The Empirical Consequences of Advertising Content in the Hungarian Mobile Phone Market*

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Abstract

This paper documents the informational content of advertisements and measures their economic effects in the Hungarian mobile phone market. To do so, we collected detailed information on both household use of mobile phones and service plans and every advertisement produced by the major providers of Hungarian mobile phone service between 2003 and 2006. We measured the informational content of each ad and examined how ads varied by content type, firm, and time. We find that most ads are either price or phone ads (or both) and that firms differ in their advertising strategies across plans, media, and time. We further find that decomposing ads by their informational content is important, both for understanding the nature of strategic interaction (e.g. synchronous versus asynchronous pulsing) as well as the impact of ads of different types on demand. Price and image ads, for example, are (alone) estimated to increase the elasticity of demand, suggesting they (but not all ads) promote competition in the Hungarian mobile phone market.

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1 Introduction

Economists have long been interested in the advertising industry for both positive and normative reasons. From a positive perspective, advertising is a ubiquitous part of daily life for the majority of people living in the western world with global media billings exceeding $500 billion on an annual basis (The Economist (2006)). From a normative perspective, advertising is recognized as playing a fundamental role in the functioning of markets, whether by informing consumers about the existence and/or characteristics of products, influencing their tastes for those products, or impacting the nature of short- and long-run competition between firms.[1] Theoretical research has emphasized that advertising can have two primary roles: it can be *persuasive*, influencing consumers' fundamental tastes for products, or it can be *informative*, educating consumers of a products existence, characteristics, price, and/or quality. Recent empirical research in particular product markets has found evidence for both views (Erdem and Keane (1996), Ackerberg (2003), Dube, Hitsch, and Manchanda (2005), Anand and Shachar (2006)).

An important limitation of most of this research is that it treats advertising messages as a "black box" without regard to the particular *content* of the ad. This is at odds with the real world, where some advertisements are clearly informative (e.g. about a product's existence, price, or other characteristics), others are clearly persuasive (e.g. Nike's famous "Be Like Mike" campaign),[2] and others cannot easily be categorized (e.g. "lifestyle" advertisements that depict a product being used in an attractive setting). In addition to (roughly) mapping the theoretical impact of advertising to observable analogs, allowing for differential advertising content raises a host of important economic questions. First, from a pure measurement perspective, what content is provided by the advertisements we actually see in the real world? Are they informative? Persuasive? Or something else? Second, what are the consequences to market performance of different types of ads? Do informative advertisements make markets more competitive? Do persuasive advertisements make them less so? How important is advertising to the successful introduction of new products? Or to summarize, what impact does advertising of different types have on demand, competition, and welfare?

An important first pass at these questions in the economics literature is the recent work of Anderson and Renault (2006) who model a monopolist's choice of price advertising, product advertising, or both in a model with consumer search and find that optimal advertising and pricing strategies differ in important ways with the magnitude of consumer search costs and rarely correspond with the social optimum. They relate their work to a larger (and older) marketing literature on "content analysis" that measures the "information cues" contained in an advertising message (e.g. availability, price, quality, performance, nutri-

[1] See Bagwell (2005) for a comprehensive survey of the economic analysis of advertising.

[2] Where "Mike" refers to the famous basketball player Michael Jordan.

tional value, and/or product warranty) and compares content across media, cultures, or regulatory regimes.[3] While informative about how to approach the goal of measuring the content of different advertisements, this literature does little to explore its consequences in contemporary product markets.

The purpose of this paper is to measure different types of advertising content and assess their effects on economic outcomes (prices, market shares, etc.) in the Mobile phone market. To do so, we exploit two rich datasets on advertisements and household purchases in this market. The first dataset contains detailed information on *every* advertisements by every Hungarian mobile phone provider across all advertising media (e.g. television, radio, newspapers, magazines, etc.) between 2003 and 2006. Included in this data are medium, the date the advertisement aired, its length, the firm doing the advertising, the product(s) (i.e. phones) and/or services (i.e. plans) being advertised, and, importantly, the actual advertisement as an image, audio, or video file (as appropriate for the medium). Based on these advertisements, we developed a metric for evaluating the content of the advertisements (e.g. Does it contain a price? Does it mention a competitor?) and measured the content of each of the ads.

The second dataset contains aggregate information about monthly plan and phone purchases for a representative panel of Hungarian individuals between 2000 and 2006. Included in this data are demographic information about the household, their current plan and phone, their past plans and phones, their future plans to purchase plans and phones, and measures of brand and product awareness.

The majority of the paper describes the data we have collected to measure the informational content of advertising and its effects in the Hungarian mobile phone market. The first section describes aggregate patterns of consumption, pricing, and revenue in the Hungarian mobile phone market. The second introduces our household-level data, focusing in particular on patterns of firm-level market shares, household spending, and household advertising recall. We find our sample market shares to be quite variable with Vodafone steadily gaining share until eventually settling around a split of roughly 43:35:22 for T-Mobile:Pannon:Vodafone. Our advertising recall results find that consumers are equally aware of each provider, suggesting the three providers are competing on equal footing on a going-forward basis.

The third, largest, section introduces our advertising data, defines how we measure advertising content, and describe how firms differ in their advertising strategies across media, plan types, ad content, and time. We focus on six main types of advertising content: image ads, price ads for plans, price ads for phones, ads for phones themselves, ads for phone options (e.g. SMS, Internet access), and ads that specifically mention rivals. Most ads in the

[3] Resnik and Stern (1977) is the seminal paper in this literature. See Abernathy and Butler (1992) for a more recent survey.

Hungarian mobile phone market (61.4%) advertise a price of some kind, and many (47.3%) also advertise phones. Ads regarding rivals are rare except by the new entrant Vodafone, for whom they comprise over 20% of all ads. While ads of all types exhibit significant evidence of pulsing, these patterns become clearer (and more regular) when distinguishing between ads with differing informational content. For example, T-Mobile and Pannon appear to advertise asynchronously overall, but synchronize their advertising for phones, whereas T-Mobile and Vodafone have the opposite pattern.

After briefly introducing our price data, we continue by estimating the (static) demand for pre-paid mobile phone service and measuring the differential effect of advertising of different types on demand. We find demand to be relatively inelastic and that lagged (but not contemporaneous) advertising influences demand. Ignoring informational content, total ads are estimated to make demand more inelastic. Broadening the specification, however, provides a contrasting view. *Price ads* and *Image ads* are estimated to make demand more elastic (and also reduce the effect of all ads), suggesting these (but not all) ads provide informational content that enhances the competitiveness of the market. A concluding section briefly suggests directions for future research.

2 Literature Review

This paper builds on a number of strands of the economic and marketing literatures analyzing the incentives for and effects of advertising. As discussed above, an important strand of this literature addresses the competitive effects of advertising: do advertising reduce consumer search costs, increasing competition and lowering prices or does it increase product differentiation, soften competition, and increase prices. Addressing this question requires first an understanding of the impact of advertising on demand. Ackerberg (2003) and Anand and Shachar (2006) explore whether advertising informs consumers of a likely match in markets for experience goods while Goeree (2005) and Barroso (2007), building on the "consideration set" literature in marketing, measure the impact of advertising on consumer awareness of alternative products. A common feature in much of the empirical advertising literature is that advertising is a "black box": it is measured by exposure or expenditure without regard to the specific content of individual ads.

Our paper seeks to unlock this black box by measuring the content of individual advertisements and exploring how advertising content varies with outcomes in the Hungarian mobile telephone market. It was inspired by the seminal work of Anderson and Renault (2006), who begin to unlock the box by analyzing the incentives of a monopolist to advertise the price and non-price characteristics of its products. It is closely related to the subsequent empirical work of Anderson, Ciliberto, and Liaukonyte (2008) who independently analyze

the content of ads in the analgesic (pain medicine) market.[4]

Both papers build on earlier empirical work (albeit limited) analyzing the content of ads. in the economic literature, Milyo and Waldfogel (1999) exploit a change in the regulation of price advertising for liquor to measure the effects of price advertising on prices. They find that prices for advertised products (only) are lower at advertising stores, with no effect at non-advertising stores.[5] In the marketing literature, "content analysis" studies in depth the content of individual ads. Our focus is different, however. While the general concern in this literature is measuring the number and impact of alternative "cues" in ads on consumer behavior, we explore the relationship between ads of alternative types, other strategic decisions taken by the firm (e.g. pricing), and outcomes (e.g. market shares) in a particular product market.

In this respect, our work is closest (and seeks to inform) the growing literature on competitive advertising. For tractability, early papers in this literature tended to ignore the dynamic impacts of advertising and treat it "just like prices" in economic models (e.g. Slade (1992), Kadiyali (1996), Vilcassim, Kadiyali, and Chintagunta (1999)). Recent paper, however, acknowledge the dynamics of advertising and the differential impact this has on optimal behavior (Dube, Hitsch, and Manchanda (2005), Sletten (2007)). Our hope is that by digging deeper into the differential effects of different *kinds* of ads, we will expand our knowledge of the underlying nature of competition with advertisements (and prices).

By virtue of the market we study, our paper is also related to the empirical literature analyzing the mobile telephone market (e.g. Huang (2007)). While we abstract from many of the issues that are the focus of that literature (e.g. demand and competition under nonlinear pricing), going forward we hope to incorporate these features into a model of competitive price and non-price advertising.

3 Industry Overview

In Hungary, the first mobile service provider, Westel Radio Telephone Ltd., a subsidiary of the incumbent fixed line operator, started it operation in 1990 with the NMT450 analogue system. In 1994, two other service providers, Westel and Pannon, were granted concession for the provision of GSM services over the 900 MHz band. In 1999, concessions for the

[4]While we share a similar focus, there are a number of differences between our papers. Anderson, Ciliberto, and Liaukonyte (2008) analyze the market for over-the-counter analgesics (medicines for the relief of minor pain) and focus on the advertising of comparative characteristics, the role of advertising in a product's life cycle, and the type of characteristics likely to be advertised (e.g. experience versus credence characteristics). We analyze the market for mobile telephones and focus on measuring the amount of image, price, and non-price (e.g. characteristics) advertising, the dynamics of advertising competition, and the impact of ads of different type on consumer demand for mobile phone plans.

[5]This confirms the findings of an older literature that, despite weaker methodological foundations, find similar effects in a variety of product markets (e.g. Benham (1972), Kwoka (1984)).

1800 MHz were granted and the third digital mobile phone service provider, Vodafone, entered the market. In 2004, on the UTMS, or third generation (3G) mobile service, all three incumbents won the right to the frequency for 15 years. The winners paid or will pay at least 52.5 billion Hungarian forint. The NMT450 analogue service was discontinued in 2003. Currently, the 3 service providers (Pannon, Vodafone, and T-Mobile) are licensed to deliver services over the 900 and 1800 MHz bands and also at the UTMS or 3G network.[6] All three providers are owned by international investors. T-mobile's main shareholder is Deutsche Telecom, Vodafone is owned by Vodafone International and Pannon is owned by Norvegian Telenor.

The primary service offered by mobile telephone providers is access to a network which permits communication by mobile telephones. As such, they are sometimes called mobile network operators. While each provider offers a wide range of service plans, they are typically of two general types: pre-paid plans and post-paid plans. Pre-paid, or "pay-as-you-go," plans allow consumers with a compatible telephone to purchase minutes in advance of their use, typically by purchasing an account with a network operator from one of many retail outlets (drugstores, convenience stores, etc.). Consumers have access to and may use the network as long as they continue to have credit in their account. Post-paid plans instead require consumers to enter into service agreements with a mobile network operator. Consumers must pay the operator for their use on a monthly basis.

Mobile network operators also sell telephones compatible with their network and often bundle telephones with network access, particularly for post-paid plans. In such cases, the operator will often offer a discount on the telephone in exchange for a commitment on the part of the consumer to purchase service for a minimum term (e.g. one or two years).

Quarterly information about service plans and telephones, consumption, pricing, and revenue in the Hungarian mobile phone industry between March 2004 and December 2007 have been collected by Gazdasagi es Kozlekedesi Miniszterium (GKM), the Hungarian Ministry of Economics.[7] Related data on the mobile phone industry has also been collected by Nemzeti Hirkozlesi Hivatal (NHH), the Hungarian National Communication Authority.[8] While these data do not generally provide detailed consumer- or firm-level information, they are useful for understanding recent development of the industry. Certain salient elements of that information is presented here.

Network Coverage Mobile operator network technology has varied over time. The late 1990's and early 2000's were characterized by so-called 2G (for second generation) technolo-

[6] Westel changed its name to T-Mobile in May, 2004.

[7] The patterns reported here were obtained from the GKM database at `http://www.e-stat.hu/ihm_h-pir/index.html`.

[8] The patterns reported here were obtained from the NHH database at `http://www.nhh.hu/hirk_stat/fejezet.nhh?&fejezet=3&nyelv=1`.

gies. While the specific communications protocols varied across countries, mobile operators in Hungary (like the rest of Europe) used the GSM standard. Table 1 reports the share of Hungary covered by each of the mobile network operators.[9] By 2003, coverage was ubiquitous, so much so that providers stopped reporting it to the NHH.

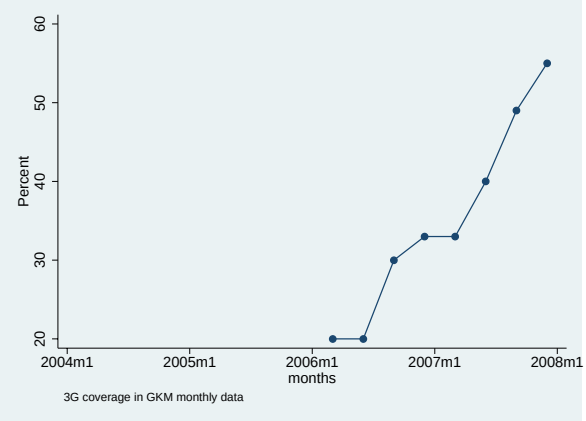
Table 1: Mobile Network Operator (GSM) Coverage by Year

Year	T-Mobile	Pannon	Vodafone
1994	96.2	—	—
1995	99.4	—	—
1996	93.0	97.5	—
1997	100.0	97.3	—
1998	95.0	97.5	—
1999	96.0	98.2	—
2000	97.0	98.2	81.0
2001	97.0	97.8	85.5
2002	97.0	97.8	85.5
2003	99.0	98.6	99.8

Source: Hungarian NHH.

The mid-2000's saw the introduction of so-called 3G (third generation) technologies. Figure 1 demonstrates the share of the Hungarian population with access to 3G networks. 3G network coverage is growing quickly and now exceeds 50% of the Hungarian population.

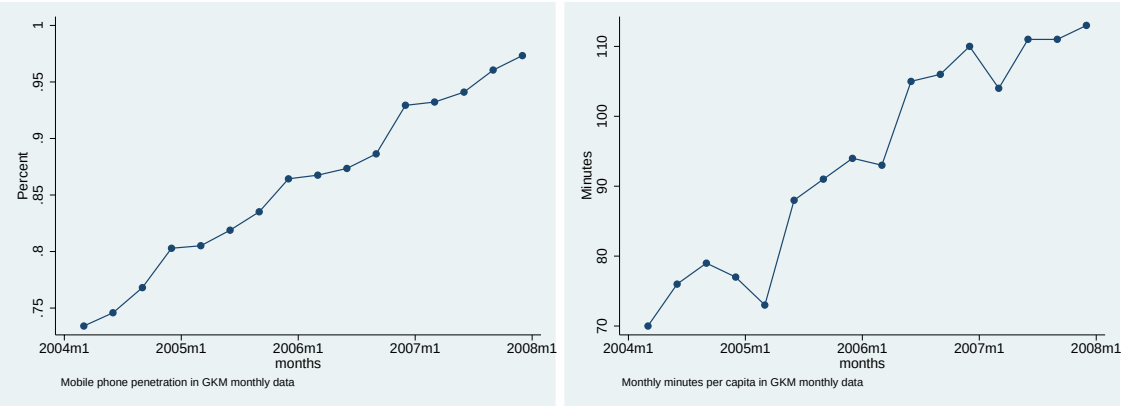
Figure 1: 3G Coverage



[9]Reported is the share of land covered by the operators. The share of population covered by operators would be higher.

Subscribers and Usage Figure 2 reports the penetration of mobile phone service and the average minutes of use per capita in the Hungarian mobile phone market between March 2004 and December 2007. Penetration is defined as the number of active subscriptions divided by the Hungarian population.[10] Minutes per capita is defined as total minutes of mobile phone use divided by the number of mobile phone subscriptions.

Figure 2: Mobile Phone Penetration and Usage



As is common worldwide, mobile phone use in Hungary has grown quickly in the last 4 years. Penetration has grown from 73.4% in March 2004 to 97.3% in December 2007, an annual growth rate of 7.8% per year. Usage has also grown, due both to increased penetration as well as increased use among those with mobile phones. Average monthly minutes of use has increased from 70 to 113, an annual growth rate of 13.6% per year.

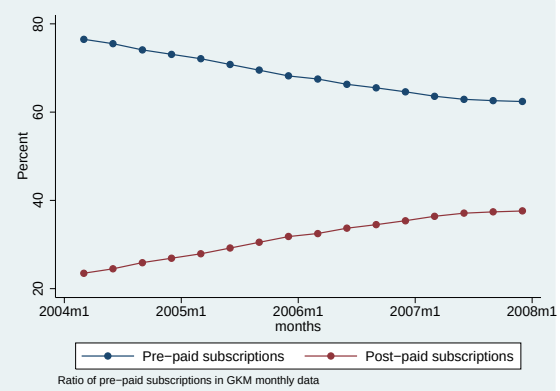
Figure 3 reports aggregate trends in subscribers' plan and call types. The left panel in Figure 3 shows that while most subscribers take a pre-paid plan, this advantage is eroding over time. The right panel in Figure 3 shows that most users call within the network of their network operator and that this effect is growing slightly over time.

