The effects of economy size on firm performance: evidence from the telecommunications sector.

Pavlos C. Symeou[1]

University of Cambridge and University of Munich (LMU)

Abstract

The main argument of this paper is that large economy size is a necessary but not sufficient condition for higher firm performance. Existing positions in the literature consider firms operating in small economies disadvantaged on the grounds of small size limitations. Recent evidence suggests that firms in small economies may exhibit comparable relative performance with corresponding firms in larger contexts. I distinguish small from large economies based on geographic, economic, and demographic criteria and employ Stochastic Frontier Analysis to empirically examine the effects of economy size on the efficiency of 54 incumbent telecommunications firms for the period 1990-2007. I concomitantly account for the effects of sector-specific policies and economy-wide factors. The results show that economy size has a positive effect on firm efficiency albeit at a decreasing rate. A firm's market structure, internal governance, and the economy's quality of institutional endowments play an important role in firm performance. The research findings are used in making recommendations to firms from small economies for enhancing performance.

Keywords: Small economies, economy size, firm performance, efficiency analysis, telecommunications, industrial change

JEL: D24, L11, L52, L96

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1 Introduction

There is an extensive literature (mostly theoretical) on international trade that relates the performance of manufacturing firms with their economy size (e.g. Campbell & Hopenhayn, 2005, Krugman, 1991, Melitz & Ottaviano, 2008). According to these studies, firms operating in larger economies and therefore in bigger markets are expected to be more productive, to sustain a broader range of products, to exhibit lower prices and lower mark-ups (Melitz & Ottaviano, 2008). Firms in small economies are more likely to produce goods that manifest low to medium degree of scale economies compared to firms in large economies, which concentrate on increasing-returns industries (Holmes & Stevens, 2005). Comparable arguments are pervasive in the literature on small economies (e.g. Alesina & Spolaore, 2003, Armstrong *et al.*, 1998, Briguglio, 1995, Easterly & Kraay, 2000) which examines, inter alia, the potential of manufacturing firms to overcome small size limitations and the corresponding role of policy.

Notwithstanding, a number of success stories of firms from small economies[2] whose performance in relative terms has been comparable with that of corresponding firms in large economies have cast light on a number of subtle advantages of smallness (e.g. Symeou, 2009). These advantages derive from small economies' closely integrated societies, the extensive openness to trade of local firms, the firms' increased exposure to international competition, and their resilient adaptation to change (Castello & Ozawa, 1999, Easterly & Kraay, 2000, Wint, 2003).

In this paper I aim to shed light on how firm performance is affected by economy size through an empirical examination. I depart from existing studies by

[2] See for example NISSOS, a project identifying "best practice" data collated from successful firms from Malta, Estonia, Finland, inter alia. http://www.islandstudies.ca/smallbusiness.html. Last visited 01.08.2009

focusing on an industry of non-tradables, telecommunications, to ensure that exporting activities are unlikely to distort the size-performance relationship. In parallel, since telecommunications are characterised by substantial fixed costs, increasing returns to scale and extensive regulation, they present an environment where economy size is most likely to affect firm performance.

I examine the relationship between economy size and firm performance by employing Stochastic Frontier Analysis. I utilise international data for 54 former telecommunications incumbents from an equal number of small and large economies for the period 1990-2007. Analysis involves the estimation of multi-input multi-output distance functions through which I obtain measures of firm technical efficiency. I simultaneously examine the effects of economy size, policy and environmental factors on firm efficiency.

The analysis shows that firms in small economies exhibit lower average technical change and efficiency than those in large economies but operate at equivalent increasing returns to scale. Economy size has a positive effect on firm efficiency, though at a decreasing rate. As this effect may create incentives for firms to operate in larger economies and for smaller economies to grow larger, its decreasing nature suggests that it will eventually become negligible if not negative over very large economy sizes. Firm efficiency is inevitably affected by sector-specific policies as well as economy-wide factors. Competition in mobile telephony and fixed voice, private ownership of operators, and high quality of institutional endowments have positive effects on firm efficiency both in small and large economies. These factors are critical for firm performance and may have a strong impact on a firm's strategic, governance, and expansion decisions. Many are exogenous to the firm on which managers have limited influence. This paper emphasises the importance of economy size and policy factors in management decisions.

The remaining of the paper is organised as follows. The next section reviews the literature on the relationship between economy size and firm performance and develops the research hypotheses. A subsequent section discusses the research methodology, model development, and data collection ending with the empirical results. The paper ends with a section of concluding remarks.

2 Economy size and firm performance

Firms in small economies have traditionally been considered as disadvantaged in the world economy (Briguglio, 1995). They lack economies of scale, which affects particularly firms in the manufacturing sector and sectors with high fixed and sunk costs. The minimum efficient scale of operation for firms in small economies happens to be very high relative to the overall size of the market culminating in the survival of few firms and the emergence of monopolistic tendencies (Armstrong et al., 1998). Firms face inefficiencies in the transformation of inputs into outputs that produces an unparalleled comparative disadvantage relative to those operating in large counterparts (Winters, 2005). The options for firms for recruiting specialised employees are restricted by the limited labour force of small economies (Castello & Ozawa, 1999). Equally important, operating in a small economy can prove detrimental to the attraction of foreign financial and social investment that contribute to development of competitive production facilities.

Nonetheless, firms in small economies can benefit from the existence of closely integrated societies depicted by strong networks of personal relationships. These social qualities facilitate efficient information flow between government and industry agents enabling effective policy development and application (Castello & Ozawa, 1999). A pervasive characteristic across firms in small economies is their trade openness which yields long-term growth benefits (Alesina & Spolaore, 2003, Winters, 2005). Domestic firms that are open to international trade are highly exposed to international competition which might engage them in a inescapable process of becoming more competitive (Maskell *et al.*, 1998). In addition, small economies tend to be more adaptive to change and administration (Wint, 2003) that might promote firm environments conducive to acceptance of innovation and efficient forms of governance. Small economies achieve higher education that according to Easterly and Kraay (2000) functions as a countermeasure against the negative effects of smallness on growth. Higher education might also relate to the multitasking capabilities that firm employees in small economies often demonstrate (Castello & Ozawa, 1999). This could counterbalance firms' limited options for specialised labour.

Evidently, there are arguments both in favour and against economy size as a determinant of firm performance. On the one hand, firms in large economies are less likely to encounter stringent market size limitations; they have larger pools of human capital; and natural resources. On the other hand, small economies are depicted by social cohesion and adaptability to change that might counterbalance other disadvantages. Moreover, so long as firm size is commensurate with the overall economy size the firm might still be able to operate efficiently. It is therefore becoming unclear to what extent a firm's efficiency is being conditioned by smallness, per se. Besides, firms that encounter no size limitations might grow too large, giving rise to largeness as an opposite extreme to smallness, which is apt to foment misallocation of resources harming efficient operation. This suggests a nonlinear relationship between economy size and firm efficiency. The following hypothesis develops from the above:

H1: There is an inverse u-shaped relationship between economy size and firm efficiency

Policy makers make concerted efforts to develop policies that are targeted on alleviating small size's negative impact on firm efficiency. Driven by an inherent tendency to trade openness and following the examples of large economies, policy makers have liberalised monopolistic markets, induced private participation in former state-owned organisations, and established sector-specific regulators responsible for market governance. Below we elaborate on the likely effects of these factors on firm performance when small economy size becomes an issue.

2.1 Competition and firm performance

Opening long-lasting monopolistic markets to competition has been justified by the expectation that competition will induce firms to better allocate resources (Viscusi *et al.*, 2005). Firms in small economies are normally more exposed to the effects of competition due to their extensive openness to international trade. Allowing for competition might also have important spillover effects on foreign inward investment. According to Wint (2003) the liberalisation of Jamaican telecommunications led to alleviation of risks pertaining to attracting foreign investment. Competition stimulated investments in new technologies that advanced growth in the market.

