



Queen's Economics Department Working Paper No. 1280

New Product Introduction and Market Evolution

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11-2011

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Abstract

We solve for an S-shaped schedule for market size for a new product that undergoes gradual widespread adoption. We hypothesize that the speed of market expansion is positively related to the current profit per unit being produced. In a mature market the unit profit is relatively low.

- key words: product cycle, successful innovation
- highlights: derivation of a product cycle, profit rate and S shape, early buyers required
- JEL Classification: O310; L190; M390

1 Introduction

We combine simple models of product development (average cost reduction) and new product "diffusion" (motion down a market demand schedule) to generate an S-shaped schedule for the evolution of the market over time. Demanders get added to the market as price declines and the expansion in market size feeds back to product development via scale economies, broadly defined. The speed of market expansion is a function of current profitability per unit produced. We view motion down the market demand curve as an imitation cascade with early buyers, having above average incomes, satisfying a taste for novelty in consumption¹ and exhibiting few concerns about product price. Subse-

¹The taste of an agent for novelty and variety in consumption has been reflected on by many including Adam Smith. Bianchi has written much on this topic. See for example Bianchi (2002).

quent buyers have the same latent desire for novelty in consumption but are more tentative as early buyers because they have less discretionary income. Risk averseness is abated when follower-buyers see early buyers using the new product successfully. Emulation of early buyers by later buyers generally plays a central role in buyer uptake.² New products represent by definition a leap into the unknown by early buyers. The product may not deliver the services that were expected of it or it may be tricky to use. Point-and-click was of course a game-changing innovation in desk-top and lap-top computers.³ Given that early adopters have higher than average incomes, they are probably less concerned about the prospect of the new product being less than perfect. Higher income consumers can deal more easily with expenditures on products that fail to meet their expectations; the marginal dollar is easier to part with when one's income is relatively high. Risk-tolerance and taste for variety are most plausibly positively related. Higher income buyers tend to be the ones who provide a revenue platform, early in the life of a product, for

²"Research suggests that there is only a small percentage of buyers in consumer markets, about 2.5 that really like to be the first to try new products. They tend to be better educated and, in a sense, are always ready to risk buying an innovative product. Not surprisingly, they're called the 'Innovators'. There is another, much bigger, group who also like to adopt innovative products, but only after seeing them being used and enjoyed by the innovators. This second and larger group of buyers is called the 'Early Adopters'. These opinion leaders represent about 13.5 percent of all the eventual buyers and because they tend to be very sociable, they influence other people. After the first two groups have risked buying the new product, the bulk of the market opens up. This is the majority of buyers. There are two groups within this majority: 'Early Majority' and the sceptics, the 'Late Majority'. Of equal size, their total represents about 68 percent of all the buyers in a particular market. There is one last group of buyers who appear to resist new products. In a sense they lag behind all the other buyers who have now started buying the new product. These 'Laggards' represent a significant number of buyers, about 16 percent." MMC Learning at <http://www.multimediamarketing.com/mkc/newproductdevelopment/>.

³Everett M. Rogers (1962) monograph on market expansion for new products cites price as well as the product's perceived advantage or benefit, the riskiness associated with the product and ease of use as some key factors influencing uptake by consumers of a new product.

the seller of a new product.

New products are often relatively expensive because the introducer has not got all the bugs out of the product as well as out of the production process for the product in question. Lower unit costs generally come when batches of production are increased. The customer base must expand so that the larger batches of production can be disposed of without a loss to the producer. Scale economies in production can be exploited when there is some assurance of a good size for the market. A new product's market matures when the unit price declines, sales increase and buyers come from the the middle and lower income strata. Profit per unit declines to a stable, "low" value and entry of competitors becomes rare.

Our view is that the first "edition" of a new product is quite different in detail from the later incarnation of the product. This was certainly true for portable computers. There is much learning by doing by the early suppliers of a new product and these early suppliers need a market in which to test the reactions of adopters. They also need production runs of a reasonable size in order to test production methods. Scale economies is a term which in part captures the processes of both product refinement and improvement in production methods.

