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Love of Novelty: A Source of Innovation-Based Growth... or Underdevelopment Traps?*

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Abstract

This study develops a new innovation-based growth model to explore the role of people's love of novelty in innovation and innovation-based growth. The model considers (a) an infinitely lived representative consumer who has the standard love-of-variety preferences for differentiated products and extra love-of-novelty preferences for new products and (b) technological progress driven by two costly and time-consuming innovation activities, new product development and existing product development. We demonstrate that if the consumer's love-of-novelty preference is moderate, new and existing product development alternately occur on an equilibrium path, whereby the economy achieves innovation and long-run growth, through cycles. However, if the love of novelty is too strong or too weak, the economy is caught in an underdevelopment trap with less innovation and no long-run growth. Our results suggest that the love of novelty is a source of innovation-based growth, but can become a cause of underdevelopment traps if too strong.

JEL Classification Codes: E32; O40; Z10

Keywords: Love/fear of novelty; innovation; innovation-based economic growth

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1 Introduction

It is generally believed that people’s desire for new ideas or love of novelty is important for innovation. For example, Fagerberg (2005, 2013) argues that “‘openness’ to new ideas, solutions, etc. is essential for innovation” because innovation requires people and firms to “search widely for new ideas, inputs and sources of inspiration.” Because innovation is widely recognized as a major driver for long-run growth, one may also think that people’s love of novelty is conducive to economic growth and especially to innovation-based growth. However, because innovation is a complex process that is more than invention and each “single innovation can involve combinations of different types of product and business process innovations” (OECD 2018), the total effect of people’s love of novelty on innovation and growth may not be as obvious as it seems.¹

How does people’s love of novelty affect innovation at the aggregate level? What is the role of the love of novelty in innovation-based economic growth in the long run? In this paper, we study these questions by proposing a new economic framework which helps us understand the costs and benefits of agents’ love of novelty to the aggregate economy.

We consider a so-called expanding varieties model of innovation-based growth (Romer 1990). We begin, in Section 2, with a class of this model in which the innovators of products enjoy temporary monopoly power (see, for instance, Matsuyama 2001 and Acemoglu et al. 2012); new and old products are clearly distinguished and have separate roles in equilibrium.² We extend this class of models in two novel ways. First, we introduce consumers’ love of novelty such that an infinitely lived representative consumer has not only preferences for differentiated products (“love-of-variety”) but also some extra preferences for new products (“love-of-novelty”). Second, to examine the effect on total innovation, we incorporate the aforementioned view, that is, a single innovation involves a combination of different types of innovation activities, namely, new product development and existing product development, which we assume involve time and resource consuming investment activities.³ In our model, as a result, ideas are first developed as new products, and they can survive as “old” products only if investments in existing product development succeed.⁴

These two new features help us identify a role of the consumer’s love of novelty in aggregate innovation and innovation-based growth. In the model, firms involved in innovation always swing between investing in new product development and existing product

¹In Appendix A, we document some suggestive evidence by showing that across countries, love of novelty and aggregate innovation might not always be positive related. Separately, Gören (2017) finds country-level evidence for an inverted-U relationship between people’s novelty-seeking traits and economic development. All this seems to suggest the ambiguous role of people’s preferences for new products in innovation and growth at the macroeconomic level.

²See also below for more information on this class of growth models.

³This categorization essentially follows the latest Oslo Manual (OECD 2018), which proposes two general categories of innovation “by comparing both new and improved innovations to the firm’s existing products.”

⁴Assuming that the success is uncertain, whether a new product ultimately survives and takes root in the economy is also uncertain. This is consistent with the nature of technological progress in history, which often referred to as “technological inertia” (Mokyr 1992). In the history of technological innovation, as Mokyr argues, most societies have exhibited a strong resistance to new ideas, experiencing technological stasis. As a result, newly developed products and technologies often fail to survive, despite their ostensible economic superiority. The survival of a new product or technology is a highly uncertain event, and innovation therefore has ever occurred only cyclically (Mokyr 2000, 2004). Examples include various products and technologies such as steam engines and the internet; see, for instance, Diamond (1997) for more details.

development. Through the marketplace, then, the relative profitabilities of these two investment activities inherently depend on the extent to which the consumer prefers new products to old products. Specifically, a stronger love of novelty by the consumer directly encourages firms to invent new products but discourages firms from improving existing old products for survival in market equilibrium. Because new and existing product development are indispensable for the entire process of innovation, the aggregate level of innovation depends on a good balance between these two effects. Our analysis demonstrates this mechanism that creates an ambiguous role of the love of novelty.

We show that the consumer's love of novelty has a non-monotonic effect on aggregate innovation and growth. If the love of novelty is very weak, firms invent fewer new products, which are the source for existing product development. Because each innovation requires new and existing product development to be completed, the aggregate level of innovation is too small for the economy to achieve long-run growth. Such an economy is caught in an underdevelopment trap. If, then, the love of novelty is not very small but moderate, both types of innovation perpetually occur along an equilibrium path, but cyclically. In this case, periods in which new product development occurs and periods in which existing product development occurs alternate along an equilibrium path,⁵ whereby the economy achieves long-run growth, through innovation cycles. These results show that the love of novelty is an essential source of innovation-based growth in the long run.

What if the love of novelty is very strong? With a very strong love of novelty, firms eventually invest only in inventing new products; thus, no improvements to old products would occur in long-run equilibrium. In this case, the economy is trapped in a situation in which new goods are invented every period because of new product development, but new goods hardly survive under the absence of existing product development. As in the case of a weak love of novelty, the economy loses a good balance between the two types of innovation, whereby the aggregate level of innovation is too low to achieve long-run growth. Thus, the love of novelty causes underdevelopment traps if it is too strong. We therefore conclude that the total effect of the consumer's love of novelty is ambiguous in that the love of novelty can be either a source of innovation-based growth or a cause of underdevelopment traps. We formally derive two threshold values of the love of novelty that determine if the economy grows or becomes trapped.

We then consider some extensions to the baseline model in Section 5. There, we present results confirming our core finding. Specifically, if we relax the assumption of a one-period monopoly to assume long-lived monopoly power as in the canonical research and development (R&D)-based growth models,⁶ new and existing product development can coexist in equilibrium. In this case, we show that the equilibrium rate of innovation for any period is an inverted U-shaped function in the consumer's love of novelty, confirming the ambiguous role of the love of novelty.

Our study contributes to the theoretical literature on innovation cycles by focusing on people's love of novelty as a new factor for cyclical innovation (Judd 1985, Shleifer 1986, Deneckere and Judd 1992, Gale 1996, Francois and Shi 1999, Matsuyama 1999, 2001, and Furukawa 2015). In the main analysis, following this theoretical literature, we assume

⁵In the baseline model, an innovative economy is always perpetually cyclical; in Section 5, however, we show that it can also stably converge to a unique balanced growth path, by considering a natural extension of the baseline model.

⁶See Segerstrom et al. (1990), Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992).

that the innovator can enjoy only a one-period monopoly. Although this assumption is relaxed in Section 5 as aforementioned, it is reasonably justifiable because the duration of patent protection or, more generally, monopoly power can be for only some finite period of time *in reality*. Allowing for a multiperiod monopoly, from a more general perspective, Iwaisako and Futagami (2007) identify an essential role of the temporary nature of monopoly in growth cycles in an innovation-based growth model with *finite* patent length.⁷ Our study extends those by characterizing the role of the consumer's love of novelty in innovation and its perpetual cycles.