The inherent scale limitations of firms in small economies might act as strong barriers to entry for potential competition and concurrently confine its beneficial impact. Where the existence of high fixed and sunk costs complicates matters in specific markets, only a few firms may be sustainable in the long-term. Firms in the markets of tradables might be able to overcome scale limitations through exporting activities. Yet, the same strategies are unlikely to apply to the non-tradables such as electronic communications[3]. Therefore, injudicious entry in small markets with characteristics akin to those of telecommunications, would culminate in market failures due to the inability of operators to reach minimum efficient scales of operation and loss of efficiency (Gal, 2003). Since competition might not always encourage market efficiency, environments of market concentration (with price regulation) might be preferred (Posner, 1976). International exposure along with openness facilitates firms in small economies to exploit outcomes of R&D conducted in large economies (Maskell et al., 1998). This could possibly lead to relatively more efficient monopolies compared to those in large economies.

Symeou (2009) derived new evidence from an in-depth analysis of the liberalisation of the Cypriot telecommunications and an econometric analysis of data for a number of small and large European economies. Research findings from both analyses were consistent and suggest that competition as an end in itself is less relevant to the success of liberalisation in small economies. That is mainly because, on one level, the market dynamics in small economies limit the prospects for efficient entry. On another level, the number of operators required to yield the anticipated outcomes of liberalisation efficiently is much smaller than in large economies.

Given that in a small economy only a small number of efficient firms are likely to be sustainable and provided that the expected outcomes from competition on efficiency are positive, the following two hypotheses can be developed:

[3] It is possible that small economy firms be part of a bigger international group. In this case they can benefit from larger network effects.

H2a: Competition has a non-positive effect on the efficiency of firms in small economies

H2b: Competition has a positive effect on the efficiency of firms in large economies

2.2 Privatisation and firm performance

Evidence that private organisations can be more efficient than public organisations has created incentives to policy makers to promote private corporate structures (Newbery, 1999). Policy makers though confront the trade-off between a one-time cash infusion into the treasury and a convenient instrument for economic and social policy (Viscusi et al., 2005).

Empirical examination of the effects of privatisation in small economies has shown that private participation in former public firms and private investment in general, has induced increases in productivity. Castello and Ozawa (1999) found that FDI in small open economies appears to be very important in economic growth. Bergeijk et al. (1999) provide the example of privatisation of publicly owned enterprises in New Zealand to indicate the resulting gains in efficiency and total welfare. Wint (2003) provides supporting evidence from the privatisation experience of Guyana.

There are a number of obstacles that firms in small economies need to overcome to increase their potential to attract international investment. Smallness creates disincentives to international investors who consider small firms as riskier borrowers (Ocampo, 2002). Therefore, these firms become more vulnerable to shocks than large firms in large economies. Wint (2003) notes that governments need to systematically reduce the risks associated with developing internationally competitive enterprises. An indication of progress toward the creation of environments attractive to international investment is the implementation of policies that advocate private involvement in former state-owned enterprises.

Despite the lower attractiveness of firms from small economies to foreign investors privatisation is expected to stimulate their efficiency. Therefore, the following hypothesis can be developed:

H3: Privatisation has a positive effect on the efficiency of firms in both small and large economies

2.3 Institutional endowments and firm performance

Institutional quality and economic growth appear to advance side-by-side (Mukand & Rodrik, 2005, North, 2005). Political and social institutions are determinant factors of a country's regulatory framework, credibility, and effectiveness that are prerequisites for effective implementation of market liberalisation and privatisation processes (Henisz & Zelner, 2001, Levy & Spiller, 1996). The absence of strong foundations of regulatory governance that is necessary for supporting regulatory flexibility may limit competition's and privatisation's success.

The issue applies to small economies whose international competitiveness to some degree depends on the enhancement of their institutional endowments (Castello & Ozawa, 1999, Wint, 2003, Winters, 2005). Wint (2003) refers to Jamaica and Guyana which witnessed high economic performance relative to other small economies that experienced higher levels of country risk. Gomez (2004) refers to the Belize experience to indicate that institutional functions have contributed to the competitiveness of the country. A number of other studies discuss country-specific cases to exemplify the paramount role of institutional endowments in effective commercial conduct. Namely, Mavris (2004) elaborates on institutional functions in Cyprus which contribute to cultivating a culture of productivity on the island, promotion of scientific research and innovations, and enhancement of entrepreneurship. Hussein and Jaggi (2004) discuss institutional initiatives in Bahrain that have helped instil an entrepreneurial culture and fostered the development of SMEs.

Briguglio et al. (2005) conclude that small economies do not have significantly worse policies than other economies in the specific measures they involve in their analysis. The importance of strong institutions might be even greater for small economies due to the sensitivity of foreign inward investment to political risk and economic freedom (Winters, 2005). Correspondingly, the following hypothesis emanates from the foregoing:

H4: Higher quality of institutional endowments has a positive effect on the efficiency of firms in both small and large economies

3 Research Methodology

I contextualise the empirical analysis in the telecommunications sector. The sector is characterised by strong scale economies and extensive regulatory guardianship. This setting enables the examination of efficiency differentials between firms operating in economies of different sizes accounting for the role of policy and other economy-wide factors.

3.1 Model description

Stochastic Frontier Analysis (SFA) is employed to estimate technical efficiency measures for telecommunications firms in small and large economies[4]. Computing these efficiency measures involves estimating an unknown production frontier for the telecommunications firm whose output is specified as a function of a non-negative random error which represents technical inefficiency and a symmetric error which accounts for noise (Aigner *et al.*, 1977, Meeusen & van den Broeck, 1977) as in (3.1):

$$\ln q_i = x_i\beta + v_i - u_i \tag{3.1}$$

The output values are bounded from above by the stochastic variable $\exp\left(x_i\beta + v_i\right)$. The random error v_i can be positive or negative and so the stochastic frontier outputs vary about the deterministic part of the model $\exp\left(x_i\beta\right)$. The most common (output-oriented) measure of technical efficiency is the ratio of observed output to the corresponding stochastic frontier output:

$$TE_i = \frac{q_i}{\exp\left(x_i\beta + v_i\right)} = \frac{\exp\left(x_i\beta + v_i - u_i\right)}{\exp\left(x_i\beta + v_i\right)} = \exp\left(-u_i\right) \tag{3.2}$$

[4] Existing efficiency studies do not normally justify their choice between the two alternative and to a degree complementary methods of efficiency analysis: SFA and Data Envelopment Analysis (DEA). DEA which is a linear programming method for predicting efficiency measures has the advantage that it can be implemented without knowing the algebraic form of the relationship between outputs and inputs. A problem with DEA is that no account is taken of measurement errors and other sources of statistical noise; thus, all deviations from the frontier are assumed to be the result of inefficiency. Moreover, SFA is unique in that it allows for the simultaneous estimation of efficiency measures and the examination of environmental influences on firm efficiency.

that takes a value between zero and one. It measures the output of the i-th firm relative to the output that could be produced by a fully-efficient firm using the same input vector.

The main assumptions about the two error terms are that each v_i is distributed independently of each u_i and that both are uncorrelated with the explanatory variables in x_i. The noise component is assumed to have properties that are identical to those of the noise component in the classical linear regression model. The main difference for the inefficiency term is that it has a non-zero mean. In a first stage, Ordinary Least Squares (OLS) is used to estimate consistent estimators of the slope coefficients. In a second stage, the method of Maximum Likelihood Estimation (MLE) is used to solve the problem of bias in the OLS intercept coefficient.