In addition to providing voice communication, mobile network operators have in recent years begun to provide and promote additional services. These include SMS ("Short Message Service"), MMS ("Multimedia Messaging Service"), Email service, and Internet access service.[11] Figure 4 displays recent patterns of SMS and MMS usage in the Hungarian mobile phone market. Both have grown considerably in the last several years: SMS by an annual growth rate of 9.4% per year and MMS (despite a recent fall-off) by an annual growth rate of 63.3% per year.

[10] Active subscribers are those that have a current post-paid plan or have recently used a pre-paid plan. Total subscribers (i.e. including inactive subscribers) are roughly 8% greater. Strictly speaking, using subscriptions instead of subscribers overestimates penetration as some consumers have more than one subscription.

[11] SMS is a protocol allowing the exchange of text messages. MMS is a protocol allowing the exchange of messages that include not only text, but also images, audio, and/or video.

Figure 3: Plan and Call Types



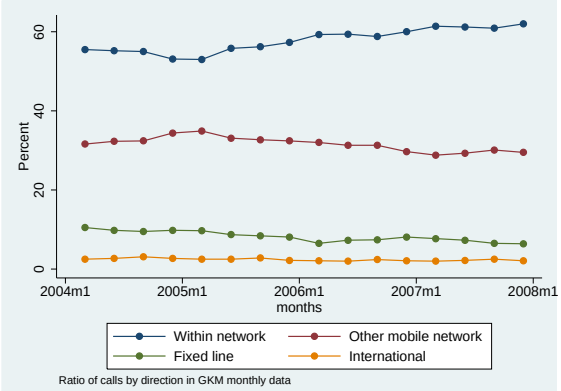
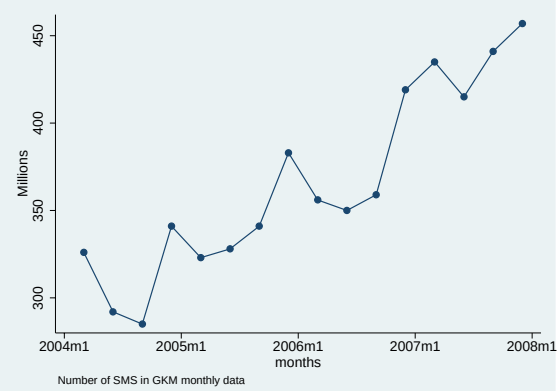
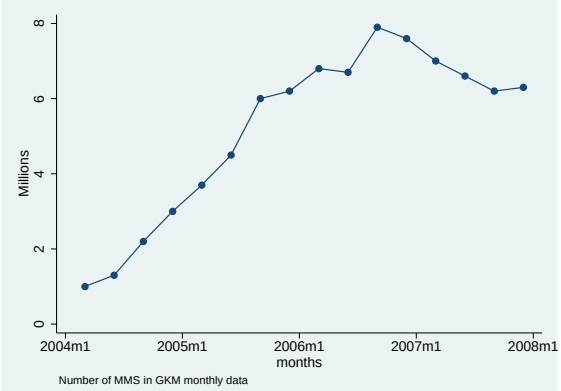


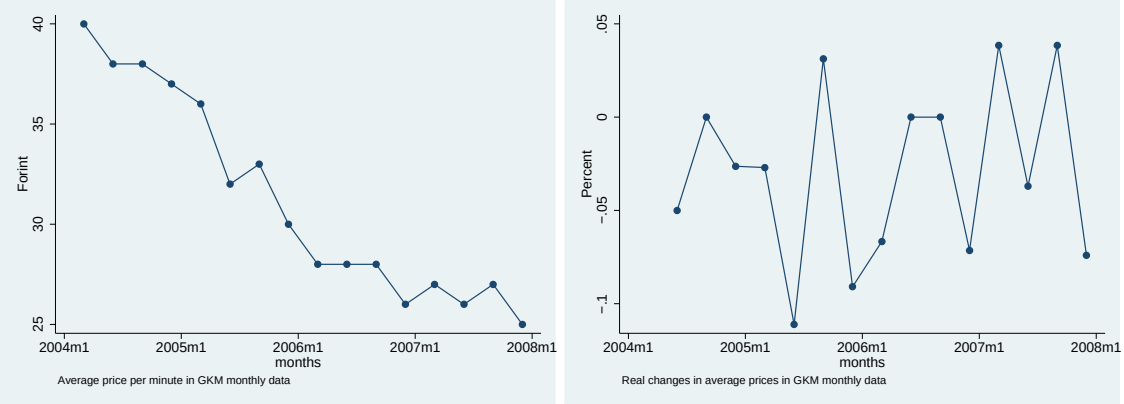
Figure 4: SMS and MMS Usage





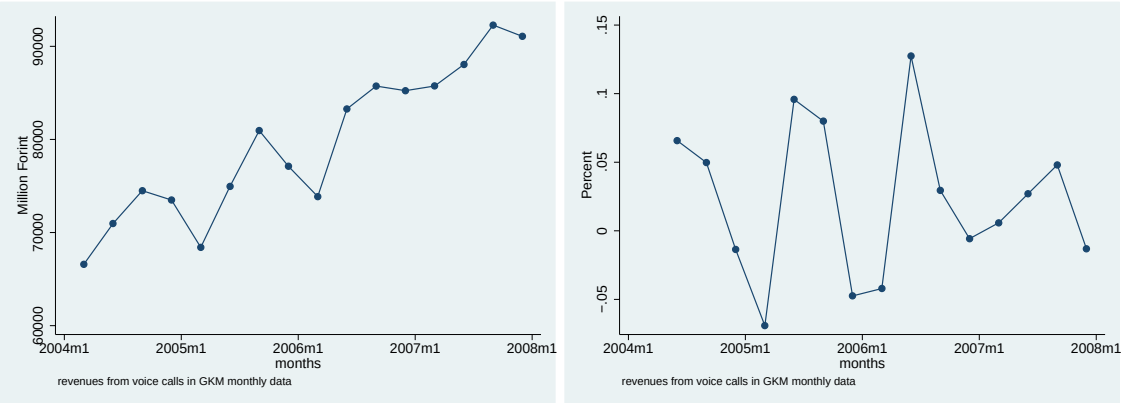
Prices and Revenue Figure 5 reports the average (nominal) price per minute and the (quarterly) change in the average price per minute in the Hungarian mobile phone market. Prices are falling rapidly in this period, from an average of 40 Forint/minute in March 2004 to an average of 25 Forint/minute in December 2007, an average quarterly decrease of 3.0% and an average annual decrease of 11.8%.[12]

Figure 5: Price per Minute: Level and Change



Despite falling prices, Figure 6 demonstrates that (nominal) network operator revenue from mobile telephone calls has grown. Call revenue has grown from 66,587 million Forint/quarter in March 2004 to 91,070 million Forint/quarter in December 2007, an average quarterly increase of 2.2% and an average annual increase of 8.7%.

Figure 6: Revenue from Mobile Telephone Calls: Level and Change



Competition Competition in the mobile phone market is dominated by the three large network operators: T-Mobile, Pannon, and Vodafone. While there are only three providers, the entry by Vodafone in 1999 was widely viewed as an important pro-competitive event.

[12]These are nominal values. The Hungarian Consumer Price Index increased 15% from January 2004 to December 2006, suggesting real mobile prices have fallen even faster.

A widely used measure of competitive intensity in product markets is the Herfindahl-Hirschman Index (HHI). It is given by the sum of the squared market shares of the market participants. A value of 10,000 may only obtain in a monopoly; values near 0 characterize (nearly) perfectly competitive markets.

Figure 7: Mobile Phone HHI

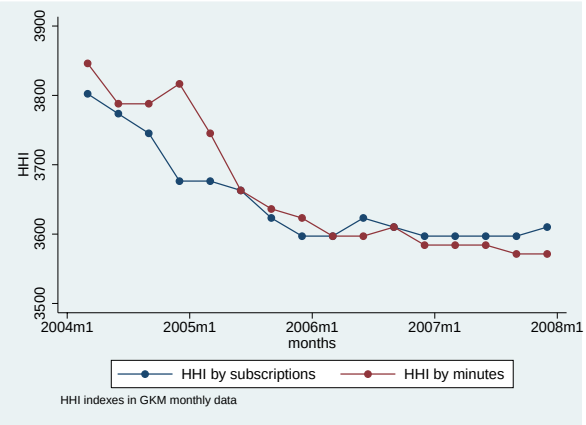


Figure 7 reports the HHI for the Hungarian mobile phone market between March 2004 and December 2007. Reported are a HHI calculated using subscriber market shares and another using minute market shares. Both tell a similar story. Following Vodafone's gradual increase in market share, the HHI has fallen to a value near 3,600. While HHI levels are insufficient to determine if a market is structurally competitive, the fall in the HHI in recent years does suggest that the market has become more competitive than it was previously.

4 Household Data

4.1 Data Overview

To measure the nature of advertising content and assess its effect on economic outcomes in the Hungarian mobile phone market, we collected data from a number of sources. We have two primary datasets. First, we purchased information on consumer behavior from TGI Magyarorszag (TGI), a market research company. Second, we purchased information on outcomes in the advertising market from TNS Media Intelligence (TNS), a media research firm. Finally, we obtained additional information about firms' pricing plans from NHH, the Hungarian National Communications Authority.

Our TGI (consumer) database is based on a monthly survey conducted between January 2000 and December 2006. The sample is representative for the Hungarian population between 14-69 years by gender, age, and settlement type. The database includes detailed information on many aspects of individuals' mobile phone consumption and use, including

their current and past service providers, their spending, and their future plans to change provider and/or phone. It also has information about individuals' awareness and responsiveness to advertising and branding by the major Hungarian network operators. We were provided with monthly aggregates of the roughly 600 survey responses in each month. Our household data therefore consists of 84 monthly average household responses.[13]

Our TNS (advertising) database is based on information TNS records and collects on all advertisements in all the major media (television, radio, newspaper, magazine, etc.) across a wide range of product categories. TNS provides information on the identity of the advertiser, the publishing media, the advertising agency, the spot, the advertised product, the expenditure on list prices, the exact date of publishing, the size or length of the spot, and, importantly, the actual advertisement as an image, audio, or video file (as appropriate for the medium). Our database includes all mobile phone advertisements that appeared in the major media in Hungary from January 1st, 2003 until December 31st, 2006. This amounts to 3,705 unique "spots" (i.e. distinct ads) appearing more than 210,000 times.

Mobile phone plans are notorious for having sophisticated pricing schemes. In Hungary, service providers are obliged by law to submit changes in their conditions of general contracts to the National Communications Authority of Hungary a month in advance. These include changes in pricing schedules. From these documents we have collected the most important prices for the major pre-paid plans for each firm. We have the peak and off-peak prices by directions, prices of short message service (SMS) and multimedia message services (MMS), the time of the off-peak period, and pricing units.

4.2 Patterns in the Household Data

Subscribers and Usage Figure 8 reports the share of households in a given month that report that they own a mobile phone for each month between January 2000 and December 2006. While there is significant variability month to month due to the rotation of the household sample, the pattern here replicates the growth in mobile phone penetration from the aggregate industry data shown earlier (in Figure 2).[14]

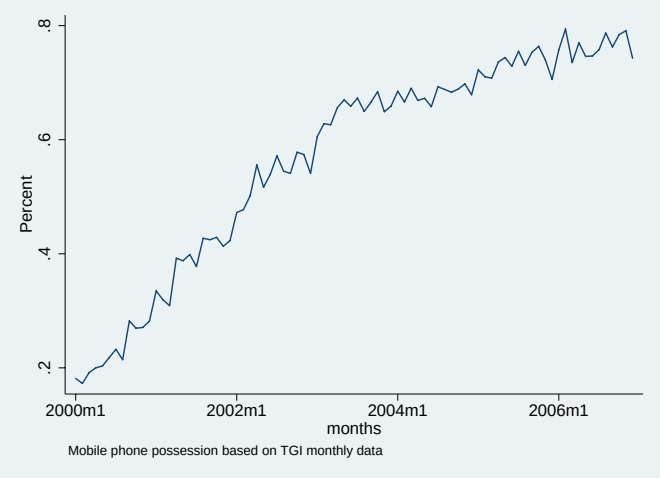
Figure 9 reports market shares by provider since 2000. The left-hand panel presents overall market shares while the right-hand panel presents market shares among mobile phone users (i.e. "inside" shares). The same variability present from the overall penetration data appears here as well.[15] Both pictures are consistent with a modest and stable market share

[13] In the regressions, an observation will be a firm-month between January 2003 and December 2006, implying 144 observations.

[14] Note however that the share of consumers that own a mobile phone (as reported here) is necessarily less than the active mobile phone subscriptions divided by population (as reported in Figure 2). The divergence between the two graphs suggests that at the end of 2006 the average number of phones per consumer was around 1.20, or that roughly 20% of mobile phone subscribers had more than one phone.

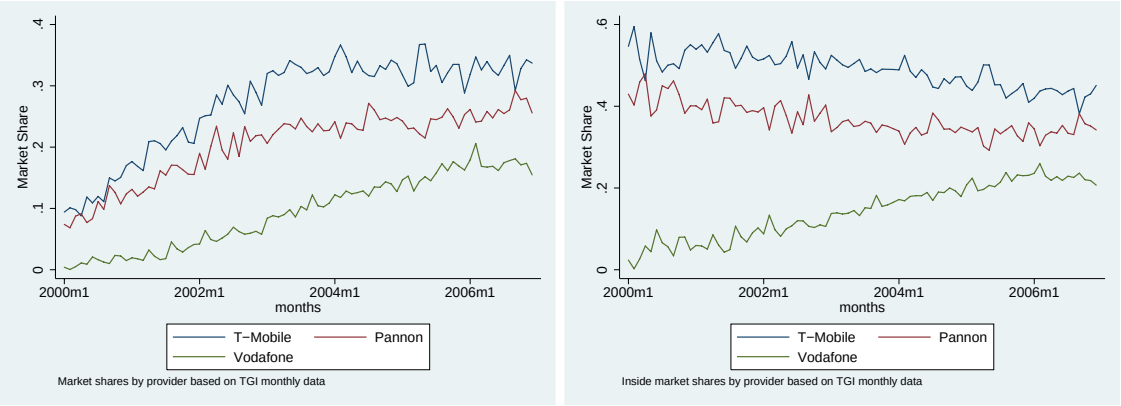
[15] We address this issue in our analysis of the relationship between market shares, prices, and advertising

Figure 8: Mobile Phone Penetration in the Household Data



advantage for T-Mobile over Pannon, with Vodafone's share steadily growing since their entry in 1999 until a late flattening near the beginning of 2006. The last several years in the data suggest T-Mobile, Pannon, and Vodafone split the market for mobile phone users in the ratio of 43:35:22.[16] This is nearly identical to results on aggregate shares published by the NHH.

Figure 9: Mobile Phone Penetration and Market Shares



Figures 10 and 11 report the market share of pre- and post-paid plans since 2004, both in the aggregate and broken down by firm.[17] Relative to Figure 3, users in the household data appear to purchase more pre-paid plans than the average Hungarian consumer (by roughly 74% versus 60%). Among both types of consumers, Vodafone maintains a consistent 20%

in Section 7.

[16] Obtained by taking the average inside market shares in the TGI data over the last 9 months of 2006.

[17] TGI began collecting specific pre- and post-paid plan information in November 2003. Note that these are "inside" shares, i.e. market shares among mobile phone users. Roughly 20% of households have no mobile phone.

of mobile phone users, while T-Mobile has a stronger position relative to Pannon in the pre-paid than in the post-paid market.