Our study also contributes to a growing body of theoretical literature on culture and growth. Galor and Moav (2002) show that individual preferences for offspring quality play a role in population growth and human capital formation.⁸ Subsequent studies by Ashraf and Galor (2007, 2013a, 2013b, 2017) explore cultural/genetic diversity and regional development at different stages and in different places.⁹ Several papers have identified an ambiguous role of some cultural factors. For example, Ashraf and Galor (2013a) show an inverted U-shaped relationship between genetic diversity within a country and regional economic development. Cozzi (1998) considers a cultural asset that is unproductive at the individual level, traded between different generations, and has positive external effects on productivity growth. Then, he shows that culture can be a bubble that causes dynamic indeterminacy and self-fulfilling stagnation. Thus, the role of culture in his model is ambiguous in that it may encourage or discourage economic growth.

The studies of Galor and Michalopoulos (2012) and Doepke and Zilibotti (2014) are more closely related to our study. Both studies have identified the critical role of entrepreneurial traits in innovation and economic growth by considering an endogenous evolution of the fraction of people who exhibit an entrepreneurial spirit (in terms of risk tolerance). Given that entrepreneurial traits should be partially attributable to openness to novelty, we can say that their studies focus on one important aspect of entrepreneurs' love of novelty. This paper contributes to this literature by examining the role of the representative consumer's love-of-novelty preference as a cultural factor in an innovation-based growth model and identifying the ambiguous role of the love of novelty.¹⁰

The literature on two-stage innovation models is also related to our study, and most models have distinguished basic and applied research (see, e.g., Aghion and Howitt 1996, Michelacci 2003, Akiyama 2009, Cozzi and Galli 2009, 2013, 2014, Acs and Sanders 2012, Chu et al. 2012, Chu and Furukawa 2013, Konishi 2015). Because we consider two separate activities of *applied* innovation, firms earn profits in both stages of innovation. This differs from existing models, in which there is no profit in early, basic research

⁷See, for instance, Iwaisako and Tanaka (2017) for endogenous growth cycles in an overlapping generations model.

⁸A large body of empirical literature is available. Tabellini (2010) shows that cultural propensities such as trust have a significant effect on regional per-capita income in Europe. Alesina and Giuliano (2010) examine the effects of family ties on economic performance. See also Bénabou et al. (2015, 2016), who show that innovation can be negatively associated with people's religiosity.

⁹See also Chu (2007), who provides the notable argument that entrepreneurial overconfidence can cause different rates of economic growth across countries. Moreover, Chu and Cozzi (2011) focus on cultural preferences for fertility. In a broader context, as Yano (2009) asserts, the coordination of such cultural factors with laws and rules is indispensable to deriving high quality markets and thereby healthy economic growth. This study extends this literature by investigating a composition effect of the public's love of novelty and patent on innovation and long-run growth. See also Dastidar and Yano (2017) and Yano and Furukawa (2019) for recent studies on market quality theory.

¹⁰Doi and Mino (2008) also explore the role of consumption-side factors in innovation and innovation-based growth by focusing on habit formation and consumption externalities.

stages of innovation. Our study thus complements the literature by first considering two commercial stages of innovation and then by characterizing the role of the consumer’s love of novelty on aggregate innovation and growth.

The remainder of this paper is organized as follows. Section 2 presents the basic model, and Section 3 characterizes the equilibrium dynamics of the model. Section 4 identifies the critical role of the love of novelty in innovation and growth in the long run. Section 5 provides extensions of the baseline model. Finally, Section 6 provides concluding remarks.

2 Innovation-Based Growth Model with Love of Novelty

This section presents our basic innovation-based growth model, in which innovation occurs endogenously as a product of the firms’ profit-seeking R&D investment and thereby the variety of products increases over time, following Romer (1990). In this section, we first proceed with the assumption that firms can only enjoy temporary (one period) monopoly power, as in Matsuyama (1999, 2001) and Acemoglu et al. (2012). This is assumed because in this class of models, new products and old products play separate but essential roles in equilibrium, facilitating the modeling of people’s love of novelty—as will be apparent later. In Section 5, this assumption of a one-period monopoly is relaxed.

To investigate the role of love of novelty of optimizing agents, our model has two new assumptions. (i) First, we assume that the representative agent is endowed with the standard love-of-product variety and love of novelty; thus, he/she would have some extra weight on new products compared with old products.¹¹ Second, (ii) we think of two types of innovation: one type is to invent new products, and the other type is to ensure invented products have a long life in the market. We refer to these two types of innovation as new product development and existing product development, which both require R&D investment by profit-seeking firms.

2.1 Consumption and Love of Novelty

An infinitely lived representative agent inelastically supplies L units of labor in each period. The representative agent solves the standard dynamic optimization of consumption and saving over an infinite horizon:

$$\max U = \sum_{t=0}^{\infty} \beta^t \ln u(t), \quad (1)$$

where $\beta \in (0, 1)$ is the time preference rate, and $u(t)$ is an index of consumption in period t . We assume that periodic utility u is defined over differentiated consumption goods, and each is indexed by j .¹² Namely, the agent is endowed with so-called love-of-variety preferences. As is standard, we consider a constant elasticity of substitution

¹¹In this literature, some models have physical capital accumulation (e.g., Matsuyama 2001). To make our analysis tractable, we abstract from this aspect because our focus is on preferences for new products, innovation, and innovation-driven growth.

¹²This follows Grossman and Helpman (1991, ch. 3). In our model, thus, the variety of consumption goods endogenously increases over time, unlike in the original Romer model (in which the variety of intermediate goods increases). Therefore, in our model, patents are granted for consumption goods, but they are often for intermediate goods in reality. Nevertheless, we adopt the present setting because we

utility function:

$$u(t) = \left(\int_{j \in A(t) \cup N(t)} (\varepsilon(j, t) x(j, t))^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}, \quad (2)$$

where $x(j, t)$ is the consumption of good j in period t , $\sigma \geq 1$ is the elasticity of substitution between any two consumption goods, and $\varepsilon(j, t)$ is a variable determining the consumer's preference for each good, j . Here, the consumption goods are categorized into two types: new goods and old goods. Let $N(t)$ be the set of new goods invented in period t and $A(t)$ be the set of old goods invented prior to period t . To simplify the description, let $A(t)$ and $N(t)$ also denote the number (measure) of goods.

When considering the innate love of novelty, we assume that the representative agent is endowed with "love-of-novelty" preferences, in addition to the standard love-of-variety preferences.