We view product development as involving the early producer moving down a steep part of an average cost curve early while market expansion (product "diffusion") can be associated with price moving down a demand curve, the motion here involving primarily more buyers at lower average incomes as price moves lower.⁴ On the production side, lower unit costs can emerge from increased effort on product and production development by the innovating firm and/or from the competition of new

⁴The generalized Bass model (Bass, Krishnan and Jain (1994)) model of the expansion of a market for a new product incorporates price effects. The production side of the development of a market for a new product (scale economies) is not included in models of the Bass type.

producers anxious for a portion of the market which they see emerging. Generally, there is a shake-out stage⁵ in which the producer who has refined the product and the process of production most successfully, ends up as the dominant seller in the mature market.⁶ We combine product "diffusion" (motion down a linear market demand curve) and product development (motion down an average cost of production curve (based on a linear total cost schedule)) to obtain an S-shaped curve capturing market expansion for a new product. We model the speed of market development as a function of current profit per unit being produced. Our simple differential equation for market expansion has a closed form solution for the market history schedule. We observe a classic S-shaped product cycle schedule.

2 The Analysis

We argue for more rapid market development (motion down an average cost schedule and down a market demand schedule) when unit profits are higher. We postulate:

$$\frac{dQ}{dt} = m \cdot \pi(Q)$$

for $\pi(Q) = p(Q) - a(Q)$, for $p(Q)$ current price, given quantity Q in the market and $a(Q)$ for current average cost of production. m is a constant relating the pace of expansion of the market to current profit level. Given each of our two schedules always declining for larger quantities, we have the market size expanding when $\pi(Q) > 0$ and the market reaching maturity when $\pi(Q) = 0$. Our interest is the product cycle (quantity against time) that emerges with $p(Q) \equiv A - BQ$, A and B positive, and $a(Q) \equiv \frac{\alpha}{Q} + M$, α and M positive. α is fixed costs of production and

⁵Some historians argue that Thomas Alva Edison failed to maintain interest in developing production processes and markets for his products after he and his group achieved successful invention. Edison invented and others did market development.

⁶Bertarelli and Censolo (2006) derive a product cycle for a new product using the Dixit-Stiglitz model of monopolistic competition. Their analysis ends with interesting simulations.

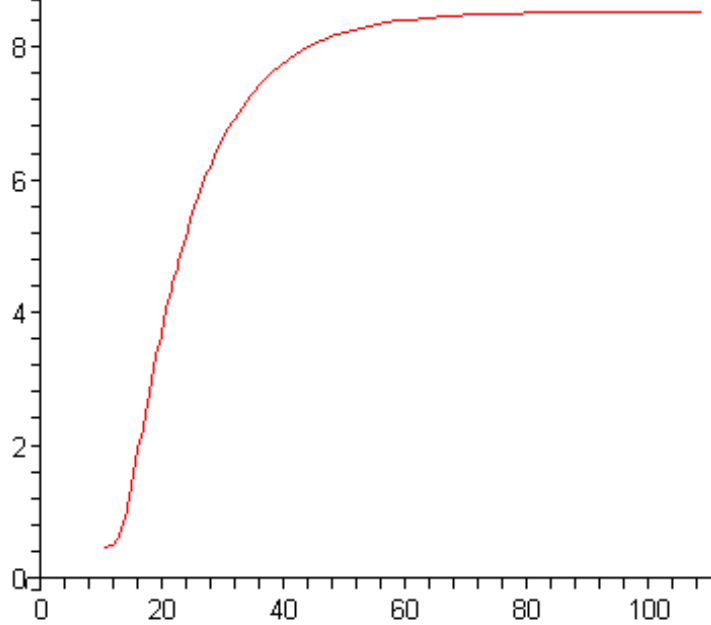


Figure 1: Time is on the x-axis and quantity on the y-axis

M is marginal cost. Observe that $\frac{dQ}{dt}$ is zero at $Q_0 = \frac{Z}{2} - \frac{(Z^2 - 4\alpha B)^{1/2}}{2}$, gets larger and then shrinks as Q approaches $Q_T = \frac{Z}{2} + \frac{(Z^2 - 4\alpha B)^{1/2}}{2}$, for $Z = A - M$. Such behavior corresponds with an *S-shaped* growth curve for $Q(t)$. We proceed to solve $\frac{dQ}{dt} = m \cdot [Z - BQ - \frac{\alpha}{Q}]$, and we obtain⁷

$$t = C1 - \left\{ \frac{\ln(ZQ - BQ^2 - \alpha)}{2mB} - \left[\frac{Z \times \arctan((Z - 2BQ)/(4\alpha B - Z^2)^{1/2})}{(mB \times (4\alpha B - Z^2)^{1/2})} \right] \right\}.$$

The plot for $A = 10$, $B = 1$, $M = 1$, $\alpha = 4$, $m = 0.1$ and $C1 = 35.74402$ is the *S-shaped* schedule in Figure 1. $Q_0 = 0.468871126$ and $Q_T = 8.531128874$.