Figure 10: Pre- and Post-Paid Market Shares in the Household Data

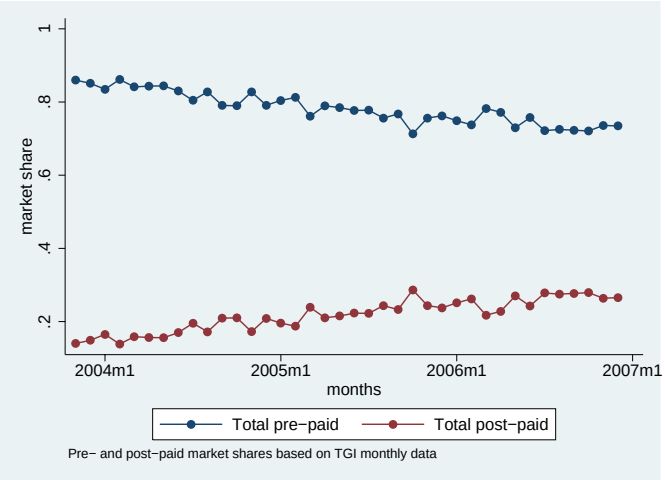
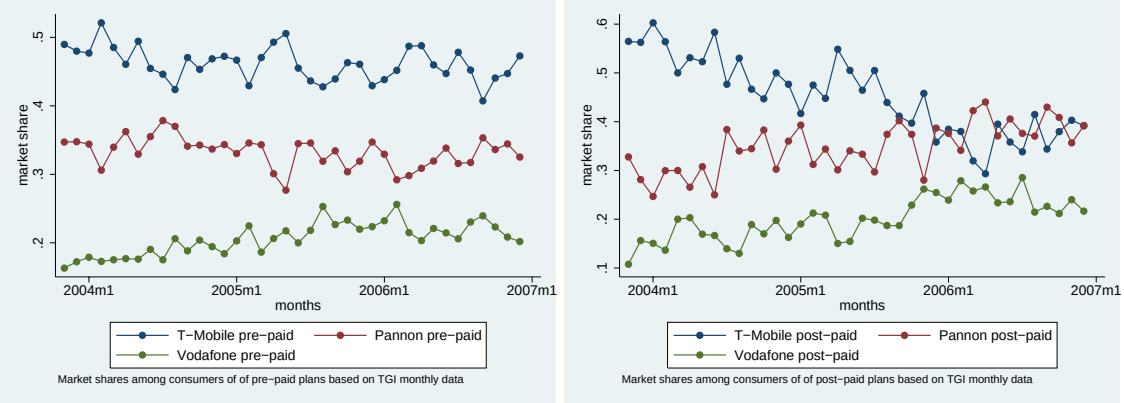


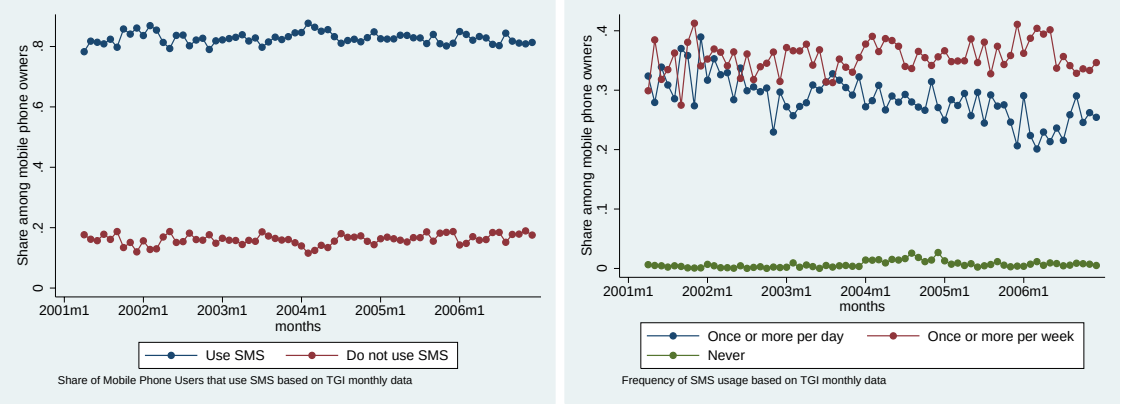
Figure 11: Market shares by provider among Pre-paid and Post-paid plans



Unfortunately, the household data do not have information on minutes of use. They do, however, collect information on SMS and MMS use, as well as use of other mobile network services. Figure 12 reports information on SMS (text-message) usage and frequency of use. The left panel reports the average share of households over time that say they use SMS while the right panel reports how frequently they use SMS. Despite the general growth in SMS messages from Figure 4, it appears this growth is concentrated among existing SMS users. Indeed if anything the data suggest the share of users who use SMS at least once per day is falling. Increased usage among those that do use it daily (teenagers?) appears to be driving the overall growth in SMS communication over time.

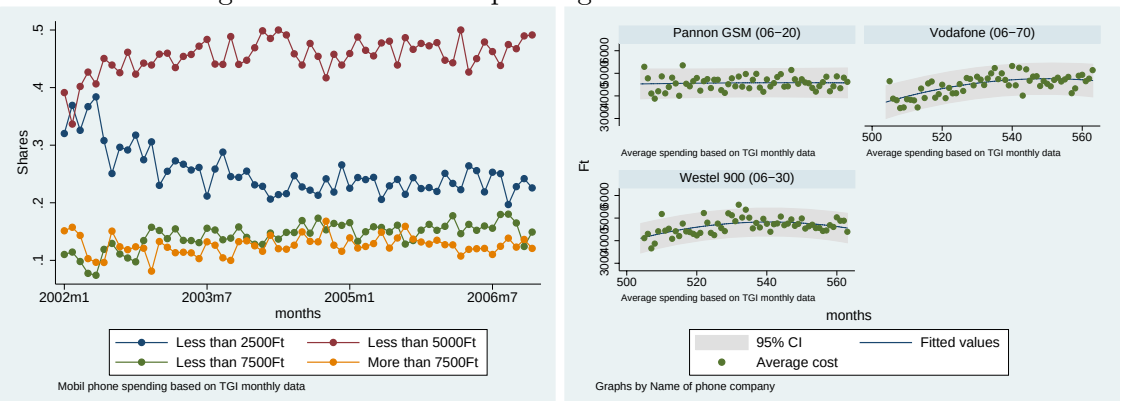
Expenditure Figures 5, 2, and 6 showed that while prices for mobile phone services are falling, revenue has been increasing due to increased usage. How has this been distributed

Figure 12: SMS Usage and Frequency



among consumers? How has it changed over time? Figure 13 addresses these questions. The left panel reports the share of households according to their monthly spending on mobile phone services while the right panel converts this to average total spending and reports differences across firms in their customers spending. Both panels suggest stable spending patterns within households. There is a slight decrease in the share of households that spend the lowest amount (2,500Ft per month) matched with very slight trending upwards in spending in the other categories. Excepting a growth in spending by Vodafone customers over time, patterns of spending across providers are also quite similar. This suggests the overall increase in industry revenue is driven exclusively by growing the share of customers who use mobile phone services and not by increased spending on those services by customers that already use them.

Figure 13: Household Spending on Mobile Phone Services

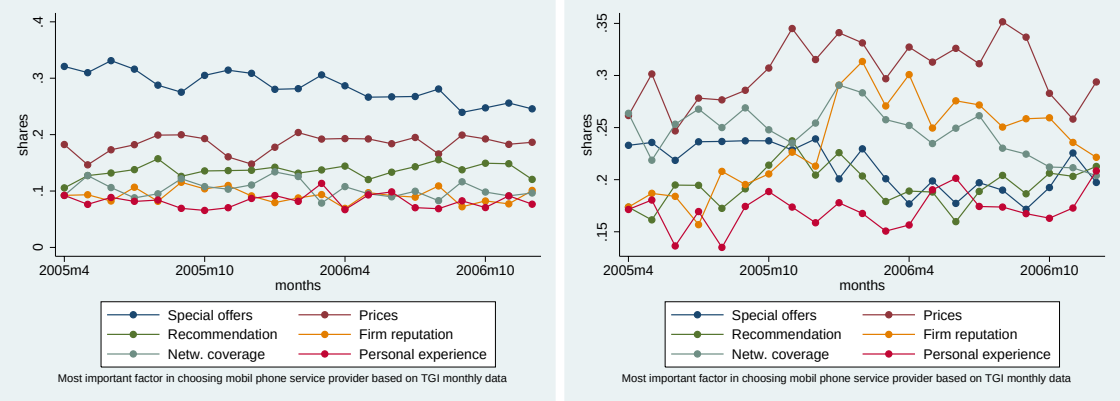


Advertising and Marketing Responses One unique and valuable feature of the TGI household survey is its (recent) inclusion of questions related to (1) the relative importance of various marketing mix variables on (stated) consumer purchase decisions (e.g. price,

brand, previous experience, etc.) and (2) the ability of consumers to recall specific information about products or their advertisements. This section describes some of these patterns in the data.

Figure 14 describes factors stated by households as important in their decision to purchase service and/or a phone from a mobile telephone service provider. The left panel reports the share of households that identified that factor as *the most important* to their decision. The right panel identifies other *other important factors* to their decision. The 6 most commonly identified factors are reported: whether the plan or phone is a special offer, the price charged, whether the plan or phone was recommended to them, the reputation of the provider, the providers network coverage, and personal experience. Other factors reported by households but not reported in the table include the provider's brand, the provider's advertising, and reception.[18]

Figure 14: Important Factors



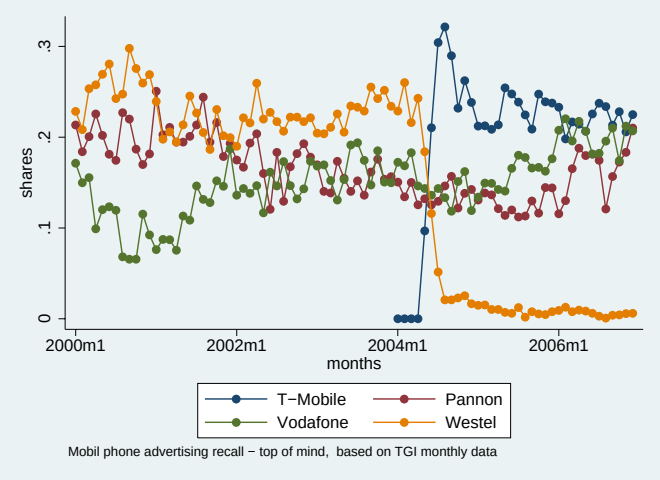
Interesting patterns emerge by examining the patterns in the figure. The most important factor to consumers (by a wide margin) is whether or not the plan or phone is a special offer, followed by the price and whether the product was recommended by a friend. Prices achieve pride of place in the list of other important factors, followed by firm reputation and (especially earlier in the data) network coverage. To the extent special offers are communicated through advertising (as is likely), these data support the primacy of price and advertising for impacting consumer purchase decisions.

Figure 15 further explores consumer perceptions of mobile phone providers. It reports the provider at the "top of a consumers mind" (i.e. first mentioned) when asked about providers of mobile phone services. Several patterns emerge. First is the switch in consumer awareness regarding between Westel and T-Mobile during and immediately after it changed its name in May 2004. Second is the gap between consumer awareness of Vodafone in the years

[18]Of course a provider's brand and advertising can influence other factors stated as being important, e.g. a provider's reputation.

following its 1999 entry into the market. Last is the equal positions of the three providers by the end of the period. While not reflected in the market shares, it suggests the three providers are competing on equal footing on a going-forward basis, i.e. for customers new to the market or newly deciding to purchase a plan and/or phone.

Figure 15: Mobile phone provider advertising recall - Top of mind



5 Advertising data

Our database from TNS contains information on 212,624 advertisements placed by mobile phone service providers between January 1, 2003 and December 31, 2006.[19] An individual piece of advertising content ("a spot") is typically shown many times, possibly across many media. Our data contain 3,705 unique spots (implying the average spot is shown 57.4 times).

Each individual advertisement comes to us with a number of important identifying characteristics. Among the most important are the name of the advertiser, the advertising medium on which the ad appeared (TV, Radio, etc.), the product category being advertised (here, mobile telecommunications), the date and time the advertisement was displayed, and its height, width, or other relevant identifying characteristics (depending on medium).[20] Importantly, the data also included the actual advertisement as an image, audio, or video file (as appropriate for the medium).

The goal of this study is to measure the information content of advertisements and their impact on economic outcomes in the mobile telephone market. To achieve this goal, we contracted with TNS to examine each of the 3,705 unique spots included in the data and

[19] See 4.1 for an overview of TNS and the information it provided for our study.

[20] In this paper, the "advertiser" means the name of the firm whose product is being advertised. The data also include the name of the ad agency that purchased the ad on behalf of the advertiser.

identify features of the products being advertised by mobile phone service providers. To simplify this process, we worked with TNS to develop a visual interface that TNS employees could use to identify the characteristics of the ads in which we were interested. Figure 16 provides an example of the interface for a Pannon ad featuring a mobile phone from Alcatel.

The information we collected included the name of the mobile phone provider, the name of the plan it was advertising (e.g. Pannon's "djuice", a pre-paid plan), if any, the name of the phone it was advertising, if any, and any features of the plan and/or phone. We focused on both price characteristics and non-price characteristics. Among price characteristics, we collected information about the per-minute price for a phone call (by various times of day and types of call), any monthly fees, any one-time fees, and the price of the phone (if one was advertised). Among non-price characteristics, we collected information about voice quality, whether the phone had a camera, radio, bluetooth, mms, wap, or gprs; whether the advertised plan or phone was a new product, whether it was on promotion, whether the address of stores, e-mail or website of the service provider appeared in the ad, and whether the advertisement had a celebrity or if the advert was sponsoring some other event (like a concert, sporting event, etc.)

5.1 Advertisements by Medium, Plan Type, Firm, and Content Type

In the analysis to follow, we focus on several categories of the information provided in each ad: the medium, the type of service plan advertised (if any), the advertising firm (T-Mobile, Pannon, or Vodafone), and (what we define as) the information content of the ad. We emphasize that this is just a preliminary analysis of what we feel are the main categories by which advertisements differ - much more analysis is possible (and planned). We begin by defining each of the categories of interest.

Ads by Medium The raw advertising data from TNS defines both a specific distribution outlet, for example a television channel (e.g. RTL, the national television broadcast channel), radio station (e.g. Juventus Radio), or newspaper, as well as the medium (e.g. Television, National Daily, or Auto Magazine). For some media (Broadcast and Cable Television, Radio), the TNS definitions were appropriate. For others (e.g. Newspapers, Magazines, and Billboards), we aggregated the TNS definitions into categories of like-minded media. In the end, we were left with 7 media: Broadcast Television, Cable Television, Radio, Newspapers, Magazines, Billboards, and Other.

The first two columns of Table 2 report the number of ads by each of these seven media in our data. The two television media and radio dominate the table, accounting for 87.7% of the ads. This is deceptive, however, as by their very nature ads are less temporally persistent on television and radio than in other media. To address this issue (among others), we also

report a measure of total (list) expenditure by medium. For each ad in the data, TNS collects information about the list price for this ad. We use this as a proxy for the expected number of consumers likely to see the ad. Thus an ad that is shown during prime-time on television is more likely to be seen than one shown at 4:00 in the morning. It is an imperfect measure, however, as it conflates the object we're interested in (the number of consumers likely to see the ad) with the price to the advertiser of reaching that number of consumers. On top of that, it is a list price and transactions prices are known to be substantially less than list prices.

Those caveats aside, we aggregated the list prices for ads within each medium to calculate the (list) expenditure on ads in that medium. The last two columns of Table 2 show the results. They suggest a different view of the alternative media, at least from the perspective of mobile telephone operators. Based on expenditure, broadcast television is the dominant medium, earning 66.2 billion Forint (in real $2003 values), or 72.8% of the ad dollars in the industry.[21] Despite the sheer number of ads in the cable television and radio industries, list prices for these ads are 5.1% and 23.6% as expensive, respectively, yielding relatively modest expenditure shares of 4.5% and 6.9%. Indeed, after broadcast television, each of radio, magazines, billboards, cable television, and newspapers earns a modest (and similar) share of expenditure between 4.4% and 6.9%. While we describe patterns of ads across all media in this section, given the dominance of broadcast television in the list expenditure data, we focus on that media in the econometric analysis in the next section.

Ads by Plan Type Because of potential differences in the characteristics and target markets of pre-paid and post-paid plans, we next tried to distinguish the type of plan being advertised in each ad. To do so, we asked the TNS employees to identify the first, second, and third advertised plan in each ad. There were many responses: 125 distinct first-identified plans and 40 distinct second-identified plans.[22] Of these, we grouped plans into plan "families", e.g. both "djuice" and "djuice nonstop" (and four other djuice-branded plans) were deemed to belong to the "djuice" family.[23] Doing so, we identified 2-3 plan families per firm.[24] Finally, we aggregated plan families into groups depending on whether they were pre-paid or post-paid plans.[25]

In so doing, we found two kinds of ads that defied simple classification. The first were ads

[21] Or roughly $455 million based on a 200 Forint/1 Dollar exchange rate.

[22] To make the data summary task manageable we didn't use the data on the third-identified plan.

[23] This tended to be non-controversial. Most of the advertised plans belonging to a family were concentrated in the "lead product" in the family. For example, over 80% of all "djuice" family ads were for the flagship plan, "djuice".

[24] For Pannon, they were djuice, Pannon Praktikum, and a variety of Pannon postpaid plans (e.g. Pannon 50, Pannon 300); for T-Mobile, they were Domino, Relax, and Kaméleon; and for Vodafone, they were Vitamax and a variety of Vodafone postpaid plans (e.g. Vodafone 800). Plans with numbers typically represented post-paid plans where the number was the number of free minutes per month.

[25] This was usually clear. It only was problematic when a plan (e.g. djuice) had both pre-paid and post-paid options. In this case, we determined it was predominantly a pre-paid plan and allocated it there.

that identified no plan at all (16.4% of all ads) or that simply identified one of the three mobile operators as the "plan". These we allocated to a separate category we call "Firm Ads."[26] The second were ads that identified certain options for a plan and/or phone, e.g. SMS (texting), WAP (internet access), or roaming. These we also allocated to a separate category we call "Options Ads".

Table 3 reports the share of ads of each of these four plan types in the data. The top panel in the table reports ad shares using the number of ads while the bottom panel in the table reports ad shares using list expenditure (as described in table 2). Focusing first on the first column of the top panel, Table 3 shows that ads are fairly equally distributed among the four categories, with the greatest number (35.2%) advertising pre-paid plans and the next greatest (28.7%) advertising the firms. Relative to the expenditure measure in the bottom panel, however, it appears that much "firm" advertising happens in relatively low-value periods. Based on expenditure, it is advertising for prepaid plans that dominates the market (at 41.6%), followed in roughly equal shares by advertising for the other plan types.

How do these patterns vary by media? Do firms concentrate their advertising for certain plan types in certain media? The short answer is they do, somewhat. Only two patterns stand out. First, relative to their share among all ads, newspaper ads are much more likely to be firm ads, particularly when measured by the number of ads (versus list expenditure). Second, radio and magazine ads are more likely to be options ads. Beyond this, firms appear to be advertising in consistent ways across media.

Ads by Firm How do the firms themselves differ in their advertising? Here the patterns are sharper. Recall from Figure 9 that the three dominant firms in the market are T-Mobile, Pannon, and Vodafone. Table 4 reports patterns of advertising by firms across the plan types defined above. As in the previous table, we report ad shares based on number of observations in the top panel and ad shares based on list expenditure in the bottom panel. Ad shares based on number of ads (42 v. 33 v. 26) is quite similar to market shares in our household sample (43 v. 35 v. 22). Comparing shares based on their list price, however, shows a different picture. Based on list expenditure, the market leader (T-Mobile) advertises considerably less (35.8%) and the market "followers" (Pannon and Vodafone) considerably more (36.5% and 27.4%). Indeed, based on list expenditure, the *second* largest firm in the market, Pannon, appears to advertise the most.