First, we attempt to observe a benchmark in which the consumer prefers new goods and old goods equally; there is no particular love of novelty. In this case, all goods should have identical $\varepsilon(j, t)$ for all $j \in A(t) \cup N(t)$. Normalizing this parameter to 1, the consumer's utility function can be written as

$$u(t) = \left(\int_{j \in A(t)} x(j, t)^{\frac{\sigma-1}{\sigma}} dj + \int_{j \in N(t)} x(j, t)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}} \quad (3)$$

Now, suppose that the consumer has some *extra* preference, ε , for *novelty* that he/she considers in terms of a good being new or a condition in which a good is new:

$$\varepsilon(j, t) = \begin{cases} 1 & \text{if } j \in A(t) \text{ (old goods)} \\ \varepsilon & \text{if } j \in N(t) \text{ (new goods)} \end{cases} . \quad (4)$$

Applying (4) to (2), (3) becomes

$$u(t) = \left(\int_{j \in A(t)} x(j, t)^{\frac{\sigma-1}{\sigma}} dj + \varepsilon \int_{j \in N(t)} x(j, t)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}} . \quad (5)$$

When $\varepsilon = 1$, first, the consumer has no preference for novelty and prefers all goods equally, as in (3). This provides the benchmark, which has been intensively investigated in the literature. When $\varepsilon > 1$, the consumer has a love of novelty and prefers new goods to old goods. The higher ε , the stronger the love of novelty. To retain generality, we also allow for $\varepsilon < 1$. When $\varepsilon < 1$, the consumer's love of novelty is very weak, or we can say that the consumer has a so-called "fear of novelty" (Barber 1961), preferring old goods to new goods. This sort of negative preference for novelty can also be observed in reality and develops from people's innate "mental resistance to new ideas" (Beveridge 1959). For simplicity, we refer to ε as the consumer's love of novelty for all $\varepsilon > 0$.¹³

The infinitely lived consumer solves the static optimization in (1); as is well known, we have the demand functions:

$$x(j, t) = \varepsilon(j, t)^{\sigma-1} \frac{E(t)p(j, t)^{-\sigma}}{P(t)^{1-\sigma}}, \quad (6)$$

are interested in modeling consumers' love of novelty. Notably, however, we can obtain similar results even if we consider an expanding variety of *intermediate* goods.

¹³For $\varepsilon < 1$, we can posit that the level of love for novelty is *negative*, which implies a fear of novelty. In this study, we exclude any possibility of $\varepsilon < 0$ because this is a trivial case, in which case the consumer obtains disutility from buying new products and thus simply chooses $x(j, t) = 0$ for all $j \in N(t)$.

where the consumer's spending on differentiated goods is:

$$E(t) \equiv \int_{j \in A(t) \cup N(t)} p(j, t) x(j, t) dj, \quad (7)$$

$P(t)$ is the usual price index, defined as

$$P(t) \equiv \left(\int_{j \in A(t) \cup N(t)} (p(j, t) / \varepsilon(j, t))^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}, \quad (8)$$

and $p(j, t)$ is the price of good j in period t . By solving the dynamic optimization, we also obtain the Euler equation:¹⁴

$$\frac{E(t+1)}{E(t)} = \beta(1 + r(t)), \quad (9)$$

where $r(t)$ denotes the interest rate.

2.2 Production

A continuum of firms produces consumption goods $j \in A(t) \cup N(t)$. Each good j , a new or old good, is dominated by a monopolistic producer. We consider a one-for-one technology in goods production. Namely, any producer, $j \in A(t)$ or $N(t)$, hires $x(j, t)$ units of labor to produce $x(j, t)$ units of good j , and monopolistically sells them to the consumer. The marginal cost is, thus, equal to the wage rate, $w(t)$.

As shown in (6), the consumption good producers, $j \in A(t) \cup N(t)$, face a constant price elasticity of market demand, equal to $\sigma \geq 1$. The unconstrained mark-up for a monopolistic producer is $\sigma/(\sigma - 1) > 1$. Thus, the mark-up goes to infinity in a Cobb-Douglas case of $\sigma = 1$. Nevertheless, to observe the role of substitutability between goods, captured by σ , in detail, we allow for the case of $\sigma = 1$,¹⁵ by introducing an upper bound of the mark-up, say, $\mu > 1$. This upper bound μ has often been called a so-called patent breadth (see, e.g., Li 2001, Goh and Olivier 2002, Iwaisako and Futagami 2013, Chu et al. 2016).¹⁶ Following the literature, we assume $\mu \leq \sigma/(\sigma - 1)$.¹⁷ Notably, this introduction of a mark-up upper bound, μ , is only for clarifying what occurs in the Cobb-Douglas case ($\sigma = 1$). Thus, the main results do not alter qualitatively at all without the upper bound μ .

Accordingly, each firm sets a monopolistic price at:

$$p(j, t) = \mu w(t) \quad (10)$$

¹⁴Here we consider the standard lifetime budget constraint as follows: $E(t+1) + Q(t+1) = (1 + r(t))Q(t) + W(t)L$, where $Q(t)$ denotes the value of financial assets (i.e., equity of monopolistic firms) owned by the representative consumer.

¹⁵When $\sigma = 1$, consumption goods are not substitutes but independent goods. Thus, if one needs to examine the role of goods substitutability, it is useful to think of the case without substitutability (i.e., the case of $\sigma = 1$).

¹⁶The breadth of a patent here is identified with “the flow rate of profit available to the patentee” and often interpreted as “the ability of the patentee to raise price” (Gilbert and Shapiro 1990). We can easily justify the existence of a price upper bound, or patent breadth, by considering potential imitators whose production cost increases with patent breadth, μ . In a different context, μ can also be considered a result of price regulation (Evans et al. 2003).

¹⁷Notably, as shown later, our result can hold when $\mu = \sigma/(\sigma - 1)$, that is, when there is no upper bound of a mark-up.

for all j . Using (4), (6), and (10), the output and monopolistic profit for a new good are given by:

$$x(j, t) = \frac{\varepsilon^{\sigma-1} E(t)}{P(t)^{1-\sigma}} (\mu w(t))^{-\sigma} \equiv x^n(t) \text{ for } j \in N(t) \quad (11)$$

and

$$\pi(j, t) = \varepsilon^{\sigma-1} \frac{\mu - 1}{\mu^\sigma} E(t) \left(\frac{w(t)}{P(t)} \right)^{1-\sigma} \equiv \pi^n(t) \text{ for } j \in N(t). \quad (12)$$

Equation (12) shows that when $\sigma > 1$, the profit for a new good, $\pi^n(t)$, increases with the love of novelty ε and the total expenditure, $E(t)$, and decreases with the real wage, $w(t)/P(t)$. When $\sigma = 1$ (the Cobb-Douglas case with no substitutability between goods), additionally, it becomes independent of the love of novelty ε , and the real wage, $w(t)/P(t)$.

We can also derive the output and monopolistic profit for an old good, from (4), (6), and (10):

$$x(j, t) = \frac{E(t)}{P(t)^{1-\sigma}} (\mu w(t))^{-\sigma} \equiv x^a(t) \text{ for } j \in A(t) \quad (13)$$

and

$$\pi(j, t) = \frac{\mu - 1}{\mu^\sigma} E(t) \left(\frac{w(t)}{P(t)} \right)^{1-\sigma} \equiv \pi^a(t) \text{ for } j \in A(t). \quad (14)$$

The profit $\pi^a(t)$ associated with an old good is always free from the love of novelty ε .

