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# AN ECONOMIC ANALYSIS OF THE SERVICE AREA SCHEME*

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Under the service area scheme, firms are required to install basic telephone service as a condition to compete in the cellular and international phone service markets. This study looks at the case of Metro Manila which was arbitrarily subdivided by the regulator into four sections as part of the scheme. Using a process model, the cost of providing basic telephone service in each section is determined for different output levels corresponding to market shares likely to be captured by a new firm. The cost data provided by the process model are then used as input for the econometric analysis where a translog cost function is estimated.

## 1. Introduction

In 1993, major reforms in the telecommunications industry were introduced under the administration of President Ramos. A first notable step was the relatively liberal granting of licenses in the formerly restricted cellular mobile telecommunications services (CMTS) and international gateway facilities (IGF) markets. Then there was the issuance of Executive Order 59 mandating interconnection between carriers. E.O. 59 was significant because it was the first time that a decision to reduce a major entry barrier emanated from the highest seat of government.

To solve the severe shortage of telephone lines, the President issued Executive Order 109 which embodies the service area policy of the government. The policy seeks to improve the telephone density

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rate[1] in the country by making reliable and affordable telecommuni tions service available in both urban and rural areas. In order promote universal service and avoid cream skimming by firms, ope tors of cellular and international toll services are required to establ local exchange carrier (LEC) services in underserved or unserved ar based on a formula that takes into account the projected population a target density rate. The National Telecommunications Commiss (NTC) implemented the policy by assigning service areas among new firms. The NTC first determined the target telephone density, a with information on the projected population, calculated the numbe telephones needed. Knowing the number of CMTS and IGF applica at that time, the NTC simply divided the targets among the fir Based on the National Telecommunications Development Plan, government initially aimed for a 3.5 density rate by 1997, 6.2 by 2 and 10.0 by 2010 (DOTC, 1993, I:35). These targets have fluctua since then moving upward to 14.3 by the year 2000[2] only to be sca down again to 5.7 for the same year[3] reflecting a change in government's formula in determining telephone demand. By insti ing the service area scheme, it is expected that these targets will achieved perhaps even sooner than planned.

These changes in policy direction are now contained in a l Republic Act 7925, which was passed in early 1995. The governm hopes that these policy reforms will spur the much needed investm in telecommunications infrastructure, thereby improving the ove performance of the industry. At this early stage of deregulation, se reform is essentially in the direction of liberalizing the market (or diffusion of market power and control) rather than reducing the rol government at once.

The liberalization of the industry was received positively by t the firms who have been eyeing the profitable telecommunicati market and the consumers who immediately felt its benefits in term increased lines mainly from the Philippine Long Distance Teleph

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[1] The number of telephone lines per 100 inhabitants.

[2] As reported in *Business World* dated March 7, 1996.

[3] As reported in *Business World* dated July 18, 1996.

Co. (PLDT) which launched the Zero Backlog Program. It is too early to see any substantial gains from the service area policy itself. There are reports that several firms are having difficulties in fulfilling their commitments, but the regulator is confident that they will be able to deliver.

In this paper, a novel approach is adopted in order to gain some economic perspective of the service area scheme. Since historical data are not available, we use simulated data for econometric estimation to analyze the cost structure of a hypothetical local telephone network.

## 2. Description of Methodology

Griffin (1977b) proposed a process-econometric approach for the study of joint product industries. He observed that traditional methods are not as useful as one might hope. In the case of engineering or pure process analysis for example, the non-differentiable nature of its production surface makes it inappropriate for the derivation of policy-relevant measures such as price and substitution elasticities. Likewise, statistical analysis is not as robust due to the inherent problems with the data used (e.g., multicollinearity for historical data). Therefore, he suggested a two-step approach that combines the best aspects of both methodologies. As Griffin demonstrated for electric power generation (Griffin 1977a), petroleum refining (Griffin 1977b), and the iron-steel industries (Griffin 1979),[4] the first step involves generating 'pseudo-data' using a process model while the next stage involves an econometric model utilizing the output of the first exercise.

In the iron and steel problem for example (Griffin, 1979, 110), a program is initially solved for cost-minimizing input levels and total costs for a given set of input prices:

$$\min \quad P_z X_z = 1,\ldots,T$$

$$s.t. \quad AX_z \leq b$$

[4] More recent applications outside the telecommunications sector are by Lady and Moody (1993), and Wood, et al. (1994).

where $P_z$ is an n x 1 vector of unit input prices and $X_z$ is an n x 1 vector of process activity levels. $A$ is the m x n matrix of technical coefficients which are based on engineering data. The vector $b$ is the m x 1 right-hand-side constraint vector where the $b_j th$ element constrains output of a predetermined output mix to exceed a given level. Then, input prices are varied sequentially for each input while holding all others constant so that different solutions are obtained. The 'pseudo-data' generated are then used as inputs for the next part involving statistical analysis. A translog cost function using the 'pseudo-data' is estimated such that the resulting statistical cost function serves as a type of single equation, reduced-form description of the technological structure embodied in the multi-equation process model.

