Forecasting the Spatial Deployment of FIOS

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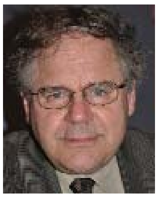

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The focus of this paper is to outline a process that first predicts *where and when* a company will expand its fiber network and then forecasts the impact(s) of that expansion. Specifically, we look at Verizon's current and future deployment of their fiber network. Forecasting a competitor's planned investment activities is important. The ability to adequately predict *where and when* Verizon will add to their network provides lead time for the cable companies to plan their own triple-play deployments; to develop customer loyalty programs; and to identify customers at risk for targeted advertising and promotions. We specify a spatial model of location choice and then test this model by comparing the model's prediction of deployment against realized deployment in California. The results suggest that the model captures key drivers of location choice.

Introduction

Until recently, United States consumers of pay TV services could choose from satellite providers or cable providers. After 2004, the landscape of competition in the provisioning of video (and high-speed broadband) service changed when large telephone companies began to offer these services *via* fiber[1]. Verizon's fiber service, called FiOS (Fiber Optic Service), presented new challenges to incumbent cable providers. Since fiber services often involved the bundling of voice, data and video services (triple-play), telephone companies could, by pricing their bundles aggressively, induce cable customers to switch to fiber-based services. A large number of consumers believed that fiber-based services represented new (and hence, better) technology compared to coaxial-based cable services.[2] To be sure, cable companies were beginning to roll out their own triple-play bundles. These actions and responses were setting the battleground for the consumer's video (and data) vote.

What is emerging is an escalating competitive environment that places value on innovation and technology, on service quality and price. FiOS is viewed as the latest technology, is highly rated[3] and, where deployed, has had a large number of customers signing up it.[4] However, the packages offered have been at significant discounts. The emergence of FiOS into the cable market thus has two negative consequences for a cable company – increased competition and churn and a likely reduction in average revenue per household as cable companies are forced to match the pricing of the telephone companies.[5] On the other hand, the positive thing from the cable company's perspective is that the provisioning of fiber to the home is both capital intensive and expensive which means cost alone forces an invading telco to stage its investment.[6] The challenge facing the cable companies is, accordingly, to forecast where and when a phone company such as Verizon will extend its FiOS footprint.

The objective of this paper is to outline a process, using Verizon as the invading telephone company, that first predicts *where and when* Verizon will expand its fiber network and then forecasts the impact(s) of that expansion. The ability to adequately predict *where and when* provides lead time for the cable companies to plan their own triple-play deployments; to develop customer loyalty programs; and to identify customers at risk for targeted advertising and promotions.

Section I provides a background of Verizon's FiOS service. Section II presents a spatial choice model for predicting the locations for future FiOS expansion. The model is based on analyzing Verizon's FiOS deployment through 2007. The results of the model are summarized in Section III where we evaluate the accuracy of the spatial 'forecast' of expansion in 2008. Discussion and conclusions are presented in Section IV.

*) *The authors wish to acknowledge and thank Centris (www.centris.com) for access and use of Centris' fiber tracking data.*

1) *Verizon's service is known as FiOS; AT&T's service is Uverse.*

2) *See eg. http://paulstamatiou.com/2007/11/27/review-verizon-fios [4 October 2008]*

3) *www.jdpower.com/corporate/news/releases/pressrelease.aspx>ID=2008204 [4 October 2008]*

4) *http://newscenter.verizon.com/press-releases/verizon/2008/verizon-reports-double-digit.html [4 October 2008]*

5) *Cable companies have begun to deploy super fast data modems (DOCSIS 3.0) in an effort to match FiOS data speeds.*

6) *www.nytime.com/2008/08/19/technology/19fios.html [4 October 2008]*

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I Background

In September 2004, Verizon initially deployed FiOS simply as an alternative to cable modems for high-speed internet access. More recently, with the granting of state-wide franchise authority and with local franchise agreements for providing video services easier to obtain, Verizon has been offering FiOS as a bundled set of services (triple-play).[7)8)]