2.3 Innovation

In this section, we present two types of innovation. One type of innovation is to invent new goods, and the other type is to ensure that invented goods have a long life in the market; we label these two types of innovation new product development and existing product development, respectively. First, R&D firms invent new consumption goods. We suppose new goods will become obsolete without further investments. Then, firms would invest in existing product development for survival. If investments succeed, new goods would survive to become “old” goods.¹⁸

2.3.1 New Product Development

There is a potentially infinite number of R&D firms. A firm can invent a new good in period t by making an investment of $1/A(t-1)$ units of labor in period $t-1$. We follow Romer (1990) to consider “external effects arising from knowledge spillovers” of the stock of existing technologies, represented by $A(t-1)$. For simplicity, there is no spillover from newly invented goods, because we suppose that they are so new that their information would not be diffused well. Nevertheless, even if we allow for new goods in the stock of existing technologies, the main results will not qualitatively change. Firms that invent new goods earn a monopolistic profit in period t , $\pi^n(t)$.

¹⁸Our two types of innovations basically correspond to the standard categories of innovations, namely, product innovation and business process innovation (OECD 2018).

As aforementioned, in the baseline model, we assume that the monopolistic firm can enjoy only a temporary (one-period) monopoly, following some endogenous growth models such as Francois and Shi (1999), Matsuyama (1999, 2001), and Acemoglu et al. (2012). The free entry condition for new product development can be written as:

$$W^n(t-1) \equiv \frac{\pi^n(t)}{1+r(t-1)} - \frac{w(t-1)}{A(t-1)} \leq 0 \text{ for } t \geq 1 \quad (15)$$

where $W^n(t-1)$ denotes the discounted present value of inventing a new good. $R^N(t-1)$ denotes the units of labor devoted to new product development in period $t-1$. Then, we have

$$N(t) = A(t-1)R^N(t-1). \quad (16)$$

2.3.2 Existing Product Development

Due to the one-period nature of monopoly power, the new goods, $N(t)$, invented in period t can potentially be manufactured by any firm in the subsequent period, $t+1$. The goods are, at this point, no longer new but “old.” We assume that each new good can be obsolete before becoming an old good unless investments for survival are made and succeed. We call this type of innovation for survival existing product development.

Specifically, an R&D firm engaging in existing product development invests one unit of labor in period t and searches through the set of the new goods, $N(t)$. From among $N(t)$, the firm then successfully makes $\chi(t)$ units of new goods survive to become old goods, and enjoys a one-period monopoly for those $\chi(t)$ goods to earn the profits of $\chi(t)\pi^a(t+1)$. The free entry condition for existing product development can be given as:

$$W^a(t) \equiv \frac{\chi(t)\pi^a(t+1)}{1+r(t)} - w(t) \leq 0 \text{ for } t \geq 0, \quad (17)$$

in which $W^a(t)$ denotes the discounted present value for existing product development. Concerning $\chi(t)$, we consider a simple technology, $\chi(t) \equiv \kappa N(t)$, in which $\kappa \in (0, 1)$ is a productivity parameter.¹⁹ With this function, we assume that firms can find more new goods when there are more new goods $N(t)$ in the marketplace.

Through this process, the new goods of $N(t)$ are partially converted into the old goods, whose number is expressed as $A(t+1) - A(t)$. Denote as $R^A(t)$ the units of labor devoted to existing product development in period t . Then we have

$$A(t+1) - A(t) = \chi(t)R^A(t) \leq N(t). \quad (18)$$

For simplicity, we assume that none of the old goods becomes obsolete, although it is easy to allow for some depreciation for $A(t)$ without rendering any essential change to the result. For descriptive purposes, we define $\rho(t)$ as a macroeconomic rate at which new goods survive to be transformed into old goods:

$$\rho(t+1) \equiv \chi(t)R^A(t)/N(t). \quad (19)$$

In the subsequent period, $t+2$, due to the temporary monopoly again, the “new” old goods, $A(t+1) - A(t)$, could potentially be produced by any firm. We follow Acemoglu

¹⁹From a broader perspective, this κ can relate to firms’ absorptive capacity (Cohen and Levinthal 1989).

et al. (2012) by assuming that monopoly rights will be, then, allocated randomly to a firm from the pool of potential firms whose ownership belongs to the representative agent. Thus, the monopoly profits for these “new” old goods will be transferred to new monopolistic firms owned by the representative agent.²⁰ Consequently, in our model, all goods are monopolistically competitively produced in equilibrium, and their profits are allocated to the representative agent as dividends.²¹

2.4 Labor Market

As shown in (12) and (14), the real wage $w(t)/P(t)$ is a critical component of the profits. Thus, having the following is beneficial:

$$\frac{w(t)}{P(t)} = \frac{1}{\mu} [A(t) + \varepsilon^{\sigma-1} N(t)]^{\frac{1}{\sigma-1}}, \quad (20)$$

which uses $p(j, t) = \mu w(t)$ for any $j \in A(t) \cup N(t)$ with (8). The labor market clearing condition is:

$$L = \int_{j \in A(t) \cup N(t)} x(j, t) dj + R^N(t) + R^A(t). \quad (21)$$

The left side in (21) denotes the labor supply, and the right side denotes the labor demand for production, new product development $R^N(t)$, and existing product development $R^A(t)$ in each period t . It is useful to derive the labor demand from the production sector as

$$\int_{j \in A(t) \cup N(t)} x(j, t) dj = \frac{1}{\mu} \frac{E(t)}{w(t)}, \quad (22)$$

which uses (11), (13), (20), and (21).

3 Equilibrium Dynamics

We are now ready to derive the dynamical system that characterizes the law of motion for the equilibrium trajectory of the economy. In doing this, it is beneficial to define $n(t) \equiv N(t)/A(t)$, which is the ratio of new to old goods. By using the free entry conditions in (15) and (17), along with (12) and (14), we derive the following lemma.

Lemma 1 *Only new product development occurs in equilibrium when $n(t) < \varepsilon^{\sigma-1}/\kappa$. Only existing product development occurs when $n(t) > \varepsilon^{\sigma-1}/\kappa$.*

²⁰The financial asset $Q(t)$ owned by the consumer (in the form of equity of monopolistic firms) earns the return rate, $r(t)$, in each period, t ; see footnote 14. As is standard in the canonical innovation-based growth model, this earning is from the profits of all monopolistic firms (in the form of dividends).

²¹Alternatively, we could also proceed in such a manner that goods are sold at a perfectly competitive price (e.g., Matsuyama 2001). However, we understand that this option would complicate the analysis without garnering new insights. In addition, the interaction between monopolistic and competitive sectors is notable but beyond our scope. Thus, in this paper, we ensure the analysis as simple as possible to highlight the main topic discussed in the introduction.

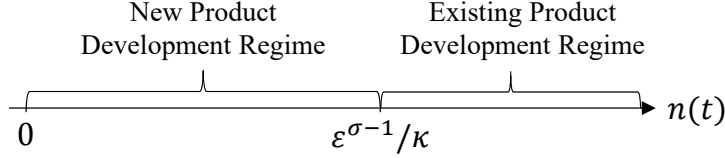


Figure 1: Illustration of Lemma 1

Proof. Suppose that firms invest in new product development in equilibrium. Then, the free entry condition (15) must hold with equality (giving firms a zero net payoff). With (12), (14), (17), and (20), this equality implies $n(t) \leq \varepsilon^{\sigma-1}/\kappa$. Where $n(t) < \varepsilon^{\sigma-1}/\kappa$, that is, (17) holds with inequality, there is no investment in existing product development in equilibrium. Using this information, we can easily prove the first half of the lemma. An analogous proof can be applied to the second half. ■

The result of Lemma 1 is presented in Figure 1. The cut-off level of $n(t)$, $\varepsilon^{\sigma-1}/\kappa$, generates two regimes in the economy. The first regime corresponds to $n(t) \in (0, \varepsilon^{\sigma-1}/\kappa)$, which we call a new product development regime. The second regime corresponds to $n(t) \in (\varepsilon^{\sigma-1}/\kappa, \infty)$, which we call an existing product development regime. At the cut-off point, the economy includes both activities; however, we can ignore it, because the point has zero measure.