As mentioned, the major advantage of the statistical cost function is that it offers a differentiable approximation to the non-differentiable engineering technology, thereby enabling calculation of statistics valuable for policy analysis such as substitution elasticities, price elasticities, and input-output coefficients. The use of statistical estimation also saves on computational expense associated with pure process analysis, which may require hundreds of runs.[5] Griffin recognized though that there is a drawback to using process models to generate pseudo-data for statistical estimation because they are subject to a measurement error and a behavioral error. Measurement error is introduced if the observed technology matrix, A, differs from the technically correct matrix, $A^*$. Behavioral error arises because the frictionless type of long-run cost minimization does not necessarily obtain in the short run.

Mitchell (1978, 1981) suggested the use of Griffin's process-econometric approach in the study of telecommunications policy issues. For example, the program could include an objective function such as profit maximization by the firm:

$$\Pi = \Sigma q_i Y_i - \Sigma c_j(K_j, p)$$

given regulatory and capacity constraints such as:

$$\Sigma Y_i \leq \bar{K}_j$$

[5] Although an important consideration at that time, this factor is admittedly of less significance today.

or that usage by all outputs using each equipment should not exceed available capacity (e.g., toll and basic services for the use of the switch). The process model would yield the quantities and prices of market services, levels of inputs, and the shadow prices of each service. Minimum cost solutions for joint production can be derived by varying the input prices orthogonally. One may also introduce new technologies, different regulatory constraints or the entry of competitors to the model. The solutions would then embody the firm's long-run responses to changing market conditions and these pseudo-data can be used to estimate a smooth multiple output cost or production function. The results from econometric estimation can give insights into the degree of scale economies, the nature of input substitution, and character of expansion paths.

### *Critique of Pseudo-data Analysis*

Maddala (1982), and Maddala and Roberts (1980, 1981) took issue with Griffin's single equation summarization of the information contained in a process model. First of all, they pointed out that a single equation cannot capture the technological structure of a complex process model. It can only capture certain aspects of the technological structure based on how the problem was set up and solved. Since the estimated function is a summary description of a particular data set generated, then a change in any of the assumptions used in generating the data will produce a different summary description. Thus, they warned that the analyst should not make general conclusions since elasticities derived, for example, are conditional on the particular product mix assumed. Secondly, they stressed that the choice of price vector (or any other variable) to generate the pseudo-data must be realistic. In particular, they criticized the price vectors chosen by Griffin for the purpose of correcting for multicollinearity.[6] They argued that "solving" the multicollinearity problem is secondary to finding the price vector that gives the best approximation to the function being studied and is empirically relevant for projections. Finally, on the nature of the error

[6] Griffin varied each input price, holding all others constant, from a level of 50 percent below to 100 percent above 1974 prices.

term, they maintained that only approximation errors are involve using pseudo-data for estimation. The error terms do not have usual interpretation in terms of variables omitted nor is there a s pling aspect to it. Care must therefore be taken in interpreting sig cance levels since the errors arise solely from not having the cor functional form. What matters is the sensitivity of the parameters w respect to the magnitude of the approximation error. Despite th objections, Maddala and Roberts do not recommend complete reject of the pseudo-data approach. They realize that some problems benefit from process analysis, particularly when solutions cannot obtained from time series data. However, they prefer to do the simu tion analysis directly from the process model itself rather than resor a summary function.

Griffin (1980, 1981) responded to the criticism by asserting t concerns about a single equation summary of pseudo-data are m placed. Questions raised by Maddala and Roberts, he argued, ap regardless of the data source. Instead, they relate to the ability generalized functional forms to approximate either real or hypo esized production surfaces. On the choice of price vector, he welcon the adoption of alternative sample designs for price variation. Ho ever, he warned that the risk of limiting the set to a priori futu relative price variation is that the production surface may not identified if unanticipated relative price variation occurs.

Smith (1982)[7] addressed two sources of disagreement related the use of summary functions. The first issue deals with the questior whether neoclassical functions utilizing pseudo-data are useful su maries of the underlying models. As Maddala and Roberts (1980) ha suggested, the use of a summary approximation is generally not nec sary if the process model is available since valuable information can derived directly from the model. While this view has some merit, this itself does not imply that the approximation has no value. In fact, t complexity of some models and the cost associated with running th models may be such that there may be advantages to having summ

[7] This volume contains eight theoretical and empirical papers involving pseu data analysis.

ties of these models. Furthermore, there are benefits that go beyond cost considerations. Individuals who are not fully informed on the technical details of the underlying model may find the summary functions more useful. The approximation errors in these cases may be less important than the errors which could arise from wrong uses of the model. Therefore, the summaries of complex models may still serve some purpose even if original models are readily available.

The second issue is concerned with whether the summary functions are "good" descriptions of the responses which would be implied by the original models. Smith (1982, xiii) noted that the performance of the summary function will depend on (i) the "true" response surface implied by the model, (ii) the choice of functional form to represent the neoclassical summary function, and (iii) the design for choosing variations in the parameters and the selection of initial conditions.

In general, the application of pseudo-data involves several decisions which Smith (1982, xv) cited as:

- The selection (or development) of a model to represent the real-world process under study;
- The construction of an experimental design indicating the variables external to the model's optimizing choices which are to be varied (and the pattern and range of their variations) in the definition of the solutions to the model; and
- The specification of a summary function and treatment of the model's endogenous and exogenous variables in that function.

The careful execution of each of these steps is essential for pseudo-data analysis to be useful.