A larger value of parameter α can lead to the point of inflection in Figure 1 closer to the centered value for Q . The shape of our curve of market evolution clearly turns on the average cost schedule being more convex than the corresponding inverse demand schedule. In addition we

⁷We employed MAPLE software for solving.

need our two points of intersection. Our dynamics will generate an S-shaped product cycle schedule quite generally. Our choice of functional forms leads to our particular closed form solution.

Product Q should be thought of as a non-durable commodity that gets bought say once a period (month perhaps) rather than a durable commodity that gets bought once every few years. In this latter case, one expects the mature market to be one for replacement of the durable good such as a Prius automobile rather than one for regular replenishment (e.g. Post-it notes). With durable goods we can envisage a market peak at which time most consumers have made their first acquisition and then a slackening in demand when the market becomes one with most purchases simply for replacement. Hence the S-shape for market evolution is most appropriate for non-durable new commodities.⁸

We have implied that the introduction of a new product results inevitably in the development of a market that ultimately "supports" regular, large-scale sales. However, many new products get introduced and fail to become large-scale sellers (brand-name products). Successful new products are more plausibly the exception rather than the rule. Few patents granted, for example, end up in products that have large markets.

3 Comment

Some economic historians are wedded to the idea that an unfolding of demand, conceived of quite generally, led to the development of modern industrial economies.⁹ Modernity becomes the development of new demands and the catering to new demands with new products. Some

⁸The estimation of product cycle schedules in Bass, Krishnan and Jain (1994) was done for durable goods: room air conditioners and color TVs. Each schedule exhibited a decline from a peak as the market matured. This conforms to the notion of a mature market being for replacement durable units. The first phase corresponds to uptake by first-time adopters and the mature phase involves buyers replacing their worn-out units.

⁹See for example McKendrick, Brewer and Plumb (1982).

might call it the product cycle theory of economic development: one darn product cycle after another. Roberts (2011) ends his survey of economic aspects of ancient Athens and Rome with a reflection on just how complete or modern were these ancient economies in their own times. Are our economies today distinctly different, he asks. "The main difference (between modern business and that of ancient times) lies in the role that modern business plays in the creation of material wealth, thanks to systems of innovation and marketing that never existed in antiquity." (p. 263). He rejects "size, the complexity or technology of operations, the products or services sold, or the nature of work and employment" as crucial features which distinguish contemporary systems from the ancient counterparts. The "creation and quickening of markets" in the ancient Greek city states "exposed people to goods they had never known about and sparked a desire for those goods. To satisfy those desires, people who had produced only the necessities for subsistence, rent and taxes now sought to earn purchasing power. To do so, they deployed their skills, assets and time to create goods and services that others wanted. In effect then, money, markets and businesses created wealth by stimulating a combination of desire and purchasing power." (p. 264) Businesses in contemporary economies, in Roberts view, have elevated "the creation and quickening of markets" to become the central process driving economic growth.

References

- [1] Bass, Frank M., Trichy V. Krishnan, and Dipak C. Jain (1994) "Why the Bass Model fits without Decision Variables", *Marketing Science*, 13, 3, Summer, pp. 203-223.
- [2] Bertarelli, S. and R. Censolo, (2006), "Taste for Variety, Taste for Novelty and Price Behavior", *Metroeconomica*, 57, pp. 93–111.
- [3] Bianchi, Marina (2001) "Novelty, preferences, and fashion: When goods are unsettling", *Journal of Economic Behavior and Organization*, 47, pp. 1-18.
- [4] McKendrick, N, J. Brewer and J.H. Plumb (1982), *The Birth of a Consumer Society*, London: Europa.
- [5] Robert, Keith (2011) *The Origins of Business, Money and Markets*, New York: Columbia University Press.
- [6] Rogers, Everett M. (1962), *Diffusion of Innovations*, New York: Free Press of Glencoe.