Economies of Scale and Scope in Increasingly Competitive New York Local Telecommunications Markets

Richard E. Schuler, Jr. *

ABSTRACT

The rapid increase in inter-modal competition in telecommunications markets has resulted in traditional local exchange telephone companies facing significant financial pressures. The increasing acceptance of wireless as a substitute for traditional voice services, combined with the more recent roll out of digital phone service by cable companies operating in rural areas has brought the need to deal with these financial pressures to the forefront. This paper examines the cost structures of New York State's incumbent local exchange telephone companies and in doing so, sheds light on possible operational improvements which could aid the incumbent companies in managing the competitive transition.

BACKGROUND

The cost structure and operating environment of traditional local exchange telephone companies provide important information to managers and regulators regarding these companies' ability to thrive in increasingly competitive markets. Prior studies of incumbent telephone system costs were focused on whether the incumbent local exchange companies were natural monopolies. If not, the incumbents' networks could arguably be broken up without a loss of efficiency. Competition was envisioned over portions of the incumbent telephone companies' network (e.g., 1980s competition only in long distance, late 1990s/early 2000s competition for switching and inter-office elements but not so much for the local loop). With end to end facilities based competition from cable providers, economies of scope between services (e.g., economies of scope in providing residence and business services) might be increasingly important. Only a limited few of the earlier cost studies focused on the distinction between residence and business service outputs. Finally, economies of scale may remain important, and critical to the success of smaller rural companies who are facing significant inroads from larger regional cable phone providers.

Smaller rural companies were generally spared from the unbundled network element based competition that occurred immediately after the 1996 Telecom Act. The more recent competition now faced by the traditional incumbent local exchange telephone companies comes from large, end to end facilities based cable phone providers, and from increasingly ubiquitous cellular providers. The increasing acceptance of wireless as a stand-alone substitute for traditional voice services, combined with the more recent roll out of digital phone service by cable companies has quickly brought the need for all

* Richard E. Schuler Jr. New York State Department of Public Service, Albany, New York 12223.
richard_schuler@dps.state.ny.us

traditional phone providers to deal with these financial pressures associated with technological change induced competition.

New York State Telecommunications Landscape

New York's forty incumbent local telephone companies will form the basis of this analysis. New York provides a rich sample in that it contains a broad mix of large, small, urban, and rural local exchange companies. Very few states have a similar degree of geographic and demographic diversity as does New York State. Also, the New York State sample is predictive of the impact of cable telephone competition in other states. The number of homes passed by cable TV in New York is unusually high given New York's somewhat unique and foresighted polices encouraging CATV build outs in the 1970s.Thus, the New York experience could be viewed as predictive of what may likely happen in other states as broad band facilities capable of providing competitive phone service are more ubiquitously deployed throughout the nation.

As shown in the table below, the forty incumbents' loss in customer access lines since 2004 has been more dramatic with respect to residential customers than it has been for business customers. None of the companies have been able to sustain market share since 2003. The table also indicates that this decline in customers has been coupled with a dramatic increase in unit costs. Cost per access line (CPAL) is a traditional metric for comparison of incumbent local exchange company costs.

Year	Real Average Monthly Cost per Access Line	Residence Access Line Customers	Business Access Line Customers
2004	85.96	7,739,313	3,437,229
2005	85.68	6,988,971	3,264,113
2006	89.63	6,093,607	3,072,150
2007	94.64	5,297,207	2,870,705
2008	105.41	4,583,299	2,666,855
2009	114.48	3,950,710	2,463,047
2010	119.76	3,533,822	2,158,220
2011	123.29	3,074,995	1,990,559
2012	126.90	2,509,699	1,944,020

It is not surprising that these dramatic increases in per customer costs have had a significant impact on the incumbent local exchange telephone companies' financial situations. Some incumbent local exchange company residential market shares have now dropped below 50%, with no end in sight. The incumbents have argued that it is necessary for them to retain and maintain plant, regardless of customer migration to competition, given the incumbents' obligation to serve and carrier of last resort obligations. However, remaining financially solvent as unit costs are going up has become increasingly difficult as monthly competitor prices for residential and business phone service packages in New York have dipped below $50 for many residence and business customers. Although the smaller incumbent exchange company retail rates have traditionally been below competitor levels, recent regulatory rate proceedings have resulted in the smaller incumbent company rates increasing closer to the competitive benchmark levels. A large portion of some of the more rural incumbents' supra competitive level cost recovery has come via high long distance company access charges and from inter-company funding mechanisms. The smaller incumbent local exchange companies have indicated their likely need to draw more heavily from these funds. Regulators are currently addressing how to best reformulate these funding mechanisms.