## 3. A Process-Econometric Model of the Local Exchange Network

Gabel and Kennet (1991, 1994) are the first to apply the process-econometric approach to telecommunications. They developed the Local Exchange Cost Minimization Model (LECOM), which calculates the cost of a local exchange facility utilizing the best practice technology.

Its program is based on algorithms that embody the engineering s dards and practices used for the design of local exchange netwo Taking as inputs demographic data for a city, price data on the tecl logical options available, and usage data for different types of users, model searches for the combination and location of switches that m mizes the cost of production.[8] Thus, the problem solved by LECOI (Gabel and Kennet 1994, 388):

$$\min_{\tau\in T^*,S,x,y} SC(\tau_s,x,y,S) + TC(\tau_r,x,y,S) + FC(\tau_f,x,y,S) + DC(\tau_d,x,y,S$$

where $\tau$ is a vector of technologies available (elements $\tau$ of are su cripted $s$ for switching, $r$ for trunking, $f$ for feeder, and $d$ for distri tion), $T^*$ is the set of feasible technologies, $S$ is the number of switc employed, $x$ is an S-vector of x coordinates for the locations of switches, $y$ is the an S-vector of y coordinates for the location switches, $SC$ is switching cost, $TC$ is trunking cost, $FC$ is feeder c and $DC$ is distribution cost. Data from repeated runs of LECOM various output levels or input prices are then used for statistical ana sis.

LECOM can provide cost estimates for up to five outputs: fo services (exchange switched service, toll switched service, local priv line and toll private line); and access lines. With the rich data generated by the model, it can be used to calculate the cost of individ services, test for natural monopoly properties, and conduct sensitiv analysis under different technologies (Gabel and Kennet, 1991, 89-9 LECOM has been used in various state rate commission hearings in t U.S. as the basis for firm cost studies.

As the authors note, there are advantages and disadvantages using process models in general and LECOM in particular in modeli the cost structure (ibid., 2-12). LECOM's major strength as a source data for the statistical analysis of the cost function is that it explici recognizes cost-minimizing behavior in the optimization routine. Thu we are confident that there is no noise in the data with regard to t

[8] The location of switches are optimized by a nonlinear, derivative-free, downh simplex routine. See Gabel and Kennet (1991, 37) for a discussion of the optimizati method used in LECOM.

cost minimization assumption. Another advantage of using the program is that it is quite flexible with regard to the technology mix, output combination, and price variation such that it can be used for the study of a wide range of issues (e.g., common cost problem, analog vs. digital, and effect of different "fill" rates in the local loop). Data simulation is particularly appealing when the problem involves technological and policy changes that lie outside the range of historical time series experience (Gabel and Kennet, 1994, 387; and Griffin, 1977b, 391). On the whole, LECOM, like other process models, provides an alternative source of information for regulators and/or policy-makers in their decision-making. It is not intended as a substitute for standard cost studies but rather a supplementary tool that regulators can use to compare against the cost estimates provided by those they regulate.

As is typical of any process model, the most serious weakness of LECOM lies in the underestimation of transaction costs. Process models are designed to capture the technology aspect of the production process. Administrative and marketing aspects are not emphasized in these models. LECOM tries to correct this by treating administrative costs as a linear function of the level of investment; therefore, it will exhibit the same economies or diseconomies as that of the plant. In addition, there is the problem of 'bounded rationality'. It is not known if the solution found by LECOM is a local or global minimum. Although it is desirable to locate the global solution, doing so with a process model would be impractical as it would entail an infinite number of possible configurations. The authors address this problem by programming LECOM so that it searches over a reasonable number of possibilities — about a thousand cost evaluations for each combination of switches.

Despite the limitations, LECOM still offers an advantage over the use of historical data particularly for analyzing entry and competition. In most cases, the historical data available to the researcher are those of a firm operating in several markets. Entry however occurs in specific markets. Therefore, econometric studies using firm level data to evaluate competition in a given geographic area may suffer from aggregation bias. The use of LECOM to generate the data for econometric estimation avoids this problem. One is able to study cost conditions in a particular market under a specified policy environment.

## 4. An Analysis of the Service Area Scheme using LECOM

We use LECOM to simulate the cost structure of a hypotheti local exchange network. By adopting the process-econometric a proach, we hope to have a better understanding of the economic und pinnings of the service area scheme.

*Background*

The current structure of the sector can be characterized as asy metrically competitive.[9] With PLDT as the dominant firm, there a now nine other public telecommunications carriers in the country a thorized to provide cellular and/or international long distance servic By virtue of E.O. 109 and R.A. 7925, the new firms are also required provide local telephone service and will therefore operate side by si with PLDT (or the current local provider[10]) within a given service are Specifically, R.A. 7925 calls for the following:

- IGF operators are required to provide a minimum of 300 loc exchange lines per one international switch termination ar must provide a minimum of 300,000 local exchange lines with a period of 3 years from the date of authority to install, opera and maintain LEC service;

- Nationwide CMTS operators are required to provide a min mum of 400,000 local exchange lines while regional CMT operators 40,000 local exchange lines within a period of 3 year

Under the plan, the firm should install one line in a rural area fo every ten lines installed in the urban areas. Failure to meet the r

[9] As defined by Sharkey (1982, 206), "competition is 'asymmetric' if one firm overwhelmingly larger than each of its potential competitors and if the rules of compet tive conduct differ between the large and small firms… The largest firm must also hav a dominant market share."

