Energy Research & Social Science 21 (2016) 84–100

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

Calling for change? Innovation, diffusion, and the energy impacts of global mobile telephony

Nuno Bento [a,b,c,*]

[a] Instituto Universitário de Lisboa (ISCTE-IUL), DINÂMIA'CET, Av. das Forças Armadas, Edifício ISCTE, Sala 2N19, 1649-026 Lisboa, Portugal
[b] Energy Technology Innovation Policy research group, Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, Mailbox 117, 79 JFK Street, Cambridge, MA 02138, United States
[c] Transitions to New Technologies Program, International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburg, Austria

ARTICLE INFO

Article history:
Received 15 February 2016
Received in revised form 10 June 2016
Accepted 15 June 2016

Keywords:
Historical descriptive
Diffusion
Energy technologies
Mobile phones

ABSTRACT

Few technologies in history diffused as intensively and fast as mobile phones, to the point where they have become the most democratic technology. The article analyzes historical patterns of mobile phone growth and their effects in energy needs. Through an empirical analysis employing diffusion models on data for 227 countries between 1980 and 2010, it is concluded that global demand may saturate at around one subscription per person and the diffusion of mobile-broadband connection has contributed to sustain growth. Demand has already showed signs of saturation in developed countries, while there is still potential for growth in developing countries. Impacts on energy consumption are assessed with the help of a field trial. Even though the energy consumed in phone charging was not very significant (6–8 TWh) in 2010, it becomes substantially higher when infrastructural needs are included (93 TWh). The actual trends suggest that mobile communication might have a sizeable direct effect on energy consumption—although the net impact on energy demand is more difficult to estimate. This can become an issue in developing countries, where the adoption of mobile phones is catching-up rapidly with the world average, in a context of generalized increasing electricity demand.

1. Introduction

The success of mobile communication over the past thirty years has had important consequences in people's daily lives at the global scale. This is an example of a relatively fast diffusion process in – end-use – energy technologies [1]. The number of mobile phone subscriptions worldwide was estimated at 6.9 billion in 2013 [2]—the number of unique mobile users is more difficult to estimate, since one user may own multiple subscriptions [3] and one subscription can be shared by several individuals (e.g. in Africa); even so market surveys have reported figures well above 4 billion people [4]. The growth of cellular networks was so spectacular that it out-paced the dissemination of electricity to the point that millions must travel significant distances and pay an astronomical premium to charge their handsets in energy kiosks [5].[1] Changes in social practices in charging and managing the power have been identified even in developed countries [6]. This situation draws attention to the power needs of the apparently low energy consumption handsets, but whose use is rapidly growing namely in developing countries.

This study examines three decades of diffusion of cellular phones from the early networks in Scandinavia to the present, with particular regard for the dynamics of growth and its implications in terms of energy demand. Existing studies of mobile phones growth apply standard epidemic models (e.g. [7–15] often used in the empirical literature of technology diffusion.[2] This paper particularly uses the logistic model which has been shown to generate the most accurate forecasts for mobile telephony growth [16]. This

* Corresponding author at: Instituto Universitário de Lisboa (ISCTE-IUL), DINÂMIA'CET, Av. das Forças Armadas, Edifício ISCTE, Sala 2N19, 1649-026 Lisboa, Portugal.
E-mail address: Nuno.Bento@iscte.pt

http://dx.doi.org/10.1016/j.erss.2016.06.016
2214-6296/

[1] It has been reported that in cites kiosks in Papua New Guinea customers pay for each bar of charge shown on the phone's display at a cost equivalent to $200 per kWh [68].

[2] The following works have played an important role in the definition of epidemic models: Griliches [69], Bain [70], and Bass [71]. For a review of diffusion models see Geroski [72] and Stoneman [73].