Further interesting patterns appear when comparing differences in firms' advertising behavior across plan types. Based on either measure, T-Mobile does considerably more "firm" and "options" advertising than do either Pannon or Vodafone. By contrast, Pannon advertises

[26] As we will show in the next section, most of these do not identify a plan or phone and are thus what we define to be "Image Ads".

heavily its PrePaid plans and Vodafone advertises heavily its PostPaid plan.

An interesting story of differentiation and market segmentation is suggested by differences in the share of ad types run by the various firms. The market leader, T-Mobile, appears to prefer to compete on brand identity and plan and/or phone options rather than on the key characteristics of its plans.[27] Pannon and Vodafone, as market followers, appear to be targeting different segments of the market: Pannon with its prepaid plans and Vodafone with its postpaid plans. We intend to investigate these patterns further in future work.

What of differences in advertising by firms across media? Table 5 reports the patterns. Three features stand out. First, T-Mobile appears not to favor any particular media: it's within-medium ad shares are reasonably close to their overall ad shares (and where they are different this appears to be explainable more by their rivals' behavior than theirs). Second, Pannon appears to favor advertising on non-television sources: their ad shares in radio, newspapers, magazines, and billboards are all far higher than their overall share. By contrast, Vodafone takes the opposite approach: they advertise almost exclusively on television, and especially on cable television.

Ads by Content Type The focus of this paper is on the information content of advertising. In this section, we define the specific types of advertising content we were able to identify and how the number and list expenditure on ads varied according to these content types.

We grouped content into seven different categories. The first is what we call "image ads". Image ads were defined as all ads that advertised *neither* a particular calling plan nor a particular phone.[28] The second and third are "price ads". Following patterns in the data, we further split these ads into two types: price ads for plans and price ads for phones. Our first price ad measure (and 2nd category overall) looks at ads for features of plan prices, e.g. the per-minute price within/outside the network during peak/off-peak periods, the monthly fee and free minutes (if any), etc. Our second price ad measure (and 3rd category overall) looks at ads for phone prices, e.g. the price of the advertised phone and/or features of the phone purchase (like discounts, installment plans, etc.). Our fourth group includes ads for the phones themselves, while our fifth group includes ads for options. The sixth group is what we call "rivals ads": they are ads by a given firm that specifically mention a rival provider. Our last group is defined by all remaining ads that couldn't be categorized into one of the groups above.

Table 6 reports the distribution of ads by type of content, type of plan, and firm. In reading the table, note that individual ads are permitted to have more than one type of content, e.g.

[27] It would be interesting to investigate if T-Mobile is also the market leader in bringing new technologies and/or features to consumers. That would certainly be consistent with the raw patterns we see here.

[28] We also included ads that identified the *firm* as the advertised plan.

an ad could contain a price for a plan, a price for a phone, and mention a rival by name. Examining the first ("All Ads") column, we see that there is indeed content heterogeneity in ads. Most ads are price ads (i.e. contain some price information), with an estimated 33.3% advertising a price of a plan, 44.7% advertising a price of a phone, and 61.4% advertising at least one price. After price ads are phone ads (often including prices) at 47.3% of all ads, followed by options ads (23.0%), image ads (18.0%), and rivals ads (5.5%). Only 5.2% of ads do not fall into one of these categories.

Comparing the patterns in numbers of ads with those in list expenditure, we see that image ads, while numerous, do not appear to target popular outlets, whereas the strength of price and phone ads increases (so much so that a full 72.0% of list expenditure is on ads that contain some kind of price). This suggests firms perceive price advertising to be an important competitive instrument in the mobile phone market.

The remaining columns in Table 6 explore the distribution of content types across plan groups and firms. Firm ads (i.e. those that do not advertise a plan) are predominantly image ads, although nearly a third do advertise a phone. Almost all PrePaid and PostPaid plan ads contain some kind of price. Many also advertise a phone, although this is more concentrated among PrePaid plans. Options ads are by definition included among Options plans, but these also often have price and/or phone information as well.

There are sharper differences in ad content across firms. While T-Mobile runs more image ads, list expenditure on image ads across the three firms is comparable. Pannon appears to aggressively advertise prices of their plans and phones relative to the other providers. One very interesting feature is that Vodafone (the new entrant) is *much* more likely to mention its rivals than are the two incumbent providers.

How advertising content vary by media? Consistent with our earlier results, image ads are more slightly prevalent on non-television media. Price ads are slightly more common on television, phone price ads are less frequently on radio, and phone ads are less common on billboards (perhaps due to a rapidly changing product set). Overall, there are no very sharp distinctions between ad types across the different media.

5.2 Dynamic Patterns of Advertising

The tables above report the patterns of average advertisements and list expenditure across the four years of our data. Further insight into how firms compete with advertising is possible looking at the pattern of their advertisements over time.

Figure 17 presents an example of the patterns in the data. Reported is the number of ads on Broadcast Television over the 208 weeks in our sample (from January 2003 to December 2006). The first three panels report the number of ads for each major mobile phone operator

and the fourth panel overlays them all. Note the difference in scale across the first three panels is reconciled in the fourth.

A number of recurring patterns are evident in Figure 17. First, there is significant heterogeneity week to week in the number of advertisements made by mobile phone operators. In particular, the data exhibit *pulsing*, alternating high and low periods of advertising activity. For Pannon in particular, there are weeks with literally no advertising adjacent to weeks with over 100 ads. Week-to-week differences of 150 or more are frequent. Second, the timing of peak advertisements may (or may not) coincide, depending on the firms involved. For example, all three firms increase their advertisements around week 100 (Christmas 2004), while (only) Pannon advertises around week 120.

Figures 18 and 19 demonstrate the time pattern of the number of ads and list expenditure by medium. Several patterns are evident. First is a data issue: as described in Section 4.1, TNS began digital collection of ads across all media in late 2003 and early 2004. A lack of ads in 2003 for some media reflects this fact. Second, pulsing is evident across all media.[29] Third, as described in Table 6, firms differ in their advertising strategies, although there is even some heterogeneity within firms over time (e.g. T-Mobile advertised heavily in radio through 2005, but stopped in 2006).

Dynamic Patterns of Advertising Content on Broadcast Television Given the similarity of the patterns in the figures measuring ads by their number versus measuring them by list expenditure, the remainder of this section presents just the first pattern. Furthermore, given the importance of the broadcast television spending from Table 2, the remaining figures focus on dynamic patterns of advertising offered only on broadcast television outlets.

What follows is a series of figures in groups of three. They present, for each of T-Mobile, Pannon, and Vodafone, patterns of advertisements broken down by a number of dimensions. The first group of three, Figures 20-22, report for each firm the total number of ads (in blue) and the number of ads broken down by Plan Group (in red): Firm Ads, PrePaid Ads, PostPaid Ads, and Options Ads. It is the analog of Table 4, albeit for broadcast television only.

We like these figures (and the six to follow) as they provide a deeper appreciation of the nature of firms' advertising decisions. They suggest to us that the blue (aggregate) figure measuring the total number of ads (or, analogously, total consumers reached by ads) commonly used in empirical research on the effects of advertising may mask important variation among the types of ads chosen by firms.

[29] For some media, this is an artifact of the frequency with which certain media are published (e.g. newspapers, magazines) or the standard length of advertising contracts (e.g. billboards).

Several patterns in these figures suggest this conclusion. First, while the aggregate number of ads for all the firms show significant variability, there does not appear to be an (at least obviously) regular pattern to advertising decisions.[30] Breaking the data into plan types, however, begins to reveal such patterns, at least for some plan types (e.g. T-Mobile advertising of PostPaid ads, all types of Pannon ads, and Vodafone advertising of Firm and Options ads). Second, it suggests that some of the very high peaks in the data for total ads (e.g. around week 80 in the T-Mobile series) may reflect the simultaneous high production of ads of different types (e.g. Firm ads and PostPaid ads).[31] To the extent that these ads have different purposes (making consumers aware of a change in the overall brand versus advertising a particular PostPaid plan), it seems important to understand the differential content of the ads to better measure their distinctive impacts.

Figures 23-25 produce similar figures for the three firms, this time broken down by the information content in the ads. The types of content reported are, in the order presented, Image Ads, All Price Ads, Price Ads for Plans, Price Ads for Phones, Phone Ads, Options Ads, Rivals Ads, and Other Ads. Table 11 reports the share of ads of each of these types in the broadcast television data. Here too we see the decomposition of ads by their information content is important. Price and Phone Ads (panels 2-5 in each figure) dominate television advertising across firms, although Options Ads appear important for T-Mobile and Vodafone. Vodafone advertises about the other providers more than the reverse, and did so quite heavily at the time of T-Mobile's name change.

Given the importance of price ads in the broadcast television medium, the next (and last) set of figures examines these ads more closely. In particular, we broke out each of the two main types of price ads into further components. For price ads for plans, we investigated whether they advertised per-minute prices, the monthly fee and/or free minutes, prices for options (e.g. SMS, roaming), and whether the ad promised an initial discount on the plan. For price ads for phones, we investigated whether the ad advertised the price of the phone itself or whether it promised a discount on the phone. Table 11 also reports the share of these types of ads by firm in the broadcast television data.

Figures 26-28 report the patterns in the price ad data. In each panel is reported the total number of ads for that firm (in blue), the total number of plan or phone price ads (as relevant) for that firm (in red), and the number of disaggregate price ads of each type above (in green). Thus the first panel of Figure 26 reports the total number of T-Mobile ads, the number of T-Mobile price ads that advertise information about a plan, and (finally) the number of those price ads that advertise information about the per-minute price(s) offered on that plan. Among plan price ads, most do advertise information about per-minute prices,

[30] Much of what we show here is suggestive. In subsequent work, we will perform more detailed analyses of the time pattern of advertising of various types, its differential (complementary?) impact on demand among alternative market segments, and the strategic nature of competition in advertising of differing types.

[31] Note that week 80 corresponds roughly to the period when T-Mobile changed its name from Westel.

although there are significant numbers of ads about other price features.

Note that as one gets more disaggregate about the information content in particular advertisements, the data become more granular and the "standard" image of pulse advertising on a regular basis becomes more evident. Table 8 confirms this view. It measures the share of weeks that each firm provides *zero* ads of a particular type. Across all weeks (in the Broadcast Television data), T-Mobile and Vodafone are advertising every week and Pannon is only not advertising in 6.3% of weeks. But these ads are of many different types. Breaking down the ads by type shows much more frequent breaks in advertisements. While not offering any price ads is still quite infrequent, even this conclusion wavers when breaking those down into smaller information categories.

Why might this matter? Existing economic theory on the impacts of advertising emphasize the presence of both threshold effects and diminishing returns to advertising. This rationalizes pulsing behavior (e.g. Dube, Hitsch, and Manchanda (2005)). The literature is less well developed on optimal advertising behavior in the presence of multiple products (as in the mobile phone market) and multiple competitors. Failing to disaggregate the content of individual ads into their constituent information provided can lead to a mis-understanding of the nature of optimal advertising in a competitive environment.

Tables 9 and 10 demonstrate the potential problems. Table 9 reports for each firm the results of a regression of the number of its ads on lags of various orders. It does this for three different dependent variables: All (broadcast TV) ads, All price ads for plans, and Per-minute plan price ads. The table demonstrates that across all ad measures, there is strong positive correlation between ads and ads lagged one week and fairly robust negative correlation between ads and ads lagged two weeks. No further effects are noticeable for all television ads. Digging deeper, however, begins to reveal further patterns. If one analyzes just price ads for plans, there appears to be a regular time pattern at around 5 weeks for Pannon. Digging deeper still (into per-minute price ads) suggests the same 5-week bump for Pannon, but also possibly a 3-week bump, as well as 5 and 4-week bumps for T-Mobile and Vodafone.[32] Analyzing ads at an aggregate level would miss these patterns, and thus prevent an understanding of demand and firm behavior in these markets.

Whereas the Table 9 examined the correlation in the number of ads within a firm across time Table 10 examines the *synchronicity* of (contemporaneous) ads across firms. It reports the results of Seemingly Unrelated Regressions (SURs) of each firms number of ads on those of its two rivals, both for all ads as well as for alternative categories of advertising content. Very different pictures emerge depending on the level of advertising content aggregation. Among all (broadcast TV) ads, those for the two market leaders, T-Mobile and Pannon, negatively co-vary, while Vodafone's positively co-vary with each. Absent further information

[32]Examining the time patterns from the first panel in Figures 26-28 provides some intuition about where these results are coming from.

about advertising content, this would suggest the market leaders produced asynchronous campaigns, with the new entrant ignoring this pattern and advertising throughout the period. A very different set of patterns emerges, however, when breaking ads down by their content. Depending on the ad type and the firms involved, many other patterns appear (e.g. synchronous advertising about phones and phone prices among T-Mobile and Pannon, with both asynchronous with Vodafone, etc.).

6 Price data

Our final dataset reports the prices charged for mobile phone plans. Mobile phone plans are notorious about the complicated pricing schemes. In Hungary, service providers are obliged by law to submit changes in their conditions of general contracts to the National Communications Authority of Hungary a month in advance. These include changes in pricing schedules. From these documents we have collected the most important prices for the major pre-paid plans for each firm. We have the peak and off-peak prices by directions, prices of short message service (SMS) and multimedia message services (MMS), the time of the off-peak period, and pricing units. We also observe prices for plans (and phones) from our advertising data. Figure 29 reports reported and advertised prices for each of the major firms in the market over the weeks in our sample. While there is only modest variation in the prices reported to the NHH over time, comparing the patterns of posted and advertised prices (naturally) suggests they elect to advertise only their lowest prices. In the analysis of demand conducted in the next section, we use the posted prices due to their consistent reporting across time.

7 Impact of Advertising Content on Outcomes in the Hungarian Mobile Phone Market

7.1 Demand for mobile phone pre-paid plans

In this section, we look at the quantitative effects of different advertising content on consumer demand for mobil phone pre-paid plans. It is a quite complicated task because of the intrinsic characteristics of mobile phones and advertising. Mobile phones are durable products, their pricing structure is quite complicated and the actual marginal price paid by the consumer depends on the consumers' calling patterns. Furthermore advertising and advertising content depends on managerial decisions and so, like prices, they could be correlated with unobserved demand shocks (i.e. demand is higher around Christmas so firms advertise more and not vice versa.) These correlation could bias our OLS (ordinary least square) estimates. Further complications arise as the effect of advertising in not necessarily

simultaneous; ads can affect future demand as well. In most of our current specifications we abstract from these dynamic effects and look only at short run, direct effects of advertisements. A fully dynamic model of course could change our results.

The logit demand specification is a relatively simple discrete-choice model in which an individual consumer consumes one unit of a brand that yields the highest utility. In this application, consumers $i = 1, ..., I_t$ maximize her indirect utility by purchasing a mobile phone pre-paid card from a service provider $j = 0, 1, 2, 3$ in $t = 1, ...T$ time period. $j = 0$ indicates the outside option, which in this case is defined as all the other potential communication device (i.e. post-paid mobile phone plans, fixed line, internet etc.). The conditional indirect utility function of consumer i from choosing service provider j's pre-paid service plan is:

$$u_{ijt} = \delta_{jt} + \epsilon_{ijt} = p_{jt}\alpha + x_{jt}\beta + \xi_{jt} + \epsilon_{ijt},$$

where p_{jt} represents the minute price paid by the consumer, x_{jt} is a vector of observed plan characteristics, in our case different types of advertising, ξ_{jt} represents plan characteristics that are unobserved to the econometrician (depicted as mean across consumers and independent across plans), ϵ_{ijt} is a random disturbance with zero mean, identically and independently distributed across consumers and choices, and $\theta_D = (\alpha, \beta)$ is the vector of mean level of taste parameters to be estimated. Note that the parameters of the utility function do not depend on individual i's characteristics. Assume that variation in consumers' taste enters only through the additive term ϵ_{ijt}. Consumers maximize their utility and choose plan j whenever it gives them the highest utility, i.e. $U(p_{jt}, x_{jt}, \xi_{jt}, \epsilon_{ijt}; \theta_D) \geq U(p_{lt}, x_{lt}, \xi_{lt}, \epsilon_{ijt}; \theta_D)$ for all $l \neq j$. The closed form solution of the multinomial logit model (assuming that the unobservables' distribution is a type-I extreme value) is the following:

$$s_{jt}(\delta_t) = \frac{\exp(\delta_{jt})}{\sum_{r=0}^{3} \exp(\delta_{rt})}, \qquad j = 1, 2, 3.$$

The logit model has its well-known problems. It restricts consumers to substitute towards other brands in portion to market shares regardless of the characteristics. Moreover if the share of the outside good is too large it also biases the substitution to the inside goods downwards. Unfortunately, currently data limitations prevent us from the application of more flexible models but for our purposes, to distinguish between the effects of different type of advertising, these problems perhaps not as serious. The share of the outside good is fairly small, the number of mobile phone service providers is quite limited and there are no huge quality differences among them so it seems not too unreasonable that the market share drives the substitution patterns.

7.2 Estimation and Results

In a discrete choice setting prices and the unobserved product characteristics enter demand equations in a nonlinear way that makes the application of instrumental variables method cumbersome. Berry (1994) proposes an estimation procedure, which avoids this problem by transforming the equation so that the parameters enter the objective function linearly. The standard logit demand equation will have the following form for demand (normalizing the mean utility of the 0th outside good to zero):

$$ln\left(S_{jt}\right) - ln\left(S_{0t}\right) = \delta_{jt} = \ln(p_{jt})\alpha + \ln(1 + x_{jt})\beta + \xi_{jt},$$

where S_{jt} is the observed market share of plan j at time t, S_{0t} is the observed market share of the outside good, and prices and advertising are in logarithms. One can estimate these equations by simple ordinary least square regressions. The prices and advertising are potentially endogenous but a standard linear instrumental variable (IV) method can be used to avoid this problem. In this application we used a general method of moments (GMM) estimator. The standard IV and two-stage least square (2SLS) estimators are special cases of the GMM estimator. We use the feasible efficient two-step GMM estimator implemented in the ivreg2 Stata command when the gmm option is used. The 2SLS can be considered as a GMM estimator with a suboptimal weighting matrix when errors are not i.i.d. This GMM estimation also generates heteroscedasticity-robust standard errors.

