subsidies when its size decreases (increases). The relationship between subsidies and network size calls for further examination.

It is clear that the three existing operators do subsidize handsets differently. In particular, the largest network subsidizes less than the others. Network size seems to allow larger companies (in terms of subscribers) to set smaller subsidies. The handset characteristics that appear to be associated with subsidies also differ across companies, suggesting that they may be targeting distinct consumer groups. This is particularly visible in a set of characteristics associated with "leisure" features and services provided by mobile telephony. The smallest network has been reducing its subsidies over time, a curious feature as its market share, in terms of subscribers, has also declined in the same time period.

Our results show that companies are heavily subsidizing handsets supporting the new 3G technology (and its associated services). Subsidies are clearly greater for 3G phones, and prices are aligned with handsets with the same characteristics but without 3G support. Both findings point to a strategy of subsidizing handsets in order to promote a take-off of 3G services.

This work complements the handset-features' analysis of Koski and Kretschmer (2006). They identified a trend during the 1990s towards vertical innovations, with a move in the early 2000s towards horizontal innovations. In accordance with their stylized facts on the type of innovation over time, we find that companies do not differ in their subsidization behavior in vertical characteristics and do differ in horizontal differentiation ones.

There are several issues left for future research. First, how do handset subsidies interact with call prices in the "competitive weapons" mix used by telecom operators? Second, do handset subsidies contribute to a faster switching to new technologies and services? Third, should regulatory authorities be concerned with the generalized use of handset subsidies, knowing they are associated with consumer switching costs. Our preliminary evidence, based on handset prices and implicit subsidies, suggest that at model level, subsidies are transitory and associated with market entry of new models and diffusion of new technology. Accordingly, and despite the need for a deeper analysis in several areas, the available evidence does not raise, for the moment, special regulatory concerns.

The exploration of the link between pricing strategies and handset adoption by consumers and handset features, which requires detailed data on sales by handset model, remains in the research agenda .

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Appendix

Descriptive statistics

Table 5: Descriptive Statistics

	Mean	Std Dev	Minimum	Maximum
PRICEOP	228.18834	111.87189	69.9	599.9
PRICEUNL	250.55235	120.61481	69	659
SUBS	22.84630	29.39562	-100.9	119.1
AGE	4.74172	3.70651	1	20
AGE2	36.20397	57.53881	1	400
AUTSB	259.29007	53.64034	85	400
AUTCONV	5.24691	2.47505	1.75	14.5
COVERS	0.51258	0.50017	0	1
GPRS	0.86887	0.33776	0	1
IR	0.50199	0.50033	0	1
HANDS-FREE	0.80795	0.39418	0	1
MMS	0.20662	0.40515	0	1
COLORSCR	0.88742	0.31629	0	1
BLTOOTH	0.27682	0.44772	0	1
POLI	0.95497	0.20751	0	1
GAMES	0.75232	0.43195	0	1
CAM	0.58940	0.49227	0	1
RADIO	0.17219	0.37779	0	1
CONNECT	0.33113	0.47093	0	1
CARKIT	0.35629	0.47922	0	1
VIDEO	0.16821	0.37430	0	1
G3	0.019868	0.13964	0	1
TIME	7.88079	5.05950	1	20
XMAS	0.059603	0.23691	0	1
AUGUST	0.078146	0.26858	0	1
TOTSUBS	3761.94040	1206.06334	2088	5215
NEWSUBS	24.98146	86.41355	-218	253

Hedonic estimations for subsidies

Table 6 reports estimates of hedonic regressions by company (TMN, VODAFONE and OPTIMUS). The statistical significance obtained is of the same order of magnitude as other studies that use hedonic price regressions, although using call charges as dependent variable (Sunada, 2005).