As the simple production frontier model does not permit the estimation of multiple-output production technologies we follow Coelli and Perelman (2000) in employing distance functions techniques. An output distance function is defined on the output set P(x) as:

$$d^O(x,q) = \min\left\{\delta : \left(q/\delta\right) \in P\left(x\right)\right\}, \tag{3.3}$$

where x is a vector of inputs; q is a vector of outputs; and δ is a distance measure[5].

The output distance function is non-decreasing, positively linearly homogeneous and convex in q, and decreasing in x. For a number of firms i, defined over M outputs and K inputs it takes the form $d_i^O = d^O\left(x_{1i}, x_{2i}, ..., x_{Ki}, q_{1i}, q_{2i}, ..., q_{Mi}\right)$ where x_{ki} is the k-th input of firm i; q_{mi} is the m-th output; and $d_i^O \leq 1$ is the minimum amount by

[5] For a more analytical description of the theoretical foundations of distance functions and their use in efficiency analysis see Coelli and Perelman (2000). Whenever possible we attempt to omit excessive technicalities aiming to preserve broader readability of this methodology.

which the production of all output quantities could be increased while still remaining within the feasible production possibility set for the given input level. If q belongs to the “frontier” of the production possibility set, then $d^O(x,q)=1$.

I specify a translog functional form for the distance function following Cuesta and Orea (2002) and Goto and Tsutsui (2008) since it is flexible, easy to calculate, and permits the imposition of homogeneity. The translog distance function for the case of M outputs and K inputs is specified as:

$$
\begin{aligned}
\ln d_i^O = {} & \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mi} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \alpha_{mn} \ln y_{mi} \ln y_{ni} \\
& + \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl} \ln x_{ki} \ln x_{li} \\
& + \sum_{k=1}^{K}\sum_{m=1}^{M} \delta_{km} \ln x_{ki} \ln y_{mi} \qquad \text{i=1,2,...,N}
\end{aligned}
\tag{3.4}
$$

where i denotes the i-th firm in the sample. To obtain the frontier surface one would set $d_i^O = 1$, which implies the left hand side of equation (3.4) is equal to zero. Following Lovell et al. (1994) we impose homogeneity of degree +1 in outputs and symmetry so that equation (3.4) can be rewritten in the general formulation of the output distance function under variable returns to scale as in equation (3.5). In the multi-output model, technical change can favour the production of one good over another. Therefore we control for Hicks-neutral technical change by including a time trend (t) and its square[6] and for non-neutral technical change we interact the other regressors with time (t).

[6] The squared term is included to provide consistency with the second order approximation notion of the translog form (Coelli et al. 2005).

$$-\ln\left(y_{M_{it}}\right)=\alpha_0+\sum_{m=1}^{M-1}\alpha_m \ln y_{mit}^{*}+\frac{1}{2}\sum_{m=1}^{M-1}\sum_{n=1}^{M-1}\alpha_{mn}\ln y_{mit}^{*}\ln y_{nit}^{*}$$
$$+\sum_{k=1}^{K}\beta_k \ln x_{kit}+\frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K}\beta_{kl}\ln x_{kit}\ln x_{lit}$$
$$+\sum_{k=1}^{K}\sum_{m=1}^{M-1}\delta_{km}\ln x_{kit}\ln y_{mit}^{*}+\zeta_0 t+\frac{1}{2}\zeta_{00}t^2+\sum_{k=1}^{K}\lambda_{kt}t\ln x_{kit}+\sum_{m=1}^{M-1}\xi_{mt}t\ln y_{mit}^{*}+v_{it}+u_{it} \qquad (3.5)$$

$$y_{mit}^{*}=\frac{y_{mit}}{y_{M_{it}}}, \qquad i=1,2,\ldots,N, \qquad t=1,2,\ldots,T$$

A measure of technical efficiency is $TE_i=\exp\left(-u_i\right)$. y_{mit} is a $m\times 1$ vector of output quantities of the i-th firm in the t-th time period; x_{kit} is a $k\times 1$ vector of input quantities of the i-th firm in the t-th time period; $\alpha, \beta, \delta, \zeta, \lambda, \xi$ are vectors of unknown parameters; t is a time trend; v_{it} are random variables which are assumed to be independent and identically distributed, have distribution $N\left(0,\sigma_v^2\right)$, and to be independent of the u_{it}. The latter are non-negative random variables assumed to account for technical inefficiency and to be independently distributed as truncations at zero of the $N\left(m_{it},\sigma_v^2\right)$ distribution. $m_{it}=z_{it}\omega$, where z_{it} is a $p\times 1$ vector of environmental variables which may influence the efficiency of a firm, such as economy size, and ω is a $1\times p$ vector of parameters to be estimated.

I estimate the model in Frontier 4.1 econometric software which supports the specification for the inefficiency term of Kumbhakar et al. (1991) which allows environmental variables to directly influence the inefficiency term. The software allows for panel data estimation according to Battese and Coelli (1995) and time varying technical inefficiency according to Battese and Coelli (1992).

3.2 Data and variable description

Performance data were obtained from the annual reports of major incumbent telecommunications firms for a maximum period of 18 years between 1990 and 2007. Whenever possible, the dataset was complemented with data obtained from the ITU's World Telecommunication/ICT Indicators Database 2008. I use two inputs (telecommunications staff and capital investment[7]) and two outputs (fixed lines and mobile subscribers). In contrast to previous studies that have arbitrarily confined outputs to fixed lines (e.g. Bartels & Islam, 2002, Lien & Peng, 2001, Sueyoshi, 1994) the current study also incorporates the technology of mobile telephony[8]. In effect non-integrated firms that operate only fixed voice or mobile telephony were excluded. Moreover, data pertain only to domestic operations. Therefore, companies with international presence that did not publish separate reports for their domestic operations or when it was unfeasible to distinguish domestic from international operations were omitted from the dataset. This filtering decreased the initial sample of 80 firms to 54.

Notwithstanding, incorporating both technologies in the production function serves several purposes. A multi-output production technology is very likely to reflect the actual production technology for telecommunications firms for they have traditionally been multi-output producers. Possible discrepancies in the model estimates due to economies of scope are alleviated whilst we account for the capacity of the integrated firm to exploit economies of scope and network externalities. It may be possible to observe firm behaviour across two products that exhibit different minimum efficient scales of production. And, incorporation of both goods accounts

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[7] All economic variables were converted to PPP international dollars.

[8] To the best knowledge of the author, only Koski and Majumdar (2000) adopt a similar description of telecommunications production technology employing DEA for the prediction of efficiency measures.

for demand-side effects on production due to the development of relationships of complementarity or substitution between the two technologies[9].

The literature on small economies has suggested a small number of measures of economy size all of which lack theoretical grounds. Population has been the most commonly used measure due to its easy availability. Yet, consistency among selected thresholds has been an issue for they lacked theoretical grounds and varied according to the study's context. For instance, Vanuatu (212,000 people) and Canada (33.3 million people) have both been classified as small economies (Gal, 2003), whilst the same authors might be found to use different thresholds in respective studies (i.e. Winters & Martins, 2004a, Winters & Martins, 2004b).

Construction of size indices sought to overcome single-criterion classifications and also to take into consideration other possible components of size, such as economic and geographical size. In this study I adopt the size index proposed by Jalan (1982) by combining an economic measure (GDP), a demographic measure (population), and a geographical measure (arable area):

$$\text{Size index} = \frac{100}{3}\left(\frac{P_i}{P_{\max}} + \frac{A_i}{A_{\max}} + \frac{Y_i}{Y_{\max}}\right), \tag{3.6}$$

where P_i, A_i, Y_i are population, arable area, and GDP for economy i. $P_{\max}, A_{\max}, Y_{\max}$ are the respective maximums. Data were obtained from the United Nations' Human Development Report and FAO and the World Bank's World Development Indicators and cover 214 economies for the period 1990-2008.