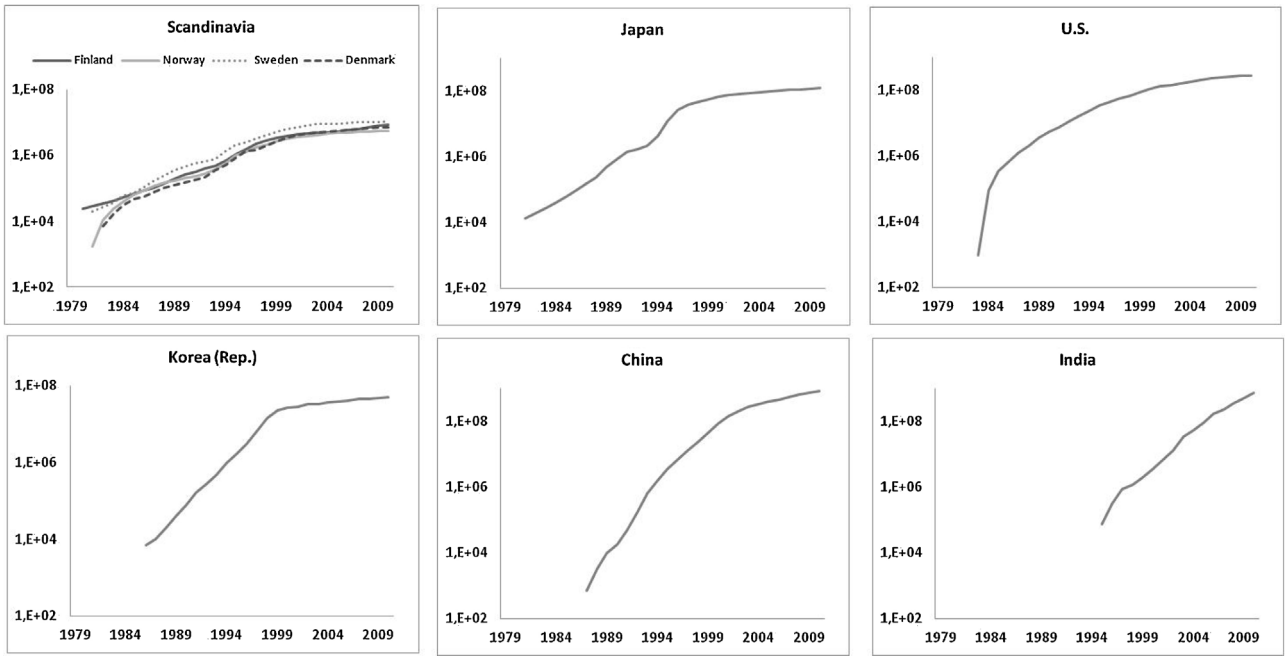

Fig. 1. The evolution of mobile phone subscriptions in selected regions (semi-log axis). Data source: ITU World Telecommunication [25,60].

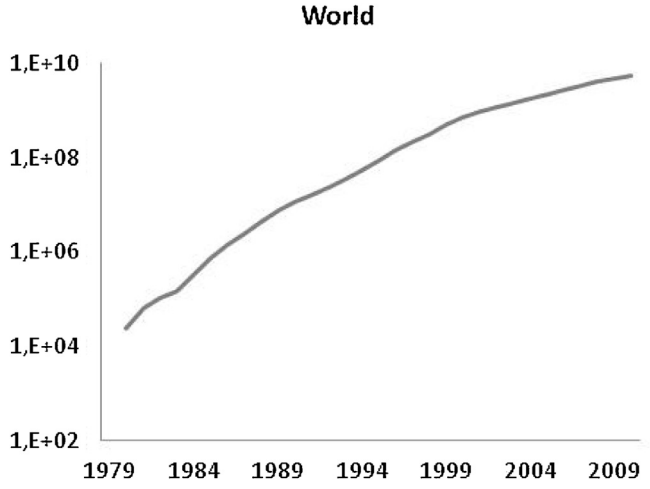

Fig. 2. The evolution of mobile phone subscriptions globally (semi-log axis). Data source: ITU World Telecommunication [25,60].

work advances over the previous investigations both in scope and approach of the analysis.

First, the use of data on the number of users in more than 200 countries between 1980 and 2010 provides a more complete picture of the diffusion of cellphones. Second, the estimation of the energy needs of the handsets reveals additional information about the repercussions of telecommunication in other sectors. This extends earlier attempts to estimate the energy consumption of mobile phone use [17,18], including in life-cycle assessments [19–21], almost always performed at a country level. Finally, the systemic analysis of market and power consumption trends provides valuable insights about the impact of mobile communication on energy consumption and, thus, on sustainability.

This analysis deals with important questions in the crossroads of energy research and social sciences [22]. The object of study has an egalitarian (including gender) and empowering character which is improving the standard of living in poor areas of the world. In addition, the analysis is historical and systemic that draws on disciplines such as science and technology studies, electrical engineering, marketing science and economics, responding to the calls for the use of a more interdisciplinary approach to enrich the explanatory power of social science researches. Finally, the examination of the factors of fast diffusion of small scale, more "granular", energy technologies like cellphones raise important questions about the relationship between technology scale and speed of diffusion that are particularly important for the definition of technology policy.

Therefore, this research addresses the following questions: What is the trend in the production and use of mobile phones? What are the energy needs of mobile telecommunication, namely in relation to other technologies? More than a straight forward application of extrapolation using logistic curves, this research analyzes diffusion patterns at both global and regional scales, as well as the likely impacts on the energy system.

The paper is structured as follows. Firstly, the extent of the mobile phone diffusion is analyzed together with the determinants of growth found in the literature. Secondly, the methodological issues and data sources are explained. Thirdly, the results of the analysis of the growth of mobile phones, as well as their energy needs, are presented. Finally, the main conclusions are discussed in terms of the characteristics of diffusion and the direct effects in energy consumption, drawing some implications for policy namely in rapidly growing markets in developing countries.

2. Historical growth and extent

Cellular phones constitute the largest electronic market, having undergone an explosive diffusion over the past two decades, with annual sales stabilizing around 1.7 billion devices in 2010–2012 [23].[3] In 2012 there were over 400 million shipments per quarter, almost as much as the number of devices sold seven years before [24].

[3] For a complete overview of global statistics on mobile phones, see: http://mobiforge.com/research-analysis/global-mobile-statistics-2014-home-all-latest-stats-mobile-web-apps-marketing-advertising-subscriber (last accessed in May 30, 2015).