Abstract
This paper builds on the literatures on small economies and on telecommunications policy to advance the study of the effects of the economy’s size and policy on its performance. It employs stochastic frontier analysis to estimate economic measures of efficiency for 139 small and large economies for the period 1990 – 2004. Simultaneously, it examines the effects that competition in fixed and mobile telephony, privatisation of the incumbent provider, institution of an independent regulator, and the level of institutional endowments have on the economy’s efficiency. Size appears to have a positive relationship with efficiency but this relationship does not seem to place small economies in a disadvantaged position. The relationship reaches a peak and becomes negative thereafter. As this kind of relationship is found to exist in both small and large economies it implies that both small and large economies can reach levels of size conducive to efficiency. Accounting for the effect of size, both small and large economies appear to benefit from the application of similar policy in the sector. The important effect of institutional endowments on efficiency has been pervasive throughout the analysis. Small economies can pursue economic integration in order to achieve the size that is conducive to efficiency. For large economies, large size is not a sufficient condition for efficient operation. The development of appropriate policy and institutional endowments are equally necessary.
Introduction
This paper looks into the important relationship between the size of the economy and its performance. The notion of small size (smallness) and its repercussions on small economies’ performance have attracted a large array of theoretical and empirical studies. A significant fraction of these studies identify salient disadvantages deriving from smallness and postulate that small economies are more likely to encounter handicaps pertaining to economic performance. A more recent stream of research builds on small economies’ distinctive characteristics and responses to smallness to suggest that they overall manage to counterbalance their size weaknesses. Notwithstanding, empirical evidence of the relationship between size and performance has been limited and vague.

Moreover, this paper identifies the important role that policy might have in the development of an economy when size becomes influential. Small economies often adopt policies developed in large economies. As this approach might have been driven by the advantages of obtaining a ready basis for the law it is uncertain whether policy from large economies can address potential handicaps emanating from smallness. Whether respective policy yields comparable results when applied in economies of different size remains largely unexplored. Herein lies the originality of the paper which proposes the empirical examination of the impact of size and regulatory policy on economic performance.

Building on the literature the paper distinguishes between economies of small and large size. Hitherto research has deployed various measures of size either separately or jointly so as to construct indexes of size. This paper utilises a formula suggested by Jalan (1982) that incorporates economic, labour, and natural resources measures to build a size index. The small economy exemplars for the respective measure are: Guinea with population 9.2 million; Singapore with GDP US $86.17 billion; and the Central African Republic with arable area 19.3 thousand km².

In order to obtain comparative economic measures of the performance of economies and facilitate the simultaneous examination of policy on performance the paper conducts an analysis of efficiency of the sector of telecommunications. Telecommunications constitute a fundamental element for economic development and the sector is depicted by intense regulatory activity. Analysis of policy effects concentrates on the opening of the market to competition; the privatisation of incumbent providers; and the establishment of an independent regulator. Efficiency analysis is conducted using stochastic frontier analysis of multitudinal data on 139 economies for the period 1990 – 2004.

The research findings allow us to gain invaluable insights into the relationship between size and efficiency. The economy size appears to have a positive relationship with efficiency but this relationship does not seem to place small economies in a disadvantaged position. The relationship reaches a peak and becomes negative thereafter. As this kind of relationship is found to exist in both small and large economies it implies that both small and large economies can reach levels of size that are conducive to efficiency. Accounting for the effect of size, both small and large economies appear to benefit from the overall application of similar policy in the sector. Throughout the analysis the important effect of institutional endowments has been pervasive.

The broader conclusions drawn from this paper can be advanced to the overall economy level. On the basis of the unprecedented role that telecommunications have in the development of the economy it can be postulated that the paper sheds some light on policy issues concerning the general economy. This implies that small
economies can equally benefit from the adoption of policy established and applied in large economies. Along with their continuous pursuance of global integration aiming to facilitate growth, small economies can achieve the optimum size that will be conducive to efficient operation. Respectively, for large economies, large size is not a sufficient condition for efficient operation. The development of appropriate policy and institutional endowments are equally necessary.

The remaining paper is organised as follows. The next section reviews the literature on small economies and identifies existing evidence of the relationship between size and performance. It juxtaposes this literature with existing research on telecommunications and develops the research hypotheses. A subsequent section unfolds the research methodology, model development, and data collection ending with the empirical results. The paper completes with a section on concluding remarks.

**Literature Review and Hypotheses Development**

The economic literature and particularly the literature on small economies demonstrate a significant number of theoretical and empirical studies of the effects of the size of the economy on its economic performance. The width of these studies spans from case studies at the level of the individual economy to comparative analyses. Throughout the literature two opposite perceptions of the role of size become evident. The first view considers the small size of the economy a crucial determinant of the efficiency of operation of local firms and overall the economy’s performance. The second group unearths and builds on small economies’ advantages to advocate the postulate that smallness does not put small economies in a disadvantaged position compared to large economies with regard to its effects on performance.

Since a discussion on smallness necessitates the clarification of small size classifications this section reviews the measures that existing studies adopt to classify the size of the economy. It then unfolds the two contrasting views about smallness’ effects and develops a critical position that will empirically examine in a subsequent section. Moreover, it takes the paper’s contribution a step further by proposing the empirical examination of a set of important policies that have been applied in both small and large economies. The aim is to gauge the potential leverage of size on the outcomes of these policies, an issue that has received limited empirical examination in the literature.

**Small economies: how small?**

It is evident in the literature that size classifications have not been consistent. The selection of different measures that often has hinged upon the intuition of the researcher has culminated in the consideration of varying small size economies, ranging from Vanuatu to Canada (Gal, 2003). Classifying economies into small and large size has traditionally been based on criteria of economic activity, natural resources, and labour (Jalan, 1982; Thorhallsson, 2006; Armstrong and Read, 1995; Briguglio and Buttigieg, 2004; Downes, 1988). Some studies draw a distinction between micro-states and mini-states. Such classifications though contribute little to the understanding of small size peculiarities (Armstrong and Read, 1995) and of the kind of policies that best apply to those contexts.

It is common practice to classify economies by population because it is easily available and provides a crude proxy for the size of domestic market and local labour force (Armstrong and Read, 1998a). Early studies such as Kuznets (1960) and Dervis, de Melo and Robinson (1982) specified a small economy as one with total labour
force of 10 million. Chenery and Taylor (1968) defined a small economy one with population less than 15 million.

More recent studies do not reveal large deviations. Winters and Martins (2004a) consider Singapore with population 4 million as the exemplar for small economies. It is noteworthy that the same authors define a small economy one with population less than 1.5 million in a different study (Winters and Martins, 2004b). Wint (2003) defines a small economy one with population less than 5 million. The threshold for Easterly and Kraay (2000) is one million whereas Browning (2006) refers to small European economies as the ones with population less than 16 million i.e. the population of the Netherlands.

Studies that combined different measures to develop a size index used its median value as the cut-off point. In particular, Demas (1965) defined a small nation as one with population of 5 million and usable land area of 10 to 20 thousand square miles. Jalan (1982) defined a small economy as one with a population of 5 million with arable land of 25 thousand square km and a GNP of $2 billion. Gayle (1986) defined a small economy as one with population between 60 thousand and eight million people, a GNP per capita within the range of $1,000 and $7,000 and an area between 234 and 285,000 square km.

This study classifies economies according to a formula proposed by Jalan (1982). The formula utilises an economy’s GDP\(^1\), population, and arable area that respectively represent economic, labour, and natural resources’ size. Applying the formula on 214 economies from data from the United Nations’ Human Development Report, the United Nations’ FAO and the World Bank’s World Development Indicators produces the country size index which takes values between 0 and 100. As suggested by Jalan (1982) the median value is the cut-off point dividing economies into small and large. A set of 56 economies fall within the range of small economies that is consistent over the 15 years of data available. This is in agreement with Wint (2003) who states that while small developing economies can become developed they are less likely to become large.

This study’s small economies have maximum population 9.2 million (Guinea); maximum GDP US $86.17 billion (Singapore); and maximum arable area 19.3 thousand km\(^2\) (Central African Republic) for 2004 data. The threshold for population is consistent with the existing literature that has classified smallness solely based on population. An illustrative list of small and large economies is given in Appendix I.

Small economies considered to be disadvantaged
Alesina and Spolaore (2003) discuss important advantages of economies of large size. They note that public goods in large economies are covered by a larger number of tax payers and therefore their costs are much lower than in small economies. Large economies are less subject to foreign aggression and can provide insurance to their regions. They also postulate that to the extent that larger economies increase productivity, they should be richer. Moreover, large regions can build redistributive schemes from richer to poorer individuals and regions, which would not be available to individual regions acting independently.

Even small economies exhibit high levels of per capita income they tend to remain weak in terms of total economic size as well as bargaining power (Castello and Ozawa, 1999). In addition, they are quite vulnerable to external shocks and cyclical fluctuations in the world economy due to their dependency on international

\(^1\) GDP is based on constant prices of 2000.
trade and their openness. This is consistent with the findings of the empirical analysis of the effects of smallness on growth by Easterly and Kraay (2000). The study shows that small economies are more volatile with respect to trade shocks.

The small absolute size of a small economy’s labour force restricts the scope for differentiation within the labour market (Castello and Ozawa, 1999). It also causes oftentimes shortages of skilled labour and training facilities that are necessary for knowledge development (Gal, 2003). Winters and Martins (2004a) provide empirical evidence that small economies are lacking semi-skilled and skilled labour. Therefore, a small economy is likely to be forced to require senior officials to act in multi-functional roles (Castello and Ozawa, 1999).