[9] Several empirical studies have examined these relationships (e.g. Barros & Cadima, 2000; Gruber & Verboven, 2001; Hamilton, 2003; Rodini, Ward, & Woroch, 2002; Sung & Lee, 2002; Taubman & Vagliasindi, 2005).

The index represents a continuous measure of economy size without imposing any arbitrary assumptions through size thresholds and allows to observe its marginal effects along the overall size continuum. It concurrently considers all fundamental factors involved in the creation of economic value, albeit it is not flawless. The allocation of equal weights to the three factors might be considered unjustifiable. However, there is no relevant theoretical development suggesting more appropriate weights.

The index's median can act as threshold for small economies (Jalan, 1982). At the median, small economies have maximum population 9.2 million (Guinea), GDP USD$86.17 billion (Singapore), and arable area 19.3 thousand km^2 (Central African Republic). These measures aptly fall within the range of values attributed to small economies in existing studies. In our sample, 23 firms operate in large economies and 31 in small economies (see Appendix 1 for firm and economy coverage).

At first, a model incorporating all sample firms is estimated to allow for the comparison of relative firm efficiency based on a common stochastic frontier. Hypothesis (H1) concerning the relationship between economy size and firm efficiency is tested by using three variables that capture size effects. The first variable (*size*) pertains to the values of the size index. Along with its square (*size_sq*) the two variables examine the linearity hypothesis between size and efficiency. The third variable (*small*) is a dummy that takes a value of 1 if the economy is small and 0 otherwise. It is used to examine whether firms operating in small economies are on average less efficient than their counterparts in large economies.

The hypothesis concerning competition's impact on firm efficiency is tested by including in the model two dummy variables *lib_fixed* and *lib_mobile*. These variables take the value of 1 when more than one firm operate in the markets of fixed voice or mobile telephony, respectively. These variables allow for a distinction between the effects of competition in different technologies, a factor that has not been taken into consideration in previous empirical studies. The effect of ownership change on firm efficiency is captured by (*privatisation*) dummy which takes a value of 1 when the firm has allowed private participation in its operations and 0 when otherwise (Li & Xu, 2004, Wallsten, 2001).

The effect of the magnitude of institutional endowments on firm efficiency is gauged by the variable *polconIII* developed by Henisz (2002). This variable estimates the feasibility of policy change and ranges between 0-100. Smaller values depict an economy with lower economic freedom, narrower institutional endowments, and higher political risks. To account for sector-specific institutional endowments we also include the dummy variable *nra* that denotes the presence of an independent National Regulatory Authority in the sector[10] (Wallsten, 2001). The International Telecommunications Union (ITU) maintains information regarding the year of establishment of the NRA and whether it is autonomous in its decision making. The variable *nra* takes a value of 1 only if the authority is characterised autonomous and 0 otherwise.

Since more open economies promote international trade, collaboration between firms, and transfer of knowledge which are expected to have an impact on firm performance the model also includes the variable *openness* to capture pertinent effects. A more analytical description of variables included in the analysis is presented in Table 3-1.

[10] Dummy variables have previously been challenged for not optimally capturing the breadth of the various regulatory policies. Some studies have even based the credibility of their empirical findings on the use of indexes instead of dummy variables, examples being Bauer (2005) and Edwards and Waverman (2006) for developing measures of privatisation and NRA, respectively. However, these studies are limited to either short time-series or cross-sectional analysis. The present paper instead uses a large number of cross-sections (54 firms) over a long period (18 years) that are expected to help overcome conventional limitations of econometric analysis that employs dummy variables.

Table 3-1: Description of variables used in the efficiency analysis

Variable name	Description	Source
Outputs		
Fixed	Fixed mainline subscribers per capita	Company annual reports; ITU’s World Telecommunication/ICT Indicators Database 2008
Mobile	Mobile subscriptions per capita	Company annual reports; ITU’s World Telecommunication/ICT Indicators Database 2008
Inputs		
Investment	Investment in Assets per capita in PPP prices of current international US dollar	Company annual reports
Staff	Total equivalent staff per capita	Company annual reports
Environmental variables		
lib_fixed	A dummy variable which takes a value of 1 when the market of fixed voice is open to competition and 0 when otherwise	ITU’s World Telecommunication Regulatory Database; Company annual reports
lib_mobile	A dummy variable which takes a value of 1 when the market of mobile telephony is open to competition and 0 when otherwise	ITU’s World Telecommunication Regulatory Database; Company annual reports
privatisation	A dummy variable which takes a value of 1 when the government has allowed for private participation in the operations of the firm and 0 when otherwise	ITU’s World Telecommunication Regulatory Database and operators' annual reports
nra	A dummy variable which takes a value of 1 when the country has established a national regulatory authority and 0 when otherwise	ITU’s World Telecommunication Regulatory Database
polconIII	Measures the quality of an economy's political system	Henisz (2002)
openness	Exports plus imports divided by GDP	Penn World Tables 6.2. The variable can be found as "openc"
size	Index estimated according to Jalan (1982)	Constructed by the author
size_sq	Square of *size*	Constructed by the author
small	A dummy variable which takes a value of 1 when the economy has an estimated value less than the sample’s median of the Jalan index.	Constructed by the author

Table 3-2 presents descriptive statistics for the sample firms and economies. Very large standard deviations relative to the variables’ means illustrate low homogeneity among firms in the same group. Firms in small economies serve more “relative” consumers in both fixed voice and mobile telephony. This might be due to their higher investments in capital and labour inputs. Instead, large economies are depicted by a higher degree of political freedom; plus their populations enjoy higher incomes. Instead, small economies appear to be far more open to international trade and investment.

Table 3-2: Descriptive statistics for telecommunications firms

Large economies	Mean	Std. Dev.	Min	Max
Telecom investment per capita (PPP US $)*	418.65	278.13	0.02	920.73
Telecom staff as a percentage of population*	0.13	0.10	0	0.42
Fixed mainlines per 100 inhabitants*	26.55	19.32	0.12	70.42
Mobile subscribers per 100 inhabitants*	23.04	23.70	0.01	145.50
polconIII	0.40	0.15	0	0.71
GDP per capita (PPP US $)	15495.15	10266.10	711.28	38180.95
Openness	71.92	36.99	13.78	191.95
Small economies	**Mean**	**Std. Dev.**	**Min**	**Max**
Telecom investment per capita (PPP US $)*	480.05	369.26	1.02	2429.60
Telecom staff as a percentage of population*	0.20	0.13	0.01	0.61
Fixed mainlines per 100 inhabitants*	29.99	17.91	2.20	63.33
Mobile subscribers per 100 inhabitants*	27.23	29.00	0.01	210.53
PolconIII	0.34	0.20	0	0.63
GDP per capita (PPP US $)	14379.67	10248.29	1411.66	49754.37
Openness	127.60	85.92	15.50	533.59