Because of the lack of data we use lagged values as instrument for both prices and advertising. Lagged values are valid instruments as long as there is some autocorrelation in the advertising and pricing decisions (as is likely) but lagged prices and ads are do not depend on current demand shocks. The relevant tests check whether the correlation between the IVs and the endogenous variables are strong enough to have explanatory power while the overidentification tests check (among other things) if the IVs are uncorrelated with the error term (the unobserved demand shocks.) We have tested the overidentifying restrictions and the relevance of the instruments with the Shea partial R^2 measure, first stage F, and Anderson statistics and the Hansen J-test. These tests are part of the standard output of ivreg2 command in Stata and their detailed description can be found for example in Baum (2006.)

Table 8 reports the estimated logit demand functions with prices and advertising using both OLS and instrumental variables We use the number of pre-paid plan advertisements as a measure of advertising. Model 1 reports the result of a simple OLS estimation without time dummies. Estimated price and advertising parameters are significant and but small in magnituted moreover the advertising has negative sign. This is probably because of endogeneity problems. The significant Vodafone and Pannon dummy could indicate T-mobile advantage of being part of a firm that offers fixed-line service as well, and in case

of Vodafone it indicates the first mover advantage of the other two firms. By including time dummies in Model 2 the price parameter increases in absolute value and becomes more significant but the advertising variable still has the negative sign. In Model 3 we use instrumental variables. The price parameter is significant and the advertising parameter still has insignificant negative sign. Unfortunately we have only lagged values available as instruments and they seem not to work very well for the advertising variable. Even though the Hansen J-test indicates that the null hypothesis of correct model specification and valid overidentificating restrictions cannot be rejected both the F statistics of the first stage advertising regression (1.1) and the Shea partial R^2 measure indicates that our instruments are not relevant. In Model 4 and 5 we directly included lagged advertising variables. Since advertisement decision are typically made in advance we included the 6-9 months lagged values of the our advertisement variable. It seems to work. All of them has positive sign and most of them are significant. In Model 5 we include a cross-product of advertising and price variables to look at the effect of advertising on price elasticity. We find that higher number of ads not only increase demand but also decreases the price elasticity. Here again the instruments are not so strong (F statistics 3.14) but at least at 5% level we cannot reject that they are relevant. The price parameters are still relatively small in absolute value. This could be cause by the difference between short run and long run substitution. In the long run substitution effect is much bigger since in the short run switching costs (both physical like loyalty agreements and monetary cost and mental such as lack of information, habit, procrastination) may prevent or delay the switching to another product. Our current specification can only pick up the short run substitution effect that is fairly low.

In Table 8 we look at the advertising by the different content measures. Model 6 ,8, 10 and 11 reports results of an OLS estimation while in Model 7 and 9 we instrumented both the price and advertising variables. In Model 6 and 7 we use the minute price ads as our measure of advertising. Price advert in both specification have a significant and postive direct effect on market shares but at the same time they increase the price elasticity of consumers. This can be interpreted the price adverts by informing consumers actually decreases the switching cost and encourage consumers to switch. As previously we have problems with the instruments´ relevance that show up in small first stage F statistics but here we cannot reject the null not even at 1% level. In Model 8 and 9, surprisingly, we find similar results for image ads as well but here unfortunately we have serious problems with the overidentification test. The Hansen J statistics indicates that endogeneity is still a problem. In Model 10 and 11 we look at the effects of price and image adverts jointly and in model 11 we also control for the total number of ads. We do not find the expected difference between price and image ads.

8 Conclusion and Avenues for Future Research

This paper documents the informational content of advertisements and conducts some preliminary analyses of their economic effects in the Hungarian mobile phone market. To do so, we collected detailed information on both household use of mobile phones and service plans and every advertisement produced by the major providers of Hungarian mobile phone service between 2003 and 2006. We measured the informational content of each ad and examined how ads varied by content type, firm, and time. We find that most ads are either price or phone ads (or both) and that firms differ in their advertising strategies across plans, media, and time. We further find that decomposing ads by their informational content is important, both for understanding the nature of strategic interaction (e.g. synchronous versus asynchronous pulsing) as well as the impact of ads of different types on demand. Price and image ads, for example, are (alone) estimated to increase the elasticity of demand, suggesting they (but not all ads) promote competition in the Hungarian mobile phone market.

In the many figures and tables we have presented here, we have tried to convey the richness of the data (especially the advertising data) we have collected for this project. The final section just begins to go beyond mere correlations to understand the nature of advertising content's role in demand.

Considerable further analysis is possible. On the demand side, understanding the dynamic nature of consumer purchase decisions and the impact of advertising of different types on those decisions is necessary. Mobile phones and service plans are similar to durable goods in their long-lasting nature and suggest an analysis that incorporates switching costs and the dynamic influence of repeated advertising exposure. Regardless of the specific framework, assessing what is the appropriate level of information disaggregation, measuring its effects on demand (both for targeted and adjacent products), and measuring the complementarity of advertising and pricing decisions (and the level of the advertised price) are all of interest.

On the supply side, the introduction of advertising of various content suggests a much richer view of the product, pricing, and strategic decisions of firms. Do, as the raw data and common sense suggest, firms target advertising of particular types to particular market segments? Can this supplement demand-side information used to identify those segments? Do firms have competitive advantages in particular strategies (low-price?, innovative?) and how does advertising complement these strategies? Our results above suggest price advertising does enhance competition - does this result hold up with a more detailed supply-side analysis?

Finally, what is the appropriate role for a competition authority in a market (like this one) with large number of products, a dynamic, technologically innovative marketplace, are interesting supply-side questions. Merger of mobile phone service providers have recently

been frequent and often contentious. Does increased concentration enhance the possibility of collusion? Can the methods of (e.g.) Gasmi, Laffont, and Vuong (1992) be adapted to advertising of different content? We look forward to exploring these questions in future work.