In setting new competition and funding policies, regulators should be cognizant of the following cost structure related issues. Are smaller telecommunications firms inefficient? The competing cable companies are generally much larger than the traditional incumbent local exchange companies. Should the smaller incumbents be subsidized to stay in business if their financial losses are the result of market share losses to cable (as opposed to financial difficulties in serving a very high cost rural area with no competitive cable or wireless provider)? Cable phone providers are now taking advantage of the economies of scope in serving residence and business services. Are economies of scope greater than the economies of scale? Regarding claims that incumbents are unfairly losing their position in the residential markets, do current policies impact the level playing field with respect to cost? Residential cable phone companies do not have the same degree of provider of last resort and low income obligations. Cable phone rates are subject to much less taxation/subsidy obligations. How do differences in telephone and cable construction permitting and franchise renewals processes impact costs?

In order to shed light on how responsive strategies by the incumbent local telephone companies might impact upon the incumbents' financial losses, those actions will be evaluated using a cost function estimated for the incumbent telecommunications industry.

Modeling ILEC Cost Structures

Central to this analysis is the estimation of the cost structure for local exchange telephone companies. According to economic theory, costs are a function of both the outputs produced, and the prices of inputs purchased. The cost model below specifies telephone company costs to be a function of two outputs and three inputs. Companies' costs should vary with the number of residence access lines served and the number of business access lines served. The number of residential access lines is chosen as an explanatory variable since the number of customers to be served directly affects the total costs of service. Business access lines were used as a second explanatory variable since business lines are correlated with more complicated high capacity and feature-rich services that business customers subscribe to. The input prices reflect each company's relative economic cost of capital deployment, labor compensation rates, and costs of purchasing materials & services.

Data Used in Cost Model

The cost model was estimated using output and input price data for each of the 40 New York State incumbent local exchange carriers. The data covered the nine year period from 2004 through 2012.

Outputs: The residential lines output variable was taken directly from the access line schedule in the companies' New York Public Service Commission (NYPSC) Annual Reports. The business access line output measure is the total access line figure from the annual reports minus the residential access line figure. Total cost for each company is defined as capital expenditures plus total non-capital related operating expenses.

Costs: Total company operating expenses are measured by Total Operating Expenses Subject to Separations (including depreciation) from Schedule 9, Column E, Line 18 of the PSC annual reports. An economic measure of the cost of capital is substituted for the depreciation and amortization expenditures reported annually to the PSC on Schedule 9, Column E, Line 17.

Input Prices: The capital input price reflects the annual economic cost of capital. Creation of this variable begin with the Telephone Plant in Service - Subject to Separations figures from the NYPSC-Annual Reports Schedule 9. In order to determine a real measure of capital stock, the TPIS amounts are deflated by the Bureau of Economic Analysis' communications equipment price index. This real measure of capital stock is multiplied by a factor of 0.0625 in order to calculate the annual economic cost of depreciation (using the annuity form of depreciation and assuming constant productivity of each asset over its useful life). A property tax rate of 1% is also applied to this measure of capital stock. Finally, the real capital stock is multiplied by an annual NYPSC allowed rate of return factor in order to estimate the cost associated with return on investment. The annual economic capital cost for each company reflects the sum of these three cost items. These capital costs are divided by the total access lines for each company in order to create the capital input price. The price of the labor input is determined by dividing the wages and benefits figures reported on the PSC 5 Year Books, Table E, Line 3 by the number of company employees reported on the PSC annual reports, schedule 65a. The catch-all materials price calculation begins with what remains in the NYPSC Annual Report's Total Operating Expenses Subject to Separations figure after depreciation and wages & benefits expenses are subtracted out. These remaining "material" expenses are divided by the total access lines for each company in order to create a materials input price.

Finally, dummy indicator variables are added for each year to capture the effects of technological change and the adoption of alternative technologies by consumers.