As shown in Lemma 1, a type of specialization occurs in this model. In reality, any economy appears to be engaged in both new and existing product development, more or less, at any point in time. We can easily remove this unrealistic aspect concerning specialization from the model by, as we do in Section 5, allowing the innovator a long-lived monopoly or simply introducing an exogenous growth factor. As will be apparent later, either change to the baseline model could provide another interesting analysis but result in the analysis being less tractable. Thus we adopt the present setting for simplicity.

In each period, t , the value of $n(t)$ should be supposed to be given, because it is a pre-determined (stock) variable. In a hypothetical situation in which $n(t)$ is taken as given, Lemma 1 implies that, for a given $n(t)$, an economy is more likely to engage in new product development if (and only if) the love of novelty, ε , is stronger and/or the productivity for existing product development, κ , is lower. This is because there is a higher relative profit for the invention of a new good, compared with the investment in existing goods' survival, when the consumer prefers new goods to old goods more strongly (due to larger ε) and/or the cost for survival investments is higher (due to lower κ). The development of technologies that earn a higher profit is encouraged in market equilibrium. For the analogous reason, an economy is more likely to engage in existing product development when $\varepsilon^{\sigma-1}/\kappa$ is smaller, in which case there is a higher relative profit for survival investments.

3.1 New Product Development Regime

With $n(t) < \varepsilon^{\sigma-1}/\kappa$, by Lemma 1, the economy falls into the new product development regime. With (9), (15), (12), and (20), the free entry condition for invention, $W^n(t) = 0$, becomes:

$$N(t+1) = \frac{A(t)}{\varepsilon^{\sigma-1}} \left[\frac{\beta \varepsilon^{\sigma-1}}{\mu/(\mu-1)} \frac{E(t)}{w(t)} - 1 \right], \quad (23)$$

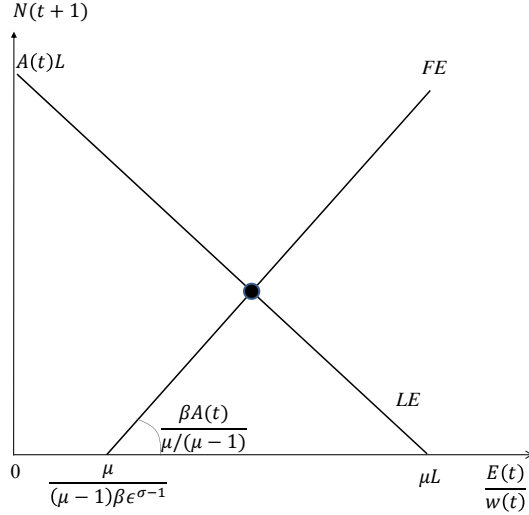


Figure 2: New Product Development Regime

which uses $A(t+1) = A(t)$ (or $\rho(t+1) = 0$). Given $A(t)$, this describes a profit-motive aspect of the inventive activity: the larger the discounted profit from selling new goods ($(\beta \varepsilon^{\sigma-1}(\mu-1)/\mu)E(t)/w(t)$), the greater the incentives for firms to invent a new good. The profit for a new good increases as the wage-adjusted expenditure $E(t)/w(t)$ increases and as the consumer's love of novelty ε increases. Additionally, when $n(t) < \varepsilon^{\sigma-1}/\kappa$, no firm has an incentive to invest in existing product development; in such a case, $R^A(t) = 0$. The labor market condition (21), thus, becomes:

$$N(t+1) = A(t) \left[L - \frac{1}{\mu} \frac{E(t)}{w(t)} \right], \quad (24)$$

which uses (16) and (22). Given $A(t)$, the greater the wage-adjusted expenditure $E(t)/w(t)$, the more resources will be devoted to production, leaving fewer resources for innovation, resulting in a smaller $N(t+1)$.

Figure 2 depicts (23) and (24) and is labeled with FE and LE , respectively, which determine the equilibrium number of new goods, $N(t+1)$, and the wage-adjusted expenditure, $E(t)/w(t)$, as a unique intersection. Given the predetermined variable, $A(t)$, new goods, $N(t+1)$, is increasing in the time preference rate β , the labor force L , and the patent breadth μ , all of which are natural effects.

The effect of the elasticity of substitution between goods, $\sigma \geq 1$, is more complex and is positive if the consumer has a love of novelty, that is, if $\varepsilon > 1$. Because σ determines the level of goods substitutability, a higher σ generally leads to a larger demand for a preferable good (relative to a less preferred good). Thus, with the consumer's love of novelty ($\varepsilon > 1$), the elasticity of substitution σ positively affects $N(t+1)$ through an upward shift of the FE curve in Figure 2, by increasing the expenditure share for a new good and thereby its profit. However, in the benchmark case of $\varepsilon = 1$, comprising neither a love or fear of novelty, the elasticity of substitution σ has no role because all goods, both new and old, are equally desirable for the consumer and thus their demands/profits are also equal. When the consumer has a fear of novelty, that is, $\varepsilon < 1$, the effect of σ on $N(t+1)$ is negative because old goods are now preferable. Again, a higher substitutability σ leads to a larger demand for a preferable good, in general. Thus, in this fear-of-novelty

case, higher σ generates a downward shift of the FE curve, by decreasing the profits for new goods (and increasing the profits for old goods).

As for the love of novelty ε , a higher ε causes an upward shift in the FE curve in the standard case of $\sigma > 1$, where goods are substitutes. This result is simply because the demand for a new good becomes larger if the consumer prefers new goods to old goods more strongly (higher ε). Then, the equilibrium profit for new goods, $(\beta\varepsilon^{\sigma-1}(\mu - 1)/\mu)E(t)/w(t)$, is also larger.²² The upward shift of the FE curve leads to an increase in $N(t + 1)$ in equilibrium. In the special case of $\sigma = 1$ (where goods are independent goods), ε has no role because the expenditure share for any independent good, new or old, is constant, and free from ε .