Table 6: Results

	TMN	VODAFONE	OPTIMUS
Constant	**773.72**	-101.30	**-772.27**
	(2.15)	(-1.25)	(-3.40)
AGE	**-3.25**	-0.78	0.86
	(-2.23)	(-0.45)	(0.42)
AGE2	0.12	-0.03	-0.09
	(1.38)	(-0.32)	(-0.93)
AUTSB	-0.01	-0.02	-0.04
	(-0.53)	(-0.34)	(-0.60)
AUTCONV	**1.61**	1.87	0.87
	(2.02)	(1.55)	(0.82)
COVERS	**-23.53**	**-11.76**	**-11.91**
	(-5.76)	(-2.50)	(-2.20)
GPRS	-8.00	12.07	0.83
	(0.17)	(1.36)	(0.10)
IR	-6.02	4.20	-8.06
	(1.53)	(0.56)	(-1.24)
HANDS-FREE	**13.53**	**17.95**	12.51
	(2.67)	(2.80)	(1.54)
MMS	-4.20	3.52	6.36
	(-1.02)	(0.90)	(0.74)
COLORSCR	-10.74	**-32.76**	-17.60
	(-1.50)	(-2.40)	(-1.01)
BLTOOTH	-7.31	5.77	0.39
	(-1.44)	(0.83)	(0.05)

Notes: in parentheses, t-ratios with White's robust standard errors.
In **bold** statistically significant coefficients at the 5% level.
(results continue in Table 7)

Table 7: Results (cont)

	TMN	VODAFONE	OPTIMUS
POLI	0.44	1.90	-3.16
	(0.03)	(0.11)	(-0.14)
GAMES	**9.95**	2.26	2.94
	(2.37)	(0.52)	(0.50)
CAMERA	**9.01**	3.73	**23.31**
	(2.18)	(0.58)	(3.25)
RADIO	-0.52	**-18.49**	**-18.12**
	(-0.08)	(-2.31)	(-2.00)
CONNECT	6.37	15.33	1.56
	(0.92)	(1.90)	(0.13)
CARKIT	-9.65	-5.88	4.53
	(-1.34)	(-0.94)	(0.46)
VIDEO	-10.23	-3.10	15.36
	(-1.66)	(-0.31)	(1.39)
3G	**239.43**	**213.49**	**400.05**
	(2.56)	(2.21)	(2.77)
TIME3G	-12.97	-12.20	**-26.44**
	(-1.80)	(0.10)	(-2.59)
TIME	2.09	-1.51	**-3.99**
	(1.64)	(-1.28)	(-2.47)
XMAS	0.88	-5.14	3.87
	(0.14)	(-0.76)	(0.60)
AUGUST	-9.52	-1.59	0.77
	(1.50)	(-0.23)	(0.09)
TOTSUBS	**-15.06**	0.04	**0.39**
	(-2.05)	(1.64)	(3.60)
NEWSUBS	0.09	-0.02	-0.02
	(1.62)	(-0.98)	(-0.67)
Average	22.44	23.71	24.73
Std Deviation	29.35	27.17	31.72
R2	0.256896	0.333086	0.313030
Obs.	343	218	207
Log-Likelihood	-1594.32	-948.515	-969.942

Notes: in parentheses, t-ratios with White's robust standard errors.
In **bold** statistically significant coefficients at the 5% level.

A simple model

We want to address the role of handset subsidization. To this end, we use a simplified model of the mobile market. In particular, we simplify the role of calls and price of calls. We consider two networks. The networks are horizontally differentiated (in the spirit of Laffont, Rey and Tirole (1998)). We assume the value to consumers of calls within the same network to be v_1 and the value of calls to the other network to be v_2. We take $v_1 > v_2$ because on-net calls are usually cheaper than off-net calls. These valuations can be seen as consumer's surplus from each type of call.[5]

Consumers have a "transport" cost of t in terms of differentiation across networks. Consumers are distributed uniformly along a line of length one, with mobile operators located at both ends of the line. Implicitly, we are also assuming that on-net and off-net prices are similar across networks. This assumption may not hold, as networks of different size may choose different pricing policies. We maintain this assumption because we wish to highlight the elements that are likely to produce the empirical finding of the network size effect on subsidies changing sign according to whether the network is large or small.

When buying a handset, consumers have the choice of picking one of the networks, and receive a subsidy given by s_i (from operator i). We take as given the handset model the consumer is willing to buy, and neglect, for the moment, the issue of SIM-locking.

In a given period, there are $n_1 + n_2 = 1$ consumers buying a new handset and willing to choose a different network (we normalize the mass of new consumers to one). There are $D_i, i = 1, 2$, loyal consumers who remain associated with their initial network.

[5] This implicitly assumes that pricing plans are changed less frequently than handset subsidies, which roughly holds true.