The scale problems of a small economy can be obviated by trading with the rest of the world (Winters and Martins, 2004b). Therefore, whereas international trade for a small economy has become indispensible for its economic development, due to its great openness, a small economy is more apt to be at the mercy of bigger economies’ policies (Wint, 2003). In addition, Castello and Ozawa (1999) stress that the fundamental policy problem facing the governments of small economies is the fact that only a small number of local institutions operate at internationally competitive levels.

Winters and Martins (2004a) emphasise that due to small scale, small economies have economic constraints with regard to conducting manufacturing or service functions. Small scale goes in tandem with inefficiency in the rate at which inputs can be transformed into outputs. They examine the comparative disadvantages of small economies relative to their sample’s median country Hungary of a size of 10 million. Their findings support the existence of significant penalties to small size in most of the costs they analyse although for some utilities results are vague and in others small countries actually have an advantage. They also find that small economies have comparable economic policies to large economies.

Findlay (2004) criticises the study by Winters and Martins (2004a) for not examining policies related to the specific sectors that possibly have an effect on small economies’ performance. According to them, the omission of sector policy variables is very likely to have led to an overstatement of the impact of size alone on small economies’ competitiveness. In fact, Winters and Martins (2004a) admit that their empirical analysis does not meet the level of sophistication necessary for the effective examination of the underlying questions.

As regards their examination of costs in the telecommunications industry, Winters and Martins (2004a) find that small economies face heavy cost disadvantages for international calls but are less expensive in line installation. Their findings contradict with the findings of an exhaustive study of the telecommunications sector conducted by the European Commission in 2006. The study shows that small economies, such as Malta and Cyprus, rank amongst the least expensive economies compared to the EU-25, Japan and USA.

Winters (2005) argues that small economies may face inefficiencies in the transformation of inputs into outputs due to their small scale. These inefficiencies are unavoidable and apply equally to all production sectors. Inability to directly address these inefficiencies would suggest trade intervention aiming to increase welfare. Moreover, Winters (2005) notes that small economies offer no advantages in terms of local market opportunities in order to attract foreign that is more sensitive to governance problems in small than in large economies. Therefore, improvement in

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2 Source: EU, 12th Implementation report on Telecommunications.
governance must become a major task for small economies. Yet, investment attraction efforts can expand the range of competitive industries in small economies but not the range of industries (Wint, 2003).

Small economies considered to be advantaged
The limitations emanating from small scale are pervasive throughout the foregoing discussion. However, a respective stream of research unearths salient characteristics for small economies which appear to counterbalance their disadvantages due to smallness. More importantly, there is a small number of empirical studies that provide evidence that size’s effects on small economies’ performance are unimportant.

In particular, Wint (2003) empirically finds that small economies are not necessarily outperformed by their larger counterparts. Yet, small economies are still vulnerable but their vulnerability is not captured by per capita income. It appears that small economies benefit from the relatively greater ability to adapt to change, and greater flexibility in administration. Wint (2003) concludes that small economies have the potential to operate successfully in the context of a global economy conditional on their developing competitive advantages on the benefit of their residents.

Castello and Ozawa (1999) note that a small economy tends to develop a closely integrated society containing a strong network of personal relationships. This facilitates a high degree of interpersonal communication and an efficient flow of information between government and industry. Because small economies are more homogeneous, they tend to suffer less from internal clashes among special interests and decision making is conducted more transparently. This implies that government has a clear idea of what economic policy tolls are accepted by the citizens. Consequently, the broader choices of the public are closer to the preferences of the average citizen than in larger economies.

Castello and Ozawa (1999) also elaborate on a number of advantages for small economies which derive from their predisposition to higher degrees of globalisation and flexibility. According to them, small economies are more able to exploit, react and adjust to opportunities and challenges in the world economy. Conditional on their economic success, small economies are more likely to specialise on differentiated manufactures and exports and eventually to transit from the status of net importers to net exporters. Furthermore, they are more sensitive in strategically managing exchange rates as a macroeconomic instrument of competitiveness for their firms and therefore achieve price stability. This has been the example of firms in Denmark, Finland and Sweden, which have developed to become highly sophisticated multinationals enhancing their economies’ international competitiveness.

Empirical evidence by Easterly and Kraay (2000) advocates the importance of higher educational attainment in small economies as a countermeasure against the negative effects of smallness on growth. Easterly and Kraay (2000) find that growth rates in small economies are more volatile due to their substantially greater exposure to international trade and fluctuations in their terms of trade. However, this volatility is outweighed by the growth benefits of their trade openness.

The authors also find that small economies have an income per capita advantage. This is partly explained by their higher productivity compared to their larger counterparts. Whereas small economies’ population growth rates are comparable with those of large economies they are portrayed by higher investment rates which provide further explanation to the income differential. As a general conclusion the study by Easterly and Kraay (2000) suggests that there is no obvious scale effect for growth rates that is related to population size. Their main finding is in agreement with
Armstrong et al. (1998) whose empirical examination suggests that population size does not significantly affect growth.

A common feature of small economies is their openness. Castello and Ozawa (1999) use the examples of Denmark and Portugal to argue that small economies pursue the creation of dynamic comparative advantages and the integration into world markets in order to overcome smallness. In support of this argument, Alesina and Spolaore (2003) emphasise that the “viable” size of an economy decreases with economic integration. To a great extent, small economies can prosper so long as they are open to international trade. Their empirical analysis shows that country size does not matter for either growth or the level of per capita income when trade is free, but large economies do better if and when they are more closed to trade. Winters (2005) notes that the most effective mode that small economies can choose to address their high manufacturing costs is to alleviate possible barriers to international trade.

Winters and Martins (2004a) conclude that in seeking to identify the effects of smallness empirically one would need to look at differences in production functions and overall efficiency across different sized economies. Herein lies the importance of this study which proposes the analysis of the efficiency of both small and large economies aiming to shed some light on pertinent issues.

The foregoing discussion unearths varying outcomes concerning the effects of size on the performance of the economy. This might be due to the implicit assumption that the relationship between size and performance (efficiency) is linear. This implies that an economy would have a persistent incentive to grow larger. Nevertheless, small economies’ size is destined to remain small. In addition, too large a size is envisaged that it will lead to misallocation of resources and deteriorate effective administration. Hence, the expectation for a continuous linear relationship between size and efficiency would be incongruous. The relationship is more probable to be denoted by an inverted u-shape. Positive relationship will be induced by the capacity of larger economies to effectively exploit increasing returns to scale. Subsequently, due to the disadvantages of largeness, the relationship is expected to become negative. Therefore, the following hypothesis stands:

\[ H1a: \text{The relationship between size and efficiency is denoted by an inverted u-shape} \]

Notwithstanding, considering that smallness is neither a necessary nor sufficient precondition for slow economic development (Srinivasan, 1986; Easterly and Kraay, 2000), both small and large economies are likely to be efficient and inefficient. Yet, due to their scale limitations, small economies are more likely to confront a handicap. Therefore, the following hypothesis will be examined in the efficiency analysis:

\[ H1b: \text{Small economies have lower efficiency than large economies} \]

This study takes hitherto research a step further and proposes the simultaneous examination of the effects of specific policies on the economy’s efficiency. The aim is to gauge the likely differential effects of these policies on the efficiency of economies of different size. These policies pertain to the opening of markets to competition, the privatisation of former state-owned enterprises, and the establishment of regulatory authorities within an economy’s spectrum of institutional endowments. Examination of the effects of these policies on the efficiency of economies of different size has been neglected. Research has been devoted to the examination of their effects on large
economies. Therefore, any assumptions made below with regard to their effects on economies of different size will rely on the postulates of the literature on small economies.

**Competition and smallness**

Structural reform through liberalisation is justified for competition’s effectiveness for allocating society’s resources efficiently (Vernon et al., 2000). Especially for small economies, whose economic “viability” is contingent on their degree of openness, competition might be an additional determinant of their efficiency.

Maskell et al. (1998) note that firms in small economies are substantially more exposed to foreign competition than firms in large economies. They emphasise that the advantageous exposure of small economies to international competition is sometimes considered as a critical factor in their economic development. International exposure along with openness facilitates small economies to reap usable outcomes from R&D conducted in large economies. To a large extent, small economies seem to benefit from hesitating before fully participating in high-tech industries.

Moreover, Wint (2003) refers to the liberalisation of telecommunications in Jamaica in 1999 which was an important development in reducing the risk of attracting foreign investment. The presence of competition incentivised investments in the type of technologies that were critical to the country’s effort to keep pace with globalisation changes.

Notwithstanding, small size insinuates a lack of economies of scale which poses a veritable handicap to development and profitable operation in any industry (Prasad, 2004). For small economies, the presence of economies of scale in many economic activities results in the existence of sub-optimal markets (Armstrong and Read, 1998b). Sub-optimality has serious repercussions on market structure since the feasible number of firms that operate in scale extensive markets is small. Alongside sub-optimality, demand often lies below the minimum efficient scale (MES) of output leading to market structures characterised by oligopoly or monopoly. Predisposition of small economies to natural monopolies has a serious impact on the efficiency of markets for non-tradeables, such as energy and telecommunications utilities (Briguglio and Buttigieg, 2004).

Moreover, according to Gal (2003) small size necessitates that efficiency become a stand-alone goal, since small economies are less able to sacrifice economic efficiency for broader policy objectives. Gal (2003) stresses that competition might not always be conducive to market efficiency. In support to this assumption, Posner (1976) notes that there is an array of cases where high industrial concentration can lead to more efficient operation and production.