[10] There are about fifty small telephone operators scattered all over the countr

quirements will result in the cancellation of their respective licenses as CMTS and IGF operators.[11]

To implement the service area policy, the NTC divided the country into eleven service areas and assigned them to the nine firms covered by the requirement. Each service area is composed of underserved or unserved territories and a profitable area. For four of these firms, the profitable area is Metro Manila. Thus, Metro Manila was subdivided into four sections for each new firm to serve. Since PLDT operates in the whole metropolitan area, this set-up has resulted in a duopoly within a section (PLDT and the new firm), with a total of five firms for the whole Metro Manila.

To analyze the service area scheme, we will use some basic data from the service territories in Metro Manila. Focus is given on the profitable area of the service area scheme since it is likely that the ability of each firm to support its local exchange service in the underserved and unserved areas will depend largely on the viability of operations in the profitable markets.[12]

Using the latest government projections, demand for telephone lines in all of Metro Manila by 1998, the deadline for the new firms to establish their line commitments, will be about 1.7 million.[13] The size of the service areas with the corresponding projected demand are shown in Table 1.

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[11] Article IV of R.A. 7925 states that "Failure to comply with the obligations within three (3) years from grant of the authority shall be a cause to cancel its authority or permit to operate as an international carries (sec. 10)" or "... mobile radio telephone system (sec.12)."

[12] The CMTS and/or IGF lines of business are supposed to help shoulder the local exchange operations in the underserved or unserved areas. A cross-subsidy from these "lucrative" activities seems unsustainable since these are highly competitive businesses (note that there are currently nine IGF operators and five CMTS operators — higher than industrialized countries!). Another source of intra-firm subsidy may be the local exchange operations in the profitable area.

[13] Based on a target density rate of 18.0 for each area and the projected population for 1998. As earlier mentioned, the government's demand projections have fluctuated since the first release of the National Telecommunications Development Plan. For this study, the most optimistic demand projections which were reported in *Business World* dated March 7, 1996 were used.

**Table 1 - Basic Description of the Service Territories in Metro Manila**

| Land Area Per Section | Projected Demand |
|---|---|
| A - 96.7 sq. km. | 546,000 lines |
| B - 236.6 sq. km. | 489,900 lines |
| C - 118.2 sq. km. | 328,300 lines |
| D - 184.5 sq. km. | 335,670 lines |

As of 1993, PLDT operated around 50 local exchanges all over th Metro Manila with a total capacity of a little more than 600,000 lines With the threat of competition brought about by liberalization, th company embarked on the Zero Backlog Project and built additiona exchanges to satisfy its unmet demand which at that time was abou 800,000 lines. Between 1993 to 1996 PLDT doubled its network size b installing about 818,224 lines, primarily in Metro Manila. According t NTC, the installed capacity of PLDT in Metro Manila as of the fourt quarter of 1996 had reached more than 1.4 million lines. This figur already achieves about 84 percent of the expected telephone demand i Metro Manila for 1998 assuming a density rate of 18.0. According t PLDT's 1996 Annual Report, we can expect further network expansio and modernization to continue until the year 2001.[14]

*How Viable is Metro Manila? Some Insights from Entry Theory*

Entry theory asserts that there is a fundamental asymmetry in the pre-entry game that enables an incumbent to modify its behavior and erect strategic barriers against an equally efficient entrant (Salop, 1979). Having first-mover advantage, the established firm who has committed resources can easily engage in activities that limit entry by a new firm or even make their entry unprofitable.

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[14] By this time, PLDT expects to have about 3.2 million lines in place for the whole country.

Capital accumulation is one way that an established firm responds to a threat of entry. The temporal asymmetry allows the incumbent to choose a level of capital that can lower an entrant's profitability. For example, by choosing to carry excess capacity in the pre-entry period, an incumbent signals his ability to expand output in the post-entry stage, thereby reducing prospective profits of the new entrant (Spence, 1977; and Dixit, 1980).[15] Since the entrant operates on the residual demand curve, a credible threat of output expansion can limit the entry of new firms. To be a credible threat, of course, requires that the investment is irreversible (i.e., sunk) such that the cost to the incumbent of being freed from the commitment is sufficiently high (Tirole, 1988; and Ware, 1992).

Such strategic behavior is apparent in PLDT's actions. Whereas huge unmet demand persisted prior to liberalization, PLDT's response via the Zero Backlog Project has substantially reduced opportunities for the competition to operate profitably in Metro Manila. Under this situation, only small-scale entry is possible for the new entrants.

With significant economies of scale, however, even small-scale entry is unprofitable. Significant economies of scale exist when the *minimum efficient scale*, the smallest scale of a plant or firm that achieves the lowest average cost, is large relative to the total industry scale, and if, in addition, average cost significantly increases at smaller than minimum optimal scale. Thus, with significant economies of scale, any firm that enters at a suboptimal scale will produce at a cost that is higher than minimum average cost. In this sense, large economies of scale constitute a barrier to entry.[16] As Bain (1957, 55) described, there are two effects of economies of scale on the condition of entry: the *percentage effect*, which reflects the importance of the share

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[15] See Tirole (1988, 314-6) for a simplified discussion of the Stackelberg-Spence-Dixit model.