Figure 16: TNS Content Interface

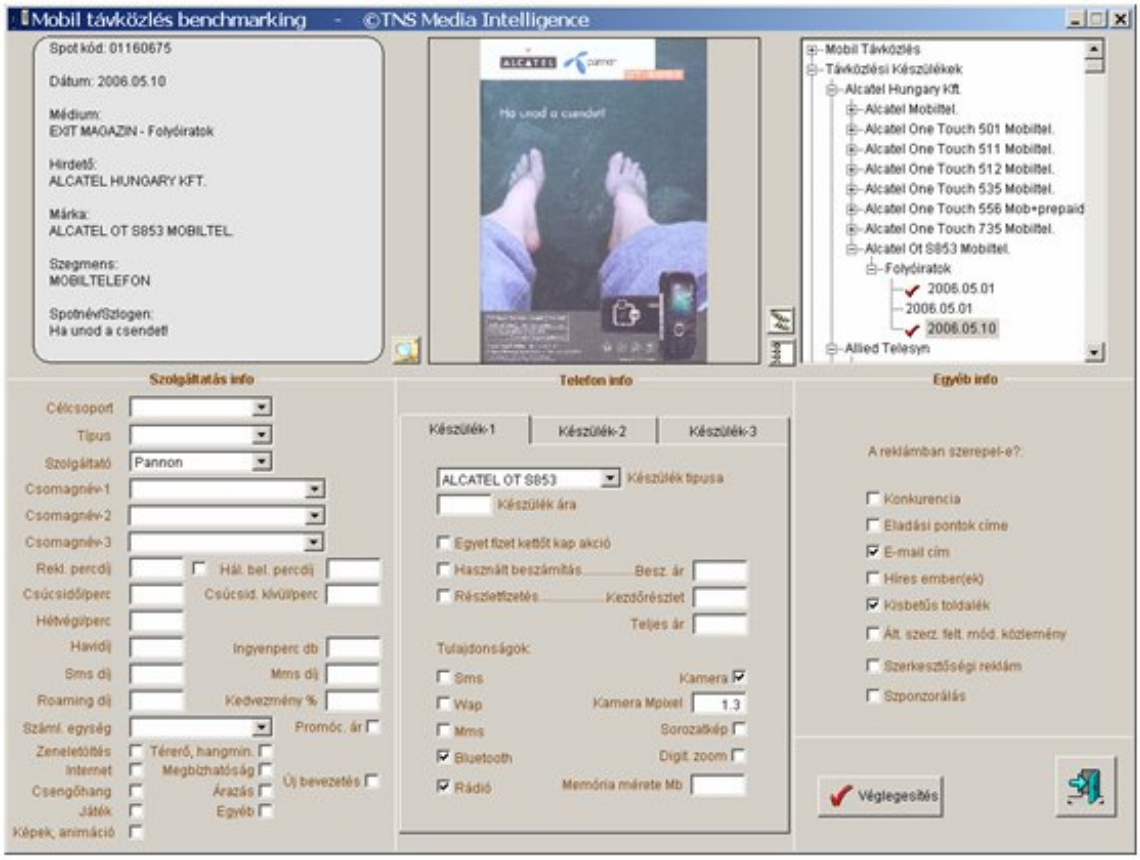


Figure 17: Number of Broadcast Television Ads Over Time by Firm

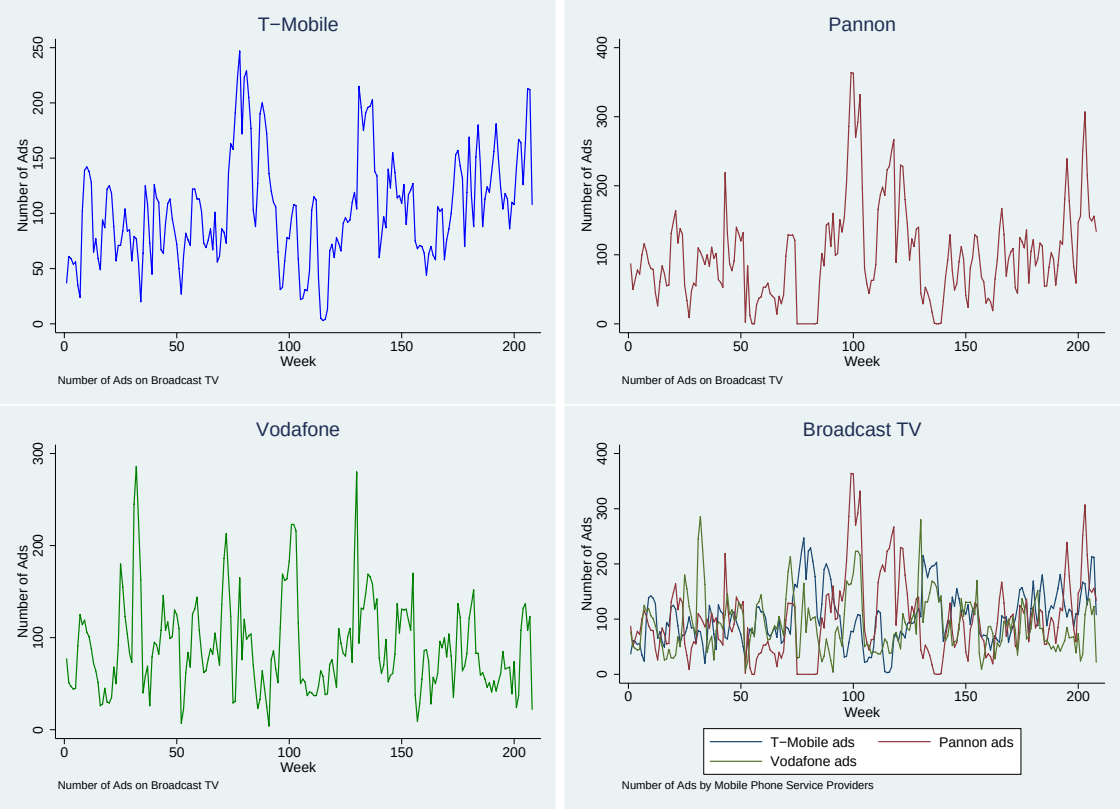


Figure 18: Number of Ads Over Time, by Firm and Medium

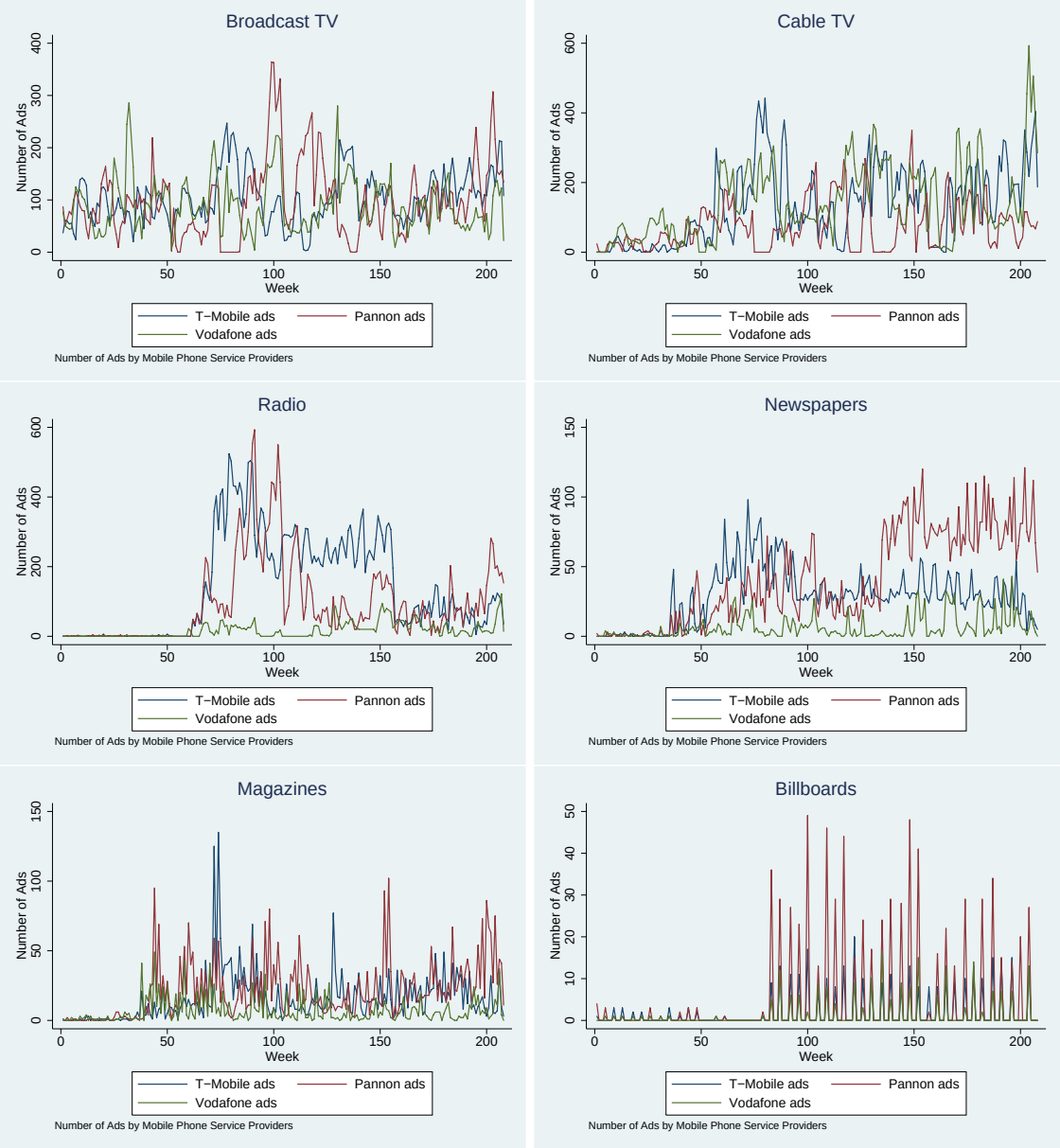


Figure 19: List Expenditure Over Time, by Firm and Medium

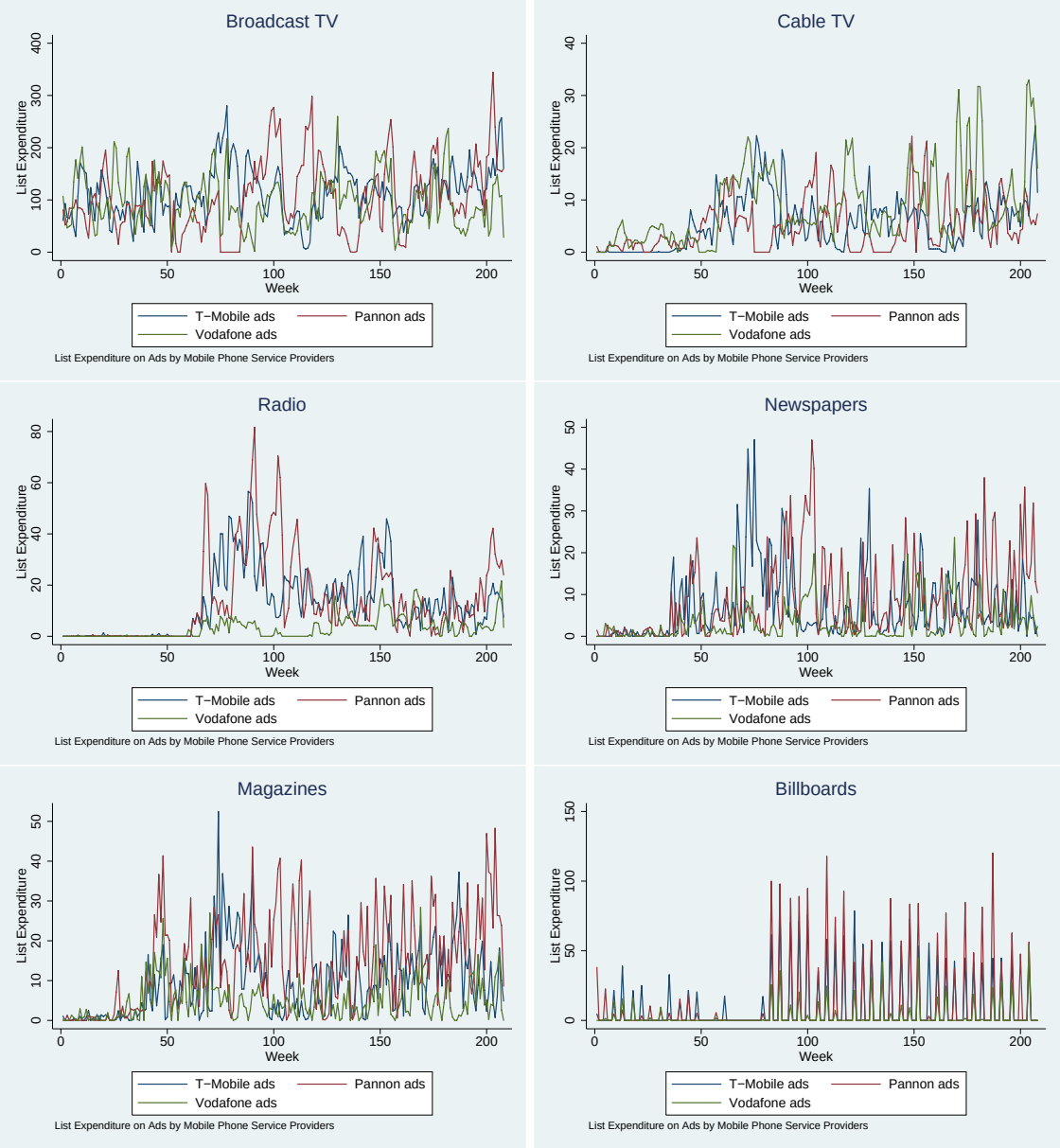


Figure 20: T-Mobile Numads by PlanGroup

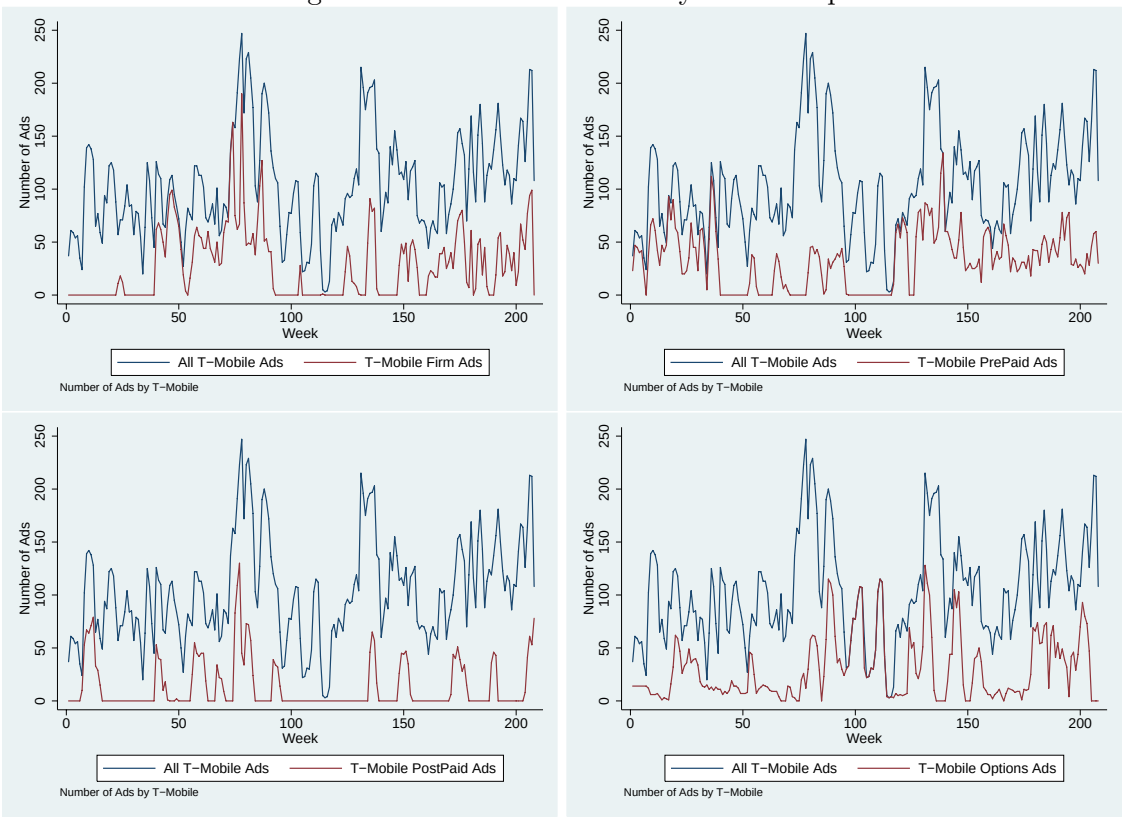


Figure 21: Pannon Numads by PlanGroup

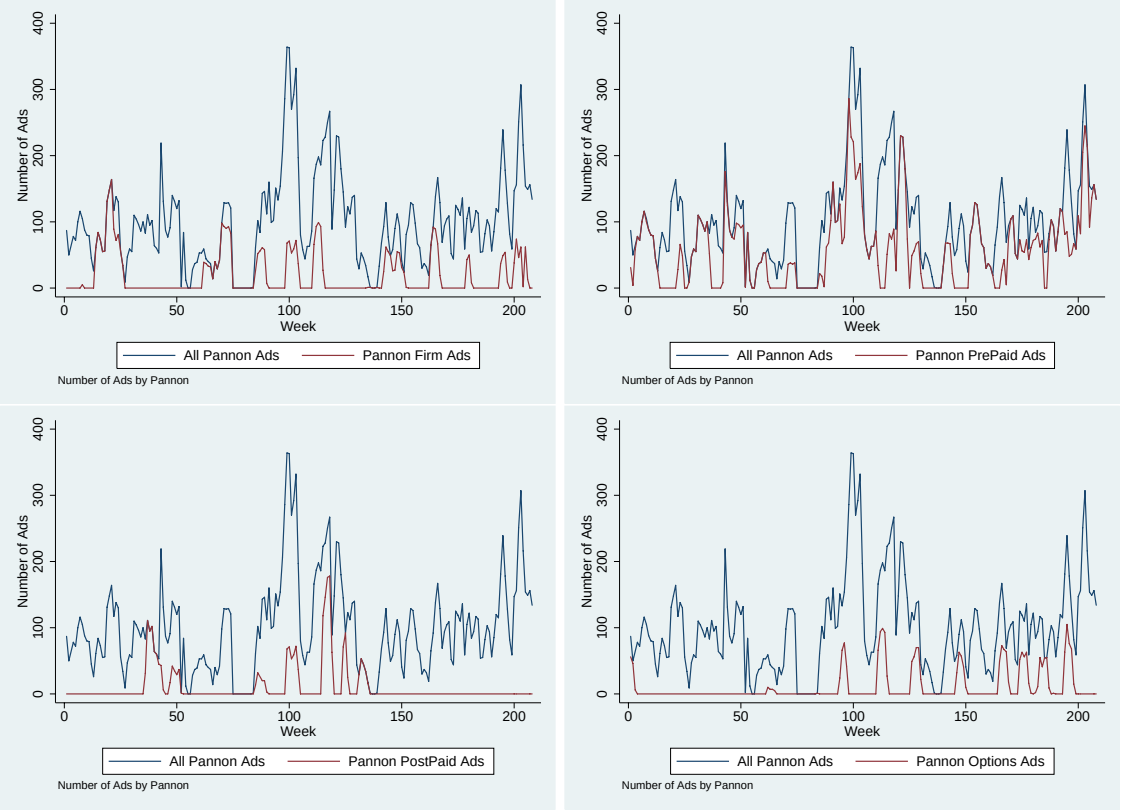


Figure 22: Vodafone Numads by PlanGroup

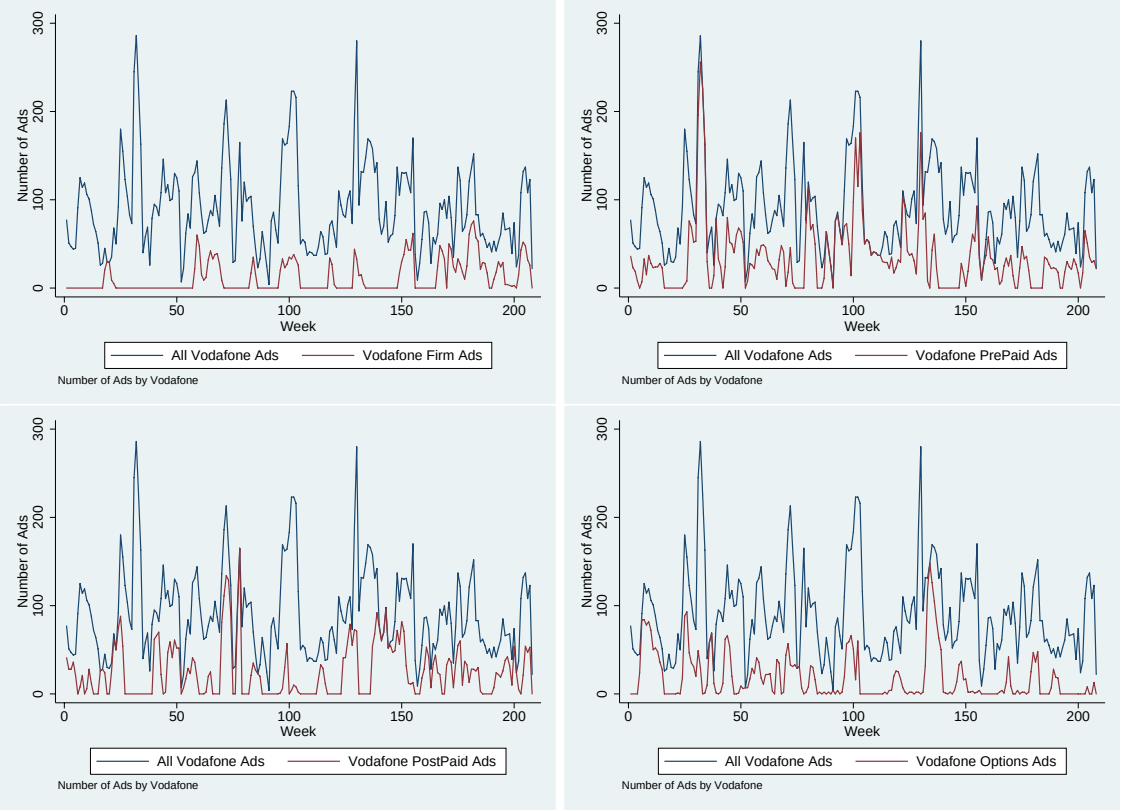


Table 2: Ads by Medium, Number of Observations and List Expenditure

	Based on Number of Observations		**Based on List Expenditure**	
Medium	**Number of Observations**	**Observation Share**	**Expenditure (mill. Forint)**	**Expenditure Share**
Broadcast TV	61,106	28.7	66,235	72.8
Cable TV	72,263	34.0	4,055	4.5
Radio	53,019	24.9	6,244	6.9
Newspapers	15,746	7.4	4,032	4.4
Magazines	9,030	4.3	5,952	6.5
Billboards	1,325	0.6	4,496	4.9
Other	135	0.1	22	0.0
Total	212,624	100.0	91,036	100.0