The demand of new consumers for each network is given by the indifferent consumer x:

$$v_1(n_1+D_1)+v_2(n_2+D_2)-tx+s_1 = v_1(n_2+D_2)+v_2(n_1+D_1)+s_2-t(1-x) \quad (1)$$

We assume operator 1 to be located at 0 on the line, and operator 2 to be located at 1. Demands are therefore $Q_1 = x$ and $Q_2 = 1 - x$. In equilibrium, $n_1 = x, n_2 = 1 - x$. Without loss of generality, we take $D_1 > D_2$.

The indifferent consumer is given by

$$x^* = \frac{v_1 d_1 + s_1 + v_2 + v_2 d_2 + t - v_2 d_1 - v_1 - v_1 d_2 - s_2}{2(t - v_1 + v_2)} \quad (2)$$

Profits of each operator are, respectively:

$$\begin{aligned} \Pi_1 &= (m_1 - s_1)x^* = & (3) \\ &= (m_1 - s_1)\frac{v_1 D_1 + s_1 + v_2 + v_2 D_2 + t - v_2 D_1 - v_1 - v_1 D_2 - s_2}{(t - v_1 + v_2)2} & (4) \\ \Pi_2 &= (m_2 - s_2)(1 - x^*) & (5) \end{aligned}$$

where $m_i, i = 1, 2$ denotes the exogenous margin that accrues to each operator from each subscriber to the network (it can be seen as the expected discounted value of profits each subscriber gives to the network, where the expectation is taken over the time the consumer will stay with the network). We assume $t > v_1 - v_2$ (this will also ensure that second-order conditions for profit maximization will be fulfilled). From the first-order conditions for profit maximization of each operator, we obtain the (Nash) equilibrium values for the handset subsidy of each operator:

$$\begin{aligned} s_1 &= \Delta v - t + \frac{-\Delta v(D_1 - D_2) + m_2 + 2m_1}{3} & (6) \\ s_2 &= \Delta v - t + \frac{\Delta v(D_1 - D_2) + 2m_2 + m_1}{3} & (7) \end{aligned}$$

where $\Delta v = v_1 - v_2$. Under the stated assumptions, sufficient conditions for a maximum of each firm's problem are also satisfied. From these conditions it is easy to see that increasing network size (increasing D_i) leads the mobile operator to offer a smaller subsidy for handsets. This is so because a larger network increases the value to consumers of choosing it, and therefore a lower subsidy is required to induce a consumer to subscribe to it.

An increase in margins also increases equilibrium subsidies of both operators (due to strategic effects), while an increase in Δv has an ambiguous effect for the larger network while unambiguously increasing the subsidy for the smaller network. If the valuation of on-net calls increase, the larger network reinforces its advantage by the network externality alone. This leads the operator to offer a smaller subsidy. On the other hand, it also makes the indifferent consumer more sensitive to the difference in subsidies. At the margin, there is an extra incentive for the operator to increase the subsidy. The net effect for the larger network has to balance the two effects. The smaller network does not face trade-off, as it needs to offer a more substantial subsidy to counteract the lower value of its network.

Hedonic price regressions

Table 8: Hedonic price regressions

Prices	TMN	VODAFONE	OPTIMUS
Constant	**2160.15**	119.16	-99.52
	(2.88)	(0.70)	(-0.30)
AGE	**-6.27**	**-14.14**	6.82
	(-2.17)	(-3.96)	(1.62)
AGE2	-0.07	-0.13	-0.26
	(-0.43)	(-0.79)	(-1.53)
AUTSB	**0.23**	0.14	**0.32**
	(3.90)	(0.79)	(2.33)
AUTCONV	**-14.17**	**-12.51**	**-7.42**
	(-9.52)	(-3.72)	(-2.67)
COVERS	**-39.18**	1.07	**-87.81**
	(-4.41)	(0.05)	(-5.94)
WAP	**59.36**	10.23	32.80
	(2.17)	(0.30)	(0.88)
GPRS	**-66.80**	**99.90**	**-78.99**
	(-2.03)	(2.16)	(-2.08)
IR	8.96	-2.76	**37.12**
	(1.00)	(-0.17)	(2.43)
HANDS-FREE	**29.97**	-5.13	47.41
	(3.16)	(-0.30)	(1.60)
MMS	13.64	-0.80	-15.29
	(1.44)	(-0.04)	(-0.64)
COLORSCR	**-50.20**	**-243.50**	**-119.44**
	(-2.08)	(-5.33)	(-3.83)

Notes: in parentheses, t-ratios with White's robust standard errors.
In **bold** statistically significant coefficients at the 5% level.
(results continue in Table 9)