Cost Model Specification

Costs are specified to be a function of both outputs ($y_{r \text{ and }} y_b$) and input prices ($p_{k,}$ p_l and p_m).

$$Cost = f(Y_r, Y_b, P_k, P_l, P_m, year)$$

r = output of residence access line customers
b = output of business access line customers
k = capital input
l = labor input
m = materials input (everything else)
year = dummy indicator variable for each year

The translog cost function is specified as follows:
(i's and j's subscript the inputs, m's and n's subscript the outputs)

$$\ln C = \alpha_0 + \sum_i \alpha_i \ln p_i + \sum_m \beta_m \ln y_m$$
$$+ \tfrac{1}{2}\sum_{ij} \alpha_{ij} \ln p_i \ln p_j + \tfrac{1}{2}\sum_{mn} \beta_{mn} \ln y_m \ln y_n$$
$$+ \sum_{im} \gamma_{im} \ln p_i \ln y_m + \tau \; year + \varepsilon$$

Assuming that the local exchange telephone companies are attempting to minimize costs in the face of competitive entry, estimation efficiency can be improved by estimating the translog cost function along with the cost minimizing input share equations. Shephard's Lemma (i.e., the derivative of the cost function with respect to factor input prices produces input share equations which sum to one) can be used to obtain the following capital, labor, and materials expense share equations. (S_i 's signify the input shares of capital, labor, and materials, respectively.)

$$S_i = \alpha_i + \sum_j \alpha_{ij} \ln p_{ij} + \sum_m \gamma_{im} \ln y_m + \varepsilon$$

Before taking logs and estimating the model, all cost model variables were scaled by their respective sample means. Also, the input prices in the share equations have been normalized by the materials price, and the materials price share equation has been dropped to avoid estimation difficulties associated with a non-singular covariance matrix. The cost function and two share equations were simultaneously estimated using non-linear least squares and the TSP econometrics software package. Heteroscedastic-consistent standard errors were computed. Before estimation, the usual symmetry and homogeneity restrictions were imposed [i.e., $\alpha_{lk}=\alpha_{kl}$, $\alpha_{mk}=\alpha_{km}$, $\alpha_{ml}=\alpha_{lm}$, $\beta_{br}=\beta_{rb}$, $\alpha_m=1-(\alpha_k+\alpha_l)$,$\alpha_{kk}=0-(\alpha_{kl}+\alpha_{km})$, $\alpha_{ll}=0-(\alpha_{lm}+\alpha_{kl})$, $\alpha_{mm}=0-(\alpha_{km}+\alpha_{lm})$, $\gamma_{kr}=0-(\gamma_{lr}+\gamma_{mr})$, $\gamma_{kb}=0-(\gamma_{lb}+\gamma_{mb})$]. Thus, 23 parameters were estimated with restrictions instead of 33 without restrictions. As shown in the Appendix, 21of the 33 parameter coefficients have t-statistics that are significant at the 5% level. The question regarding the reasonableness of the assumption that regulated companies minimize costs with respect to factor inputs often arises with any analysis of regulated utility company cost functions. Thus, to assess the impact of this assumption, the cost function for these regulated local exchange telephone companies is also estimated without the share equations. See the Appendix (*This is available from Author) for the results of the cost function estimation without the share equations. Finally, it was suggested that a fixed effects model specification might be more appropriate. Coefficient estimates associated with a fixed effects estimation are also shown in the Appendix.

Elasticities of Substitution

The predicted input shares and coefficient estimates for the system of equations are used to estimate elasticities of substitution. In responding to the significant competitive inroads by the cable and wireless providers, the firms have on average increased their relative use of capital and reduced their shares of labor and materials. In 2004 the shares of capital labor and materials were 44%, 28% and 28%, respectively. By 2012 these input shares had changed to 52%, 25% and 23%. Increased reliance upon capital might be a risky proposition since any increases in the level of fixed costs must be recovered from an increasingly smaller base of customers.

Elasticities of substitution and input price elasticities indicate how readily one factor input is substituted for others in the production process.