Figure 23: T-Mobile Numads by Content Type

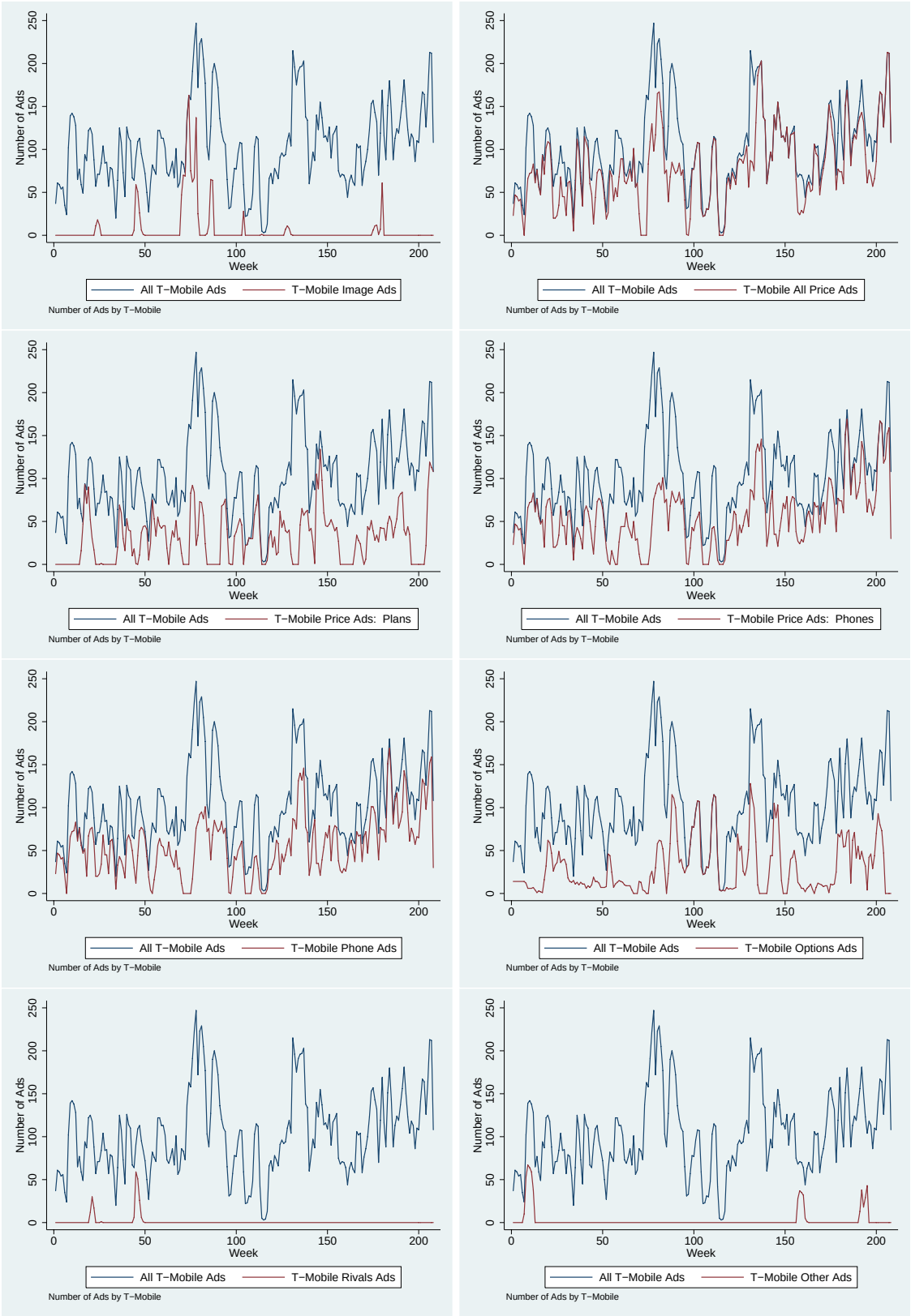


Figure 24: Pannon Numads by Content Type

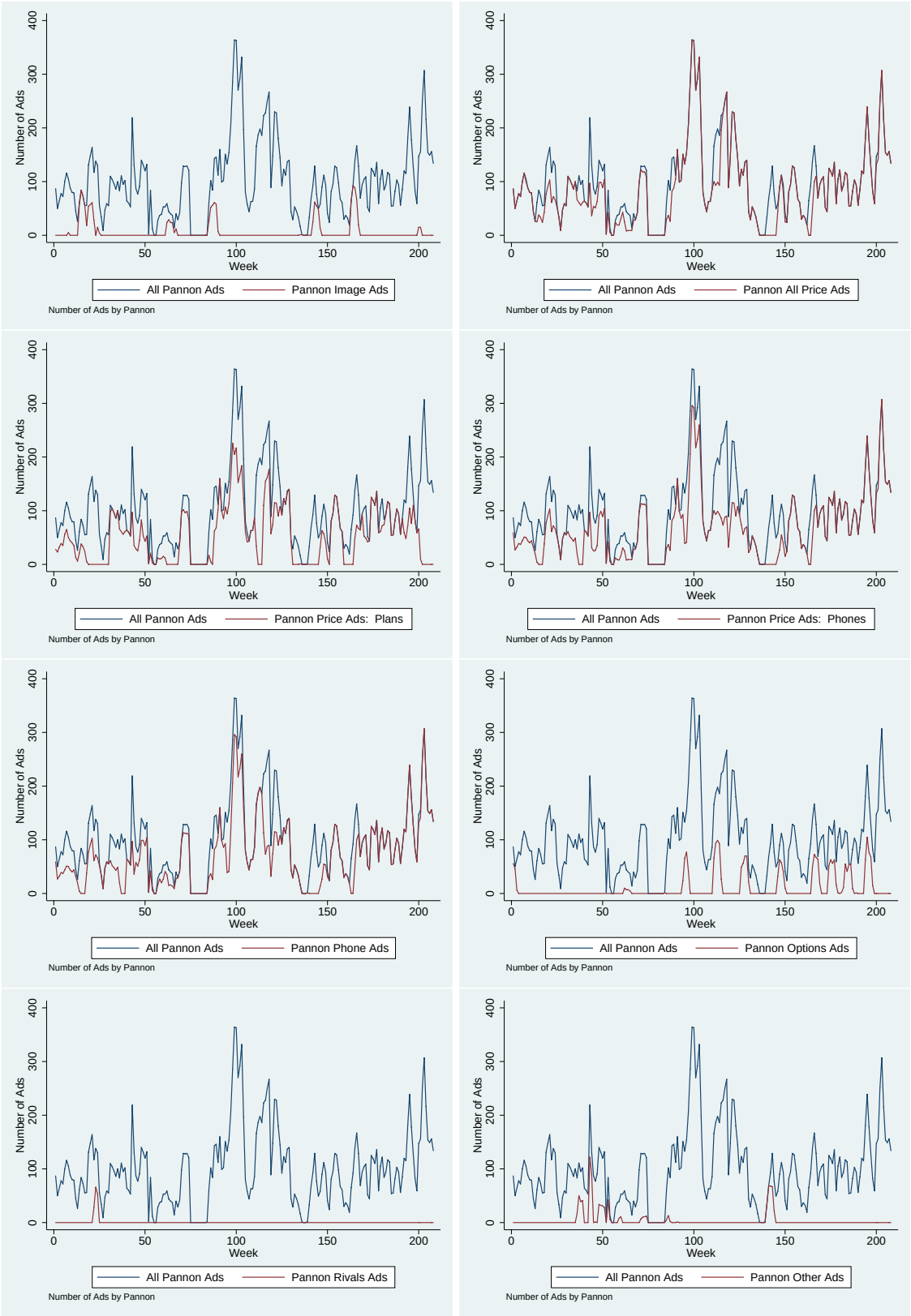


Figure 25: Vodafone Numads by Content Type

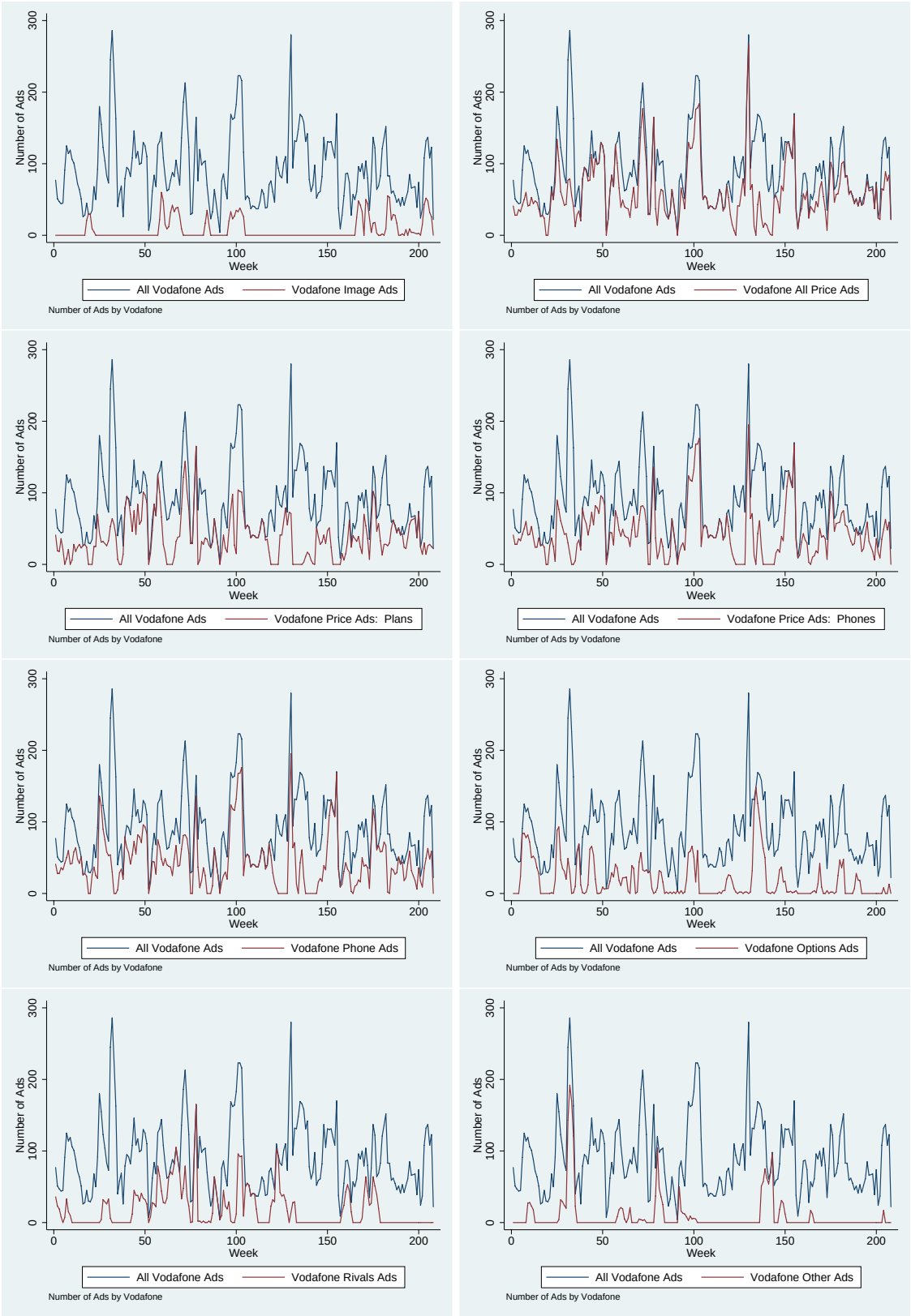


Figure 26: T-Mobile Numads by Price-Ad Content Type

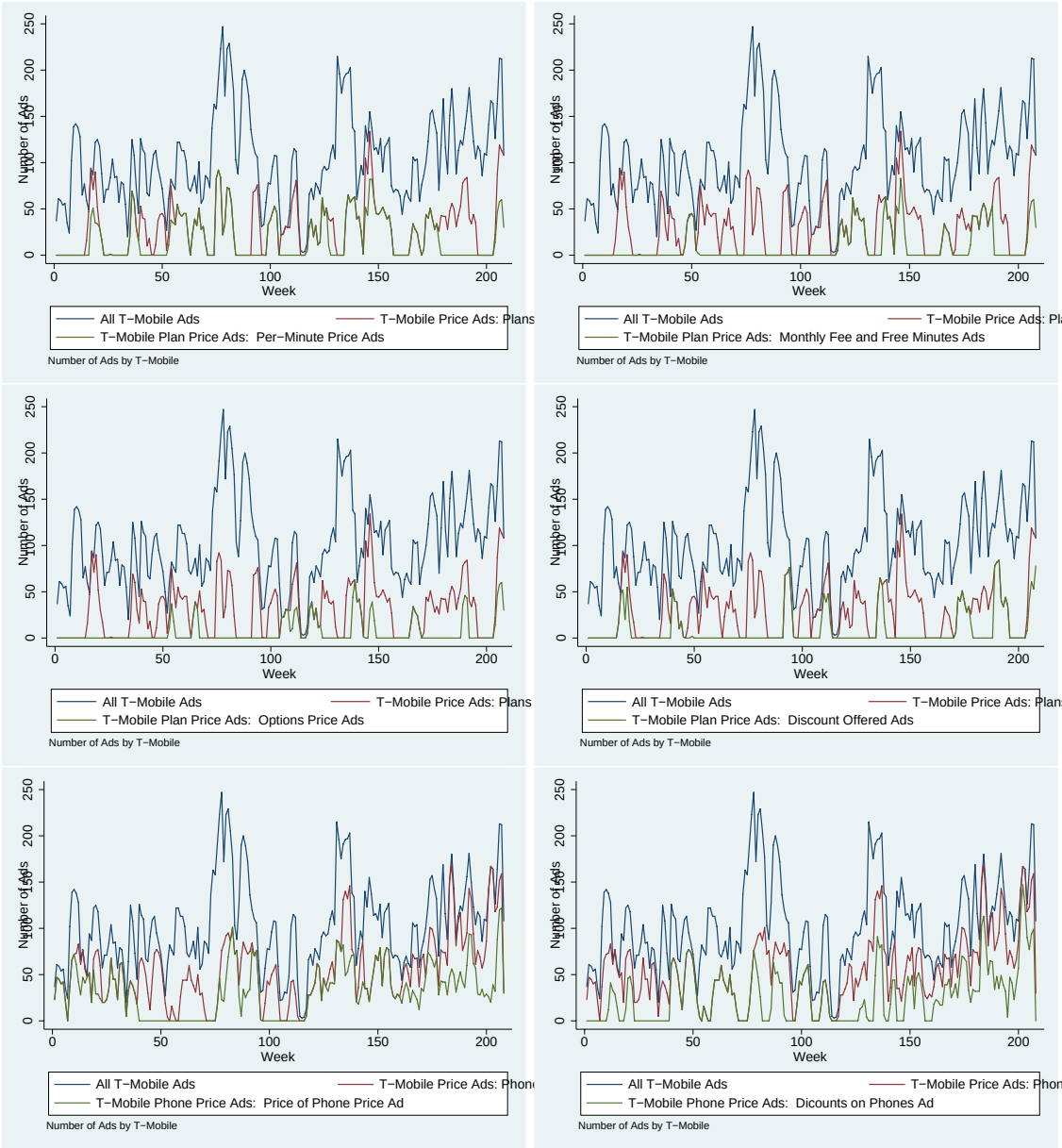


Figure 27: Pannon Numads by Price-Ad Content Type

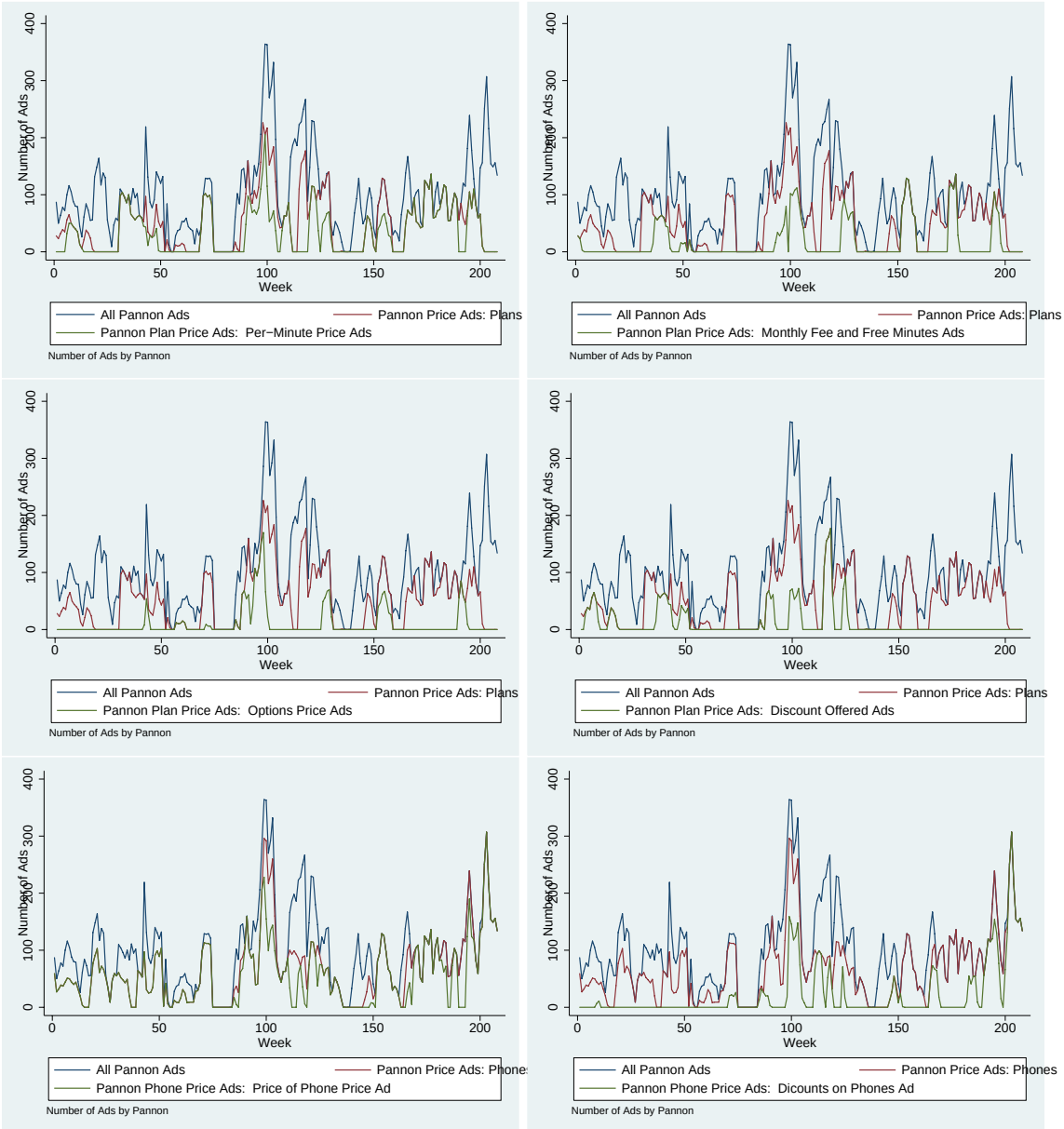


Figure 28: Vodafone Numads by Price-Ad Content Type

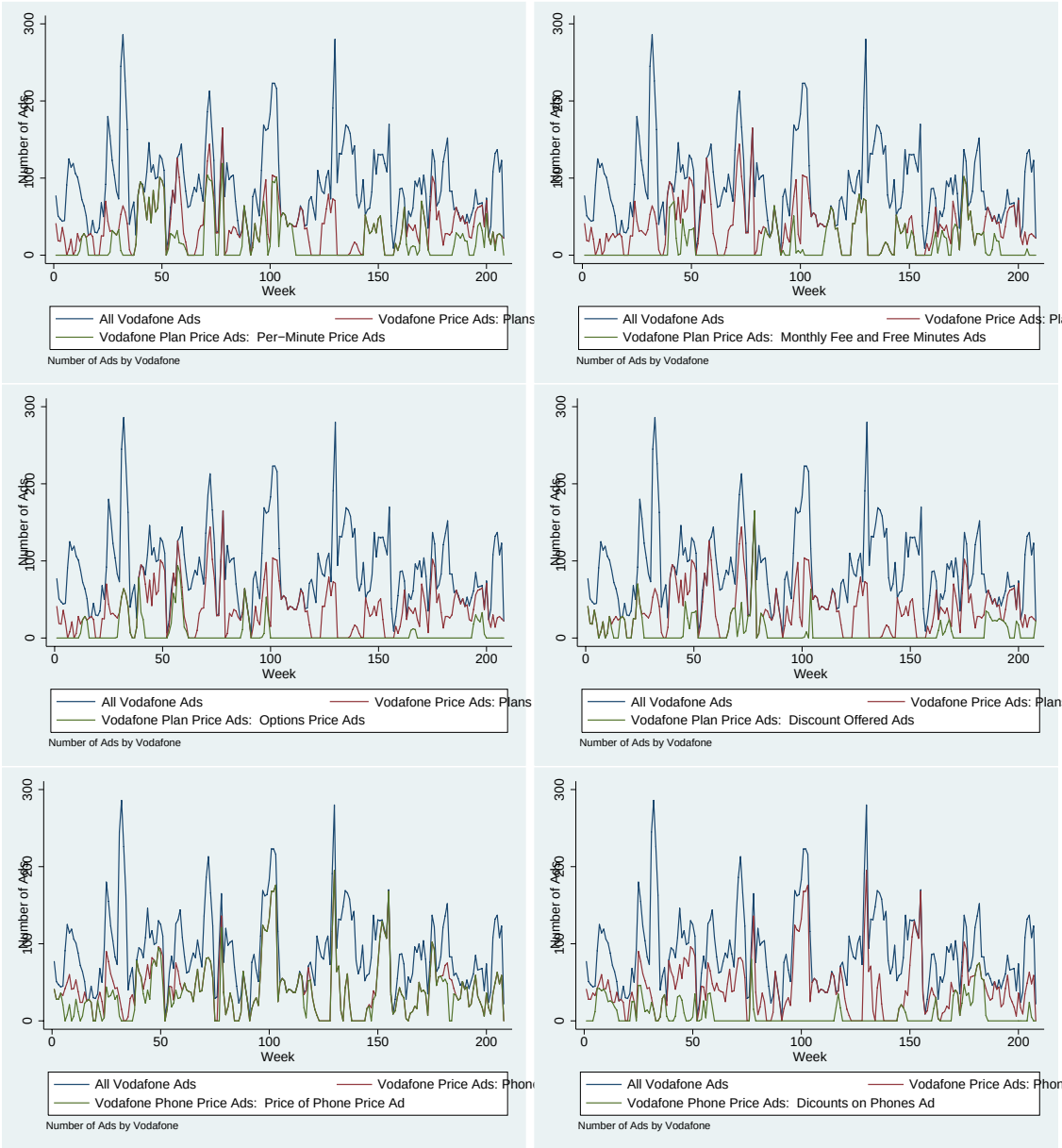


Figure 29: Per-Minute Calling Prices by Firm

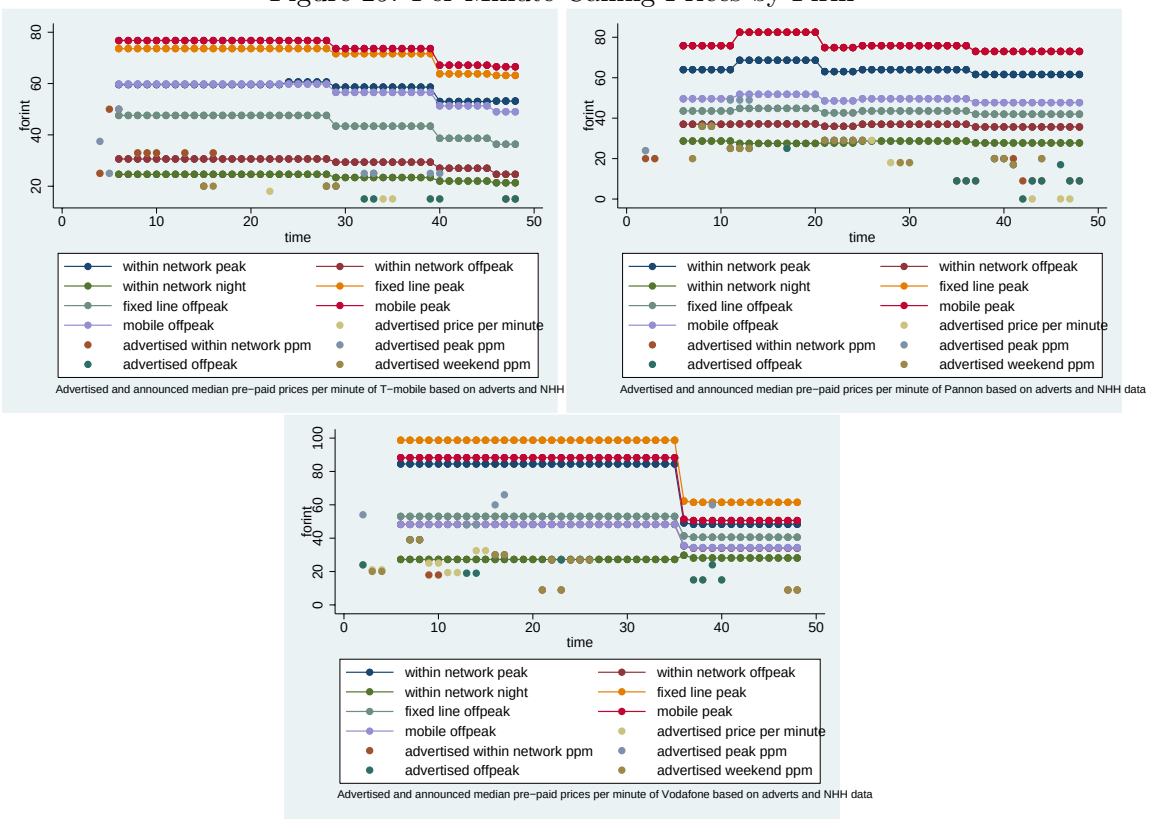


Table 3: Ads by Plan Type and Medium

Plan Type	**All Ads**	**Broadcast TV**	**Cable TV**	**Radio**	**News**	**Mags**	**Billboards**
Based on Number of Observations							
Firm	28.7	20.1	23.6	32.5	70.9	34.5	15.6
Prepaid	35.2	43.0	36.8	31.2	11.6	32.3	45.4
Postpaid	13.1	16.7	18.1	5.1	5.3	10.0	12.8
Options	23.0	20.2	21.5	31.3	12.3	23.3	26.3
NumObs	212,624	61,106	72,263	53,019	15,746	9,030	1,325
Based on List Expenditure							
Firm	19.8	18.6	22.0	25.8	32.0	20.7	15.8
Prepaid	41.6	43.2	40.1	38.6	30.8	34.1	44.0
Postpaid	16.3	17.1	18.0	7.4	14.3	17.0	14.1
Options	22.4	21.3	19.7	28.2	23.0	28.2	26.2
ListExpn	91,000	66,200	4,060	6,240	4,030	5,950	4,500

Table 4: Ads by Firm and Plan Type

Firm	**All Ads**	**Firm Ads**	**PrePaid Ads**	**PostPaid Ads**	**Options Ads**
			Based on Number of Observations		
T-Mobile	41.5	52.6	27.3	31.0	55.5
Pannon	32.9	31.4	46.4	19.9	21.3
Vodafone	25.6	16.0	26.3	49.1	23.1
NumObs	212,624	61,108	74,737	27,879	48,900
			Based on List Expenditure		
T-Mobile	35.8	44.7	27.4	30.3	47.9
Pannon	36.5	31.9	49.9	21.7	26.0
Vodafone	27.4	23.3	22.5	47.8	26.2
ListExpn	91,000	18,000	37,900	14,800	20,400

Table 5: Ads by Plan Type and Medium

Plan Type	All Ads	Broadcast TV	Cable TV	Radio	News	Mags	Billboards
Based on Number of Observations							
T-Mobile	41.5	35.3	38.2	55.7	37.8	35.9	25.1
Pannon	32.9	33.9	21.5	37.6	54.1	48.4	59.1
Vodafone	25.6	30.8	40.3	6.7	8.2	15.8	15.8
NumObs	212,624	61,106	72,263	53,019	15,746	9,030	1,325
Based on List Expenditure							
T-Mobile	35.8	35.8	29.3	42.1	37.0	32.6	39.6
Pannon	36.5	33.5	25.4	47.0	45.4	50.1	48.0
Vodafone	27.4	30.7	45.1	11.0	17.5	17.3	12.4
NumObs	91,000	66,200	4,060	6,240	4,030	5,950	4,500

Table 6: Ads by Content Type, Plan Group, and Firm

Content Type	All Ads	Firm Ads	PrePaid Ads	PostPaid Ads	Options Ads	T-Mobile	Pannon	Vodafone
				Based on Number of Observations				
Image Ad	18.0	62.6	0.0	0.0	0.0	20.7	19.1	12.2
Any Price Ad	61.4	37.9	80.9	90.5	44.4	57.7	64.4	63.7
Price Ad: Plan	33.3	3.1	46.9	75.8	25.9	23.4	41.1	39.2
Price Ad: Phone	44.7	37.0	66.7	36.8	25.4	39.5	50.8	45.5
Phone Ad	47.3	37.4	71.1	37.0	29.1	40.0	57.1	46.5
Options Ad	23.0	0.0	0.0	0.0	100.0	30.7	14.9	20.8
Rivals Ad	5.5	3.7	10.2	5.1	1.0	0.5	0.3	20.4
Other Ad	5.2	0.0	11.6	8.3	0.0	1.7	7.2	8.0
NumObs	212,624	61,108	74,737	27,879	48,900	88,328	69,863	54,433
				Based on List Expenditure				
Image Ad	10.5	53.3	0.0	0.0	0.0	10.8	9.5	11.5
Any Price Ad	72.0	48.5	86.4	90.2	52.9	71.8	78.8	63.2
Price Ad: Plan	44.5	6.2	55.4	76.8	34.9	36.6	54.0	42.4
Price Ad: Phone	50.2	46.6	67.4	37.3	30.8	43.9	62.3	42.4
Phone Ad	52.1	46.7	69.4	37.8	34.9	43.4	66.5	44.2
Options Ad	22.4	0.0	0.0	0.0	100.0	29.9	16.0	21.2
Rivals Ad	6.3	6.6	9.6	4.7	1.2	1.1	0.3	21.1
Other Ad	5.1	0.0	8.7	9.1	0.0	2.4	5.7	7.6
ListExpn	91,000	18,000	37,900	14,800	20,400	32,564	33,188	24,891

Table 7: Ads by Content Type and Medium

Plan Type	All Ads	Broadcast TV	Cable TV	Radio	News	Mags	Billboards
			Based on Number of Observations				
Image Ad	18.0	7.2	9.3	25.1	68.8	30.7	13.4
Any Price Ad	61.4	76.4	72.2	43.3	21.8	48.0	72.9
Price Ad: Plan	33.3	41.0	40.3	20.9	12.4	30.2	55.6
Price Ad: Phone	44.7	57.0	49.8	34.3	16.1	34.0	38.0
Phone Ad	47.3	58.9	54.1	35.7	16.3	37.9	36.8
Options Ad	23.0	20.2	21.5	31.3	12.3	23.3	26.3
Rivals Ad	5.5	7.0	9.4	0.3	1.7	2.9	0.1
Other Ad	5.2	5.5	4.5	5.8	3.0	7.5	5.8
NumObs	212,624	61,106	72,263	53,019	15,746	9,030	1,325
			Based on List Expenditure				
Image Ad	10.5	8.4	11.6	15.8	26.7	14.9	13.4
Any Price Ad	72.0	74.2	69.0	57.4	60.9	67.9	77.2
Price Ad: Plan	44.5	45.7	45.1	28.7	35.3	43.9	58.4
Price Ad: Phone	50.2	52.2	46.9	45.3	47.5	47.2	36.8
Phone Ad	52.1	53.9	51.8	48.2	48.5	50.6	35.9
Options Ad	22.4	21.2	19.7	28.2	22.9	28.3	26.2
Rivals Ad	6.3	7.3	11.6	1.0	4.6	3.1	0.0
Other Ad	5.1	5.2	4.3	5.2	3.9	5.3	4.2
ListExpn	91,000	66,200	4,060	6,240	4,030	5,950	4,500

Table 8: Share of Weeks with Zero Ads, by Content Type and Firm

Content Type	**T-Mobile**	**Pannon**	**Vodafone**
All Ads	0.0	6.3	0.0
All Price Ads	4.3	11.5	3.4
Price Ads: Plans	31.7	30.3	14.9
Per-Minute Price Ads	54.8	48.1	49.0
Monthly Fee and Free Minutes Ads	74.5	73.6	59.6
Options Price Ads	78.8	79.3	80.3
Discount Offered Ads	77.4	76.4	68.3
Price Ads: Phones	8.2	14.4	13.0
Price of Phone Price Ads	27.4	22.1	18.8
Dicounts on Phones Ads	37.5	67.8	66.8
Image Ads	83.2	81.7	69.7
Phone Ads	7.2	13.9	13.5
Options Ads	9.1	75.5	35.1
Rivals Ads	95.2	98.6	50.0
Other Ads	91.8	86.5	74.0

Table 9: Ads on Lagged Ads, by Ad Content, Firm, and Lag Length

	All Ads			**Price Ads: Plans**			**Plan Price Ads: Per-Minute Price Ads**		