In terms of technology, Verizon FiOS products are delivered over a fiber to the premise (FTTP) network using passive optical network (PON) technology. Voice, video, and data travel over three wavelengths in the infrared spectrum. To serve a home, a single optical fiber extends from an optical line terminal (OLT) at a FiOS Central office out to the neighborhoods where an optical splitter fans out the same signal on up to 32 fibers – thus serving up to 32 subscribers. At the subscriber's home, an optical network terminal (ONT) transfers data onto the corresponding copper wiring for phone, video and internet access. One of the three wavelength bands is devoted to carrying television channels that are compatible with cable type television products. The other two wavelengths are devoted to all other data, one for outbound and the other for inbound data. This includes IPTV video, telephone and internet data. This allocation of wavelengths adheres to the ITU-T G.983 standard also known as APON or BPON. Verizon initially installed slower BPONs but now only installs gigabit PONs (GPON) specified in the ITU-T G.984 standard.[9)]

Quarter \ Year	2004	2005	2006	2007	2008	Total
Q1		86	21	7	179	
Q2		56	78	25	248	
Q3	5	54	89	62		
Q4	13	70	53	68		
Total	18	266	241	162	427	1,114

Table 1 Verizon FiOS Deployment 2004 – 2008 (Source: Verizon and Centris[12)])

State	Number of Wire Centers	Number of Wire Centers with FiOS	Percent with FiOS End of 2007	Percent with FiOS August, 2008
California	262	75	28.7 %	55.1 %
Delaware	33	11	33.3 %	90.9 %
Florida	90	49	54.3 %	76.7 %
Maryland	201	50	25.6 %	41.6 %
New Jersey	204	86	42.2 %	69.8 %
New York	511	117	22.9 %	35.7 %
Pennsylvania	499	79	15.8 %	26.6 %
Rhode Island	30	10	33.3 %	73.3 %
Texas	247	40	16.2 %	17.4 %
Washington	97	9	9.3 %	12.4 %

Table 2 Percent of Verizon Wire Centers with FiOS Deployed (Source: Centris)

Because of the way that the telephone network is structured technologically, Verizon's selection and deployment strategy for FiOS has a strong spatial dimension, as investment occurs within a geography called a wire center. A wire center's central office is a point where physical circuits are connected. The physical circuits are loops that connect local exchanges (as identified by the first three digits of the 7-digit local number) to the switches in the central office. Hence, from a forecasting perspective, the provisioning of FiOS is both a function of required capital (investment) and rank ordering their 'next' locations (wire centers). Capital requirements of deployment are large, and accordingly limit both the when and the where of the next set of FiOS enabled wire centers. Unsurprisingly, Verizon does not publish their list of next locations.

Table 1 displays the deployment of FiOS over the period 2004 through 2007. Verizon had deployed FiOS to approximately fifteen percent (15 %) of their wire centers.[10)] Verizon accelerated FiOS deployment in 2008 with 427 new FiOS equipped wire centers added.[11)] As of June 2008, the total number of FiOS enabled wire centers was 1,114 which represents an annual growth rate of nearly four hundred percent (386 %).

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7) *See eg. www.heartland.org/policybot/results.html?articleid=18899, [4 October 2008] www.publicknowledge.org/news/testimony/gbsohn-testimony-20060215, [4 October 2008] www.usdoj.gov/atr/public/workshops/telecom2007/submissions/230502.htm [4 October 2008]*

8) *The triple-play bundles traditional voice telephone service (usually a Voice over internet Protocol, VoIP), data service and video services. The quadruple-play adds mobile telephone service. All at a lower price than the total of each purchased separately.*

9) *A more generic description of FiOS comes from Wikipedia: "Verizon FiOS, sometimes simply FiOS which stands for "Fiber Optic Service", is an Internet, telephone, and TV service that is presently offered in some areas of the United States by Verizon. Verizon has attracted consumer and media attention in the area of broadband Internet access as the first major U.S. carrier to offer such a service. In their rapidly expanding coverage areas, FiOS provides telephone, Internet and digital video services to the subscriber's premises. Some areas do not have service due to franchise agreements, and some can only receive the Internet access, also due to franchising." [25 October 2008]*

10) *See eg. www.telcordia.com. Verizon has, as of August, 2008, 4,614 wire centers. [9 September 2008]*

11) *See eg. www.Centris.com. [4 October 2008]*

12) *Centris is a market research firm based in Ft. Washington, Pennsylvania. Centris tracks FiOS deployment.*

Map 1 FiOS Deployment (Source: Centris MarketView)

Table 2 displays the percent of wire centers that have FiOS. The analysis is summarized for selected states through 2007.