Table 9: Hedonic price regressions (cont)

	TMN	VODAFONE	OPTIMUS
BLTOOTH	**106.52**	**157.54**	**61.47**
	(10.50)	(6.30)	(3.89)
POLI	64.05	**196.38**	**168.13**
	(1.66)	(4.16)	(3.24)
GAMES	19.11	1.09	**46.29**
	(1.62)	(0.09)	(2.37)
CAMERA	**102.68**	**79.83**	**55.00**
	(8.72)	(3.99)	(2.52)
RADIO	-20.77	-62.69	**-39.59**
	(-1.77)	(-1.85)	(-2.53)
CONNECT	**79.14**	**99.66**	**127.77**
	(4.73)	(4.88)	(4.30)
CARKIT	**-60.00**	**-110.22**	**-48.65**
	(-4.23)	(-6.21)	(-2.43)
VIDEO	-23.50	-16.17	-3.91
	(-1.78)	(-0.31)	(-0.18)
3G	112.40	103.96	**167.32**
	(1.57)	(1.07)	(3.11)
TIME3G	-1.53	-3.09	**6.86**
	(-0.30)	(-0.49)	(3.34)
TIME	3.41	4.67	**-13.58**
	(1.14)	(1.50)	(-4.06)
XMAS	**-34.26**	2. 96	-11.83
	(-2.87)	(0.18)	(-1.14)
AUGUST	14.48	-2.43	2.52
	(1.06)	(-0.19)	(0.21)
TOTSUBS	**-0.40**	0.0058	0.11
	(-2.66)	(0.11)	(0.72)
NEWSUBS	0.20	**0.09**	0.07
	(1.83)	(2.02)	(1.15)
Average	229.549	222.104	232.138
Std Deviation	109.075	116.012	112.320
R2	.752222	.829715	.820510
Obs.	334	211	210
Log-Likelihood	1807.56	1115.16	1108.61

Notes: in parentheses, t-ratios with White's robust standard errors.
In **bold** statistically significant coefficients at the 5% level.

Correlation matrices

Table 10: Correlation matrix – TMN

	AGE	TOTSUBS	NEWSUBS	AUTSUB	AUTCONV	COVERS
TOTSUBS	0.50	1.00				
NEWSUBS	0.28	0.63	1.00			
AUTSB	0.004	0.12	0.02	1.00		
AUTCONV	-0.02	-0.16	-0.05	0.34	1.00	
COVERS	0.01	-0.05	-0.06	0.24	-0.13	1.00
WAP	0.03	-0.08	0.03	-0.09	0.15	-0.30
GPRS	0.06	0.05	0.05	0.02	0.13	-0.33
IR	0.12	0.07	0.13	0.07	0.09	-0.30
HANDS-FREE	0.11	0.14	0.06	0.10	-0.16	0.20
MMS	-0.15	0.08	-0.07	0.10	-0.03	-0.12
COLORSCR	0.10	0.13	0.05	0.004	0.08	-0.32
BLTOOTH	0.11	0.12	0.04	-0.09	0.22	-0.35
POLI	0.03	0.14	0.08	-0.03	0.08	-0.23
GAMES	0.11	0.24	0.13	-0.06	-0.05	-0.24
CAMERA	0.18	0.28	0.19	-0.002	0.13	-0.32
RADIO	0.06	0.23	0.16	0.02	-0.17	0.05
CONNECT	-0.10	0.47	0.25	-0.01	-0.12	-0.07
CARKIT	-0.10	0.54	0.23	0.04	-0.16	-0.10
VIDEO	-0.12	0.30	0.19	0.04	-0.14	-0.16
G3	0.23	-0.05	-0.01	0.01	-0.12	0.13

Table 11: Correlation matrix – TMN (continued)

	WAP	GPRS	IR	HANDS-FREE	MMS
GPRS	0.73	1.00			
IR	0.30	0.32	1.00		
HANDS-FREE	0.21	0.21	0.17	1.00	
MMS	0.07	0.18	-0.35	-0.13	1.00
COLORSCR	0.44	0.75	0.31	0.21	0.17
BLTOOTH	0.17	0.20	0.32	0.15	-0.02
POLI	0.68	0.67	0.21	0.40	0.12
GAMES	0.45	0.63	0.30	0.12	-0.05
CAMERA	0.27	0.40	0.50	0.24	-0.30
RADIO	0.12	0.14	0.31	0.24	-0.10
CONNECT	0.01	0.07	0.25	0.15	0.04
CARKIT	-0.06	0.08	0.13	0.05	0.19
VIDEO	0.13	0.15	0.35	0.25	-0.06
G3	0.04	0.04	-0.13	0.07	0.23