Lags	**One Lag**	**Two Lags**	**Six Lags**	**One Lag**	**Two Lags**	**Six Lags**	**One Lag**	**Two Lags**	**Six Lags**
T-Mobile									
L1	**0.80**	**0.92**	**0.93**	**0.75**	**0.90**	**0.87**	**0.78**	**0.95**	**0.95**
	(0.04)	(0.07)	(0.07)	(0.05)	(0.07)	(0.07)	(0.04)	(0.07)	(0.07)
L2		**-0.15**	**-0.23**		**-0.21**	-0.09		**-0.22**	**-0.18**
		(0.07)	(0.10)		(0.07)	(0.09)		(0.07)	(0.10)
L3			0.04			**-0.16**			-0.07
			(0.10)			(0.10)			(0.10)
L4			0.12			-0.01			-0.05
			(0.10)			(0.10)			(0.10)
L5			-0.10			0.08			**0.17**
			(0.10)			(0.10)			(0.10)
L6			0.03			-0.06			-0.09
			(0.07)			(0.07)			(0.07)
Pannon									
L1	**0.82**	**0.91**	**0.93**	**0.84**	**0.95**	**0.96**	**0.81**	**1.03**	**1.07**
	(0.04)	(0.07)	(0.07)	(0.04)	(0.07)	(0.07)	(0.04)	(0.07)	(0.07)
L2		**-0.12**	**-0.19**		**-0.13**	-0.14		**-0.27**	**-0.37**
		(0.07)	(0.10)		(0.07)	(0.10)		(0.07)	(0.10)
L3			0.11			0.07			**0.18**
			(0.10)			(0.10)			(0.10)
L4			-0.10			**-0.25**			**-0.27**
			(0.10)			(0.10)			(0.10)
L5			0.12			**0.20**			**0.25**
			(0.10)			(0.10)			(0.10)
L6			-0.08			-0.01			-0.06
			(0.07)			(0.07)			(0.07)
Vodafone									
L1	**0.69**	**0.81**	**0.81**	**0.64**	**0.74**	**0.74**	**0.68**	**0.77**	**0.77**
	(0.05)	(0.07)	(0.07)	(0.05)	(0.07)	(0.07)	(0.05)	(0.07)	(0.07)
L2		**-0.18**	**-0.21**		**-0.15**	**-0.20**		**-0.14**	**-0.18**
		(0.07)	(0.09)		(0.07)	(0.09)		(0.07)	(0.09)
L3			0.05			0.05			-0.04
			(0.10)			(0.09)			(0.09)
L4			-0.05			0.02			**0.19**
			(0.10)			(0.09)			(0.09)
L5			0.05			0.01			-0.01
			(0.09)			(0.09)			(0.09)
L6			-0.03			-0.02			-0.04
			(0.07)			(0.07)			(0.07)

Table 10: Synchronization of Ads, by Ad Type

	All Ads			Price Ads: Plans			Price Ads: Phones		
	T-Mobile	Pannon	Vodafone	T-Mobile	Pannon	Vodafone	T-Mobile	Pannon	Vodafone
T-Mobile		**-0.28**	**0.29**		-0.07	0.00		**0.36**	**-0.37**
		(0.05)	(0.06)		(0.04)	(0.07)		(0.04)	(0.07)
Pannon	**-0.59**		**0.46**	-0.20		**0.78**	**0.83**		**1.07**
	(0.10)		(0.09)	(0.12)		(0.11)	(0.10)		(0.10)
Vodafone	**0.32**	**0.24**		0.00	**0.29**		**-0.33**	**0.41**	
	(0.07)	(0.05)		(0.07)	(0.04)		(0.06)	(0.04)	
	Image Ads			Phone Ads			Options Ads		
	T-Mobile	Pannon	Vodafone	T-Mobile	Pannon	Vodafone	T-Mobile	Pannon	Vodafone
T-Mobile		-0.06	**-0.38**		**0.22**	**-0.27**		0.04	-0.08
		(0.08)	(0.10)		(0.04)	(0.07)		(0.09)	(0.08)
Pannon	-0.04		-0.05	**0.62**		**0.98**	0.02		**-0.35**
	(0.06)		(0.09)	(0.11)		(0.10)	(0.05)		(0.06)
Vodafone	**-0.16**	-0.03		**-0.28**	**0.37**		-0.06	**-0.45**	
	(0.04)	(0.05)		(0.07)	(0.04)		(0.06)	(0.07)	

Table 11: Broadcast Television Ads, by Content Type and Firm

Content Type	**Broadcast TV All Ads**	**T-Mobile**	**Pannon**	**Vodafone**
All Price Ads	76.4	75.7	85.8	66.9
Price Ads: Plans	41.0	29.3	52.1	42.0
Per-Minute Price Ads	24.8	17.2	35.0	22.3
Monthly Fee and Free Minutes Ads	12.9	8.6	16.1	14.3
Options Price Ads	7.5	5.9	9.9	6.7
Discount Offered Ads	10.0	8.7	11.9	9.4
Price Ads: Phones	57.0	53.7	68.4	48.2
Price of Phone Price Ads	42.8	31.3	56.0	41.4
Dicounts on Phones Ads	20.1	26.3	23.0	9.7
Image Ads	7.2	6.2	7.0	8.4
Phone Ads	58.9	53.9	72.5	49.5
Options Ads	20.2	29.0	11.0	20.1
Rivals Ads	7.0	1.0	0.7	20.9
Other Ads	5.5	2.6	4.2	10.3

Table 12: Logit Demand Models with Number of Adverts

	model1	model2	model3	model4	model5
	b/se	b/se	b/se	b/se	b/se
withinoffreal	-0.194	-0.449	-0.278	-0.363	-0.578
	(0.060)	(0.111)	(0.065)	(0.064)	(0.126)
lNumads3	-0.003	-0.005			-0.030
	(0.004)	(0.004)			(0.024)
idV	-0.736	-0.636	-0.659	-0.637	-0.607
	(0.030)	(0.047)	(0.023)	(0.022)	(0.040)
idP	-0.284	-0.226	-0.271	-0.264	-0.236
	(0.023)	(0.030)	(0.020)	(0.019)	(0.028)
L6.lNumads3			0.004	0.004	
			(0.002)	(0.003)	
L7.lNumads3			0.007	0.009	
			(0.002)	(0.002)	
L8.lNumads3			0.004	0.004	
			(0.002)	(0.002)	
L9.lNumads3			0.005	0.006	
			(0.002)	(0.002)	
withinoffrealNumads3				0.000	0.000
				(0.000)	(0.000)
constant	0.078	0.863	0.245	0.462	1.414
	(0.201)	(0.378)	(0.213)	(0.209)	(0.436)
N	111	111	84	84	105
F	485	55	163	139	42
$\bar{R}^2$	0.946	0.951	0.971	0.969	0.934
RMS error	0.080	0.076	0.041	0.042	0.068

Table 13: Logit Demand Models with Price and Image Advertising

	model6	model7	model8	model9	model10	model11
	b/se	b/se	b/se	b/se	b/se	b/se
withinoffreal	-0.323	-0.245	-0.364	-0.231	-0.243	-0.262
	(0.114)	(0.128)	(0.111)	(0.098)	(0.114)	(0.117)
withinoffreallpricead5a	-0.052	-0.108			-0.045	-0.039
	(0.018)	(0.036)			(0.017)	(0.017)
lpricead5a	0.177	0.383			0.153	0.133
	(0.061)	(0.129)			(0.059)	(0.060)
idV	-0.648	-0.646	-0.637	-0.653	-0.654	-0.654
	(0.045)	(0.031)	(0.044)	(0.031)	(0.043)	(0.043)
idP	-0.238	-0.271	-0.233	-0.258	-0.244	-0.246
	(0.029)	(0.032)	(0.029)	(0.023)	(0.028)	(0.028)
withinoffreallImagead			-0.058	-0.092	-0.054	-0.057
			(0.017)	(0.027)	(0.016)	(0.016)
lImagead			0.196	0.308	0.182	0.195
			(0.058)	(0.093)	(0.056)	(0.056)
withinoffrealNumads3						0.000
						(0.000)
lNumads3						-0.012
						(0.006)
constant	0.460	0.119	0.537	0.344	0.163	0.249
	(0.384)	(0.448)	(0.382)	(0.331)	(0.389)	(0.397)
N	111	105	111	105	111	111
F	59	80	62	114	65	63
$\bar{R}^2$	0.956	0.935	0.958	0.959	0.961	0.962
RMS error	0.073	0.068	0.071	0.054	0.068	0.067

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