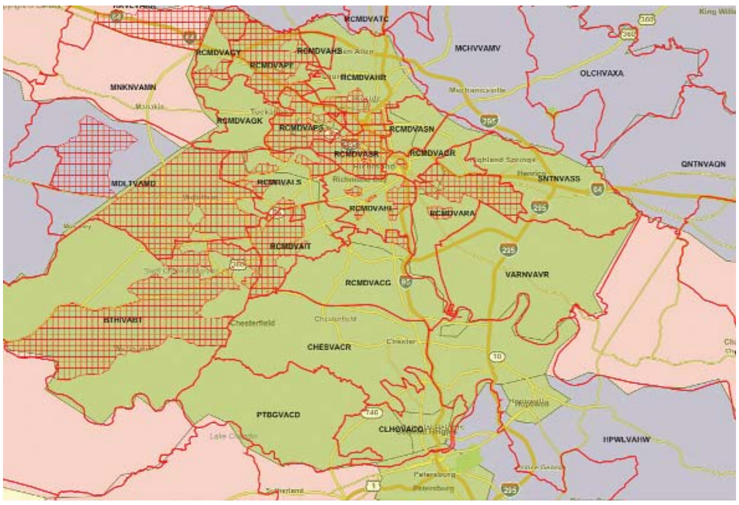
Over 58 % of Verizon's 2008 growth of FiOS, in terms of enabled wire centers, can be attributed to expansion of the states identified in Table 2. Thus, a baseline predictor of expansion can be based on where FiOS had already been deployed. However, there were 239 additional wire centers deployed in 2008 that were in states not included in Table 2. Wire centers vary in geographic size and density. Once Verizon has targeted a wire center for FiOS upgrade, the wire center is re-engineered for connection. However, actual connectivity is a function of the cost (eg. obstacles) inherent in reaching customers. Arial connections provide the least cost access and hence are given a higher priority. Customers where access requires extensive digging or crossing major highways are given a lower priority.

The average number of households over all Verizon wire centers is 7,250. The corresponding number for FiOS enabled households is 17,000. To put this in perspective, 68 % of all Verizon wire centers serve less than 5,000 households. However, to this point, 81 % of FiOS enabled wire centers serve over 10,000 households, while only 6 % serve less than 5,000 households. Thus, there is clearly a focus on larger wire centers. Within FiOS households, approximately 68 % of all households could receive FiOS service.[13)]

As is evident in the following maps, competition between cable and FiOS is inherently local, as no useful information can be gleaned for future FiOS deployment by simply looking at states as in the first of the following maps.

However, when the focus shifts to a much smaller geography, the local nature of deployment is easily seen. Map 2 displays Verizon's FiOS deployment in a small area of Rhode Island. In this map, in which wire center boundaries are denoted, the hatched areas identify FiOS deployment. The red boundaries identify Verizon wire centers. With this map, the localism of competition is really brought to the fore, in that it shows that not all households in a wire center may actually be able to receive FiOS services, and, also, that other factors need to be taken into account regarding the deployment of service. Such factors may include the presence of natural barrier (streams, highways, parks – all which add to the cost of deployment) and insufficient density.

