Available online at www.sciencedirect.com
ScienceDirect
Research Policy 36 (2007) 591–604
research policy
www.elsevier.com/locate/respol

The short-run price-performance dynamics of microcomputer technologies

J. Christopher Westland [a,*], Eric Wing Kuen See-To [b,1]

[a] *Department of ISMT, University of Science & Technology, Hong Kong, Clearwater Bay, Kowloon, Hong Kong*
[b] *Department of Management Science, Lancaster University Management School, Lancaster, United Kingdom*

Received 27 May 2006; received in revised form 2 September 2006; accepted 20 September 2006
Available online 20 April 2007

Abstract

Models of technology growth are often conceived in terms of long-run trends in performance and price because, in general, short-run parameter stability and even the form of the growth function have proved elusive. Yet short-run growth models are arguably more useful for managers and research scientists, because the majority of their decisions are concerned with discretionary spending and operations rather than longer run strategic plans and investments. Our research explores short-run growth in microcomputer technologies by specifying growth models and parameter estimates for six commercially important computer technologies over short time periods with weekly data. Observations were acquired in a homogeneous market, limited to a collection time frame of less than two years. Data was collected at granular, weekly intervals, with concurrent tests to determine whether parameters were stable over successively longer intervals; conversely candidate growth models from longer 'strategic' planning horizons were tested to determine whether they scaled down to operational planning horizons. We found that an exponential model of performance-to-price growth is supported over short time horizons in all but one microcomputer technology (nonvolatile RAM). The exponential model and technology specific parameter estimates that are valid over short horizons were found to accurately scale up to longer planning horizons. We expect our results to contribute to more accurate price-performance forecasting at the corporate and product level; better decision making concerning inventory management, capacity utilization, lead and lag times in supply-chain operations, and efficiency of logistics.

Keywords: Exponential performance growth; Technology economics; Supply-chain operations; Moore's Law; Logistics

1. Planning horizons

Our research investigates a growing problem for corporate management—the forecasting of future price-performance of a given technology. This paper investigates microcomputer technologies, which can be considered to represent both a class of services and goods produced by an expanding industry segment, as well as an increasingly complex and expensive input factor to production of many products and services. The problem is likely to grow in significance in the future as computers evolve from end-products to ubiquitous components in a variety of consumer products, as Paul David (1990) has suggested is now happening in his widely read comparison of technology evolution in "The Dynamo and the Computer." Price-performance forecasting has grown in importance for three reasons: (1) the ratio of performance-to-price appears to be increasing at an

* Corresponding author. Tel.: +852 2358 7643; fax: +852 2358 2421.
E-mail addresses: westland@ust.hk (J.C. Westland), e.see-to@lancaster.ac.uk (E.W.K. See-To).
[1] Tel.: +44 1524 593868; fax: +44 1524 844885.

0048-7333/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.respol.2006.09.030

accelerating pace; (2) 'performance' is growing qualitatively more rich and complex (particularly in networked products), leading to; (3) difficulty in identifying hidden costs and value in technology, and thus difficulty in fully pricing out performance.

Short-run price/performance plays a role in a wide range of managerial decisions. This is especially true with logistic and supply-chain decisions that comprise the vast majority of ongoing decisions made by the firm. The rate at which prices decrease for a given quality-adjusted amount of a resource will tend to influence lead times and safety stock. Most managerial decisions are the mundane sort that primarily influence events over a short to medium time horizon, ranging from a few hours to a few months. Such decisions are 'operational' involving day-to-day operations of the business; or 'tactical' meaning they typically fall within a single discretionary budgeting cycle of 12–24 months. Firms may also engage in longer run 'strategic' decision making such as planning for changes in production capacity and market structure. If frequency of decision making were the only criterion, then operational decisions would dominate management's agenda.

Rapid growth in the performance of information technology has significantly influenced operational decision making (Westland, 2002, 2003). For example, Dell Computer completely depreciates finished computer inventories over a short three month interval (Hesseldahl and Holahan, 2006) and requires its suppliers to retain ownership of parts inventory until a few hours prior to assembly. In this way, Dell has reengineered its supply-chain to accommodate the rapid quality-adjusted drops in price (claimed to be 1% per week) for a particular information technology performance level; similar supply-chain innovations appear in other computer firms. Such methods need not be predicated on accurate forecasts for IT performance-to-price (which typically are not available), but if such forecasts *were* available, they could be expected to allow the design of even more efficient systems for logistics and day-to-day operations. In support for that goal, this paper explores the empirical evidence for specific functional forms, and empirically supported parameter estimates for these functional forms for the ratio of performance-to-price over short time horizons.

The research is presented in the following order. Section 2 covers the literature that motivates and directs this research. Section 3 details data collection, preparation and selection of subsets of records to bring the number of variables to a manageable range, of longitudinal empirical data on performance and price of several personal computer technologies. Section 4 tests the validity of the exponential model specification of performance-price growth when compared to related power and logarithmic formulations; it conducts the empirical investigation of a set of competing models of technology performance growth over time to assess the comparative accuracy of exponential growth curve models in fitting observations of performance-price over time in the marketplace. Section 5 investigates the scalability of the exponential model of technology growth into longer time horizons. Section 6 reconciles the approach used in this research, and that invoked in the hedonic methods literature, showing how the research context of this paper provides a model with greater parameter stability than traditional hedonic methods in the assessment of information technology data. Finally, Section 7 discusses the implications of our research for selected categories of managerial decisions, as well as suggesting possible directions for future research.

2. Literature

A primary source of supply-chain risk is poor forecasting, which can result in substandard purchases, overpayment for resources, delays, and other results of miscalculating market dynamics. Such problems underlie the 'bullwhip effect' identified by Jay Forrester (1961) and are central to the dynamics of the popular "Beer Game" classroom role-playing simulation developed at MIT in the 1960s. Sitkin and Pablo (1992) defined risk as 'the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized.' Similarly, MacCrimmon and Wehrung (1986) identified three components of risk: the magnitude of loss, the chance of loss and the potential exposure to loss. The variation in how these 'losses' may be perceived is why particular risks are ultimately taken on (March and Shapira, 1987). Technically, risk may be defined as the probability of incurring a loss (Knight, 1921), where risky decisions in business are taken on the basis of generating a potential gain (Blume, 1971), while recognizing that this may not be certain (i.e. few if any business or investment decisions would be undertaken solely to avoid losses).

We focus on a particular sort of supply-chain risk in this paper: the risk that the growth in performance of a particular technology will be mis-forecasted, and ultimately result in loss. Christopher (1998) describes a supply-chain as a network of organizations that are involved, through upstream (i.e. supply sources) and downstream (i.e. distribution channels) linkages, in the