Due to scale limitations, competition in small economies might not be in position to perform at the MES compared to competition in large economies. This implies a smaller number of efficient operators in small economies. Yet, available competition might still be able to induce better allocation of resources and incentivise the former monopoly to increase its efficiency. Therefore, two hypotheses emerge from the foregoing discussion:

**H2a:** Competition has a positive effect on the efficiency of small economies

**H2b:** Competition has a smaller impact on the efficiency of small economies compared to large economies
**Privatisation and smallness**

The assertion that public enterprises operate less efficiently and less profitably than their private counterparts has persuaded policy makers to privatisate publicly-owned telecommunications firms (Newbery, 1999). The decision to privatise public operators confronts the government with an awkward trade-off between substantial one-time cash infusions into the treasury and a lost income stream and a convenient instrument for economic and social policy implementation (Vernon et al., 2000).

Particularly for small economies, Wint (2003) notes that governments need to attract firms capable of internationally competitive operations in order to rectify the problem of inadequate internationally competitive entrepreneurial activity. Investment attracted to small economies is more likely than domestic firms to build internationally competitive production facilities. Hence, small economies need to systematically reduce the risks associated with developing internationally competitive enterprises.

However, small economies face two important challenges in attracting internationally competitive investment (Wint, 2003; Winters and Martins, 2004a). The first concerns their traditional inability to attract investment in a globalised market due to their high costs of imported inputs and isolation. Second, they have to be willing to implement policies that will make their territories conducive to investment. These policies might encompass ownership and equity involvement in previously state-owned enterprises.

Empirical studies in small economies conclude that privatisation and generally private investment increases productivity and performance. Castello and Ozawa (1999) empirically find that FDI in small open economies appears to be very important explaining changes in economic growth. Bergeijk et al. (1999) refer to the privatisation process of former state-owned enterprises in New Zealand. They point to major gains in productive efficiency and net gains to allocative efficiency and welfare to the economy as a whole accruing from privatisation. Wint (2003) discusses Guyana’s successful change in economic policy which through encouragement of private investment improved the economy’s growth prospects.

The effects of privatisation appear to benefit the efficiency of small economies. These effects most likely do not vary with the economy’s size and give rise to the following hypotheses:

\[ H3a: \text{Privatisation has a positive impact on the efficiency of small economies} \]

\[ H3b: \text{Privatisation’s impact on the efficiency of small economies is comparable to large economies} \]

**Regulatory institutions, institutional endowments and smallness**

Successful implementation of liberalisation and privatisation insinuates the existence of strong political and social foundations (Levy and Spiller, 1996; Henisz and Zelner, 2001). Levy and Spiller (1996) argue that credibility and effectiveness of a regulatory framework vary according to the country’s political and social institutions. The economy may reach satisfactory performance so long as there are substantive restraints on discretion actions by the regulatory institutions. Exploiting the full potentials of competition and privatisation might be unfeasible if institutional and regulatory governance foundations are inadequate to support regulatory flexibility.
The literature on small economies advocates that their international competitiveness to some degree depends on the development of strong institutional endowments (Castello and Ozawa, 1999; Wint, 2003; Winters, 2005). Therefore, improvements in governance in small economies must rank fairly high.

Wint (2003) notes that low levels of political and country risk are likely to be essential to prosperity among small economies. He suggests that small economies identify the local sectors for which low risk is critical for their development. These might include sectors, such as telecommunications, that play important role in their success. Wint (2003) uses the examples of Jamaica and Guyana to exemplify that economic performance might stagnate and deteriorate when small economies experience higher levels of country risk relative to others. His empirical outcomes illustrate that small economies with political and social stability perform substantially better than others. The general conclusion from his study is that risk reduction in an industry would lead to improvements in productivity.

Small economies traditionally adopt policies from large economies (Gal, 2003). This approach might have been driven by the advantages of obtaining a ready basis for the law or by the ability of large economies to enforce their regulatory policy on smaller economies. This is supported by the findings of Winters and Martins (2004a) and Briguglio et al. (2005) who find that small countries do not have significantly worse policies than other countries in the dimensions they measure. Notwithstanding, Wint (2003) emphasises the importance of institutions in the implementation of successful policy. This might be more important for small economies considering that investment might be more sensitive to governance problems in small economies rather than their larger counterparts (Winters, 2005). The rationale is that small economies offer limited advantages in terms of local market opportunities to offset any shortcomings might exist in production conditions.

It is of paramount importance that policy in small economies be orchestrated by competent regulatory authorities. Beyond the authorities’ conventional duties of establishing regulatory policy and impeding anti-competitive conduct, they are additionally required to analyse changes in efficiency due to policy change. The operation of regulatory authorities in small economies becomes more challenging as they often operate under sub-optimal specialised personnel relative to their larger counterparts (Stern, 2000). Lack of skilful personnel and technical competence render effective administration and governance disproportionately costly compared with large economies (Armstrong and Read, 1998a) and internationally uncompetitive (Wint, 2003).

Considering the foregoing discussion, it becomes prevalent that institutional endowments and regulatory authorities have an increasingly important role in the efficiency of small economies. This role is likely to be more important than in large economies. Therefore, the empirical analysis of efficiency will attempt to shed light on the following hypotheses:

\[ H4a: \text{Institutional endowments and regulatory authorities have a positive impact on the efficiency of small economies} \]

\[ H4b: \text{Institutional endowments and regulatory authorities have a larger impact on the efficiency of small economies compared to large economies} \]
In order to examine the research hypotheses the paper contextualises its empirical analysis in the sector of telecommunications. Telecommunications constitute a fundamental element for economic development and the sector is depicted by intense regulatory activity. Whether the efficiency of the sector and policy outcomes vary according to the size of the economy is a critical question.

The literature on telecommunications policy depicts a large array of studies about the effects of pertinent policies on the sector’s performance. Early research focused on the separate effects of liberalisation, privatisation, or the existence of an independent national regulatory authority (NRA). More recent literature holistically attempts to gauge the combined effect of these policies, what this paper calls the “Trinity”, as well as the role of institutional endowments.

Table 1 classifies major studies according to the underlying policies examined. This classification unveils two important observations. The research outcomes of existing studies have been vague. In addition, whereas the role of institutional endowments appears to have a consistent positive effect on telecommunications performance existing studies have neglected its simultaneous examination along with important policies. Hence, this study is additionally expected to shed light on the outcomes of important policy in telecommunications and extent the literature on telecommunications policy.

<table>
<thead>
<tr>
<th>Study</th>
<th>Main dependent variable</th>
<th>Competition</th>
<th>Privatisation</th>
<th>NRA</th>
<th>Institutional endowments</th>
<th>Cross-sections</th>
<th>Time series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosotto et al. (2005)</td>
<td>Labour productivity</td>
<td>+</td>
<td></td>
<td></td>
<td>133 countries</td>
<td>1990 – 1999</td>
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</table>
Research Methodology

*Efficiency methods and studies in telecommunications*

The main tools used for efficiency analysis are Data Envelopment Analysis (DEA), a mathematical programming method and Stochastic Frontier Analysis (SFA), an econometric method. The two methods pertain to the measurement of performance of firms which convert inputs into outputs. There can be two behavioural orientations within these two methods. In an output orientation, the aim is to assess the ability of the subject to augment output given available inputs. In an input orientation, the aim is to assess the ability of the subject to conserve inputs given the outputs that it has produced with these. Both the focus of DEA and SFA can suitably be directed on the measurement of performance at the industry or economy aggregate level.

DEA involves the use of linear programming methods to construct a non-parametric production frontier over the data. Efficiency measures are then calculated relative to this surface. Firms that are located on the frontier surface are considered efficient in contrast to firms that portray a deviation. DEA received wide attention after the papers by Charnes, Cooper, and Rhodes (1978) and Banker, Charnes, and Cooper (1984) which proposed models that assumed constant returns to scale and variable returns to scale, respectively. The DEA method is computationally simple and has the advantage that it can be implemented without knowing the algebraic form of the relationship between outputs and inputs (Coelli et al., 2005). A problem with frontiers estimated by 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 (Kumbhakar and Lovell, 2000).

In order to provide a solution to the problem a stochastic production frontier was instead independently proposed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977) which introduced another random variable representing statistical noise. For the basic stochastic production frontier model, output is specified as a function of a non-negative random error which represents technical inefficiency, and a symmetric random error which accounts for noise. More recent contributions to SFA proposed models that allow the determination of environmental factors on efficiency (i.e. Kumbhakar et al., 1991) which is not possible with the DEA method. However, SFA faces an important challenge: the necessity to choose an algebraic functional form of the relationship between outputs and inputs.