Table 12: Correlation matrix – TMN (continued)

	COLORSCR	BLTOOTH	POLI	GAMES	CAMERA
BLTOOTH	0.19	1.00			
POLI	0.68	0.13	1.00		
GAMES	0.45	0.32	0.42	1.00	
CAMERA	0.39	0.39	0.26	0.61	1.00
RADIO	0.14	0.24	0.09	0.22	0.34
CONNECT	0.24	0.18	0.16	0.23	0.37
CARKIT	0.24	0.17	0.16	0.23	0.29
VIDEO	0.15	0.28	0.10	0.24	0.38
G3	0.04	0.21	0.03	0.07	0.10

Table 13: Correlation matrix – TMN (continued)

	RADIO	CONNECT	CARKIT	VIDEO	G3
CONNECT	0.58	1.00			
CARKIT	0.44	0.88	1.00		
VIDEO	0.55	0.63	0.49	1.00	
G3	0.29	0.17	0.17	0.27	1.00

Table 14: Correlation matrix – VODAFONE

	AGE	TOTSUBS	NEWSUBS	AUTSUB	AUTCONV	COVERS
TOTSUBS	0.47	1.00				
NEWSUBS	0.29	0.44	1.00			
AUTSB	-0.11	-0.04	-0.12	1.00		
AUTCONV	-0.10	-0.32	-0.03	0.33	1.00	
COVERS	-0.04	-0.11	-0.08	0.26	-0.08	1.00
WAP	0.02	-0.18	-0.03	-0.32	0.23	-0.37
GPRS	0.03	-0.004	0.02	-0.13	0.18	-0.40
IR	0.13	0.07	0.04	-0.20	0.20	-0.33
HANDS-FREE	0.08	0.001	-0.05	-0.21	-0.21	0.24
MMS	-0.18	0.16	-0.01	0.09	-0.09	-0.21
COLORSCR	0.01	0.15	0.06	-0.17	0.13	-0.34
BLTOOTH	0.06	0.09	-0.02	-0.14	0.27	-0.43
POLI	0.01	0.14	0.13	-0.38	0.06	-0.19
GAMES	0.04	0.14	-0.02	-0.08	0.04	-0.28
CAMERA	0.15	0.20	0.02	-0.10	0.14	-0.15
RADIO	-0.15	0.31	0.003	-0.07	-0.25	0.06
CONNECT	-0.24	0.42	0.07	-0.07	0.04	-0.05
CARKIT	-0.17	0.52	0.10	0.05	-0.11	-0.03
VIDEO	-0.20	0.35	-0.001	0.02	-0.16	-0.11
G3	-0.07	0.12	-0.09	-0.001	-0.12	0.14

Table 15: Correlation matrix – VODAFONE (continued)

	WAP	GPRS	IR	HANDS-FREE	MMS
GPRS	0.71	1.00			
IR	0.35	0.36	1.00		
HANDS-FREE	0.06	0.10	0.23	1.00	
MMS	0.04	0.25	-0.43	-0.33	1.00
COLORSCR	0.51	0.86	0.30	0.16	0.21
BLTOOTH	0.29	0.32	0.64	0.18	-0.13
POLI	0.38	0.48	0.14	0.45	0.12
GAMES	0.48	0.71	0.51	0.18	0.03
CAMERA	0.29	0.48	0.69	0.37	-0.23
RADIO	-0.12	-0.09	0.20	0.22	-0.05
CONNECT	0.03	0.06	0.24	0.09	0.05
CARKIT	-0.32	-0.10	-0.06	-0.06	0.29
VIDEO	0.18	0.20	0.38	0.21	-0.05
G3	0.06	0.07	-0.14	0.07	0.27

Table 16: Correlation matrix – VODAFONE (continued)