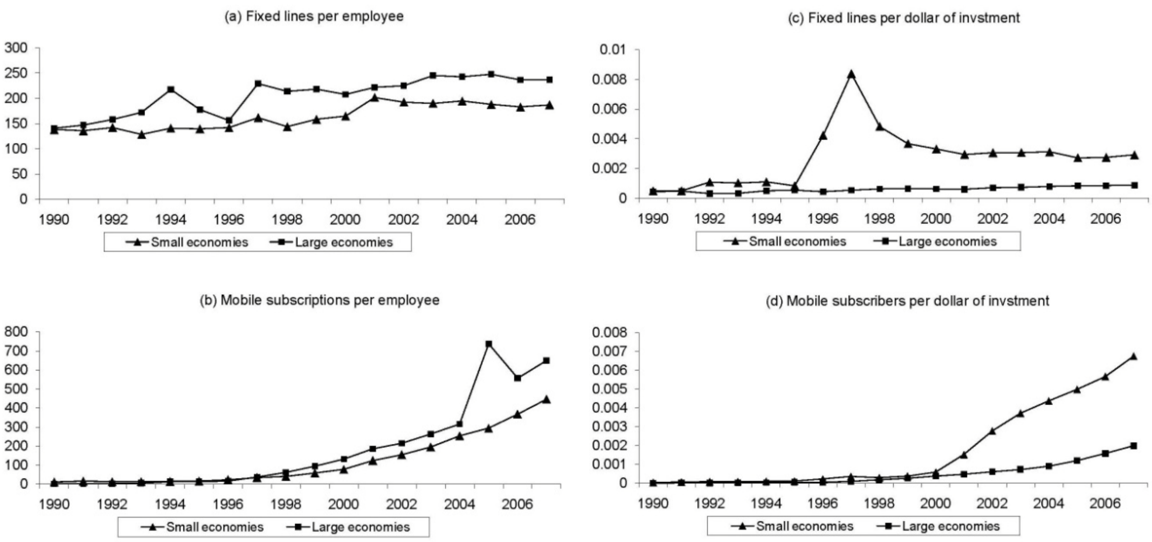
Notes:
* represents firm data

Exhibit 3-1 pertains to a series of single-indicator measures of firm efficiency regularly used in efficiency studies (e.g. Lien & Peng, 2001) and portrays the relative relationships between various inputs and outputs. Graphs *a* and *b* represent the relative outputs for fixed voice and mobile telephony attributed to each employee for firms operating in the two groups of economies. Firms in large economies exhibit higher output per employee for both technologies. Despite a few shocks in the trends of firms in large economies, both groups follow similar efficiency trends. The ratio of fixed lines per employee follows a smooth increase, whilst mobile subscriptions per employee follow an exponential growth pattern.

In graphs *c* and *d* firms in small economies appear to yield higher output per dollar invested for both technologies. With regard to fixed voice, this relationship is more evident as of 1996 where the ratio for firms in small economies rises radically, reaching its peak in 1997 and declining thereafter maintaining a sustainable gap from the ratio for large economies. For mobile telephony, both groups exhibit exponential growths as of 2001; yet, for firms in small economies, growth is substantially greater.

The ordering of labour and capital efficiency reverses suggesting that firms in small economies are more investment efficient and less labour efficient that firms in large economies. There is no obvious explanation why this difference exists, albeit it gives an indication of the scope for improvement.

Exhibit 3-1: Sample firm level efficiency measures: telecommunications outputs with respect to inputs.



4 Empirical findings

All variables have been mean corrected prior to estimation; namely, each input and output variable has been divided by its geometric mean. In this way, the first-order coefficient can be interpreted as distance elasticities evaluated at the sample means (Cuesta & Orea, 2002). The estimated parameters of the distance function are presented in Table 4-1. The coefficients for staff $(\ln x_1)$, investment $(\ln x_2)$ and mobile telephony $\left(\ln y_1^*\right)$ are statistically significant at the 5% level and have the expected signs at the geometric mean. At least 95% of all coefficients are statistically significant, which reveals a good fit of the model to the observed data.

To check for robustness in the environmental effects the corresponding variables (Zs) were included in the model sequentially and likelihood ratio tests were employed to examine the contribution of additional variables in the nested models. In general, additional variables increased the explanatory power of the model and the variables exhibited the relationships presented in Table 4-1 with an expected variation in the magnitudes of the estimated coefficients. To examine for possible collinearity issues we regressed each of the outputs on the environmental variables. Different permutations of the OLS regressions were estimated in STATA 10 where no issue of collinearity was detected.

Another issue that could affect the consistency of the model estimates was the possible existence of endogeneity in the environmental variables. However, studies that have used comparable variables in similar contexts and employed instrumental variables techniques to account for endogeneity effects have concluded that the estimates produced by instrumental and non-instrumental models did not differ qualitatively (Gutiérrez, 2003, Ros, 1999).

Table 4-1: Stochastic Frontier Analysis output: a global frontier

Environmental Variables	coefficient	st. error	Distance Function Parameters	coefficient	st. error
δ_0	1.385	0.13***	b_0	-3.216	1.32***
privatisation	-0.219	0.06***	t	-0.283	0.10***
lib_fixed	-0.049	0.07	t^2	0.003	0.00*
lib_mobile	-0.339	0.07***	$\ln y_1^*$	0.887	0.23***
nra	-0.014	0.07	$\ln x_1$	-2.863	0.35***
polconIII	-1.036	0.23***	$\ln x_2$	-0.254	0.12**
openness	-0.001	0.00**	$\left(\ln y_1^*\right)^2$	0.086	0.01***

size	-0.039	0.01***	$(\ln x_1)^2$	-0.086	0.02***
size_sq	0.001	0.00***	$(\ln x_2)^2$	0.007	0.00**
small	0.035	0.08	$\ln y_1^* \times \ln x_1$	0.127	0.02***
σ^2	0.131	0.02***	$\ln y_1^* \times \ln x_2$	-0.008	0.03
γ	0.593	0.11***	$\ln x_1 \times \ln x_2$	-0.038	0.01***
			$t \times \ln y_1^*$	0.021	0.01***
Mean efficiency	0.69		$t \times \ln x_1$	-0.029	0.01***
Log likelihood function	-129.19		$t \times \ln x_2$	-0.021	0.01***
LR test of the one-sided error	222.42				
Firms	54				
Years	18				
Total observations	493				

Notes:
*,**,*** Statistically significant at the 0.1, 0.05, and 0.01 level, respectively.
The coefficient of γ suggests that 60% of the estimation error can be attributed to technical inefficiency.
A minus sign for the Z variables' coefficients suggests a negative effect on inefficiency.

From the estimated parameters of the distance function we can estimate firm-specific measures of returns to scale (RTS) and technical change (TC). Following Färe and Primont (1995) technical change is derived from the first order derivative of the distance function with respect to time t:

$$TC = \frac{\partial \ln y_{Mit}}{\partial t} = \zeta_0 + \zeta_{00} t + \sum_{\kappa=1}^{K} \lambda_{kt} \ln x_{kit} + \sum_{m=1}^{M-1} \xi_{mi} \ln y_{mit}^*, \quad (4.1)$$

where coefficient estimates are taken from the estimation of equation (3.5). Correspondingly, the scale elasticities of output with respect to each input are estimated from:

$$\varepsilon_k = \frac{\partial \ln y_{Mit}}{\partial \ln x_{mit}} = a_k + \sum_l \beta_{kl} \ln x_{lit} + \sum_{m=1} \delta_{km} \ln y_{mit}^* + \lambda_{kt} t, \quad \text{where} \quad (4.2)$$

$$\sum_{k=1}^{K} \varepsilon_k , \quad (4.3)$$

gives the RTS. When equation (4.3) equals 1 suggests the existence of constant returns to scale (C-RTS); when it is higher suggests increasing returns to scale (I-RTS), and when it is lower suggests decreasing returns to scale (D-RTS).

The estimation of equation (4.1) results in a yearly average TC of 0.036 for firms in small economies and 0.062 for firms in large economies. The difference appears to be large. It is also statistically significant as the t-test statistic rejects the hypothesis of equality in the means at the 1% level of significance.

The estimation of equation (4.3) gives a mean yearly value of 1.07 for firms in large economies and 1.03 for firms in small economies. This result suggests that firms in large economies might be somewhat more capable of exploiting higher returns to scale. The difference though is not statistically significant at conventional levels of significance. This finding contradicts with the conventional wisdom that firms in small economies are incapable of exploiting high RTS.

Hicks-neutral technical change is initially decreasing and subsequently increasing (t and t^2 have opposite and statistically significant coefficients). Non-neutral technical change is present illustrated by the coefficients of the time-interaction effects. The negative coefficients for $t \times \ln x_1$ and $t \times \ln x_2$ suggest that technical change is staff and investment saving. The positive coefficient for $t \times \ln y_1^*$ suggests that development in mobile telephony increases fixed voice efficiency. This result possibly points to gains from economies of scope associated with integrated operation.