We can formally confirm this effect of ε by solving (23) and (24):

$$N(t + 1) = \Theta A(t), \quad (25)$$

where

$$\Theta \equiv \frac{\varepsilon^{\sigma-1}(\mu - 1)L - 1/\beta}{\varepsilon^{\sigma-1}((\mu - 1) + 1/\beta)}. \quad (26)$$

Equation (25) determines the equilibrium amount of new goods in the new product development regime. The coefficient Θ is increasing in the love of novelty ε and the standard parameters β , L , and μ . We can interpret the parameter composite Θ as the potential demand for new goods. Assuming $\Theta > 0$, we exclude a trivial case where there is no invention of new goods in any situation, by imposing $\varepsilon^{\sigma-1}\beta(\mu - 1)L > 1$, which provides a lower bound of ε as $[1/(\beta(\mu - 1)L)]^{1/(\sigma-1)} \equiv \varepsilon_0$. Additionally, because $R^A(t) = 0$ and thus $\rho(t + 1) = 0$ in the present regime, from (18), the old goods do not increase; $A(t + 1) = A(t)$. Therefore, we easily verify that if $\Theta > \varepsilon^{\sigma-1}/\kappa$ holds, $N(t + 1)/A(t + 1) \equiv n(t + 1) > \varepsilon^{\sigma-1}/\kappa$ holds, whereby the economy moves to the existing product development regime in period $t + 1$. Conversely, if $\Theta < \varepsilon^{\sigma-1}/\kappa$, $n(t + 1) < \varepsilon^{\sigma-1}/\kappa$. Then, the economy is trapped in the new product development regime. In this situation, $N(t)$ and $A(t)$ are constant over time, resulting in less innovation in the sense that there is only one type of innovation, that is, new product development, $N(t)$. Consequently, there is no long-run growth because the variety of goods, $N(t) + A(t)$, is constant over time.

Lemma 2 *The economy is trapped in the new product development regime if and only if $\Theta < \varepsilon^{\sigma-1}/\kappa$.*

3.2 Existing Product Development Regime

With $n(t) > \varepsilon^{\sigma-1}/\kappa$, by Lemma 1, the economy is in the existing product development regime in period t ; $R^A(t) \geq 0$, and $R^N(t) = 0$. Rearranging the labor market condition (21), with (22), yields the survival rate for new goods as:

$$\rho(t + 1) = \kappa R^A(t) = \kappa \left(L - \frac{1}{\mu} \frac{E(t)}{w(t)} \right). \quad (27)$$

²²See also (12).

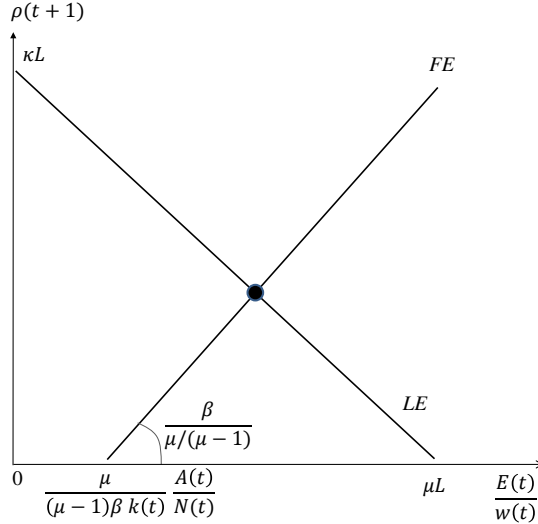


Figure 3: Existing Product Development Regime

Analogous to (24), (27) captures the trade-off on resources between the production of goods and the investment in existing product development. With (9), (14), and (17), the free entry condition $W^a(t) = 0$ becomes

$$\rho(t+1) = \frac{\kappa\beta}{\mu/(\mu-1)} \frac{E(t)}{w(t)} - \frac{A(t)}{N(t)}, \quad (28)$$

which uses $N(t+1) = R^N(t) = 0$ from (16) and $A(t+1) = A(t) + \chi(t)R^A(t) = A(t) + \chi(t)\rho(t+1)/\kappa$ from (18). Naturally, the transformation rate $\rho(t+1)$ increases with the discounted profit from producing the old good $(\beta(\mu-1)/\mu)E(t)/w(t)$ and also increases with the number of new goods $N(t)$, because R&D firms can find more inventions (i.e., opportunities for improvement). Figure 3 illustrates how $\rho(t+1)$ is determined by (27) and (28). Solving (27) and (28), we obtain:²³

$$\rho(t+1) = \min \left\{ \frac{1}{1 + \beta(\mu-1)} \left(\kappa\beta(\mu-1)L - \frac{A(t)}{N(t)} \right), 1 \right\}. \quad (29)$$

Using (29), with (18), the growth of old goods is as follows:

$$A(t+1) = A(t) \min \left\{ \frac{\beta(\mu-1)}{1 + \beta(\mu-1)} \left(1 + \kappa L \frac{N(t)}{A(t)} \right), 1 + \frac{N(t)}{A(t)} \right\} \quad (30)$$

In the present regime, the new goods do not increase; $N(t+1) = 0$ from (16). This result implies $n(t+1) = 0$, which is clearly lower than $\varepsilon^{\sigma-1}/\kappa$. We therefore have Lemma 3.

Lemma 3 *The existing product development regime is always unstable; thus, the economy necessarily shifts to the new product development regime.*

²³Notably, $\rho(t+1) > 0$ always holds, due to $\varepsilon^{\sigma-1}\beta(\mu-1)L > 1$. When $\rho(t+1) = 1$ holds in (29), all new goods survive in period $t+1$. In this case, the free entry condition (28) does not hold anymore; the labor market condition (27), with $\rho(t+1) = 1$, would determine the equilibrium value of the wage-adjusted expenditure, $E(t)/w(t)$. Whether $\rho(t+1) < 1$ or $\rho(t+1) = 1$ occurs in equilibrium, our results do not alter qualitatively. Only for reference, it is notable that $\rho(t+1) < 1$ occurs if and only if $\kappa L < 1 + 1/(\beta(\mu-1))$.

4 The Role of Love of Novelty in Innovation and Long-run Growth

In this section, we examine the effects of consumers' love of novelty on innovation and growth in the long run. We follow the standard literature to assume $\sigma > 1$.²⁴ Lemma 2 shows that in the case with $\Theta < \varepsilon^{\sigma-1}/\kappa$, the economy is fatally caught in the trap without existing product development, in which no long-run growth is possible because new goods $N(t)$ and old goods $A(t)$ are constant. In such a trapped economy, the inventive potential Θ is relatively low, and the consumer's love of novelty, ε , is relatively strong. On the one hand, the new product development regime is larger due to a high ε ; on the other hand, the invention flow $N(t)$ within the regime tends to be low, due to a low Θ . These two effects are negative on innovation; thus, the economy with $\Theta < \varepsilon^{\sigma-1}/\kappa$ is trapped. To avoid traps, $\Theta > \varepsilon^{\sigma-1}/\kappa$ must hold as shown in Lemma 3. As is common in the standard R&D-based growth model, traps can be avoided only if labor is sufficiently abundant.²⁵ Specifically, we assume the following condition:

$$L > 2\sqrt{\frac{1}{\kappa} \left(1 + \frac{1}{\beta(\mu-1)}\right) \frac{1}{\beta(\mu-1)}} \equiv L_0. \quad (31)$$

Lemma 4 *Under (31), there exist threshold values $\varepsilon_+ > \varepsilon_- > \varepsilon_0$ for which*

$$\Theta > \varepsilon^{\sigma-1}/\kappa \iff \varepsilon \in (\varepsilon_-, \varepsilon_+).$$