From a competitor's perspective, these tables and maps represent both good and not-so-good-news. The good news is that FiOS's deployment is somewhat limited. The not so-good-news is that, with adequate



Map 2 Local FiOS Deployment (Source: Centris MarketView)

13) *Statistics derived from Centris fiber tracking database*

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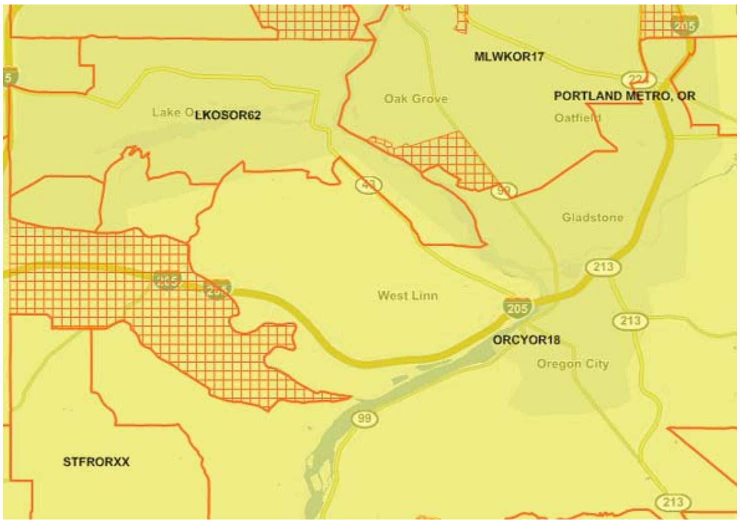

Map 3 FiOS Deployment Selected Wire Centers in Portland, Oregon (Source: Centris MarketView)

capital, Verizon has considerable room to grow. The obvious question facing Verizon competitors is where will Verizon dig next? To put this question in perspective, consider Map 3, which identifies FiOS deployment in the Northwest portion of Comcast's West Division.[14] The hatched areas represent wire centers that are FiOS enabled; the other areas represent wire centers without FiOS. The question for Comcast division managers is "How high are the other areas in Verizon's priority list"? Is wire center LKOSOR62 next?

II Model of Spatial Choice

We now turn to a model for predicting the likely future deployment of FiOS. Since the wire center defines the geography of FiOS, a spatial choice model is developed that incorporates wire center information in the framework of a discrete choice model.[15]

In the traditional model of choice between outcomes *i* and *j* we note the dependent variable takes on two values:

$y_i = 1$ if choice *i* is selected,
$y_i = 0$ otherwise.

With a discrete dependent variable, the interest lies in estimating the probabilities of a specific outcome;

$$p_i = P \quad y_i = 1$$

Since y has only 2 values (0, 1), a model of y of the form $y_i = x_i'\beta + \varepsilon_i$ is inefficient since predicted values of y could lie outside of the range (0, 1).[16]

Introducing an unobservable continuous variable U_i leads to:

$$(1.1) \quad y_i = \begin{cases} 0 \text{ if } U_i < 0 \\ 1 \text{ if } U_i \geq 0 \end{cases} \qquad U_i = x_i'\beta + \varepsilon_i$$

This transformation leads to

$$(1.2) \quad p_i = P\{y_i = 1\} = P\{x_i'\beta + \varepsilon_i \geq 0\} = F_\varepsilon(x_i'\beta)$$

Where, using the logistic function, we have:

$$(1.3) \quad F_\varepsilon(z) = \frac{e^z}{(1+e^z)} \quad \text{or}$$

$$(1.4) \quad \log\left(\frac{p_i}{1-p_i}\right) = x_i'\beta$$

The specification (1.4) represents a binary discrete choice. In the case of FiOS, this would amount to the choice of deploying FiOS in wire center *i*.

In reality, Verizon faces the choice of deploying FiOS across a set of potential wire centers. In this scenario, the choice is no longer binary. Verizon must choose from a set of alternatives A. For situations where the choices are limited, the traditional approach to this choice problem is to use a multinomial discrete choice model.[17]

$$(1.5) \quad P(A_i|A) = \frac{e^{\sum_i x'\beta}}{\sum_j e^{x'\beta}} \quad i \neq j$$

Where A_i is location *i* and *x* is a vector of location attributes. This approach is not practical when the set of alternative locations is measured in the thousands. Hence, we adopt a discrete choice framework to estimate the probability that a specific wire center will be chosen. We then rank order these probabilities to define the deployment order. The model used in this paper incorporates spatial attributes into the determination of FiOS deployment.[18] Verizon's choices are