Firms in small economies on average are less efficient than those in large economies with mean efficiency 0.64 compared to 0.76 and the difference is statistically significant at the 1% level. The efficiency rankings are consistent with the foregoing where the average ranking for firms in small economies is 30 compared to 20.3 for firms in large economies. However, two firms from small economies (Bezeq, the Israeli incumbent and Bulgarian Telecommunications Company) rank in the top ten most efficient operators which indicates the potential of firms in smaller contexts to outpace those from larger contexts (see Appendix 1).

The positive coefficient of *small* also supports that firm efficiency in small economies on average falls behind that in large economies; yet, it is statistically insignificant[11]. Instead, the opposite signs of *size* and its square indicate the existence of non-linearity between economy size and firm efficiency[12]. Because the coefficients of the environmental variables do not have the normal interpretation of conventional marginal effects as for example in OLS (Coelli, 1996) we are unable to accurately determine whether a turning point in the relationship falls within the observed economy sizes in the sample. For instance, by taking the first derivative of $m_{it} = z_{it}\omega$ with respect to *size* and setting it equal to zero gives a value for *size* of 19.5. This value is associated with Brazil (~17) one of the largest economies in the sample indicating that the positive effect of economy size on firm efficiency is sustainable even at very large economy sizes. However, this value is unlikely to be valid. Wang (2002) concluded that the marginal effects and the slope coefficient have the same sign which leads to the safe conclusion that economy size has a positive effect on firm efficiency (negative coefficient for *size*) but at a decreasing degree (positive coefficient for *size_sq*). The relationship encompasses the possibility of a negative effect over very large sizes, which partially supports (H1).

Despite the foregoing limitations it is instructive to work through an example to illustrate the effect of economy size on firm efficiency. Germany has had an increase

[11] A positive coefficient for the coefficients of the environmental variables implies a negative effect on efficiency.
[12] To check robustness in the effect of economy size, I estimated the same model by replacing variable *size* with its constituent variables and the square of population size. Overall, the results were consistent with the ones presented above. Population and its square exhibited the same relationships with firm efficiency as the *size* and *size_sq* variables. Results are available from the author.

in its economy size index from 11.13 in 1990 to 17.82 in 2007, which amounts to a 2.6 percent compounded annual growth in its economy size over 18 years. Using the estimate of -0.039 for *size* and following Röller and Waverman (2001: 917) we obtain a compounded annual growth effect of 0.9 percent[13]. In other words, this estimate implies that growth in Germany's economy size boosted Deutsche Telecom's efficiency by some 0.9 percent annually. In the case of Cyprus, a small economy whose size grew from 0.09 in 1998 to 0.13 in 2007, which amounts to a 4 percent compounded annual growth over 10 years, increase in its economy size contributed by 0.83 percent annually to CYTA's efficiency. Combined these findings suggest that economy size has a considerable effect on firm efficiency.

Policy and other environmental factors also appear to have an important effect on firm efficiency. Competition, privatisation, the institution of an independent regulator, higher quality of institutional endowments, and greater openness of the economy are all conducive to firm efficiency.

The coefficients for competition in fixed voice and the NRA are statistically insignificant though. A possible explanation for the former is that its effects might be captured by the effects of competition in mobile telephony. Both denote market environments where former monopolists confront rival operation. Spillover effects across the two markets are very likely, particularly when the two technologies become competitive with one another. Moreover, it is very likely that high quality institutional endowments and low risk overwhelm the favourable role that a governing agency might play in the industry. This finding could be in support of industry governance

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[13] $\left[\left(\frac{size_{2007} - size_{1990}}{size_{1990}}\right) * \left(-0.039 + 1\right)\right]^{\frac{1}{18}}$

based on generic competition law rather than industry-specific regulation, given that the economy depicts strong institutional foundations.

To account for the joint effects of different policies on firm efficiency we extend the current model by introducing an interaction variable (*trinity*). This variable takes a value of 1 if the economy has allowed for competition in either of the two markets of fixed voice and mobile telephony; has authorised private ownership in the incumbent operator; and has established a NRA, and 0 if otherwise (find output in Appendix 2). The coefficient of *trinity* has a statistically significant positive value of 0.139 suggesting that the joint effect of competition, privatisation, and NRA have a negative effect on firm efficiency. Whilst all other environmental variables maintain their relationships with efficiency and their coefficients exhibit similar magnitudes, *lib_fixed*'s effect on inefficiency increases and the coefficient becomes statistically significant at the 10% level. These relationships suggest that firms benefit more in terms of efficiency when the three policy measures take place at different times. A possible explanation is that firms commit substantial resources to effectively respond to radical industry reform that functions to the detriment of its efficiency.

Testing the remaining hypotheses involves estimation of the model for each of the two groups of firms (Table 4-2). All input and output first order coefficients have the correct signs and are statistically significant (apart from $\ln y_1^*$ for large economies). A comparison of efficiency scores across models is inappropriate since relative firm efficiency is based on different frontiers. The following discussion focuses on the effects of environmental factors on firm efficiency.

Table 4-2: Stochastic Frontier Analysis output: Small economies VS Large economies

	Small Economies		Large Economies	
	coefficient	st. error	coefficient	st. error
b_0	-12.306	0.99***	-10.947	1.20***
t	0.024	0.05	0.334	0.20**
t^2	-0.002	0.00***	-0.003	0.00
$\ln y_1^*$	0.188	0.13*	0.297	0.43
$\ln x_1$	-1.856	0.57***	-1.877	0.53***
$\ln x_2$	-0.684	0.21***	-0.756	0.26***
$(\ln y_1^*)^2$	0.047	0.01***	0.098	0.02***
$(\ln x_1)^2$	-0.132	0.07**	-0.039	0.03***
$(\ln x_2)^2$	-0.007	0.01	-0.022	0.01**
$\ln y_1^* \times \ln x_1$	0.326	0.05***	0.060	0.04**
$\ln y_1^* \times \ln x_2$	0.091	0.04***	0.001	0.04
$\ln x_1 \times \ln x_2$	-0.005	0.01	0.016	0.02
$t \times \ln y_1^*$	0.014	0.01**	-0.012	0.02
$t \times \ln x_1$	0.015	0.01	0.024	0.01**
$t \times \ln x_2$	0.004	0.00	-0.026	0.01***
δ_0	1.382	0.23***	1.022	0.24***
privatisation	-0.311	0.12***	-0.225	0.13**
lib_fixed	-0.287	0.19*	-0.090	0.08*
lib_mobile	-1.234	0.74**	-0.241	0.18*
nra	0.073	0.13	-0.391	0.10***
polconIII	-2.272	0.63***	-1.582	0.35***
openness	-0.003	0.00**	0.001	0.00*
size	1.021	0.16***	-0.015	0.01**
size_sq	-0.287	0.18**	0.000	0.00***
σ^2	0.233	0.04***	0.065	0.01***
γ	0.738	0.24***	0.77	0.12***
Mean efficiency	0.80		0.88	
Log likelihood function	-71.59		-70.96	
LR test of the one-sided error	135.30		42.21	
Companies/economies	31		23	
Years	18		18	
Total observations	305		188	

Notes:
*,**,*** Statistically significant at the 0.1, 0.05, and 0.01 level, respectively.
A minus sign for the Z variables' coefficients suggests a negative effect on inefficiency.