Studies of efficiency of telecommunications have employed both methods (Table 2). A number have focused on ascertaining whether firms under question operate close to their most productive scale size (i.e. Majumbar and Chang, 1996; Bartels and Islam, 2002; Giokas and Pentzaropoulos, 2000; Koski and Majumdar, 2000; Lien and Peng, 2001; Pentzaropoulos and Giokas, 2002). Others attempt to measure the effect of specific reform policies on the efficiency performance of affected firms. Namely, Uri (2001) examines the effects of price caps; Resende and Façanha (2002) and Sueyoshi (1998) gauge the effects of privatisation; and Majumdar (1995) and Sueyoshi (1996) assess the efficiency outcomes of divestiture measures. Moreover, the telecommunications industry has been utilised for the application and testing of new developments in efficiency analysis methods (i.e. Athanassopoulos and Giokas, 1998; Sueyoshi, 1994). Other studies have examined the efficiency effect of telecommunications on economic growth (i.e. Thompson Jr. and Garbacz, 2007).
<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Inputs</th>
<th>Outputs</th>
<th>Source</th>
<th>Panel</th>
<th>Time-series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Majumdar and Chang (1996)</td>
<td>DEA</td>
<td>Number of switches; Number of lines; Employees; Total net plant; Maintenance and depreciation expenses; Traffic, commercial and general office expenses; Other expenses</td>
<td>Local calls; Toll calls</td>
<td>FCC (National Regulatory Authority)</td>
<td>39 local operating US companies</td>
<td>1975, 1978, 1981, 1984, 1987 and 1990</td>
</tr>
<tr>
<td>Sueyoshi (1998)</td>
<td>DEA</td>
<td>Total assets; Total access lines; Total employees</td>
<td>Total revenues</td>
<td>Japanese incumbent (NTT) NTT</td>
<td></td>
<td>1953 to 1994</td>
</tr>
<tr>
<td>Koski and Majumbar (2000)</td>
<td>DEA</td>
<td>Investment of operators; Total telecommunications staff</td>
<td>Number of mainlines; Percent of digital mainlines; Number of cellular subscribers</td>
<td>OECD</td>
<td>22 OECD countries</td>
<td>1980-1995</td>
</tr>
<tr>
<td>Lien and Peng (2001)</td>
<td>DEA</td>
<td>Number of mainlines installed; Number of staff; Total amount of operator investment</td>
<td>Total revenue</td>
<td>OECD</td>
<td>24 OECD countries</td>
<td>1980-1995</td>
</tr>
<tr>
<td>Uri (2001)</td>
<td>DEA</td>
<td>Labour; Capital; Material</td>
<td>Local service intrastate toll divided by access service interstate service Revenue</td>
<td>FCC (National Regulatory Authority)</td>
<td>USA</td>
<td>1985-1998</td>
</tr>
<tr>
<td>Pentzaropoulos and Giokas (2002)</td>
<td>DEA</td>
<td>Access lines; Mobile subscribers; Number of employees</td>
<td>Total revenue</td>
<td>OECD</td>
<td>19 countries</td>
<td>1999</td>
</tr>
<tr>
<td>Resende and Facanha (2002)</td>
<td>DEA</td>
<td>Technical employees; Consumer assistance employees, central office switches employees; Number of access lines Capital investment; Telecommunications service Revenues</td>
<td>Local call pulses; Minutes of long-distance calls</td>
<td>Anatel (National Regulatory Authority)</td>
<td>Brazil</td>
<td>July 1998 and December 1999</td>
</tr>
<tr>
<td>Sueyoshi (1994)</td>
<td>DEA and econometrics</td>
<td>Telecommunications employees; Telecommunications service Revenues</td>
<td>Number of telephone lines installed</td>
<td>OECD</td>
<td>24 OECD countries</td>
<td>1987</td>
</tr>
<tr>
<td>Sueyoshi (1996)</td>
<td>DEA and econometrics</td>
<td>Total assets; Total access lines; Total employees</td>
<td>Total operating expenses; Fixed charge for Japanese incumbent (NTT) NTT telephone subscriptions; Variable charge for telephone usage; Other charges</td>
<td>Japanese incumbent (NTT) NTT</td>
<td></td>
<td>1953 to 1994</td>
</tr>
<tr>
<td>Athanassopoulos and Giokas (1998)</td>
<td>DEA and econometrics</td>
<td>Technical personnel; Investment on fixed assets; Consumption of materials; Total operating costs; Total number of employees; Investment on fixed assets; Installed capacity</td>
<td>Number of new connections and transfers of telephone lines; Local number of calls; National number of calls; International number of calls; Installed capacity; Total operating revenue; Telephone connections</td>
<td>Greek incumbent (OTE)</td>
<td>Greece</td>
<td>1971-1993</td>
</tr>
<tr>
<td>Bartels and Islam (2002)</td>
<td>SFA</td>
<td>Telecom investment; Total investment in the economy; Telecom staff</td>
<td>Total operating revenue</td>
<td>PWT, ITU</td>
<td>28 countries</td>
<td>1982-1992</td>
</tr>
</tbody>
</table>

Notes:
[1] Telecommunications variables used as determinants of inefficiency included the penetration rates in fixed voice, mobile telephony, and the Internet.
Model development
The paper employs Stochastic Frontier Analysis (SFA) to estimate technical efficiency measures for small and large economies. Computing these efficiency measures involves estimating the unknown production frontier by enveloping data using an arbitrarily-chosen function. The output of this stochastic production frontier model 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) and Meeusen and van den Broeck (1977) proposed the stochastic frontier production function model of the form

\[ \ln q_i = x_i \beta + v_i - u_i \]  

(1)

where the output values are bounded from above by the stochastic variable \( \exp(x_i \beta + v_i) \). The random error \( v_i \) can be positive or negative and so the stochastic frontier outputs vary about the deterministic part of the model, \( \exp(x_i \beta) \).

The most common (output-oriented) measure of technical efficiency is the ratio of observed output to the corresponding stochastic frontier output:

\[ TE_i = \frac{q_i}{\exp(x_i \beta + v_i)} = \frac{\exp(x_i \beta + v_i - u_i)}{\exp(x_i \beta + v_i)} = \exp(-u_i) \]  

(2)

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

The estimation of the parameters of the stochastic production frontier model (1) involves the making of specific assumptions concerning the two random variables \( v_i \) and \( u_i \). The main assumptions about these two terms are that each \( v_i \) is distributed independently of each \( u_i \) and that both errors are uncorrelated with the explanatory variables in \( x_i \). Namely, 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.

Estimating the parameters involves, in a first stage, the estimation of consistent estimators of the slope coefficients using ordinary least squares (OLS). In a second stage, certain distributional assumptions are made about the two error terms and the method of Maximum Likelihood Estimation (MLE) is used to solve the problem of bias in the OLS intercept coefficient. The \( v_i \), are assumed to be independently and identically distributed normal random variables with zero means and variances \( \sigma_v^2 \). As regards the \( u_i \), there are four main distributions that might be assumed: half-normal, truncated-normal, exponential, and gamma. Kumbhakar and Lovell (2000) provide support for the half-normal and truncated-normal distributions, whereas Coelli et al. (2005) note that parsimony advocates the simpler half-normal and exponential models.

Jondrow et al. (1982) and Battese and Coelli (1988) provide two alternative formulas to predict \( u_i \) in order to obtain the efficiency of the individual economy. The predictor by Battese and Coelli (1988) is the one built in the software package Frontier 4.1 which the paper uses to obtain individual efficiency predictions. The
efficiency for a group of economies can be viewed as the average of the efficiencies of all economies in the respective group.

A limitation of the simple production frontier model is that it does not permit multi-output production. Particularly, where no price information is available and it is inappropriate for firms in an economy to minimise costs or maximise revenues, such as in the case of regulated industries, distance functions can be used to estimate the characteristics of multiple-output production technologies (Coelli et al., 2005). One example is the case of telecommunications, where the vast majority of organizations are both government-owned and highly regulated.

Coelli and Perelman (2000) illustrate how (input and output) distance functions can be used in the analysis of production in multi-output industries\(^3\). The output distance function is defined on the output set, \(P(x)\), as:

\[
d^0(x, q) = \min \left\{ \delta : (q / \delta) \in P(x) \right\}
\]  

(3)

As noted in Coelli and Perelman (2000), \(d^0(x, q)\) is non-decreasing, positively linearly homogeneous and convex in \(q\), and decreasing in \(x\). An output distance function \(d_i^0\) for a number of economies \(i\), defined over \(M\) outputs and \(N\) inputs takes the form \(d_i^0 = d^0(x_{i1}, x_{i2}, \ldots, x_{IN}, q_{i1}, q_{i2}, \ldots, q_{iM})\) where \(x_{im}\) is the \(n\)-th input of economy \(i\); \(q_{im}\) is the \(m\)-th output; and \(d_i^0 \leq 1\) is the minimum amount by 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 \(d^0(x, q) = 1\).

A translog functional form is specified for the distance functions in this paper. The translog form has been used in other distance function studies (e.g. Cuesta and Orea, 2002; Goto and Tsutsui, 2008) since it is flexible; easy to calculate; and permits the imposition of homogeneity. In contrast, the Cobb-Douglas form is not flexible because of its restrictive elasticity of substitution and scale properties. In addition, the Cobb-Douglas transformation function is not an acceptable model of a firm in a purely competitive industry because it is not concave in the output dimensions (Kumbhakar and Lovell, 2000).

The translog distance function for the case of \(M\) outputs and \(K\) inputs is specified as:

\[
\ln d_i^0 = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mi} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \ln y_{mi} \ln y_{ni} \\
+ \sum_{k=1}^{K} \beta_k \ln x_k + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \ln x_k \ln x_l \\
+ \sum_{k=1}^{K} \sum_{m=1}^{M} \delta_{km} \ln x_k \ln y_{mi} \\
i=1,2,\ldots,N
\]

(4)

\(^3\) The particular interest of this paper is upon an output distance function because of the assumption made that firms in the telecommunications industry tend to have more control over outputs than inputs. This assumption is very common for regulated industries (Coelli et al. 2005).
where \( i \) denotes the \( i \)-th economy in the sample. To obtain the frontier surface one would set \( d^0 = 1 \), which implies the left hand side of Equation 4 is equal to zero. The restrictions required for homogeneity of degree +1 in outputs are:

\[
\sum_{m=1}^{M} a_m = 1 \quad \text{and} \quad (5)
\]

\[
\sum_{n=1}^{M} a_{mn} = 0 \quad m = 1, 2, ..., M \quad (6a)
\]

and

\[
\sum_{m=1}^{M} \delta_{km} = 0 \quad k = 1, 2, ..., K \quad (6b)
\]

and those required for symmetry are

\[
\alpha_{mn} = \alpha_{nm} \quad m, n = 1, 2, ..., M \quad (7a)
\]

and

\[
\beta_{kl} = \beta_{lk} \quad k, l = 1, 2, ..., K \quad (7b)
\]

