



The product cycle hypothesis: The role of quality upgrading and market size



Yan Ma

Graduate School of Business Administration, Kobe University, 2-1, Rokkodai, Nada, Kobe 657-8501, Japan

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ABSTRACT

We develop a dynamic model in which the timing of innovating firm to relocate the production of a new product from North to South is endogenously determined. The decision of whether to produce in the South involves a trade-off between marginal cost savings from lower wages against a fixed coordination cost. The innovating firm invests in R&D to improve the quality of a new product, which raises the size of the market and the cost savings from producing in the South. We demonstrate that a new product is initially produced in the North and its production location is shifted to the South when its quality is sufficiently improved. We also investigate the interaction between the location of production and the rate of quality improvement.

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1. Introduction

In a highly influential paper [Vernon \(1966\)](#) introduced the product cycle hypothesis, which states that a typical new good experiences different innovation stages. He argued that most goods are developed in the industrialized North. In the maturing stage, these products are improved in the North and their market penetration keeps expanding. The standardized stage comes when the appropriate designs have been worked out and their market penetration has become large enough. In this stage, innovating firms shift their production to the less developed South, where wages are lower. This cycle is reignited when the future innovation in the North replaces old versions manufactured in the South. In Vernon's formulation of a product's life cycle, shifting the production to the South is a profit-maximizing decision from the view of innovating firms.

An extensive theoretical literature has developed to formulate various aspects of Vernon's product cycle hypothesis.¹ In most of the literature, the shift of production location is assumed to be driven by Southern imitation. In this paper, we develop a simple dynamic

E-mail address: mayan003@kobe-u.ac.jp.

¹ For example, [Krugman \(1979\)](#) developed a simple model to exogenously formulate the technology transfer. [Jensen and Thursby \(1986, 1987\)](#) introduced a decision-theoretic framework into the Krugman model. The innovation in their papers is undertaken by only a single Northern firm and imitation by only a Southern utility-maximizing central planner. [Grossman and Helpman \(1991a,b\)](#) built models in which endogenous product cycles are driven by purposeful Northern innovation and Southern imitation. In [Grossman and Helpman \(1991b\)](#), they developed a "quality-ladders" model in which the rate of quality improvement is exogenous, and the shift of production location is due to the imitation of Southern firms. There are many good studies following [Grossman and Helpman \(1991b\)](#). For example, [Glass \(1997\)](#) and [Sener and Zhao \(2009\)](#).

model to formulate the product's life cycle described by Vernon and endogenously determine the timing of shifting the production to the South by innovating firms.

In our set-up, an innovating firm invests in R&D to improve the quality of a new product. The common assumption in the literature on the product cycle driven by quality improvement is that the rate of quality improvement is fixed. In this paper, the rate of quality improvement is endogenously determined and hence our study provides the first attempt to examine the interaction between the location of production and the rate of quality improvement.

As is standard in the literature, we assume that the North has a comparative advantage in R&D so that all R&D occurs in the North. Our demand side differs, however, from the literature in that consumer preference is assumed to be heterogeneous, and potential consumers have a higher willingness to pay for a higher quality of the product. This demand side specification allows us to capture the market penetration expansion process of a good along its life cycle. Real world examples such as textiles, electric appliances and personal computers support this specification. For example, few people could afford the personal computer when it was first introduced in the U.S., but nowadays almost every family has one. The quality of modern computers is higher, and most are manufactured in the developing countries.

In addition, we assume that there is a coordination cost of producing in the South. This cost can be thought of as the cost of sending Northern experts to the South for training the local workers, solving the production problems and overseeing the production to make sure that contracts are enforced in the South.² In our paper, the decision to relocate the production to the South involves a trade-off between the fixed cost of coordinating the production in the South and the marginal production cost savings obtained by producing in the South.

We demonstrate that the policy function for quality improvement is not monotonic in quality if the product cycle emerges. There is a rapid increase in quality improvement just before the shift of the production location. In addition, market penetration rises rapidly before the shift of the production location. The case of MP3 players confirms this result. As reported by Michael Paxton in "MP3 Player Sales to Skyrocket", "MP3 player sales will soar from \$126 million in 1999 to \$1.25 billion by the end of 2002."³ The Apple's mini-iPod was introduced as the state-of-the-art MP3 player in 2002. It was designed in California while manufactured in Taiwan in 2002.⁴

Moreover, we demonstrate that there exists a region of coordination cost and relative marginal production cost, within which the product cycle emerges. When the good is new and the quality adjusted price is high, production in the South is unattractive because it bears large coordination cost with little marginal production cost savings. Conversely, when the improvement in quality raises the market penetration to such a scale that marginal cost savings dominate the coordination costs, the shift of the production to the South becomes attractive. Beyond this region, no product cycle emerges because marginal cost savings can never dominate the coordination costs.⁵ For example, Nike relies on production facilities in over 50 countries, mostly in Latin America and Asia, but has almost no factories in Africa.⁶ Our model suggests that this is because coordination costs in Africa remain large. As pointed out by Golub et al. (2007, page 4), despite abundant availability of unskilled and under-employed labor, Africa is generally unattractive to foreign investors because the business environment in Africa remains hostile. Another example is that the production of aircraft still remains in the North.⁷ Some recent empirical studies also indicate that the product cycle emerges only in certain industries.⁸

Our study shares the view of Vernon (1966) and Antras (2005) in that the shift of production location is driven by the voluntary decisions of Northern firms, and thus imitation is not our focus. Antras (2005) is the first study that formulates the standardization process of a new product with the contribution of product development to its output decreasing at an exogenous rate along its life cycle. Antras focused on how incomplete contracts affect the organizational structure of firms, but ignores the role of quality improvement in the product cycle. In this paper, we introduce the shift of the production location into Saha (2007) to formulate Vernon's formulation of a product's life cycle.⁹ Our set-up is a partial equilibrium model, and thus, our analysis abstracts from interactions between the product cycle, the rate of innovation and the wage rate.

The model is developed in Section 2. In Section 3, we demonstrate that there exist two possible interior steady states. In Section 4, we examine how the coordination cost and the marginal production cost affect the emergence of the product cycle. Furthermore, we investigate how the potential for the production relocation affects the rate of quality improvement. Section 5 is the concluding remarks. All proofs and calculation are provided in Appendices A, B, C.

² Some existing studies point out that overseas production incurs some additional costs. In Jones and Kierzkowski (1990, 2001), service links is necessary for fragmentation of production process. The development of service links entails substantial fixed costs consisting of both sunk start-up costs and maintenance costs for infrastructure. In Antras and Helpman (2004), overseas production incurs fixed organizational costs. In Antras (2005), incomplete contracts give rise to transaction costs for overseas manufacturing.

³ This news is available on http://findarticles.com/p/articles/mi_m0EKF/is_3946/ai_69673813/.

⁴ See page 1 in Sener and Zhao (2009).

⁵ We consider that more complex products incur higher coordination costs and higher marginal production costs. The complexity of products is defined in Costinot (2009) as the number of tasks that must be performed to produce one unit. However, product cycle is not the issue in Costinot (2009).

⁶ See this in Page 4 of Golub, Jones, and Kierzkowski (2007).

⁷ According to Costinot (2009), aircraft is the second complex industry.

⁸ For example, Zhu (2005).

⁹ Saha (2007) analyzed product innovation and process innovation from the perspective of their relationship with consumer preferences. Product innovation is considered as quality improvement in his paper. Our analysis abstracts from process innovation as we think the shift of the production location is a way to cut down the marginal production costs. In addition, no steady state exists in Saha (2007). In contrast, there exist two possible interior steady states in our study.

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