[16] In the old industrial organization literature, an entry barrier was generally defined as a cost advantage enjoyed by the incumbent. In the new industrial organization literature, a welfare criterion is added. von Weizsacker (1980, 400) defines a barrier to entry as "a cost of producing which must be borne by a firm which seeks to enter the industry but is not borne by firms already in the industry and which implies a distortion in the allocation of resources from the social point of view."

of output supplied by an optimal plant to total demand; and the *absolute-capital-requirement effect*, which refers to the huge capital investment needed for efficiency and an entrant's access to such funds. These two factors are important considerations for the new firms because the Philippine telecommunications market is not large and can therefore accommodate only a few providers. Moreover, telecommunications investment requires huge capital funds, a substantial component of which is, in foreign exchange, needed to purchase imported capital equipment.

### *The Cost Model — $C(q, p_L, p_K, p_M)$*

Estimation of the cost function allows us to determine if, indeed, significant economies of scale exist which may affect the profitability of entrants. We assume that each firm establishes a local exchange network within its assigned section of Metro Manila such that all potential subscribers can be served on demand. Since all firms have access to the same technology (as embodied in LECOM), the cost faced by individual firms is a function of the number of lines served and input prices:

One output: $q$ = Number of Lines

Three input prices: $p_L$ = Price of Labor
$p_K$ = Price of Capital
$p_M$ = Price of Materials

We estimate a Translog Cost Function for each firm:

$$\ln C = \alpha_0 + \alpha_q \ln q + \beta_L \ln p_L + \beta_K \ln p_K + \beta_M \ln p_M + \frac{1}{2}\gamma_{qq} \ln_q \ln_q +$$

$$\frac{1}{2}\delta_{LL} \ln p_L \ln p_L + \frac{1}{2}\delta_{LK} \ln p_L \ln p_K + \frac{1}{2}\delta_{LM} \ln p_L \ln p_M +$$

$$\frac{1}{2}\delta_{KL} \ln p_K \ln p_L + \frac{1}{2}\delta_{KK} \ln p_K \ln p_K + \frac{1}{2}\delta_{KM} \ln p_K \ln p_M +$$

$$\frac{1}{2}\,\delta_{ML}\ln p_M \ln p_L + \frac{1}{2}\,\delta_{MK}\ln p_M \ln p_K + \frac{1}{2}\delta_{MM}\ln p_M \ln p_M +$$

$$\rho_{qL}\ln q \ln p_L + \rho_{qK}\ln q \ln p_K + \rho_{qM}\ln q \ln p_M$$

The translog function is a second-order Taylor series approximation to a multi-product cost function around a point of expansion given by $q = p_j = 1$ (j=1,2,3).[17]

By Shepard's Lemma:

$$x_i = \frac{\partial C}{\partial p_i} \qquad \textit{where } x_i \textit{ is quantity demanded of ith factor}$$

Cost Share Equations:

*Labor* $$S_L = \frac{p_L x_L}{C} = \frac{\partial \ln C}{\partial \ln p_L} = \beta_L + \delta_{LL}\ln p_L + \delta_{LK}\ln p_K + \delta_{LM}\ln p_M + \rho_{qL}\ln q$$

*Capital* $$S_K = \frac{p_K x_K}{C} = \frac{\partial \ln C}{\partial \ln p_K} = \beta_K + \delta_{KL}\ln p_L + \delta_{KK}\ln p_K + \delta_{KM}\ln p_M + \rho_{qK}\ln q$$

*Material* $$S_M = \frac{p_M x_M}{C} = \frac{\partial \ln C}{\partial \ln p_M} = \beta_M + \delta_{ML}\ln p_L + \delta_{MK}\ln p_K + \delta_{MM}\ln p_M + \rho_{qM}\ln q$$

Symmetry restrictions:

$$\delta_{LK} = \delta_{KL},\ \delta_{ML} = \delta_{LM},\ \delta_{MK} = \delta_{KM}$$

[17] Data are scaled around the sample mean.

Homogeneity restrictions:

$$\beta_L + \beta_K + \beta_M = 1$$
$$\delta_{LL} + \delta_{LK} + \delta_{LM} = 0$$
$$\delta_{KL} + \delta_{KK} + \delta_{KM} = 0$$
$$\delta_{ML} + \delta_{MK} + \delta_{MM} = 0$$
$$\rho_{qL} + \rho_{qK} + \rho_{qM} = 0$$

Thus, four systems of three equations composed of a cost function a the associated labor and capital share equations are estimated emplo ing the Zellner's procedure for Seemingly Unrelated Regression Equ tions (SURE).

*Design of Experimental Data*

The data set used for econometric estimation was generated usi LECOM. For each firm assigned to a particular section of Met Manila, the cost of a telephone network was computed taking as inpu basic data for the area as contained in Table 1, price data on t technological options available, and usage data for different types users. Repeated runs of LECOM were conducted for various outp levels and input prices. Output levels were varied based on differe market shares for that area ranging from 0.05 to 20.0 percent. Inp prices were varied from a range of ±.10 of 1995 prices using a rando sampling tool. To allow for comparison, the same combinations market shares and input prices were used for all firms.[18] With fo firms (sections), a total of 160 data points were generated each consis ing of the total cost, output level, and input price levels. The da produced by LECOM were then used for the next step involving econ metric estimation of the cost function.