[14] *Centris.com*

[15] *See eg. Maddala, G.S. (1969), McFadden, D. (1994), Train, K.E., McFadden, D.L, and Ben-Akiva, M. (1987), Hensher, D.A., Rose, J.M. and Greene, W.H. (2005) and Train (2003).*

[16] *See Perrachi (2001).*

[17] *See eg. Cramer (2001).*

[18] *Examples of spatial choice models include Jank W. and Kannan, P.K. (2005), Cressie, N.A. (1993), Orpana, T. and Lampinen, J. (2003) and Ben-Akiva, M. and Watanatada, T. (1978).*

modeled in terms of the traditional random utility model, in which utility associated with the selection of a wire center is based on a set of location specific attributes or alternatives. Specifically the location with the highest utility among all alternative locations is assumed to be determined by:

- Density of the market
- Number of households
- Income
- Age
- Previous investment (wire centers in areas with previously significant deployment)
- Degree of competition

Density is represented by degree of urbanization. Income and age are represented as distributions (eg. the percent of households with income under $25,000, between 25,000 and 35,000 and so forth). Previous investment or activity in an area is proxied by the percent of wire centers in the area previously chosen for FiOS deployment.[19] The degree of competition is represented by indicator variables for the large cable providers – Comcast, Time Warner, Cox and Charter.[20]

The dependent variable in the analysis is equal to 1 if the wire center has FiOS deployed and 0 otherwise.[21]

For a firm that has to rank new locations from a large set of possible locations, the estimated probabilities are used to rank order the set of possible or next locations.

III Model Assessment

Table 3 summarizes the results of the estimation.[22]

In terms of overall classification, using a threshold of .50, the model predicted 94 % of the classifications correctly.

The within sample results are quite remarkable. First, density and number of households appear to rank high in terms of location specific factors, although this may be simply related to economics of scale in deploying fiber. As already noted, previous deployment adds significant weight to the selection process, which may be related to economics of scope in operation of the fiber. Income is the most significant variable among the demographic variables analyzed. This may be due to targeting potential customers who are most likely to purchase the product. This is supported by Centris' survey (see below). The indicator variables for Verizon's video competitors, Comcast, Time Warner and Cox are positive and significant, suggesting that a wire center may be selected, everything else equal, to gain a competitive foothold in a market previously only served by the local cable company.

Explanatory variable	β Coefficient	p-value
Urban	0.155	0.000
Suburban	0.047	0.001
Rural	-2.08	0.000
Income	0.803	0.000
Age	0.040	0.312
Number of households	4.231	0.000
Comcast	2.245	0.000
Time Warner	0.397	0.025
Cox	1.390	0.002
Charter	0.004	0.992
Previous Deployment	7.487	0.000

Table 3 Estimated Coefficients

Actual	Predicted No FiOS	Predicted FiOS	Percent
No FiOS	3368	122	96.5
FiOS	170	944	84.7

Table 4 Classification Table

Some Caveats

The analysis does not take into account whether a location had received franchise authority to provide video services. Nor did the analysis take into account factors that would label a location as a high cost area for example, such factors could include the presence of highways and other barriers and the age of existing plant and equipment.

19) *For activity in close areas we use the number of wire centers in a LATA that have FiOS deployed. LATA refers to local access and transport area. LATAs were created under the terms of the Modification of the Final Judgment (MFJ) that led to the breakup of the original AT&T to the 'baby bells'.*

20) *Except in rare instances, the cable companies are not in each other's franchised territories.*

21) *Data for this analysis was obtained from Centris. Centris tracks fiber deployment. In addition, Centris maintains a database of wire center boundaries, cable boundaries and demographics associated with those geographies. See www.centris.com for more details.*

22) *The underlying dataset for this estimation is all of Verizon's wire center.*

Wire Center	Estimate Probability
CLMTCAXF	0.86
GRHLCAXF	0.97
COVNCAXF	0.88
LAPNCAXF	0.83
LAPNCAXG	0.86
MNBHCAXF	0.86
MNRVCAXG	0.91