	COLORSCR	BLTOOTH	POLI	GAMES	CAMERA
BLTOOTH	0.27	1.00			
POLI	0.56	0.15	1.00		
GAMES	0.60	0.44	0.34	1.00	
CAMERA	0.41	0.61	0.23	0.68	1.00
RADIO	-0.16	0.25	0.10	0.05	0.21
CONNECT	0.25	0.29	0.14	0.18	0.27
CARKIT	0.03	0.15	0.17	0.07	0.05
VIDEO	0.17	0.27	0.09	0.27	0.40
G3	0.06	0.22	0.03	0.10	0.14

Table 17: Correlation matrix – VODAFONE (continued)

	RADIO	CONNECT	CARKIT	VIDEO	G3
CONNECT	0.48	1.00			
CARKIT	0.42	0.68	1.00		
VIDEO	0.74	0.68	0.38	1.00	
G3	0.33	0.24	0.20	0.35	1.00

Table 18: Correlation matrix – OPTIMUS

	AGE	TOTSUBS	NEWSUBS	AUTSUB	AUTCONV	COVERS
TOTSUBS	0.68	1.00				
NEWSUBS	0.51	0.55	1.00			
AUTSB	0.02	0.05	0.09	1.00		
AUTCONV	-0.15	-0.21	-0.14	0.21	1.00	
COVERS	-0.01	0.07	0.03	0.35	-0.13	1.00
WAP	0.03	-0.22	-0.10	-0.33	0.22	-0.33
GPRS	0.07	-0.10	0.04	-0.17	0.22	-0.37
IR	0.12	0.12	0.10	-0.09	-0.04	-0.33
HANDS-FREE	0.18	0.23	0.25	-0.26	-0.28	-0.04
MMS	-0.16	-0.11	-0.07	0.14	0.11	-0.10
COLORSCR	0.11	0.12	0.13	-0.20	0.14	-0.31
BLTOOTH	0.10	0.12	0.10	-0.16	0.05	-0.47
POLI	0.03	0.12	0.16	-0.39	0.07	-0.20
GAMES	0.12	0.06	0.09	-0.16	0.02	-0.26
CAMERA	0.22	0.18	0.19	-0.21	0.02	-0.37
RADIO	0.02	0.30	0.24	0.15	-0.16	0.14
CONNECT	-0.09	0.42	0.35	0.09	-0.08	0.04
CARKIT	-0.11	0.43	0.35	0.05	-0.13	0.04
VIDEO	-0.13	0.14	0.16	0.08	-0.12	-0.16
G3	-0.04	0.13	0.08	0.03	-0.14	0.13

Table 19: Correlation matrix – OPTIMUS (continued)

	WAP	GPRS	IR	HANDS-FREE	MMS
GPRS	0.77	1.00			
IR	0.37	0.40	1.00		
HANDS-FREE	0.18	0.23	0.30	1.00	
MMS	0.09	0.16	-0.37	-0.38	1.00
COLORSCR	0.46	0.78	0.33	0.30	0.14
BLTOOTH	0.21	0.25	0.46	0.17	-0.08
POLI	0.46	0.51	0.18	0.55	0.08
GAMES	0.53	0.70	0.59	0.31	-0.21
CAMERA	0.42	0.55	0.66	0.42	-0.33
RADIO	-0.02	0.04	0.25	0.20	-0.04
CONNECT	-0.06	0.03	0.30	0.15	-0.07
CARKIT	-0.27	-0.11	0.17	0.15	-0.04
VIDEO	0.15	0.18	0.28	0.16	0.02
G3	0.05	0.06	-0.15	0.06	0.38

Table 20: Correlation matrix – OPTIMUS (continued)

	COLORSCR	BLTOOTH	POLI	GAMES	CAMERA
BLTOOTH	0.22	1.00			
POLI	0.59	0.13	1.00		
GAMES	0.53	0.36	0.35	1.00	
CAMERA	0.48	0.46	0.28	0.79	1.00
RADIO	-0.01	0.19	0.11	0.17	0.26
CONNECT	0.26	0.13	0.15	0.17	0.25
CARKIT	0.09	0.13	0.15	0.05	0.14
VIDEO	0.15	0.38	0.09	0.26	0.32
G3	0.05	0.24	0.03	0.09	0.11

Table 21: Correlation matrix – OPTIMUS (continued)

	RADIO	CONNECT	CARKIT	VIDEO	G3
CONNECT	0.59	1.00			
CARKIT	0.56	0.86	1.00		
VIDEO	0.61	0.59	0.41	1.00	
G3	0.29	0.21	0.21	0.35	1.00

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