In order to impose the homogeneity constraint upon Equation (4) Lovell et al. (1994) note that homogeneity implies that

\[
d^0(x, \psi y) = \psi d^0(x, y) \quad \text{for any } \psi > 0 \quad (8)
\]

Arbitrarily choosing one of the outputs and setting \( M_1/y \psi = y \) yields

\[
d^0(x, y/y_m) = d^0(x, y)/y_m \quad (9)
\]

For the translog form this provides:

\[
\ln \left( \frac{d^0}{y_{Mi}} \right) = \alpha_o + \sum_{m=1}^{M-1} \alpha_m \ln y_{mi}^* + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln y_{mi}^* \ln y_{ni}^* + \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \ln x_{ki} \ln x_{li} \quad (10)
\]

\[
+ \sum_{k=1}^{K} \sum_{m=1}^{M-1} \delta_{km} \ln x_{ki} \ln y_{mi}^* + v_i \quad i = 1, 2, ..., N \quad y_{mi}^* = \frac{y_{mi}}{y_{Mi}}
\]

where \( v_i \) is a random variable introduced to account for errors of approximation and other sources of statistical noise. To facilitate Maximum Likelihood Estimation, Equation (10) is rewritten as
\[-\ln (y_{mi}) = \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \ln y_{mi}^* + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln y_{mi}^* \ln y_{ni}^* \]
\[+ \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \ln x_{ki} \ln x_{li} \]
\[+ \sum_{k=1}^{K} \sum_{m=1}^{M-1} \delta_{km} \ln x_{ki} \ln y_{mi}^* + v_i - u_i \quad i = 1, 2, \ldots, N \]  

where \( u_i \equiv \ln \left( d_i^\alpha \right) \) is a non-negative variable associated with technical inefficiency.

In addition, a radial output-oriented measure of technical efficiency is

\[ \text{TE}_i = \frac{1}{d_i^\alpha} = \exp(-u_i) \]  

The empirical efficiency analysis of this paper involves the use of panel data. According to Coelli et al. (2005) panel data can be expected to give more efficient estimators of the unknown parameters and more efficient predictors of technical efficiencies. In panel data estimation two classifications are commonly made with regard to the inefficiency effects in equation 11: time-varying or time-invariant inefficiency effects. Considering that the industry of telecommunications is depicted by continuous technological change time-varying effects will be considered as the most appropriate in this case.

Battese and Coelli (1992) developed a model for time-varying technical inefficiency that takes the form: (e.g. Cuesta, 2000)

\[ f(t) = \exp\left[ \eta(t - T) \right] \]  

where \( \eta \) is an unknown parameter to be estimated. The model has the properties \( f(t) \geq 0 \) and \( f(T) = 1 \) and is either non-increasing or non-decreasing, depending on the sign of \( \eta \) and is convex for all values of \( \eta \). A limitation of the model is that it does not allow for a change in the rank ordering of firms over time\(^4\).

A principal task of this study is to assess the effects of telecommunications policy on sector efficiency. Initial attempts to account for the effects of environmental variables on production involved the incorporation of these variables into the deterministic component of the production frontier. A different approach would predict firm-specific technical efficiencies and subsequently regress them on the environmental variables\(^5\). Kumbhakar and Lovell (2000) and Coelli et al. (2005) note that the latter approach is problematic. Failure to include environmental variables in the first stage leads to biased estimators of the parameters of the non-stochastic part of the production frontier and also to biased predictors of technical efficiency.

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\(^4\) This model is the default for efficiency estimation using Frontier 4.1 application. More flexible models have recently appeared that allow for changes in the ranking order (e.g. Cuesta, 2000). However, they are not available in existing econometric software.

\(^5\) A respective (and criticised) approach has been the use of non-parametric methods, such as DEA, for the prediction of efficiency in a first stage. Efficiency predictions would then be regressed on environmental variables.
Instead, Kumbhakar et al. (1991) developed a specification for the inefficiency term which allows environmental variables to directly influence the stochastic component of the production function. They assumed that:

\[ u_i \sim N^+ \left( z_i' \omega, \sigma_u^2 \right) \]  

where \( z_i \) is a px1 vector of variables which may influence the efficiency of a firm and \( \omega \) is an 1xp vector of parameters to be estimated. Therefore, the distributions of the inefficiency effects in the frontier model vary with \( z_i \) (environmental variables). The model was later generalised to the panel data case by Battese and Coelli (1995).

Due to technological advances, production functions often change over time (Chambers, 1988). In the presence of Hicks-neutral technical change, the functions shift up and down but their slopes do not alter. It is common to include a time trend \( t \) and its square in the model for the possibility of Hicks-neutral technical change. Presence of non-neutral technical change implies that the movement of the production functions will be biased in favour of certain inputs and/or outputs and against others. In the multi-output model, technical change can favour the production of one commodity over another. Non-neutral technical change can be accounted for by also including terms involving the interactions of the other regressors and time.

Considering the foregoing, the general formulation of the output distance function under variable returns to scale, controlling for both neutral and non-neutral technical change can be expressed as follows:

\[
\begin{align*}
-\ln \left( y_{Mi} \right) &= \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \ln y_{M^*} + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln y_{M^*} \ln y_{nit} \\
&+ \sum_{k=1}^{K} \beta_k \ln x_{kit} + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \ln x_{kit} \ln x_{lit} \\
&+ \sum_{k=1}^{K} \sum_{m=1}^{M-1} \delta_{km} \ln x_{kit} \ln y_{nit} + \frac{1}{2} \sum_{k=1}^{K} \zeta_{0k} t^2 + \sum_{k=1}^{K} \kappa_k t \ln x_{kit} + \sum_{m=1}^{M-1} \xi_{mt} t \ln y_{nit} + v_{it} - u_{it} \\
\end{align*}
\]

\[
y_{nit}^* = \frac{y_{nit}}{y_{M^*}}, \quad i = 1,2,...,N, \quad t = 1,2,...,T
\]

where \( y_{nit} \) is a mx1 vector of output quantities of the i-th economy in the t-th time period; 
\( x_{kit} \) is a kx1 vector of input quantities of the i-th firm in the t-th time period; 
\( \alpha, \beta, \delta, \zeta, \kappa, \xi \) are vectors of unknown parameters; 
\( t \) is a time trend; 
\( v_{it} \) are random variables which are assumed to be iid, have distribution \( N\left(0,\sigma_v^2\right)\), and independent of the

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6 The squared term is included to provide consistency with the second order approximation notion of the translog form (Coelli et al. 2005).
\( u_i \) which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the \( N(m_{ui}, \sigma^2_{ui}) \) distribution;

\[ m_{ui} = z_{ui} \omega, \]

where \( z_{ui} \) is a p×1 vector of variables which may influence the efficiency of a firm and \( \omega \) is an 1xp vector of parameters to be estimated.

The ability of the model to estimate a stochastic production frontier is depicted by the variation in the parameterisation \( \sigma^2 = \sigma^2_v + \sigma^2_u \) and \( \gamma = \sigma^2_u / (\sigma^2_v + \sigma^2_u) \). The parameter \( \gamma \) lies between 0 and 1. The higher the value it takes, the more of the estimation errors can be attributed to technical inefficiency.

**Data and variable description**

Telecommunications related data were primarily obtained from the ITU’s World Telecommunication/ICT Indicators Database 2006. Whereas the database encompasses data on more than 210 economies for a number of telecommunications and other indicators, the paper utilises complete data for 139 economies for the years 1990-2004. Economic, geographical, and demographic data were obtained from the United Nations’ Human Development Report of 2005 and the World Bank’s World Development Indicators.

The paper uses two inputs (telecommunications staff as a percentage of total population and investment in telecommunications per capita) and three outputs (fixed lines per 100 inhabitants; internet users per 100 inhabitants; and mobile subscribers per 100 inhabitants). In contrast to previous studies that have arbitrarily confined outputs to fixed lines (e.g. Bartels and Islam, 2002; Lien and Peng, 2001; Sueyoshi, 1994) the current study attempts to take into account this flaw in analysis and also incorporates the technologies of mobile telephony and Internet.

Incorporating all three technologies in the production function also allows for controlling relationships of complementarity or substitution that may have developed over time. Several empirical studies have examined these relationships (e.g. Barros and Cadima, 2000; Gruber and Verboven, 2001; Hamilton, 2003; Rodini et al., 2002; Sung and Lee, 2002; Taubman and Vagliasindi, 2005) arguing that different countries, constrained by limited resources, choose to produce different combinations of various technologies.

The hypotheses concerning the two relationships between size and efficiency are tested by the inclusion of three variables which capture the effects of size in the model. The first variable pertains to the values estimated by the formula suggested by Jalan (1982). This is a continuous variable and allows for temporal change. The higher the value, the larger the economy is. In conjunction with its squares the two variables examine the linearity hypothesis between size and efficiency. The third variable is a dummy that takes a value of 1 if the economy is small and 0 otherwise. It is aimed to examine whether small economies on average are less efficient than their larger counterparts. These hypotheses will be examined based on a model that encompasses both small and large economies. This allows for their comparison based on a communal stochastic frontier depicting their relative international competitiveness.

The assessment of liberalisation’s impact on telecommunications efficiency is captured by two variables that depict whether the markets of fixed voice or mobile

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7 To the best knowledge, only Koski and Majumdar (2000) adopt a similar description of telecommunications production technology employing DEA for the prediction of efficiency measures.
telephony have been opened to competition. The variables take the value of 1 if the economy allows additional operators to compete with the incumbent in the respective market and 0 if otherwise. Information about the opening of the respective markets was obtained from the ITU’s World Telecommunication Regulatory Database. These variables allow a distinction between the effects of competition in different technologies, a factor that has not been taken into consideration in previous empirical studies.