Elasticities of Substitution (estimated at 2004-2012 sample means)

Parameter	Estimate	Standard Error	T-Statistic	P-Value
SEKL	.232972	.052181	4.46466	[.000]
SEKM	.113871	.038060	2.99190	[.003]
SELM	.089146	.058777	1.51669	[.129]
SELK	.232972	.052181	4.46466	[.000]
SEMK	.113871	.038060	2.99190	[.003]
SEML	.089146	.058777	1.51669	[.129]
SEKK	-.140831	.031893	-4.41574	[.000]
SELL	-.794216	.161642	-4.91343	[.000]
SEMM	-.280459	.044521	-6.29942	[.000]

The average substitution elasticities over the entire sample period are not in line with expectations. The traditional view is that, given the high degree of technological change, a cost minimizing telecommunications firm should substitute capital for labor. Also, the amount of materials is often viewed as a complement to the amount of labor. However, the annual substitution elasticities which underlie these averages have changed dramatically over time, from positive to negative, as the local exchange telecommunications companies have been dealing with the impact of substantial market share losses.

Returns to Scale Analysis

The partial derivatives of the total cost function with respect to the two outputs are taken in order to evaluate economies of scale.

Evaluated at sample means

Parameter	Estimate	Standard Error	t-statistic	P-value
$\partial C/\partial Y_r$	.739724	.018991	38.9503	[.000]
$\partial C/\partial Y_b$	.231016	.018625	12.4033	[.000]

The overall output elasticity is the sum of the individual output cost elasticities.

$\partial C/\partial Y_r + \partial C/\partial Y_b = 0.9707$

This implies returns to scale (RTS) of $1/(\partial C/\partial Y_r + \partial C/\partial Y_b) = 1.030$