[18] Note that although market shares are the same, actual number of lines will different depending on the size of the market (population) served by the firms.

*Empirical Results*

A total of four sets of parameter estimates were obtained consisting of a cost function and two share equations for each of the four firms. Estimated coefficients of the restricted cost function[19] are presented in Table 2.[20]

*Economies of Scale*

The degree of scale economies is given by:

$$\varepsilon = \frac{\partial \ln C}{\partial \ln q} = \alpha_q + \gamma_{LL} \ln q + \rho_{qL} \ln P_L + \rho_{qK} \ln P_K + \rho_{qM} \ln P_M$$

where $\varepsilon < 1$ implies increasing returns to scale, $\varepsilon > 1$ implies decreasing returns to scale, and $\varepsilon = 1$ implies constant returns to scale. Evaluated at the sample mean, elasticity of scale is simply $\alpha_q$. From Table 2, we can see that each firm experiences increasing returns to scale at the sample mean which is about 10 percent of their respective markets.[21]

*Effect of Densification*

The second-order coefficient for telephone lines, $\gamma_{qq}$, reflects the impact of further densification. In three areas, namely B, C, and D, this term is negative, reflecting cost savings from having shorter loop lengths with additional switches. However, the quasi-fixed cost of

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[19] With homogeneity and symmetry restrictions imposed.

[20] It must be noted that the data were generated deterministically and the exact probability distribution of the error term is not known. As a result, the validity of the $t$-ratio for the significance test of each of the estimated parameters will depend on how close the actual but unknown probability distribution of the error term is to a normal distribution.

[21] Recall that output levels were based on the market shares which we varied from 0.05 percent to 20 percent of the expected demand in each area.

**Table 2 - Parameter Estimates for the Cost Function in Restricted System of Equations**

| Parameter | Firm A | Firm B | Firm C | Firm D |
|---|---|---|---|---|
| Constant $\alpha_0$ | 17.71 (2666) | 18.20 (1463) | 17.64 (1769) | 17.94 (1942) |
| Lines $\alpha_q$ | 0.453 (36.38) | 0.290 (12.48) | 0.272 (16.21) | 0.218 (13.03) |
| Price of Labor $\beta_L$ | 0.399 (837.9) | 0.399 (746.9) | 0.399 (784.3) | 0.399 (746.2) |
| Price of Capital $\beta_K$ | 0.501 (699.6) | 0.503 (976.2) | 0.503 (830.0) | 0.502 (790.2) |
| Price of Material $\beta_M$ | 0.100 (127.4) | 0.098 (144.7) | 0.098 (127.6) | 0.099 (139.3) |
| Lines*Lines $\gamma_{qq}$ | 0.111 (8.882) | -0.015 (-0.65) | -0.073 (-4.68) | -0.092 (-5.62) |
| Labor*Labor $\delta_{LL}$ | 0.242 (41.37) | 0.238 (37.15) | 0.245 (42.83) | 0.230 (37.37) |
| Labor*Capital $\delta_{LK}$ | -0.209 (-37.7) | -0.199 (-39.7) | -0.208 (-45.3) | -0.200 (-36.8) |
| Labor*Material $\delta_{LM}$ | -0.033 (-5.51) | -0.039 (-6.20) | -0.037 (-5.87) | -0.030 (-4.92) |
| Capital*Capital $\delta_{KK}$ | 0.264 (27.34) | 0.251 (35.47) | 0.255 (38.30) | 0.245 (28.84) |
| Capital*Material $\delta_{KM}$ | -0.055 (-6.18) | -0.053 (-7.95) | -0.047 (-6.93) | -0.045 (-5.78) |
| Material*Material $\delta_{MM}$ | 0.088 (8.124) | 0.092 (9.819) | 0.084 (8.268) | 0.075 (7.525) |
| Lines*Labor $\rho_{qL}$ | 0.001 (0.964) | -0.001 (-0.98) | -0.001 (-1.09) | -0.0015 (-2.47) |
| Lines*Capital $\rho_{qK}$ | 0.001 (1.105) | 0.002 (3.672) | 0.001 (1.467) | 0.003 (4.109) |
| Lines*Material $\rho_{qM}$ | -0.001 (-1.59) | -0.002 (-2.04) | -0.0004 (-0.44) | -0.0015 (-1.83) |
| $R^2$ | 0.9851 | 0.9279 | 0.9594 | 0.9584 |

* *T*-ratio in parenthesis

deploying additional switches sets in with further densification which may explain why this value is positive and significant for Firm A which serves the most densely populated area.

*Minimum Efficient Scale*

In computing the cost of producing a given output level, LECOM treats all inputs as variable and seeks the combination of facilities that will minimize the cost of production. Thus, the estimates generated are consistent with long-run cost minimization such that the minimum efficient scale of production can be determined from the average cost curve. Figures 1 to 5 show the various average cost curves with factor prices fixed at the sample mean (i.e., 1995 prices).

As defined earlier, the minimum efficient scale is the minimum level of output that achieves the lowest average cost. It can also mean the minimum level of output beyond which further reductions in unit cost can be considered insignificant. In our case, the MES can be interpreted as the level of output where managerial diseconomies begin to take over. This characterization seems appropriate since managerial or administrative costs are not fully captured in the process model and will therefore not be completely reflected in the average cost curve.[22]

The figures reveal that due to the size of the territories, each entrant faces a different average cost curve which means that the minimum efficient scale of the network varies from one market to another. Since efficient production in their respective markets require entry at different scales of production then the absolute-cost-requirements will vary from one entrant to another.