Table 5 Estimated Probabilities

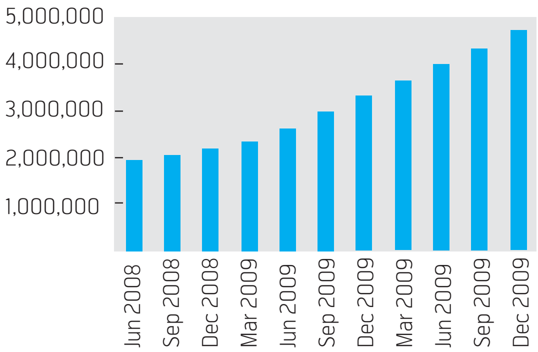

Chart 1 Short Term Forecast of FiOS Subscribers (Source: Verizon and Centris)

State	Number of wire centers	Percent with FiOS	Forecasted Percent with FiOS	Net Growth in Deployed Wire Centers
California	263	55	66	26
Connecticut	2	100	100	0
Delaware	33	91	91	0
District of Columbia	14	0	0	0
Florida	90	77	79	2
Idaho	28	0	0	0
Illinois	381	0	10	38
Indiana	208	5	10	11
Maryland	202	41	55	28
Massachusetts	271	32	50	48
Michigan	207	0	20	41
New Jersey	205	70	75	10
New York	512	36	65	148
North Carolina	39	3	3	0
Ohio	252	0	15	37
Oregon	57	42	48	3
Pennsylvania	499	26	45	95
Rhode Island	30	73	77	2
South Carolina	37	0	10	4
Texas	247	17	38	52
Virginia	311	35	45	31
Washington	97	12	12	0
West Virginia	141	1	1	0
Wisconsin	116	0	10	11

Table 6 Projected Increase in FiOS Deployed Wire Centers (Source: Centris)

Projections

Turning now to projections of likely future FiOS deployment by Verizon, the discrete-choice function that has been estimated can be used to assign a probability to every wire center in the Verizon service area. These wire centers can be sorted and subsequently ranked by probability. The wire centers with the highest probabilities are then labeled as "next of the list". As a test of the model, we looked at wire centers in California that were identified as FiOS deployed wire centers at the end of 2007. We then looked at the ranking of California wire centers that had not had FiOS in 2007 but were selected in 2008. Table 5 lists selected wire centers in California that did not provide FiOS in 2007 but were selected in 2008. The estimated probability of selection was also included. There were 70 additional wire centers in California that had FiOS deployed in 2008. The choice model assigned a probability of greater than 80 % to 55 of these wire centers. However, on the negative side, the model produced low probabilities (under 0.15) for 10 wire centers for which FiOS were in fact deployed.

Clearly, a number of factors that undoubtedly enter into a Verizon FiOS planning and deployment decisions include measures that were not included in the model. These omitted variables may include political and jurisdictional factors, the typography of the build-out, internal sales objectives and the availability of construction crews.

Verizon provided guidance in terms of their forecast of FiOS homes passed through 2011.[23)]

Chart 1 displays the aggregate forecast for Verizon's FiOS product. Assuming the forecast of subscribers, the related question is where will these subscribers come from?

Within two years from initial deployment, Verizon's share of the pay-TV market has so far averaged close to 18 % in the areas served by FiOS.[24)] Based on the forecast of 4.6 million subscribers by the end of 2010 and a penetration rate of 18 %, using the spatial location model, Verizon would need to reach an additional 597 wire centers. Table 6 provides the state distribution of these estimates.

For a competitor, the final step would be to overlay the projected deployed wire centers over a competitor's footprint.

23) *http://investor.verizon.com/news/20080610/ [25 October 2008]*

24) *Verizon and Centris*

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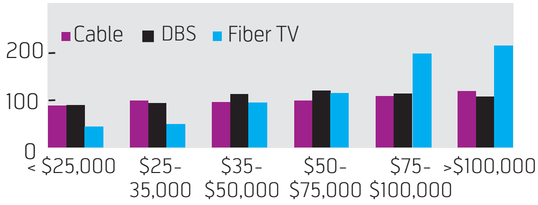

Chart 2 Demand for Pay-TV as a Function of Income (Source: Centris omnibus survey)

The Demand for Pay-TV service

The analysis of deployment represents a firm's perspective on where to use capital. The spatial choice model focuses on a set of factors that, presumably, correlate with expected demand. The following charts provide implicit confirmation for these factors.