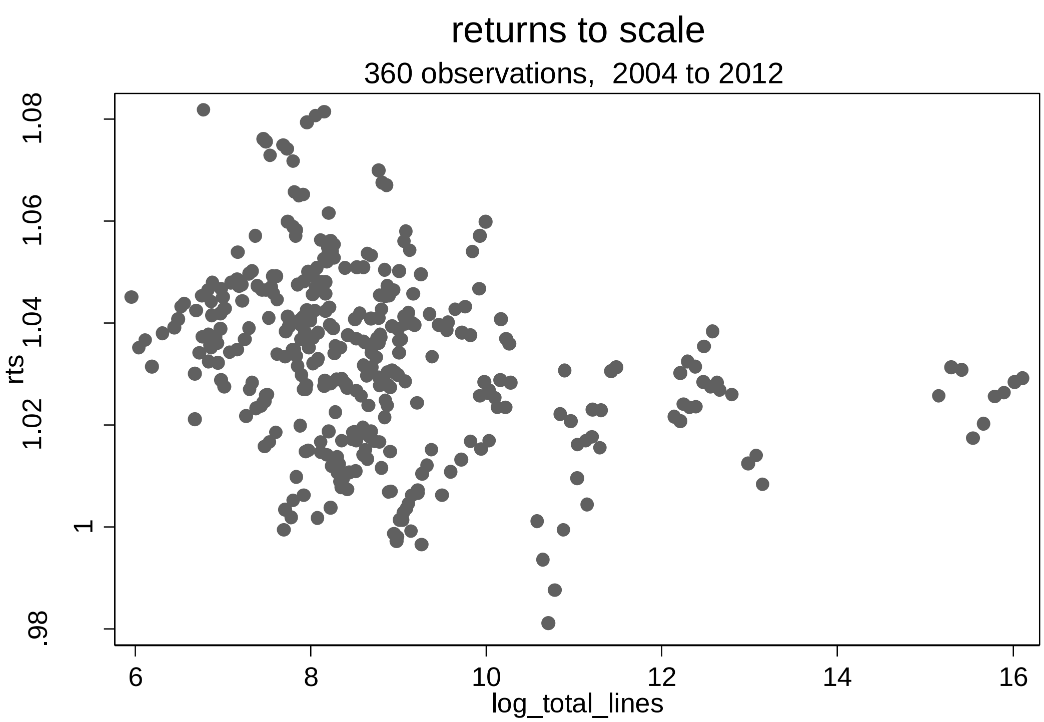
Evaluated at sample means

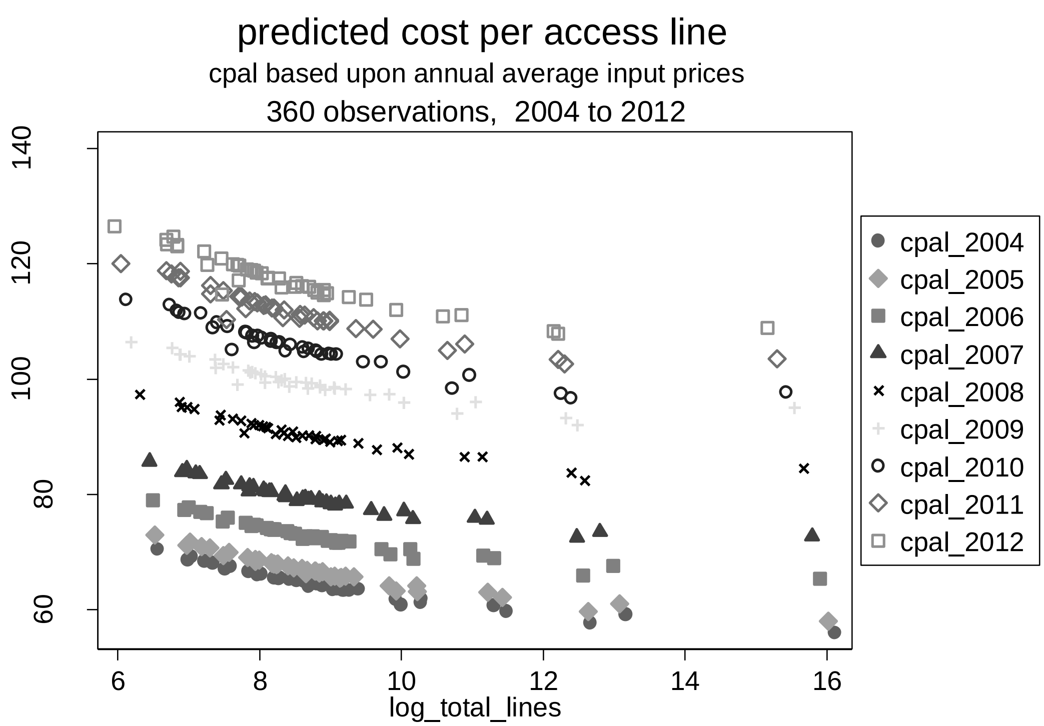
Parameter	Estimate	Standard Error	t-statistic	P-value
Output Elasticity	.970739	.446588E-02	217.368	[.000]
Returns to Scale	1.03014	.473916E-02	217.368	[.000]

Returns to scale can also be calculated at each of the 360 sample observations using the outputs and prices for each observation and the trans log model parameter estimates. The table below presents a summary of the 360 combined output elasticity and returns to scale calculations. The 360 returns to scale estimates are plotted against the log of total access lines (sum of residential and business access lines). The degree of scale economies falls as the number of access lines served increases. However, the scale economies rarely fall below the constant returns to scale level. Returns to scale would be decreasing if RTS<1.

The overall scale economies appear to be fairly slight for the larger companies in the sample. However, larger economies of scale appear to exist for the smaller companies. Thus, losses in overall customer levels might be problematic for the smallest incumbent telephone companies.

The figure below shows predicted cost per access line assuming each of the forty local exchange companies face the same input prices for capital labor and materials. The upward shift in cost per access line over time appears to have a much larger impact on unit costs than movement along the unit cost curves. This may relate to the local exchange companies' inability to quickly manage down input costs in the face of rapidly decreasing market shares.


returns to scale
360 observations, 2004 to 2012
rts
1.08
1.06
1.04
1.02
1
.98
6
8
10
12
14
16
log_total_lines


predicted cost per access line
cpal based upon annual average input prices
360 observations, 2004 to 2012
140
120
100
80
60
6
8
10
12
14
16
log_total_lines
cpal_2004
cpal_2005
cpal_2006
cpal_2007
cpal_2008
cpal_2009
cpal_2010
cpal_2011
cpal_2012

Impact of Losses in Business vs. Residence Customers

At first blush, the increases in overall cost per access line appear to be inconsistent with constant returns to scale. However, the estimated coefficient for the business to residence cross term βBRB is -0.108693 and highly significant, indicating the possibility of trans-ray convexity in the cost function, meaning that costs would decrease with the joint provision of residential and business services. As shown below, the proportion of business customers to total customers has increased as competitive wireless and cable companies have been more successful in attracting away residence customers than business customers. Unit costs might be higher than they otherwise would be if residence customers are competed away disproportionately. On average, the percentage of business customer lines of total residence and business customer lines has increased from 21% in 2004 to 26% in 2012.