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[22] Our results are not too different from those found in other studies. Scherer and Ross (1990) state that the long-run average cost function of industrial firms is characterized by a minimum efficient scale that is followed by a range of output levels where unit cost remains more or less constant. Beyond some point, however, the managerial diseconomies intrude thereby driving the average cost upward. In a study of U.K. manufacturing industries, Pratten (1971, 1991) found that most industries face a continuously declining average cost curve but added that further reductions in the average cost can be considered negligible after some point.

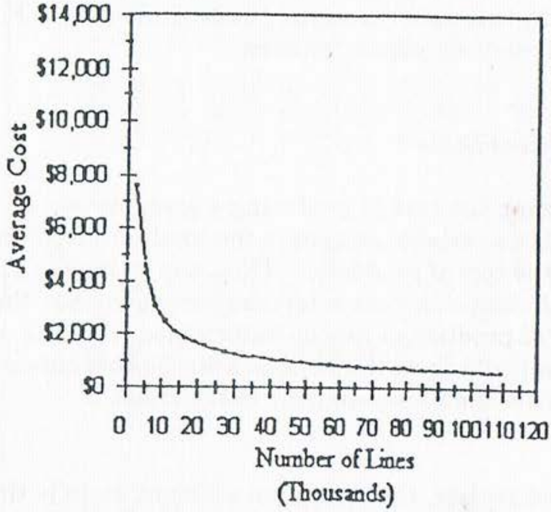


**Figure 1 - Average Cost Curve of Plant A**

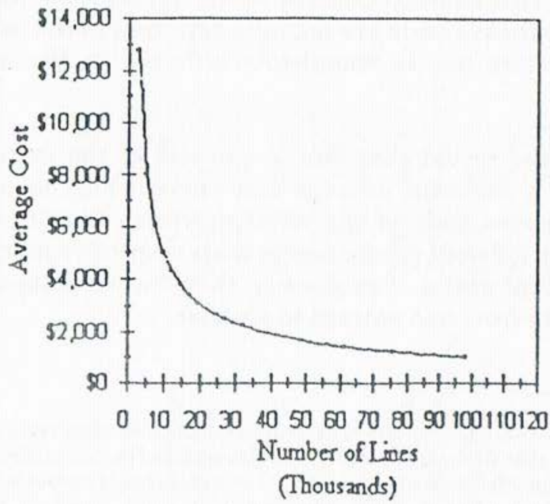


**Figure 2 - Average Cost Curve of Plant B**

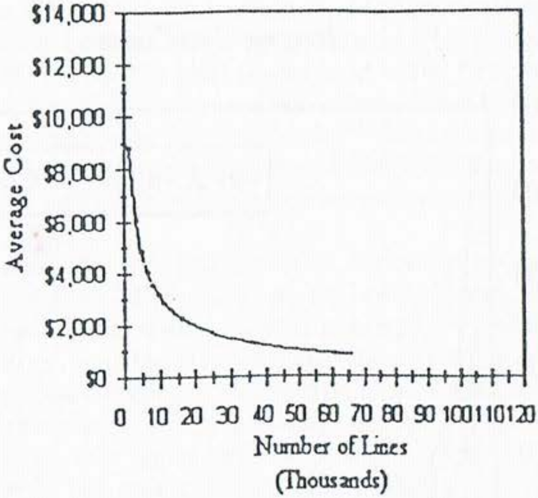


**Figure 3 - Average Cost Curve of Plant C**

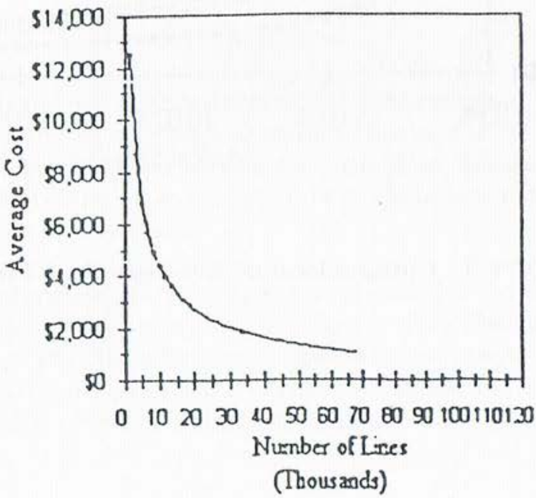


**Figure 4 - Average Cost Curve of Plant D**

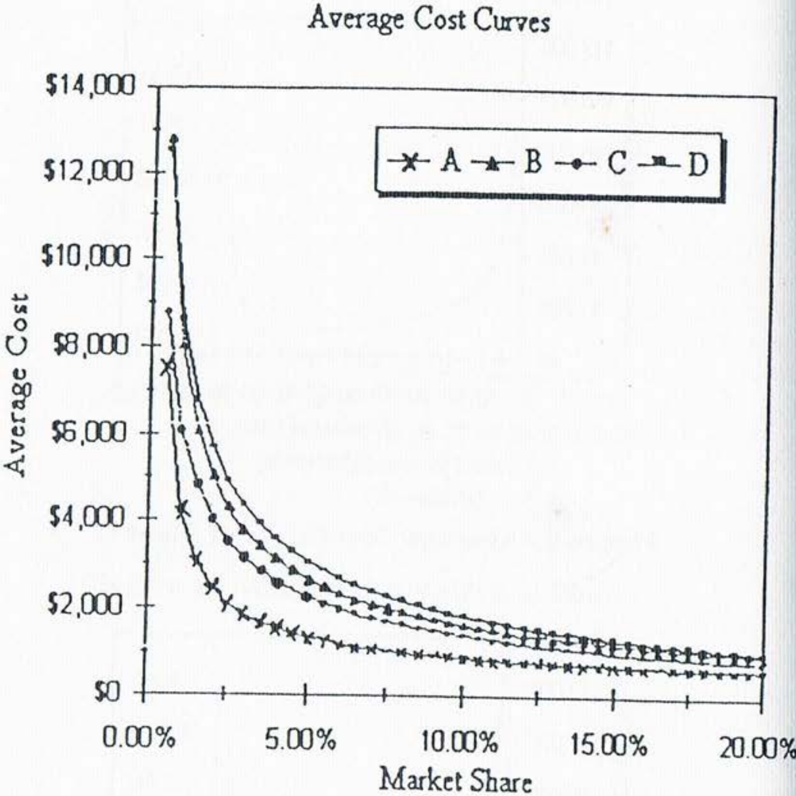


**Figure 5 - Comparison of Average Cost Curves**

Entry that achieves the minimum scale of production may not be feasible depending on how much or how little PLDT has penetrated that section of Metro Manila that is assigned to the firm and of course, on the demand for lines in that area. Since PLDT's lines are not uniformly distributed over Metro Manila,[23] some firms may find entrance accommodated (the plant is not underutilized) while for others it is deterred (plant suffers from too much excess capacity).

One can also infer that the entrants, which are actually competitors in the IGF and/or CMTS markets, are handed unequal handicaps. Supposing that each firm is able to capture ten percent of the market in its service territory, note that the unit cost incurred by firm D is double the cost of firm A (see Figure 5). Although a more realistic scenario is where new entrants secure different market shares, it is clear that the competitiveness of new firms will be affected by factors which are beyond its control. The potential handicap in the local exchange line of business may affect the profitability of the firm itself and an otherwise efficient CMTS or IGF operator may find itself driven out of the competition.

## 5. Conclusion

The simulation exercise we conducted demonstrated that it is not the number of lines alone which determine the cost of local exchange service but the size of the territory as well. All other things being equal, the smaller the area being served by a local exchange network is, the lower the cost per line will be.

The importance of market share was revealed as well. It not only affects the viability of an entrant from the revenue side (as commonly viewed) but from the cost side, too. Expanding one's market share not only increases sales but, for production technologies that are characterized by economies of scale, a growing market share dramatically re-

[23] There is speculation that PLDT concentrated on serving high revenue generating customers (UBS 1995, 31).