Proof. From (26), we can show that $\Theta > \varepsilon^{\sigma-1}/\kappa$ if and only if

$$F(\varepsilon^{\sigma-1}) \equiv \frac{1}{\kappa} \left(1 + \frac{1}{\beta(\mu-1)}\right) (\varepsilon^{\sigma-1})^2 - L\varepsilon^{\sigma-1} + \frac{1}{\beta(\mu-1)} < 0. \quad (32)$$

Because F is quadratic and convex in $\varepsilon^{\sigma-1}$, (32) is possible only when $F(x) = 0$ has two distinct real roots. The positiveness of the discriminant ensures this, that is,

$$D \equiv L^2 - \frac{4}{\kappa} \left(1 + \frac{1}{\beta(\mu-1)}\right) \frac{1}{\beta(\mu-1)} > 0, \quad (33)$$

which is equivalent to (31). Suppose that (31) holds and let the solutions to $F(x) = 0$ be $\varepsilon_-^{\sigma-1} < \varepsilon_+^{\sigma-1}$.²⁶ As is easily verified, $\varepsilon_+^{\sigma-1} > 0$ holds. Because $F(0) > 0$, $\varepsilon_-^{\sigma-1} > 0$ also

²⁴If $\sigma = 1$, the consumption goods are independent goods; thus, the expenditure share between new and old goods is constant, and free from love of novelty ε . Notably, under $\sigma = 1$, the condition in Lemma 2 becomes independent of ε .

²⁵This is due to the well-known scale effect within the model. Although the existence of the scale effect has been empirically rejected from a long-run perspective, by using 100 years of data (Jones 1995), it might play a role in world development in the *very* long run: As Boserup (1965) argues, population growth often triggers the adoption of new technology, because people are forced to adopt new technology when their population becomes too large to be supported by existing technology. The empirical finding of Kremer (1993) also suggests that total research output increases with population. Consistent with these views, Lemma 4 shows that population size affects technological progress in the long run. The threshold level of L in (31), L_0 , comprises several parameters. Because, for instance, L_0 decreases with κ , the productivity of firms has a role in avoiding traps, which is natural and intuitive.

²⁶ $\varepsilon_-^{\sigma-1} = \frac{L - \sqrt{D}}{(2/\kappa)(1 + 1/(\beta(\mu-1)))}$, $\varepsilon_+^{\sigma-1} = \frac{L + \sqrt{D}}{(2/\kappa)(1 + 1/(\beta(\mu-1)))}$.

holds. To prove that $\varepsilon_0^{\sigma-1} = 1/(\beta(\mu-1)L) < \varepsilon_-^{\sigma-1}$, it suffices to show that $F(\varepsilon_0^{\sigma-1}) > 0$ and $F'(\varepsilon_0^{\sigma-1}) < 0$. In fact,

$$F(\varepsilon_0^{\sigma-1}) = \frac{1}{\kappa} \left(1 + \frac{1}{\beta(\mu-1)} \right) (\varepsilon_0^{\sigma-1})^2 > 0,$$

$$F'(\varepsilon_0^{\sigma-1}) = \frac{2}{\kappa} \left(1 + \frac{1}{\beta(\mu-1)} \right) \frac{1}{\beta L(\mu-1)} - L = \frac{1}{2L} (L_0^2 - L^2) < 0.$$

Because the solution set to $F(x) < 0$ is $(\varepsilon_-^{\sigma-1}, \varepsilon_+^{\sigma-1})$, with $\varepsilon_0 < \varepsilon_-$, any $\varepsilon \in (\varepsilon_-, \varepsilon_+)$ satisfies both $\varepsilon > \varepsilon_0$ and the no-trap condition. Conversely, any $\varepsilon > \varepsilon_0$ outside of this interval violates the no-trap condition. ■

Condition (31) is indispensable for our analysis. Notably, there exists an $\varepsilon > \varepsilon_0$ that satisfies the no-trap condition, $\Theta > \varepsilon^{\sigma-1}/\kappa$, if and only if (31) holds.²⁷ Thus, in the following analysis, we assume (31) to avoid the trivial case of any economies getting trapped in the no-innovation situation.

Lemma 4 characterizes the parameter range in which the economy has the potential to innovate and grow in the long run. Lemma 4 also states that the role of love of novelty ε in achieving $\Theta > \varepsilon^{\sigma-1}/\kappa$ is ambiguous because Θ is increasing in ε , which generates two opposite effects of ε . On the one hand, (a) a higher ε makes the invention of new goods profitable relative to the investment in existing product development. As a result of this relative profitability effect, the new product development regime $(0, \varepsilon^{\sigma-1}/\kappa)$ will become large, whereby the economy is more likely to become trapped in the new product development regime. However, (b) a higher ε also leads to a larger potential demand Θ , and there are more new goods $N(t)$ to be created in the new product development regime. This leaves more incentives for firms to engage in existing product development, noting that new goods are the essential source of existing product development. With this positive indirect effect of ε , the economy is more likely to jump out of the new product development region. These two opposite effects interact to create an equilibrium role for ε . The following two propositions show that the role of the love of novelty ε in innovation is also ambiguous.

Proposition 1 *When the infinitely lived consumer's love of novelty ε is moderate, such that $\varepsilon \in (\varepsilon_-, \varepsilon_+)$, the economy achieves long-run growth, through perpetual cycles between periods of new product development and existing product development.*

Proof. For $\varepsilon \in (\varepsilon_-, \varepsilon_+)$, because of Lemmas 2 and 4, $\Theta > \varepsilon^{\sigma-1}/\kappa$ holds and the new product development regime is always explosive. Thus, any path starting from initial values lower than $\varepsilon^{\sigma-1}/\kappa$ eventually moves toward the existing product development regime. Then, because of Lemma 3, the economy will necessarily go back to some point within the new product development regime. Therefore, if ε is moderate, the economy perpetually fluctuates, moving back and forth between the two regimes. In this case, innovation occurs perpetually and cyclically because both N_t and A_t permanently grow over time, but alternately. ■

Proposition 1 suggests that the love of novelty ε can be a source of innovation-driven growth in the long run, because there are permanently expanding goods spaces, $N(t)$

²⁷The sufficiency of (31) is proven in Lemma 4. Notably, $D \leq 0 \Leftrightarrow L \leq L_0$. (31) is also necessary because quadratic inequality (32) has no solution if $L \leq L_0$.

and $A(t)$. Innovation-driven growth occurs here because the aforementioned two opposite effects of ε can be balanced well in a moderate range of ε . However, if the level is extreme, the love of novelty ε can be a cause of underdevelopment traps rather than the source of growth, by depressing innovation.