Cable TV operators traditionally focused on providing service to residential customers. Those residential customers then became the cable companies' first targets when rolling out their newer cable phone offerings. In contrast, regulators found that cable companies had an initially limited role in providing phone service to larger business customers. Cable TV facilities had not been built out to many office parks and industrial locations. However, indications are that the cable companies have recently expanded their efforts provide service in the business market. The cable companies appear to be taking advantage of the significant economies of scope which are available via the addition of business service customers. According to Bailey and Friedlaender, "economies of scope become the substitute for the economies of scale which firms cannot achieve given the market conditions they face."Unit costs would increase substantially if the incumbent local exchange companies were left with only residence or only business customers.

Analysis of Customer Density

There are a couple of ways that firms can expand or contract. The returns to scale analysis in the previous section analyzed how the telecommunications firms would fare as they either added or lost customers. However, the assumption is that the size of the service territory remains constant. This section will focus on whether firms can improve by expanding the square mileage of their service areas, or conversely how they will fare if they exit portions of their existing service territories. One way that firms can expand the size of their service areas is to merge with other with other firms. Another way is to "edge out" and compete with firms in adjacent service territories. In order to analyze the impact of customer density, two output variables were added to the cost model. The first additional output variable measures the square mileage of each of the incumbent telephone companies' service territories. Square mileage is chosen as an explanatory variable since it is highly correlated with the amount of outside facilities that must be constructed and maintained to provide landline telephone service to far reaching customers. Outside plant distances have also traditionally impacted the number and location of telephone companies' central office switching facilities. The service territory area output variable is measured in square miles and was obtained from NYPSC's Graphical Information Systems section. The second additional output variable reflects the total number of residential and business customer locations within each service territory. The incumbent telephone companies built out their networks as a result of their traditional common carriage and provider of last resort obligations. The incumbents have argued that it is necessary for them to retain and maintain plant, regardless of customer migration to competition, given the incumbent firms' obligation to serve and carrier of last resort obligations. However, it is unclear to what extent those obligations still remain. The number of customer lines served at the height of their monopolistic service provision at the turn of the century was used as a proxy for the maximum number of customers required to be served by each company. This could be viewed as describing each company's carrier of last resort obligation. Thus the cost model was expanded as follows.

$$Cost = f(Y_r, Y_b, Y_a, Y_d, P_k, P_l, P_m, year)$$

r = output of residence access line customers
b = output of business access line customers
a = output area of service territory size in square miles
d = output of total servable residential and business customer locations within service territory
k = capital input
l = labor input
m = materials input (everything else)
year = dummy indicator variable for each year

The estimated coefficient results and their significance levels for this four output cost function are shown in the Appendix. The estimated cost elasticities associated with the two additional output variables are relatively slight.

Evaluated at sample means.

Parameter	Estimate	Standard Error	t-statistic	P-value
$\partial C/\partial Y_r$	.702940	.046579	15.0913	[.000]
$\partial C/\partial Y_b$	.247303	.039942	6.19161	[.000]
$\partial C/\partial Y_a$	.011631	.011907	.976828	[.329]
$\partial C/\partial Y_d$	.677526E-02	.064076	.105738	[.916]

The marginal costs associated with the two added output variables are extremely small. Thus, the estimated model predicts that there will be little change in cost as the area of service territory size in square miles changes, or as the number of total servable residential and business customer locations within service territory changes. Also, over the 2004 to 2012 sample period, the cost elasticity associated with business line customers has increased while the cost elasticity associated with the change in residence customers has decreased. This might be reflective of the relatively greater importance of business customers to costs as the proportion of residence customers has decreased over the estimation time period.

However, given the extremely small cost elasticities for the two added variable representing the square mileage of the service territory and population of customer locations in the service territory, it is the number of business and residential customers served within that population that most greatly impacts upon the incumbent telephone company costs. The model results suggest that attempts to become more cost efficient by expanding service territory will not be very effective. The results also indicate that maintaining density of residential and business customers is important for maintaining overall cost efficiency.