As regards the hypotheses concerning policy effects on efficiency, they are tested by two separate models for each group of economies. The estimates from these models are utilised in the comparison of the magnitudes of policy effects on each group’s efficiency. The change in the ownership of the incumbent provider is captured by a variable which takes a value of 1 when the incumbent has offered private participation in its operations and 0 when otherwise. Information for the formation of this variable was obtained from the ITU’s World Telecommunication Regulatory Database as well as from the financial reports of operators. Information from the same database was also used to construct the variable for regulators. The variable takes a value of 1 when the economy has established a NRA and 0 when otherwise8.

Analysis of Trinity constitutes an important extension to hitherto empirical studies which have practically neglected the combined effects of the above policy measures on telecommunications efficiency. Trinity is measured by a variable constructed by the interaction between the above four variables. It takes a value of 1 if the economy has liberalised either of the two markets of fixed voice and mobile telephony; has allowed private ownership in the incumbent operator; and has established an NRA, and 0 if otherwise.

Institutional endowments are being proxied using the variable PolconIII developed by Henisz (2002). This variable estimates the feasibility of policy change, namely, the extent to which a change in the preferences of any one actor may lead to a change in government policy. It is an internationally comparable measure of political constraints and encapsulates the structure of political systems for the economies concerned. The variable takes values in the range of 0-100. Smaller values depict an economy with lower economic freedom, narrower institutional endowments, and higher political risks. The model also includes a variable to capture the effect of openness of the economy. A more analytical description of variables included in the analysis is presented in Table 3.

### Table 3: Description of variables used in the efficiency analysis

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outputs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed</td>
<td>Fixed mainlines per 100 inhabitants</td>
<td>ITU’s World Telecommunication/ICT Indicators Database 2006</td>
</tr>
<tr>
<td>Mobile</td>
<td>Mobile subscriptions per 100 inhabitants</td>
<td>ITU’s World Telecommunication/ICT Indicators Database 2006</td>
</tr>
<tr>
<td>Internet</td>
<td>Internet users per 100 inhabitants</td>
<td>ITU’s World Telecommunication/ICT Indicators Database 2006</td>
</tr>
<tr>
<td>Inputs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment</td>
<td>Total telecommunications investment on constant prices of 2000 in US $ per capita</td>
<td>ITU’s World Telecommunication/ICT Indicators Database 2006</td>
</tr>
</tbody>
</table>

8 Dummy variables have previously been challenged as they may not offer the optimum measure for 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 based on either short time-series or cross-sectional analysis and on a small number of countries. The present paper uses a large number of cross-sections (139 economies) for a long period (15 years) which are expected to help overcome a large part of conventional limitations of econometric analysis that employs dummy variables.
Table 4 projects the main variables’ statistics for large and small economies. A shared characteristic for the two groups of economies is the large degree of variance within each group with regard to nearly all variables. Very large standard deviations relative to the variables’ means illustrate low homogeneity among economies in the same group. Large economies seem to invest more in telecommunications, but they employ lower labour compared to small economies. Telecommunications technologies appear to have higher penetration in large economies. The latter are also depicted by a higher degree of political freedom and their populations are enjoying higher incomes. Instead, small economies appear to be far more open to international trade and investment.

### Table 4: Main variables’ statistics for small and large economies

<table>
<thead>
<tr>
<th>Large Economies</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecom investment per capita (US $)</td>
<td>6203.51</td>
<td>7614.02</td>
<td>11.60</td>
<td>56868.90</td>
</tr>
<tr>
<td>Telecom staff as a percentage of population</td>
<td>0.16</td>
<td>0.13</td>
<td>0.01</td>
<td>0.53</td>
</tr>
<tr>
<td>Fixed mainlines per 100 inhabitants</td>
<td>24.57</td>
<td>22.35</td>
<td>0.20</td>
<td>75.76</td>
</tr>
<tr>
<td>Mobile subscribers per 100 inhabitants</td>
<td>13.28</td>
<td>22.48</td>
<td>&lt;0.01</td>
<td>98.07</td>
</tr>
<tr>
<td>Internet users per 100 inhabitants</td>
<td>6.06</td>
<td>11.60</td>
<td>&lt;0.01</td>
<td>56.21</td>
</tr>
<tr>
<td>PolconIII</td>
<td>0.37</td>
<td>0.20</td>
<td>0</td>
<td>0.71</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>8968.83</td>
<td>10784.48</td>
<td>141.19</td>
<td>38182.18</td>
</tr>
<tr>
<td>Openness</td>
<td>65.99</td>
<td>33.08</td>
<td>4.83</td>
<td>228.87</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Small Economies</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecom investment per capita (US $)</td>
<td>5130.25</td>
<td>7144.40</td>
<td>1.07</td>
<td>96853.54</td>
</tr>
<tr>
<td>Telecom staff as a percentage of population</td>
<td>0.18</td>
<td>0.12</td>
<td>0.01</td>
<td>0.67</td>
</tr>
<tr>
<td>Fixed mainlines per 100 inhabitants</td>
<td>19.60</td>
<td>18.06</td>
<td>0.14</td>
<td>79.75</td>
</tr>
<tr>
<td>Mobile subscribers per 100 inhabitants</td>
<td>11.47</td>
<td>19.12</td>
<td>&lt;0.01</td>
<td>119.38</td>
</tr>
<tr>
<td>Internet users per 100 inhabitants</td>
<td>5.11</td>
<td>9.57</td>
<td>&lt;0.01</td>
<td>59.93</td>
</tr>
<tr>
<td>PolconIII</td>
<td>0.29</td>
<td>0.21</td>
<td>0</td>
<td>0.61</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>5686.67</td>
<td>8175.97</td>
<td>159.81</td>
<td>44702.04</td>
</tr>
</tbody>
</table>
With respect to the adoption of different policies by the two groups of economies and their attitude towards structural reform, Table 5 unfolds a timeline for the four fundamental policy measures. Concerning large economies, the year 1995 signalled the take-off of liberalisation in fixed voice and mobile telephony markets. Two strong shocks of mass privatisations are apparent in 1994 and 1997; whereas a large wave of erecting NRAs took place in 1997 and 1998. Until 2004, 70% of the sample economies liberalised fixed voice; 92% liberalised mobile telephony; 61% proceeded with privatisation of their incumbent providers; and 75% established a regulatory office.

As regards small economies, fixed voice liberalisation took off in 1998 where in 2003 a large series of parallel liberalisations occurred. Liberalisation in mobile telephony took off somewhat earlier in 1995 with subsequent radical diffusion among other small economies. Privatisation progress followed a softer linear evolution. As of 1990 many small economies had already allowed private presence in their incumbents. The years 2000 and 2001 achieved the highest increments of newly established regulatory offices. By 2004, 40% of the sample economies had achieved liberalisation in fixed voice; 64% liberalised mobile telephony; 60% allowed private participation in the incumbent; and 50% established an NRA. On average, large economies were more progressive in liberalising their markets and establishing a regulator, whereas small economies were more progressive in allowing private ownership in the incumbent.

A preliminary indication of efficiency for small and large economies is illustrated in Exhibit 1. Exhibit 1 pertains to a series of efficiency measures that regularly appear in efficiency studies (e.g. Lien and Peng, 2001) and portray the relative relationships between various inputs and outputs. Graphs a-c represent the relative outputs, depicted by the three technologies of fixed voice, mobile telephony and Internet attributed to each employee for the two groups of economies. Large economies
exhibit higher output per employee for all three technologies; but both groups of economies follow a similar increasing trend that becomes more noticeable as of 1995.

In graphs d-f small economies appear to yield higher output per dollar invested in all three technologies. This relationship is more evident in fixed voice. For mobile telephony and Internet, the output-per-dollar gap is smaller where both groups also exhibit a comparable increasing trend. Similarly, this trend takes off as of 1995.

Exhibit 1: Efficiency measures: telecommunications outputs with respect to inputs.

Empirical findings
The estimated parameters of the distance function are presented in Table 6. The coefficients for investment \((lx1)\) and staff \((lx2)\) are statistically significant at the 1% level and have the expected signs. At least 65% of all coefficients are statistically significant, which reveals a good fit of the model to the observed data. Since the production function is estimated as an approximation to an unknown form, the first-order coefficients are the elasticities of production at the expansion point and the other coefficients are less important.
### Table 6: Stochastic Frontier Analysis output: a global frontier

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Error</th>
<th>z-statistic</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>z-statistic</th>
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<td>b0</td>
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<td>1.64</td>
<td>1.06</td>
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<tr>
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<td>0.06</td>
<td>-0.87</td>
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<tr>
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<td>&lt;0.01</td>
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<td>lib_fixed</td>
<td>-0.25</td>
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<tr>
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<td>0.08</td>
<td>5.49****</td>
<td>lib_mobile</td>
<td>0.05</td>
</tr>
<tr>
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<td>6.39****</td>
<td>privatisation</td>
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</tr>
<tr>
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<td>0.01</td>
<td>4.28****</td>
<td>nra</td>
<td>-0.32</td>
</tr>
<tr>
<td>ly3</td>
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<td>0.02</td>
<td>-6.57***</td>
<td>openness</td>
<td>-0.01</td>
</tr>
<tr>
<td>ly2</td>
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<td>0.09</td>
<td>-0.66</td>
<td>smallness_cont</td>
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</tr>
<tr>
<td>ly1</td>
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<td>0.08</td>
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<td>smallness</td>
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</tr>
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<td>smallness_cont</td>
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<td>0.01</td>
<td>-3.63***</td>
<td>Gamma</td>
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<td>lx1*lx2</td>
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<td>0.01</td>
<td>5.49****</td>
<td>Mean efficiency</td>
<td>0.88</td>
</tr>
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<td>-0.89</td>
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<td>1.33*</td>
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<td></td>
</tr>
<tr>
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<td>-0.22</td>
<td>Log likelihood</td>
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</tr>
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<td>-0.31</td>
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</tr>
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<td>0.01</td>
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<td>Cross-sections</td>
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</tr>
<tr>
<td>t*lx2</td>
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<td>0.01</td>
<td>-1.73**</td>
<td>Years</td>
<td>15</td>
</tr>
<tr>
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<td>0.01</td>
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<td>Total observations</td>
<td>1246</td>
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<td>t*ly2</td>
<td>0.01</td>
<td>0.01</td>
<td>0.92</td>
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<td></td>
</tr>
</tbody>
</table>

Notes:

*Statistically significant at the 0.1 level; **Statistically significant at the 0.05 level; ***Statistically significant at the 0.01 level

The homogeneity restriction is achieved by normalizing all the outputs by fixed voice. In the LHS there is the logarithm of fixed mainlines per 100 inhabitants. In the RHS there are mobile subscriptions per 100 inhabitants (y1) and Internet users per 100 inhabitants (y2) both first being divided by fixed mainlines per 100 inhabitants and then been transformed into logarithms.