The left scale represents an index (100 = overall pay-TV average). Thus, for households with income greater than $100,000, the demand for fiber-based video service is over two times the overall average for pay-TV.[25)]

Reasons for switching to fiber are displayed in Chart 3.

Chart 4 summarizes subscriber's level of satisfaction with fiber.

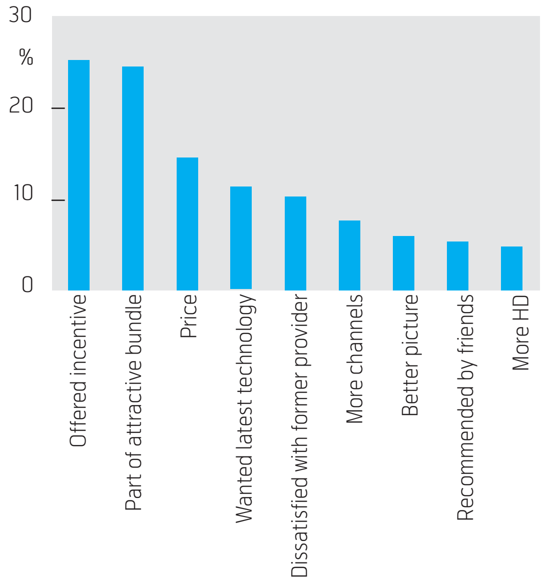

Chart 3 Reasons for Switching to Fiber (Source: Centris omnibus survey)

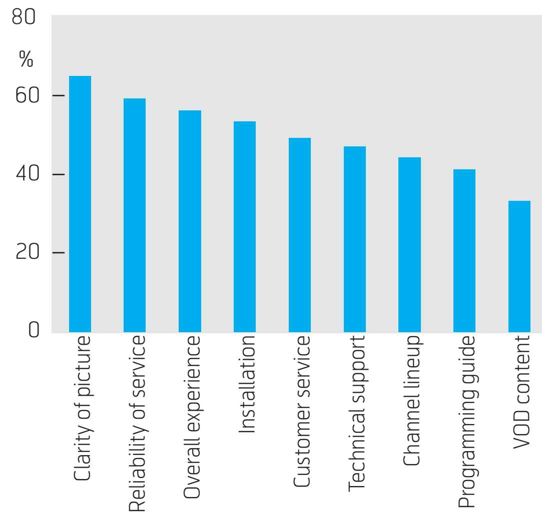

Chart 4 Level of Satisfaction of FiOS Subscribers (Source: Centris omnibus survey)

IV Discussion and Conclusions

This paper has presented a spatial choice model for projecting the likely future deployment of FiOS availability. Since fiber-based video services represent a real and continuing threat to satellite and cable providers, the model provides these competitors with (1) the ability to forecast and simulate where Verizon next deploys their fiber product, FiOS, and (2) what the likely impact(s) are of that new deployment on DBS's and cable's customer base. In developing the model, it has been recognized that competition in this market is local, with determining factors that include information on density, number of households and socio-economic demographics, all of which are readily available. Judgmental and qualitative factors that are company-specific, on the other hand, are not taken into account, as these may be based on longer term internal considerations such as investment strategies, new pricing models, the desire and ability to offer more extensive bundles (eg. voice, video, data and wireless), and other competitive positioning factors.

These potential factors notwithstanding, the model is shown as capable of generating a rank ordering over all Verizon locations (wire centers) which is consistent with Verizon's 2008 FiOS deployments as well as to their stated forecasts of subscribers. What is missing in this analysis, however, is the capital budget forecast, which is a serious omission, as the ultimate constraint on FiOS investment is obviously the availability of capital.

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25) DBS is Direct Broadcast Satellie; a satellite video service.

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