Conclusion

The incumbent local exchange telephone companies appear to be facing increased difficulty as competition from cable and wireless phone providers continues to erode their market shares. This is apparent in their rising unit costs over time. The cost model estimated herein provides a number of insights regarding how the incumbent telephone companies can best respond to the increasing level of competition. The substitution of capital for labor and/or materials is a two edge sword —increasing cost efficiency, but also potentially stranding fixed costs. Incumbent telephone companies should be vigilant in retaining both residence and business customers so as to take advantage of significant economies of scope. Responsive strategies associated with mergers and competitive entry into adjacent service areas are not expected to result in a large degree of marginal efficiency improvements. Finally, maintaining customer density is essential in keeping unit costs in check.

ENDNOTE

*****The analyses and conclusions in this paper are the author's and do not necessarily reflect the position of the New York State Department of Public Service. The author is grateful for a number of very helpful comments and suggestions from his colleagues at the NYSDPS and from fellow participants of Session D43 of the October 2013 NYSEA conference.

REFERENCES

Bailey, Elizabeth E. and Ann F. Friedlaender, (1982), Market Structure and Multiproduct Industries, *Journal of Economic Literature*, Vol. 20, No. 3, (Sep., 1982), pp. 1024-1048

Berndt, Ernst R. (1991) The Practice of Econometrics: Classic and Contemporary, Addison Wesley, Chapter 9

Brown, Randall S., Douglas W. Caves and Laurits R. Christensen, (1979), Modelling the Structure of Cost and Production for Mulitproduct Firms, *Southern Economic Journal*, Vol. 46, No. 1., (July 1979), pp. 256-273

Cummins, Clint, (2000), User's Guide and Reference Manual - Time Series Processor Version 4.5, by Bronwyn H. Hall and, TSP International, 2000

Currie, Kent A., (2000) Cost Efficiency and Technology of Rural Telephone Companies, in Expanding Competition in Regulated Industries, edited by Michael A Crew, Kluwer Academic Publishers, 2000

Evans, David S. and James J. Heckman, (1984), A Test for Subadditivity of the Cost Function with an Application to the Bell System, *The American Economic Review*, Vol. 74, No. 4, (Sep., 1984), pp. 615-623

Foreman, R. Dean and Edward Beauvais, (1999), Scale Economies In Cellular Telephony: Size Matters, *The Journal of Regulatory Economics*, Vol. 16 (1999), pp. 297-306

Krouse , Clement G., Kenneth L. Danger, Christos Cabolis, Tanja D. Carter, Jon M. Riddle, Daniel J. Ryan, (1999), The Bell System Divestiture/Deregulation and the Efficiency of the Operating Companies, *Journal of Law and Economics*, The University of Chicago Press , Vol. 42, No. 1 (April, 1999), pp. 61-87

McKenzie, David J. and John P. Small, (1997), Econometric Cost Structure Estimates for Cellular Telephony in the United States, *The Journal of Regulatory Economics*, Vol.12 (1997), pp.147-157

New York Public Service Commission, (2008), Case 07-C-0349 – In the Matter of Examining a Framework For Regulatory Relief. Order Adopting Framework (Issued and Effective March 4, 2008)

Norsworthy, John R., Show-Ling Jang, James C MacDonald, HweiAn Tsai, Cecile Fu and Yi Jing, (1993), Measurement of Productivity and Marginal Costs for Incentive Regulation of Telecommunication Services, Report Prepared for the New York State Department of Public Service, January 1993

Roberts, Mark J., (1986), Economies of Density and Size in the Production and Delivery of Electric Power, *Land Economics*, Vol. 62, No. 4 (Nov., 1986), pp. 378-387

Schuler, Jr., Richard E., (2007), Pricing Strategies for Competitive Inter-Modal Telecommunications Markets, paper presented at the Rutgers Advanced Workshop in Regulation and Competition, 26th Annual Eastern Conference, Skytop, PA, May 17, 2007

Schuler, Jr., Richard E., (2008), Economies of Scope and Scale in New York Local Telecommunications Markets, Rutgers Advanced Workshop in Regulation and Competition, 27th Annual Eastern Conference, Skytop, PA , May 14-16, 2008

Shin, Richard T., and John S. Ying, (1992), UnNatural Monopolies in Local Telephone, *The RAND Journal of Economics*, Vol. 23, No. 2. (Summer, 1992), pp. 171-183.