For small economies, competition in fixed and mobile telephony contributes to higher firm efficiency and the respective coefficients are statistically significant. These findings reject hypothesis H2a that suggested that competition in small economies has a non-positive effect on firm efficiency. Privatisation of the firm and strong institutional endowments create environments conducive to firm efficiency, giving partial support to H3 and H4. On the other hand, the impact of *nra* on firm efficiency is statistically insignificant, which can be attributed to the overwhelming positive effect of institutional endowments. Comparable results for the policy effects on firm efficiency can be observed in large economies. That is apart from *nra* which is statistically significant and increases efficiency. These findings support H2b and complement statistical support for H3 and H4.

Similar to the single model, focal policies applied in tandem appear to have a negative effect on firm efficiency (see Appendix 3). The joint measure does not induce firm efficiency most likely because a newly restructured firm requires excessive resources to concurrently respond to radical industrial reform. For small economies, inclusion of *trinity* causes *privatisation* to lose its significance and change its sign, and the coefficient for *nra* becomes significant with a positive effect on firm efficiency. For large economies, *trinity* is positive and statistically insignificant and causes *lib_mobile* to lose its statistical significance.

The coefficients for the two size variables are statistically significant for both groups of firms but have opposite signs. Namely, economy size has a positive effect on firm efficiency in large economies and a negative effect on firm efficiency in small economies. The latter is unexpected and contradicts with the conventional wisdom that firms operating in small economies are negatively affected by smallness.

In the light of the foregoing and considering the limitations in interpreting the Z variables' coefficients, the stationary point in the relationship between economy size and efficiency for small economies is cautiously estimated at 1.78 which exceeds the sample's sizes. This suggests that the relationship for small economies may never reach a minimum also calling for more caution against the interpretation of the relationship.

The stationary point for large economies is estimated at 38.93, which only India and therefore Bharti Airtel exceed. This suggests that firms may face incentives to work in larger economies as this is more likely to allow them improve their technical efficiency. In parallel, large economies themselves may have incentives to grow larger to create environments conducive to firm efficiency. Operating in extremely large economies though, such as India, may have a minimal or even negative impact on firm efficiency if the actual relationship eventually becomes negative. Therefore, hypothesis H1 that suggested an inverted u-shaped relationship between economy size and firm efficiency remains partially supported. Overall the analysis lends support to a positive relationship between economy size and firm efficiency though at a decreasing rate.

5 Discussion – Concluding Remarks

The empirical findings in this paper suggest that telecommunications firms in small economies exhibit lower average technical change than their counterparts in large economies. This differential might reflect the common behaviour of firms from small economies to adopt technologies and import knowhow from developed large economies (Maskell et al., 1998). As they also appear to operate at increasing returns to scale (IRS), similar to firms in large economies, they demonstrate the potential to expand production to reach minimum efficient scales and increase efficiency whilst regulators may have incentives to intensify competition.

Firms in small economies manifest lower efficiency than firms in large economies. This is commensurate with the positive effect that economy size has on firm efficiency albeit it gradually decreases with larger sizes. The effect may eventually become negligible if not negative over very large economy sizes. The positive relationship may create incentives for firms to operate in larger economies. Whilst this potential is minimal for firms based in island and remote economies it may be possible for firms based in land-locked economies to expand into neighbouring economies. In parallel, smaller economies may develop incentives to grow larger to develop environments conducive to firm efficiency.

Firms in small economies appear to be more efficient employers of capital investment than labour capital relative to firms in large economies (Exhibit 3-1). The former may be attributed to the likely development of more effective modes of allocation of competitive capital investment in the production process. The latter appears to be consistent with claims from the literature on small economies and telecommunications policy according to which politicians might pursue social policy by exerting influence on firms' employment decisions. This could lead to over-employment and, due to the limited specialised human capital available, to the procurement of low quality labour inputs.

Firms may find it beneficial in the long-term to establish collaborations with local educational institutions to develop subsidised training programmes for domestic human capital. They may also consider employing international labour. Higher quality of human capital can improve the absorptive capacity of a firm in a small economy which is particularly important given its inherent lack of domestic resources of R&D, innovation, and capital.

The various policies characterising the telecommunications sector are also critical for firm performance. Competition in both mobile telephony and fixed voice has a positive effect on the efficiency of both groups of firms. Competition appears to induce incumbent firms to contract input usage at a rate greater than the loss of market share (output) over to new entrants. For firms in large economies, this finding lends support to the long claimed advantages of competition. For firms in small economies though it challenges existing arguments against the excessive use of competition as an end in itself on the grounds of small markets and insufficient resources for efficient production (e.g. Gal, 2003). This raises the issue of the effects of competition intensity on firm performance, though the current study was restricted to the analysis of the effects of competition existence per se. Nonetheless, these findings complement existing empirical evidence that suggests that the number of rival firms required to yield the anticipated outcomes of competition in small economies is much smaller than in large economies (e.g. Symeou, 2009).

Firms with private ownership exhibit higher technical efficiency than state-owned ones. An equivalent relationship is found for firms in both small and large economies. Policy makers and local governments therefore find herein ancillary evidence to existing empirical and theoretical studies (e.g. Dewenter & Malatesta, 2001, Yarrow & Jasiński, 1996); one of a positive relationship between private ownership and firm performance. Particularly for small economies, policy makers may have stronger incentives to promote environments conducive to investment as they are considered riskier borrowers.

The foregoing goes in tandem with the positive impact that higher quality of institutional endowments exhibit on firm efficiency. Higher quality of institutional endowments and lower political risk in the economy not only do they induce firm efficiency they may also alleviate the perceived riskiness of the economy in the global market. Institutional endowments might overwhelm the favourable role that an industry-specific governing agency, such as the NRA, could otherwise have. This supports the evolving impression in the literature on telecommunications policy that generic competition law might suffice for the sustainment of a healthy competitive environment and renders industry-specific regulation unwarranted, provided that strong institutional foundations and low political risk are in place.

It is noteworthy that whilst nearly all policies examined exhibit a positive relationship with firm efficiency their joint effect does not for our sample. A possible explanation is that when policy is applied sequentially allows firms for time to re-organise and respond to corresponding change. Otherwise, a firm might commit substantial resources so as to effectively adjust to reform that distorts its efficiency.

The empirical analysis unveiled important factors for firm performance, external to the firm, on which managers may have limited influence. Factors such as economy size and industrial change induced by policy play an unparalleled role in firm performance. They demand for their consideration in managerial decisions concerning the firm’s competitive strategies, corporate governance, and growth. Managers in close proximity to policy makers and regulators may increase their likelihood to prevent any negative effects of policy on firm performance. Policy may have varying effects on different facets of firm performance, particularly for utility and integrated firms. The collaboration of managers with regulators and policy makers can establish that firm strategy and policy aim at convergent targets, such as higher firm efficiency that may translate into increase in social welfare through lower prices and greater accessibility to services. Convergent firm and regulatory targets may render policy development unnecessary alleviating the burdens of policy adherence and development for firms and policy makers, respectively.

This study aimed to advance current knowledge about the nexus between economy size and firm performance, taking into consideration the effects of policy and institutional endowments. Future research may consider expanding the breadth of analysis beyond the telecommunications sector. Firms in different sectors manifest different production technologies and their performance might be exposed to different effects than the ones identified in this study. Moreover, the development of more detailed measures of industry structure and corporate governance may shed some more light on their effects on firm performance.