duces per unit cost as well. These two factors, area size and mark share, are important considerations in analyzing the service ar scheme.[24]

There are other issues beyond the scope of the process-econome ric model adopted here which are equally important. To be sure, the are disadvantages of having several firms in the market, and of limitin their operations within service areas. There is significant scope f rapid expansion of telecommunication networks in developing cou tries such as the Philippines; however, such gains can be most exploite by firms which are not constrained by size. As Saunders, Warford, an Wellenius (1994, 57) describe, the extent to which economies of sca reduce the unit cost of telephone service depends on how fast th network expands. This, in turn, is affected by the availability of capit funds needed for large-scale projects, the responsiveness to consume demands, and the effectiveness of procurement practices. All othe things being equal, a firm with a large and rapidly growing syste should be able to offer its customers more service for the same amoun of money than one which has a smaller system and a network that i growing more slowly.

Keeping firms small not only ignores savings from scale econo mies but also weakens the bargaining power of each firm vis-a-vis th incumbent in negotiating tariffs and interconnection arrangement This is because the dominant firm has little incentive to grant favorabl terms to a firm with a small network of subscribers. Another disadvan tage to being small is related to the demand behavior of subscribers. A Noam (1994, 23) points out, demand for telecommunications service i a function of price and benefits, both of which are a function of the siz of the network. Therefore, we can expect a firm that is kept small b government regulation to find its subscriber base shrinking further i there is dissatisfaction among its members. Another consideration i

[24] Interestingly, multiple operators at the local exchange level is not a new idea This was allowed beginning in the 1960s but due to lack of interconnection an coordination, the system became fragmented. Eventually, consolidation was ordered i 1981 to improve the financial position and capacity of operators. It was then that PLDT acquired smaller companies, thereby reinforcing its position as the dominant firm (SGV Consulting 1992, 8-9).

the increased transaction cost that the industry as a whole incurs due to the number of players involved.[25] Finally, one should ask whether or not the smaller profit margins that result from both intense competition and the service obligations augur well for further network expansion and improvement by the new firms beyond 1998.

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[25] In the same way that an $n$ node network requires $n(n-1)/2$ direct links in the absence of a central switch (Sharkey, 191), an industry with $n$ players may have to engage in up to $n(n-1)/2$ bilateral negotiations.

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