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Income distribution and the diffusion of networks: An empirical study of Brazilian telecommunications

Helena Bohman *

Department of Economics, Jönköping International Business School, P.O. Box 1026, Jönköping SE-551 11, Sweden

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ABSTRACT

Telecommunications is often considered to be an important contributor to economic growth, and most countries have therefore adopted several initiatives to improve coverage of fixed as well as mobile telephones. This paper focuses on the role of income distribution on the diffusion of fixed telecommunications in Brazil. The focus is on how the distribution of income may affect affordability and thereby the market size. The result is that an uneven income distribution may result in higher coverage for the poorest municipalities in the study since the uneven distribution allows for at least some consumers to reach the critical level of income. For municipalities above a certain average income level, the effect is reversed and coverage will be adversely affected by high inequality. The findings are robust to different measures of inequality.

1. Introduction

Although significant progress has been made on the coverage of telecommunications networks and services at the global level, many countries still face challenges concerning how to achieve universal access in different regions. Addressing these issues requires policy makers to understand network dynamics and agents' decisions. Several studies, theoretical as well as empirical, indicate a link between income distribution and the diffusion of telecommunications, but the causality has seemed unclear. Some of these studies (Estache, Manacorda, & Valletti, 2002; Milne, 2000; Navas-Sabater, Dymond, & Juntunen, 2002) claim that income inequality makes it more difficult to diffuse a network. Others like Calderón and Servén (2004) contend conversely that extending telecommunication networks leads to decreased income inequality. For most of these studies, the issue of income inequality is subordinated to other topics and, consequently, the causal link between income distribution and diffusion of telecommunication is not addressed in depth.

So far, there seems to have been little systematic analysis of how income distribution affects diffusion of telecommunications. Two broad arguments can be used to explain this mechanism. The first one refers to institutions and states basically that with high levels of inequality, there may be little incentive for the ruling elite to engage in public investments such as infrastructure, as discussed in e.g. Engerman and Sokoloff (2002). Although today most investments are made by private investors, the foundations of the networks were made in the setting of a public monopoly, and it seems plausible that the effects of this can still be observed. In addition to this, even today complementary investments for low-yield projects are made through the initiative of government authorities in different universal access programs. Public investment may therefore still be significant. The second argument is market-oriented and states that different structures of income distribution will result in differences in market size and hence different diffusion patterns.

* Tel.: +46 36 101742; fax: +46 36 121832.
E-mail address: helena.bohman@jibs.hj.se

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This paper is based on the second argument and its purpose is to analyze the role of income distribution in the process of telecommunication coverage from an affordability approach. The focus is on fixed telecommunications in Brazil between 1991 and 2000, followed up by a discussion of mobile telecommunications in 2005. The data used is from household surveys (UNDP, 2000). Brazil provides an interesting case since, in addition to having one of the most unequal distributions of income in the world, the size of the economy and large regional differences offer plenty of information for empirical analysis.

This paper contributes to the existing literature in three ways. First, it provides a theoretical setting clarifying why income distribution can be expected to affect the diffusion of technology. Secondly, it shows how this link can be connected to traditional ways of measuring distribution and can therefore be incorporated easily into economic analysis. Thirdly, it provides robust empirical findings that support the theory, using the case of Brazilian diffusion of fixed telecommunications as a reference point. Some previous studies exist focusing on the affordability aspect. Artle and Averous (1973) use affordability to derive a logistic diffusion curve. Milne (2000) uses an affordability approach and demonstrates a non-linear relation between telecommunications and income distribution. Through simulations she predicts that high inequality has a positive effect on network size at incomes below a certain average income level, whereas above that level, an unequal distribution becomes detrimental for the diffusion process. In this paper, the affordability approach is applied to Brazilian data and the results are well in line with Milne (2000).

The structure of the paper is as follows: Section 2 contains a theoretical discussion of why income inequality can be expected to affect diffusion of telecommunications. This is followed by a consideration of some previous research on this topic. Section 3 provides some background information on the Brazilian economic environment and introduces the telecommunications sector and income distribution in Brazil. In Section 4, the empirical part is introduced by discussing data and calculations of variables. Section 5 presents the results from the empirical study, followed by conclusions in Section 6.

2. The telecommunication market

This section focuses primarily on why the distribution of income may be expected to affect the diffusion of networks. Why should the distribution of income be expected to drive diffusion rather than the other way around? Initially, the section will discuss affordability and then move on to some characteristics of the telecommunications market and a discussion on causality. In empirical studies, there are often remarks on the role of income distribution in telecommunications network diffusion, although most of them do not proceed with the discussion much further. One example is a study on internet diffusion by Estache et al. (2002) in which they find a substantial negative link between income inequality (measured by the Gini coefficient) and internet diffusion, and conclude that a 10 percent fall in the Gini coefficient leads to a doubling of internet diffusion. Other studies, such as Navas-Sabater et al. (2002) refer to income distribution by stating that higher inequality should imply more challenges in the diffusion process. Milne (2000) is one of the few studies that focuses the attention to the mechanisms involved.

2.1. A theoretical model of income distribution and diffusion of networks

Telecommunications are characterized by demand side economies of scale, sometimes referred to as network externalities. The network character of telecommunications leads to an inverted U-shaped demand curve and as an effect of this, networks may exhibit multiple equilibria (for more discussion on this, see Shy, 2001). Before there are any adopters, the network has no value, and for this reason new technology may never become diffused. When more and more subscribers join the network, the value of being connected to the network starts to increase and so does demand. After reaching a certain point, normal demand characteristics apply, and the curve slopes downward. That is, once the network has matured, the marginal utility of a new subscriber starts to decrease. For the telecommunications sector, the critical mass at the global level has already been reached, but at a local level the challenge may still exist.

The notion that a successful diffusion of a technology follows an S-shape pattern has become a common feature in the technology diffusion literature (Geroski, 2000; Griliches, 1957). Artle and Averous (1973) were among the first to develop a model of this dynamics in a setting of static population with static income. The model used here is an application of their model and for the sake of simplicity the same denotations will be used.

The number of subscribers to the network is denoted by x, so it can be assumed that over a time period t there are $\mathrm{d}x/\mathrm{d}t = \dot{x}$ new subscribers. At time t the network can then be expressed as

$$x(t) = \int_0^{\mathrm{T}} \dot{x}(s)\,\mathrm{d}s \tag{1}$$

Furthermore, let h be the size of the total population and p_z be the subscription price of fixed telephones. The level of an individual's income is denoted y and $\psi(y)$ is the income distribution expressing the share of the population with an income below y (i.e. the cumulative distribution function or CDF).

For developing the model, it is assumed that the income distribution $\psi(y)$, income levels y, population h and prices p_z are constant over time. Furthermore, subscribers enter the network in order of income so that

$$x(t) = h\{1 - \psi[z(t)]\} \tag{2}$$