Moreover, it is essential to evaluate whether or not the degrees of returns to scale (RTS) and technical change (TC) measures are economically reasonable by using the estimated parameters of the functions. In the context of an output distance function Färe and Primont (1995) define technical change as the first order derivative of the production function with respect to time t. Therefore,

\[
TC = -\frac{\partial \ln d_{it}^O}{\partial t} = \frac{\partial \ln y_{Mit}}{\partial t} = \zeta_0 + \zeta_{0f} + \sum_{k=1}^{K} \lambda_k \ln x_{kit} + \sum_{m=1}^{M-1} \xi_m \ln y_{mit}^* ,
\]

where coefficient estimates are taken from the estimation of equation (15) and variable values concern their yearly means. Correspondingly, Färe and Primont (1995) estimate the scale elasticities of output with respect to each input as:

\[
\varepsilon_k = \frac{\partial \ln D^O(x_{it}, y_{it})}{\partial \ln x_{sv}} = a_k + \sum_{t} \beta_{kt} \ln x_{it} + \sum_{m=1}^{M-1} \delta_{km} \ln y_{mit}^* + \lambda_{kt} t ,
\]

where

\[
\sum_{k=1}^{K} \varepsilon_k = 1
\]

gives the RTS at the mean. When equation (19) equals 1 suggests the existence of constant returns to scale (C-RTS); when it is higher it suggests increasing returns to scale (I-RTS), and when it is lower it suggests decreasing returns to scale (D-RTS).
The coefficient of time (t) variable is negative but statistically insignificant. Instead, the coefficient for t-sq variable is positive and statistically significant implying that Hicks-neutral technical change is initially regressive and subsequently becomes progressive. Technical progress appears to be captured also by non-neutral technical change illustrated by the statistical significance of the coefficients of time-interaction effects. The coefficients for \( t^*lx2 \) and \( t^*ly1 \) are negative implying that technical change decreases with staff accumulation and that development in mobile telephony decreases fixed voice efficiency. Whereas the former conclusion implies that technical progress is labour saving, the latter gives evidence of a relationship of substitution between fixed voice and mobile telephony.

The estimation of equation (17) results in a yearly average TC for small economies of 0.0175 and for large economies of 0.0178. The difference appears to be marginal. In order to examine whether the two group’s mean TC is equal a t-test is conducted. The t-test statistic cannot reject the hypothesis of equality implying that both groups experience equivalent TC over time.

Concerning RTS, the estimation of equation (19) gives a mean yearly value of 0.96 for large economies and 0.94 for small economies. The results suggest that small economies might be less capable of exploiting higher returns to scale. The t-statistic estimated to test the hypothesis that large economies on average operate at higher RTS rejects the hypothesis. Therefore on average small economies and large economies are equally capable of exploiting economies of scale.

Small economies on average are less efficient than large economies with mean efficiency 0.69 compared to 0.74\(^9\). The respective medians are 0.73 and 0.80. The t-test conducted to test equality in the mean efficiency of the two groups yields a statistic that rejects the null hypothesis. This implies that large economies are more efficient than small economies at the average. This finding is further supported by the negative and statistically significant coefficient of smallness that suggests small economies on average fall behind their larger counterparts with regard to efficiency. In parallel, the negative and statistically significant coefficient for \( smallness_{cont} \) implies that size is positively related with efficiency. Whereas these two relationships support the hypothesis that small economies have lower efficiency (H1b) the positive and statistically significant coefficient for \( smallness_{cont_{sq}} \) indicates the existence of a non-linear relationship between size and efficiency. This finding supports the hypothesis that the relationship between size and efficiency is denoted by an inverted u-shape (H1a). An emerging issue concerns where the peak of the relationship between size and efficiency falls. This will be examined by the re-estimation of the production function separately for each of the two groups of economies.

Before that, it is important to consider the effects of policies on efficiency. The results on Table 6 indicate that policies with regard to competition, privatisation, and the institution of an independent regulator increase the efficiency of the telecommunications sector. A very important finding concerns the effect of institutional endowments on the efficiency of the sector. This appears to have the largest effect on efficiency compared to other policies. With a smaller magnitude, openness of the economy is also conducive to efficiency.

An unexpected result pertains to the coefficient of liberalisation in mobile telephony. This is positive and statistically insignificant suggesting that competition in mobile does not induce efficiency. This might be additional evidence of the

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\(^9\) The \( \gamma \) coefficient is nearing the unit which suggests that the estimation error can be attributed to technical inefficiency.
relationship of substitution between fixed voice and mobile telephony. The production function’s output combines both technologies (along with Internet). Competition between the two technologies might preserve their joint output at lower levels. This would be unlikely if the two technologies were complementary to one another.

Moreover, in order to examine the joint effect of the three focal policies, the same model is estimated including trinity. The coefficient of trinity has a large value of -1.73 and is statistically significant at the 1% level. privatisation and nra lose their statistical significance whereas lib_mobile becomes statistical significant at the 10% level. These findings suggest that, the effects of the privatisation of the incumbent provider and the establishment of an NRA on efficiency are more important jointly rather than separate. Liberalisation in fixed voice appears to be conducive to efficiency regardless of the coexistence of privatisation and the establishment of the regulator. In addition, the positive effect of competition in fixed voice on efficiency outperforms the negative effect of competition in mobile.

Table 7 presents the results from the estimation of the two separate models. It is noteworthy that since the stochastic frontiers are estimated separately a direct comparison of the efficiency scores is inappropriate. Rather, all conclusions drawn will pertain to the respective group of economies. Generally, the two models fit the observed data well. The coefficients for investment (lx1) and staff (lx2) are statistically significant and have the expected signs and at least 65% of all coefficients are statistically significant.

For brevity, further analysis will only concentrate on the exogenous effects on efficiency in order to examine the focal research hypotheses. With regard to small economies, there are unexpected results concerning the effects of competition in fixed voice and mobile telephony. The null hypothesis (H2a and H2b) assumed that competition has a positive effect on the efficiency of small economies and the effect is smaller than large economies. Nevertheless, the coefficients for lib_fixed and lib_mobile are positive and the coefficient for lib_mobile is statistically significant. These results indicate that competition in fixed voice has no effect on small economies’ efficiency and that mobile telephony leads to higher inefficiency. This might suggest that the substitution relationship between the two technologies is quite strong in small economies, leading to the loss of efficiency. The substitution relationship might also explain the positive and statistically significant coefficient for lib_mobile for large economies. For large economies, competition in fixed voice appears to have a statistically significant positive effect on efficiency. Therefore, the above null hypotheses are rejected.

As regards privatisation in small economies, the coefficient for the respective variable is statistically significant and has the expected sign. This finding supports hypothesis H3a which stated that privatisation has a positive impact on efficiency in small economies. Nevertheless, the respective coefficient for large economies is substantially larger rejecting hypothesis H3b which assumed that the effect of privatisation in small economies is stronger compared to large economies.

The coefficients for nra and polconii are statistically significant and have the expected signs for both groups of economies. This gives support to hypothesis H4a which assumed that institutional endowments and regulatory authorities have a positive impact on the efficiency of small economies. Comparison of the coefficients’ sizes for the two groups unveiling a stronger effect for small economies giving support to hypothesis H4b. With respect to the effect of the openness of the economy, this is positive and statistically significant for both groups of economies.
Similar to the single model, focal policies applied in tandem appear to have stronger impact on efficiency rather than applied separately. Inclusion of trinity in the two models causes privatisation and nra to become insignificant. In addition, in the case of large economies inclusion of trinity causes lib_fixed to lose its statistical significance whereas for small economies lib_fixed becomes statistically significant and exhibits a positive effect on efficiency. It becomes pervasive in the analysis that the opening of markets to competition and private participation in the incumbent, when applied concurrently and orchestrated by an independent regulator, are more likely to induce efficiency rather than being applied separately.