Appendix 1: Telecommunications firms and economies included in efficiency analysis

Large Economy	Firm	Efficiency	Eff. Rank	TC	RTS	Small Economy	Firm	Efficiency	Eff. Rank	TC	RTS
Argentina	Telecom Argentina	0.83	9	0.10	1.46	Bahamas	BTC	0.49	46	0.02	0.93
Australia	Telstra	0.83	10	0.01	0.89	Bahrain	Batelco	0.50	45	0.02	1.04
Austria	Telekom Austria	0.74	21	0.03	1.06	Barbados	Cable and Wireless (Barbados)	0.69	31	0.00	1.61
Belgium	Belgacom	0.85	5	0.04	1.38	Belize	BTL	0.39	52	0.03	1.03
Czech Republic	Telefonica O2	0.77	17	0.02	1.03	Bolivia	Entel	0.80	14	0.13	1.07
Egypt	Telecom Egypt	0.58	42	0.03	0.88	Bosnia and Herz.	Telekom Srpske	0.47	47	0.08	1.47
Germany	Deutsche Telekom	0.84	7	0.00	1.02	Bulgaria	Bulgarian Telecom. Company	0.84	8	0.05	1.48
Greece	OTE	0.87	4	0.01	0.84	Croatia	Hrvatske Telekomunikacije	0.73	24	0.02	1.01
Hungary	Magyar Telekom	0.75	20	0.04	0.99	Cyprus	CYTA	0.66	35	0.02	0.98
India	Bharti Airtel	0.73	22	0.31	1.20	Denmark	TDC	0.71	28	0.02	1.02
Indonesia	Telkom	0.85	6	0.16	1.28	Estonia	Eesti Telecom	0.69	32	0.04	1.05
Italy	Telecom Italia	0.90	1	0.05	1.01	FYR Macedonia	Makedonski Telekomunikacii	0.72	26	0.03	0.98
Kazakhstan	Kazakhtelecom	0.44	49	0.00	0.85	Guyana	GT&T	0.82	12	0.15	1.15
Mexico	Telmex	0.80	13	0.06	0.82	Hong Kong	PCCW	0.78	16	0.00	0.99
Mozambique	Telecomunicacoes de Mocambique	0.77	18	0.25	1.40	Iceland	Siminn	0.53	44	0.00	0.97
Nepal	Nepal Telecom	0.42	50	0.15	1.17	Israel	Bezeq	0.88	3	0.03	0.92
Pakistan	Pakistan Telecom. Company	0.41	51	0.11	1.42	Jamaica	Cable and Wireless (Jamaica)	0.66	36	0.03	0.93
Peru	Telefonica del Peru	0.73	23	0.10	1.22	Jordan	Jordan Telecom	0.65	37	0.08	1.14
Philippines	PLTD	0.70	30	0.16	1.30	Malta	Go	0.59	40	0.01	0.80
Poland	Telekomunikacja Polska	0.88	2	0.06	1.25	Mauritius	Mauritius Telecom	0.76	19	0.05	1.60
Portugal	Portugal Telecom	0.83	11	0.05	0.96	Namibia	Telecom Namibia	0.35	53	0.09	1.19
Romania	Romtelecom	0.68	33	0.02	0.78	New Zealand	Telecom New Zealand	0.80	15	0.03	0.95
Venezuela	CANTV	0.72	25	0.08	1.09	Paraguay	Copaco	0.54	43	0.02	0.82
						Senegal	Sonatel	0.63	39	0.16	1.24
						Singapore	SingTel	0.71	29	0.00	0.85
						Slovakia	Slovak Telecom	0.67	34	0.02	1.08
						Slovenia	Telecom Slovenia	0.72	27	0.09	0.88
						Sri Lanka	SLT	0.45	48	0.09	1.07
						St Lucia	Cable and Wireless (St Lucia)	0.59	41	0.05	1.12
						Swaziland	Swaz. Posts and Telecom. Corp.	0.25	54	0.09	1.13
						Uruguay	Antel	0.65	38	0.01	0.88
Mean		0.76	20.3	0.06	1.07	Mean		0.64	31	0.03	1.03

Appendix 2: Stochastic Frontier Analysis output: a global frontier (including "*trinity*")

Environmental Variables	coefficient	st. error	Distance Function Parameters	coefficient	st. error
δ_0	1.409	0.13***	b_0	-3.038	1.33**
privatisation	-0.240	0.08***	t	-0.294	0.10***
lib_fixed	-0.128	0.09*	t^2	0.003	0.00*
lib_mobile	-0.334	0.07***	$\ln y_1^*$	0.895	0.22***
nra	-0.045	0.07	$\ln x_1$	-2.842	0.36***
polconIII	-0.995	0.25***	$\ln x_2$	-0.268	0.12**
openness	-0.001	0.00**	$\left(\ln y_1^*\right)^2$	0.086	0.01***
size	-0.038	0.01***	$\left(\ln x_1\right)^2$	-0.084	0.02***
size_sq	0.000	0.00***	$\left(\ln x_2\right)^2$	0.007	0.00**
small	0.051	0.08	$\ln y_1^* \times \ln x_1$	0.127	0.02***
trinity	0.139	0.10*	$\ln y_1^* \times \ln x_2$	-0.007	0.03
σ^2	0.128	0.02***	$\ln x_1 \times \ln x_2$	-0.039	0.01***
γ	0.591	0.11***	$t \times \ln y_1^*$	-0.021	0.01***
			$t \times \ln x_1$	0.029	0.01***
Mean efficiency	0.68		$t \times \ln x_2$	0.022	0.01***
Log likelihood function	-127.97				
LR test of the one-sided error	224.84				
Firms	54				
Years	18				
Total observations	493				

Notes:
*,**,*** Statistically significant at the 0.1, 0.05, and 0.01 level, respectively.
The coefficient of γ suggests that 59% of the estimation error can be attributed to technical inefficiency.
A minus sign for the Z variables' coefficients suggests a negative effect on inefficiency.

Appendix 3: Stochastic Frontier Analysis output: Firms in small economies VS Firms in large economies (including "*trinity*")

	Small Economies		Large Economies	
	coefficient	st. error	coefficient	st. error
b_0	-2.066	2.06	-10.868	1.59***
t	-0.229	0.10***	0.299	0.18**
t^2	0.001	0.00	-0.002	0.00
$\ln y_1^*$	0.595	0.21***	0.196	0.42
$\ln x_1$	-1.362	0.63**	-1.983	0.47***
$\ln x_2$	-0.279	0.20*	-0.773	0.26***
$\left(\ln y_1^*\right)^2$	0.045	0.01***	0.096	0.02***
$\left(\ln x_1\right)^2$	0.015	0.03	-0.046	0.03**
$\left(\ln x_2\right)^2$	0.010	0.00***	-0.023	0.01**
$\ln y_1^* \times \ln x_1$	0.108	0.04***	0.062	0.04**
$\ln y_1^* \times \ln x_2$	0.152	0.04***	-0.015	0.04
$\ln x_1 \times \ln x_2$	-0.025	0.01**	0.025	0.02
$t \times \ln y_1^*$	0.005	0.01	-0.014	0.01
$t \times \ln x_1$	-0.015	0.01	0.028	0.01**
$t \times \ln x_2$	0.016	0.01***	-0.025	0.01***
δ0	1.869	0.23***	1.195	0.23***
privatisation	0.045	0.15	-0.337	0.14***
lib_fixed	-2.979	0.86***	-0.208	0.13*
lib_mobile	-1.304	0.20***	0.286	0.17**
nra	-0.192	0.14*	-0.503	0.13***
polconIII	-2.922	0.40***	-1.762	0.25***
openness	-0.006	0.00***	0.001	0.00*
size	3.802	0.78***	-0.016	0.01**
size_sq	-2.449	0.61***	0.000	0.00**
trinity	2.815	0.85***	0.186	0.16
σ^2	0.316	0.05***	0.063	0.01***
γ	0.907	0.04***	0.702	0.03***
Mean efficiency	0.74		0.88	
Log likelihood function	-59.16		-50.73	
LR test of the one-sided error	160.17		45.58	
Companies/economies	31		23	
Years	18		18	
Total observations	305		188	

Notes:
*,**,*** Statistically significant at the 0.1, 0.05, and 0.01 level, respectively.
A minus sign for the Z variables' coefficients suggests a negative effect on inefficiency.

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