Table 7: Stochastic Frontier Analysis output: Small economies VS Large economies

<table>
<thead>
<tr>
<th></th>
<th>Small economies</th>
<th></th>
<th></th>
<th>Large economies</th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>st. error</td>
<td>z-statistic</td>
<td>Coefficient</td>
<td>st. error</td>
<td>z-statistic</td>
</tr>
<tr>
<td>b0</td>
<td>0.81</td>
<td>0.62</td>
<td>1.31*</td>
<td>0.02</td>
<td>0.41</td>
<td>0.04</td>
</tr>
<tr>
<td>t</td>
<td>-0.17</td>
<td>0.13</td>
<td>-1.32*</td>
<td>0.05</td>
<td>0.08</td>
<td>0.58</td>
</tr>
<tr>
<td>t-sq</td>
<td>0.01</td>
<td>0.01</td>
<td>1.64**</td>
<td>&gt;-0.01</td>
<td>0.00</td>
<td>-0.19</td>
</tr>
<tr>
<td>lx1</td>
<td>0.39</td>
<td>0.11</td>
<td>3.42**</td>
<td>0.68</td>
<td>0.14</td>
<td>4.79***</td>
</tr>
<tr>
<td>lx2</td>
<td>1.25</td>
<td>0.27</td>
<td>4.60**</td>
<td>0.70</td>
<td>0.17</td>
<td>4.12***</td>
</tr>
<tr>
<td>ly2-sq</td>
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<td>0.01</td>
<td>-1.35*</td>
<td>0.01</td>
<td>0.01</td>
<td>0.73</td>
</tr>
<tr>
<td>ly3-sq</td>
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<td>-2.17**</td>
</tr>
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<td>0.19</td>
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<td>-1.77*</td>
<td>-0.84</td>
<td>0.16</td>
<td>-5.10***</td>
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<td>-0.43</td>
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<td>0.00</td>
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<td>0.12</td>
<td>5.97***</td>
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<td>129.83</td>
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The results from the two models provide important insights into the relationship between the size of the economy and efficiency. This information pertains to the coefficients for the two size variables smallness_cont and smallness_cont_sq. These two variables have been reconstructed in order to measure the economy’s size relative to the largest economy in the group. The coefficient for smallness_cont is negative and statistically significant for both groups of economies, implying that size is an important determinant for the achievement of efficiency. However, the positive coefficient of smallness_cont_sq in both models indicates that size does not have a continuous linear relationship with efficiency. Rather, the relationship reaches a peak and subsequently becomes negative. Most importantly, a respective peak exists for both models implying that both small and large economies can operate at a size that is conducive to efficiency. It also implies that size is not always conducive to efficiency. Most likely economies exceeding their respective peaks will have to deploy appropriate policy measures to counteract disadvantages accruing from largeness.

Discussion – Concluding Remarks
This paper examines critical concerns raised by the literature on small economies with regard to the relationship between the economy’s size and performance. It accumulates important existing studies to demonstrate that hitherto empirical evidence of the kind of the relationship has been vague. The paper suggests the examination of pertinent questions with respect to the above relationship. It also takes existing knowledge a step further by proposing the examination of the effects of policy on the economy performance. In order to obtain comparative economic measures of the performance of economies and facilitate the simultaneous examination of policy on performance it proposes an analysis of efficiency of the sector of telecommunications. Analysis is conducted using SFA to analyse multitudinal data on 139 small and large economies between 1990 and 2004.

The research findings allow us to gain invaluable insights into the relationship between size and efficiency. The economy size appears to have a positive relationship with efficiency but this relationship does not seem to place small economies in a disadvantaged position. The relationship reaches a peak and becomes negative thereafter. As this kind of relationship is found to exist in both small and large economies it corroborates the paper’s hypothesis that both small and large economies can reach levels of size that are conducive to efficiency.

On average, small economies operate at lower levels of efficiency than large economies; yet, this differential is not substantial. Small economies have comparable capacity of exploiting economies of scale with large economies. Actually, both groups appear to operate very close to constant returns to scale and exhibit an analogous degree of annual technical change.

Accounting for the effect of size, both small and large economies appear to benefit from the overall application of similar policy in the sector. With the exception regarding the liberalisation of the markets of fixed voice and mobile telephony both groups of economies exhibit similar relationships between policy and efficiency.
Namely, fixed voice telephony for small economies does not have an effect on efficiency in comparison with their larger counterparts for which competition in fixed voice has a positive effect on efficiency. Concerning mobile telephony, efficiency is negatively affected by competition in the market for both groups of economies.

These relationships might be explained by the existence of a relationship of substitution between the two technologies of fixed and mobile telephony. Competition between the two technologies might preserve their joint output at lower levels. This would be unlikely if the two technologies were complementary to one another. This negative effect on efficiency is envisaged that it will not last in the long-run, conditional on the expectation that mobile telephony will prevail over the fixed voice.

Moreover, private participation in the incumbent provider has a positive effect on sector efficiency for both groups of economies. However, the effect for small economies is weaker. With regard to the establishment of an independent regulatory authority in the sector, both groups of economies appear to benefit with increases in efficiency. In this case, the effect is stronger for small economies. An important finding concerns the joint effect of focal policies on sector efficiency. Accounting for their joint effect (Trinity) leads to the conclusion that when policies are applied concurrently and being orchestrated by an independent regulator, they are more likely to induce efficiency rather than being applied separately. To an extent, Trinity might be capable of altering the negative effect that individual policies might have on sector efficiency as in the case of fixed voice competition in small economies.

Throughout the analysis the important effect of institutional endowments has been pervasive. Regardless of the estimation of different models, the coefficient of the variable denoting institutional endowments has maintained its statistical significance and magnitude. In fact, institutional endowments account for the largest impact on the efficiency of the sector amongst all policies. Its impact appears to be substantially larger for small economies rather than large economies.

Existing studies on the effects of size have illustrated the important role of openness of the economy on its growth. This paper’s results give support to existing evidence. The variable used in the various models to capture the degree of openness of the economy has been consistently positively related to efficiency.

The broader conclusions drawn from this paper can be advanced to the overall economy level. On the basis of the unprecedented role that telecommunications have in the development of the economy it can be postulated that the paper sheds some light on policy issues concerning the general economy. This implies that small economies can equally benefit from the adoption of policy established and applied in large economies. Along with their continuous pursuance of global integration aiming to facilitate growth, small economies can achieve the optimum size that will be conducive to efficient operation. Respectively, for large economies, large size is not a sufficient condition for efficient operation. The development of appropriate policy and institutional endowments are equally necessary.

There are two important streams for further research that develop from this paper. The first concerns the comparative analysis of the performance (efficiency) of sectors with similar importance for the economy to telecommunications, in the context of both small and large economies. This will allow the comparison and likely corroboration of research findings for this study. Empirical analysis of a broader spectrum of sectors will culminate in the drawing of concrete conclusions about the impact of size on the performance of the overall economy. The second route concerns the emerging issue of “largeness” of the economy. It appears that not only smallness might lead to inefficient operation but excessive size might have respective
repercussions. It is therefore of paramount importance that respective research is pursued.


Appendix I: A snapshot of small and large economies

<table>
<thead>
<tr>
<th>Ten Largest Large Economies</th>
<th>Population ('000)</th>
<th>Arable Area (km²)</th>
<th>GDP (billion $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>295409.6</td>
<td>1760180</td>
<td>8785.22</td>
</tr>
<tr>
<td>China</td>
<td>1294845.5</td>
<td>1426210</td>
<td>1418.9</td>
</tr>
<tr>
<td>India</td>
<td>1065702.4</td>
<td>1617150</td>
<td>698.50</td>
</tr>
<tr>
<td>Russia</td>
<td>143807.8</td>
<td>1234650</td>
<td>485.03</td>
</tr>
<tr>
<td>Brazil</td>
<td>184545.8</td>
<td>589800</td>
<td>611.74</td>
</tr>
<tr>
<td>Japan</td>
<td>127923.5</td>
<td>44180</td>
<td>3630.13</td>
</tr>
<tr>
<td>Canada</td>
<td>31957.8</td>
<td>457440</td>
<td>856.62</td>
</tr>
<tr>
<td>Germany</td>
<td>82645.3</td>
<td>117910</td>
<td>2163.73</td>
</tr>
<tr>
<td>Australia</td>
<td>19942.4</td>
<td>483000</td>
<td>496.67</td>
</tr>
<tr>
<td>France</td>
<td>60256.8</td>
<td>184490</td>
<td>1605.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ten Largest Small Economies</th>
<th>Population ('000)</th>
<th>Arable Area (km²)</th>
<th>GDP (billion $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central African Rep.</td>
<td>3729.7</td>
<td>19300</td>
<td>1.43</td>
</tr>
<tr>
<td>Singapore</td>
<td>4666.2</td>
<td>10</td>
<td>86.16</td>
</tr>
<tr>
<td>Latvia</td>
<td>2337</td>
<td>18320</td>
<td>7.55</td>
</tr>
<tr>
<td>Rwanda</td>
<td>7921.2</td>
<td>11160</td>
<td>3.22</td>
</tr>
<tr>
<td>Guinea</td>
<td>9229.8</td>
<td>9000</td>
<td>4.68</td>
</tr>
<tr>
<td>Somalia</td>
<td>8292.1</td>
<td>10450</td>
<td>0.84</td>
</tr>
<tr>
<td>Honduras</td>
<td>6820.1</td>
<td>10680</td>
<td>4.79</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>4949.3</td>
<td>13450</td>
<td>2.06</td>
</tr>
<tr>
<td>Uruguay</td>
<td>3437.4</td>
<td>13000</td>
<td>11.19</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>6939.7</td>
<td>9300</td>
<td>1.63</td>
</tr>
</tbody>
</table>

Source: Data were obtained from the United Nations’ Human Development Report of 2005

Index value = \((100/3)*(P/P_{\text{max}} + A/A_{\text{max}} + Y/Y_{\text{max}})\),
P, A, and Y are population, arable area, and GDP of each country, respectively;
P_{\text{max}}, A_{\text{max}} and Y_{\text{max}} represent the highest values of population, arable area, and GDP, respectively.