Proposition 2 *When the infinitely lived consumer's love of novelty ε is sufficiently weak or strong, such that $\varepsilon \notin (\varepsilon_-, \varepsilon_+)$, a globally stable equilibrium trap occurs in which new products are invented but none can survive in the market, due to the absence of existing product development. The economy fails to achieve long-run growth.*

Proof. For $\varepsilon \notin (\varepsilon_-, \varepsilon_+)$, because of Lemmas 2 and 4, $\Theta \leq \varepsilon^{\sigma-1}/\kappa$ holds and the new product development regime is a trap. Because of Lemma 3, the existing product development regime is always explosive, and any path starting from any point in either regime is eventually trapped in the new product development regime. ■

Proposition 2 implies that the “fear of novelty” (Beveridge 1959, Barber 1961) and love of novelty may both cause an economy to fall into an underdevelopment trap. It is straightforward to understand that the consumer's fear of novelty negatively affects innovation. Intuitively, with a smaller ε , the consumer has a smaller demand for new products $N(t)$, implying smaller $N(t)$. Because new goods are the input for existing product development, a smaller $N(t)$ discourages existing product development by lowering its net benefit, which comes from the aforementioned effect (b). As a result, with a strong fear of novelty, or a very low ε , the economy is more likely to be caught in the trap, in which investments in new product development occur and investments in existing product development do not occur. Because both types of innovative investments are essential, the numbers of new goods and old goods, $N(t)$ and $A(t)$, are constant over time. Thus, a very weak love of novelty, or a strong fear of novelty, can cause the underdevelopment trap of no long-run growth. This result is consistent with the historical view in Mokyr (2000), who considers that the lack of “receptivity of a society to new technological ideas” is “an integral part of underdevelopment.” The innate fear of novelty for consumers should be an important source of the absence of receptivity.

Equally important, Proposition 2 also identifies the negative role of a too *strong* love of novelty. This role may seem counter-intuitive but the mechanism is natural. Due to effect (b), a high ε encourages new product development, providing more new goods $N(t)$. Then, it further encourages existing product development, because existing product development uses new goods as input. However, due to effect (a), ε increases the relative profitability of new product development to existing product development. When ε is very high, this relative profitability effect dominates the positive one to take away from firms any incentives for existing product development. In this case, only new product development occurs in equilibrium. The economy is trapped again, in which $N(t)$ and $A(t)$ are constant over time. Thus, no long-run growth is observed in an economy with a too strong love of novelty.

Those two propositions identify the ambiguous role of the consumer's love of novelty in innovation and innovation-based growth. The following theorem provides a summary.

Theorem 1 *When the love of novelty is moderate, it is the fundamental source of innovation-based economic growth in the long run. However, a too strong love of novelty and a too weak love of novelty causes an underdevelopment trap, in which new goods are invented*

(due to the presence of new product development) but do not survive (due to the absence of existing product development). In the trapped situation, the total number of goods, $N(t) + A(t)$, is constant over time; there is no long-run growth.

Proof. Proven in the text by using Propositions 1 and 2. ■

In Theorem 1, we identify an ambiguous role of the public’s love of novelty in innovation and innovation-based economic growth. Intuitively, the love of novelty encourages the invention of new goods, but each innovation also involves investments for the survival of those invented (existing) goods. Thus, innovation at the aggregate level can be maximized with a good balance between new and existing product development. This is why the role of love of novelty is ambiguous; a too weak and a too strong love of novelty depresses innovation, whereby the economy can be caught in underdevelopment traps with no long-run growth. In summary, we conclude that the love of novelty is a source of innovation-based growth but can become a cause of underdevelopment traps when too strong. The threshold values of the love of novelty ε determine which case occurs and are formally derived in Lemma 4.

As shown in Appendix A, we observe suggestive evidence that supports our result. First, using cross-country data, we observe inverted U-shaped relationships between the love of novelty and innovation. This result is consistent with our theoretical finding of the ambiguous role of love of novelty in innovation. Second, we also observe a positive relationship between the love of novelty and the level of *originality* of innovations at the country level. Assuming new product development generates more *original* innovations than existing product development, the evidence suggests a positive effect of the love of novelty on new product development. As explained, the positive effect on new product development is the key mechanism for our theoretical result. All in all, the cross-country patterns may support the relevance of our theory.

5 Extensions

In this section, we explore two extensions to our baseline model. First, our economy features only trap and cycle in dynamic equilibrium. By introducing an exogenous growth factor into the baseline model, we show that the model can have a balanced growth equilibrium similar to the standard growth model. Second, for analytical tractability, we assume the one-period nature of monopoly power. We relax this assumption and allow for a long lived monopoly, whereby the model is more similar to the canonical R&D-based growth models (Romer 1990, Grossman and Helpman 1991, Aghion and Howitt 1992). In these extensions, our main message continues to hold: a too strong love or fear of novelty can depress innovation and economic growth in the long run. Notably, these extensions also resolve another limitation of the baseline model, by generating a new equilibrium in which new and existing development coexist.

5.1 Balanced Growth and Path Dependence

To allow for a balanced growth equilibrium, we add minimal elements to the process of innovation. Following Anderlini et al. (2013), we introduce an exogenous growth

factor, $\eta(t) \geq 0$, into new product development;²⁸ the number of endogenously invented goods, $A(t)R^N(t)$, together with the number of exogenously given ones, $\eta(t)$, determine the dynamics of new goods by $N(t+1) = A(t)R^N(t) + \eta(t)$. This captures so-called “invention by accident,” which sometimes occurs in reality.²⁹ Without any intended investments or efforts, researchers can simply create new ideas by accident or mistake as a by-product of regular, intentional research activity. For the sake of simplicity, we assume $\eta(t) = \eta N(t)$, with $\eta \in [0, 1)$.³⁰ When $W^n(t) = 0$, the new good $N(t)$ thus evolves in the new product development regime due to

$$N(t+1) = \Theta A(t) + \eta N(t), \quad (34)$$

which corresponds to (25). When $W^a(t) = 0$, the free entry condition similar to (28) is now

$$\rho(t+1) = \frac{\kappa\beta}{\mu/(\mu-1)} \frac{E(t)}{w(t)} - \frac{A(t)}{N(t)} - \eta\varepsilon^{\sigma-1}, \quad (35)$$

which uses $N(t+1) = \eta N(t)$ because $R^N(t) = 0$. From (27) and (35), in the existing product development regime, the old good $A(t)$ evolves due to

$$\rho(t+1) = \frac{1}{1 + \beta(\mu-1)} \left(\beta(\mu-1)\kappa L - \frac{A(t)}{N(t)} - \eta\varepsilon^{\sigma-1} \right).^{31} \quad (36)$$

Combining (34) and (36), we can derive the equilibrium dynamic system as:

$$n(t+1) = \begin{cases} \eta n(t) + \Theta \equiv \varphi^N(n(t)) & \text{for } n(t) < \varepsilon^{\sigma-1}/\kappa \\ \frac{\eta(1+\beta(\mu-1))n(t)}{\beta(\mu-1)+(\beta(\mu-1)\kappa L - \eta\varepsilon^{\sigma-1})n(t)} \equiv \varphi^A(n(t)) & \text{for } n(t) > \varepsilon^{\sigma-1}/\kappa \end{cases}, \quad (37)$$

which uses (18).³² Function φ^N is linear, φ^A is concave, and both are increasing in $n(t)$, each of which has a unique fixed point for $n(t) > 0$, labeled n^* and n^{**} , respectively.

With a slight modification to the conditions, Proposition 1 continues to hold at least locally. (A proof requires a tedious sequence of similar calculations, which is omitted here.)³³ Suppose

$$L > \frac{1-\eta}{\kappa} \left(1 + \frac{1}{\beta(\mu-1)} \right) + \frac{1}{\beta(\mu-1)} \equiv L'_0,$$

to avoid the trivial case likewise. Then, we can revise Lemma 4 as follows: Under the coexistence of endogenous and exogenous innovation, there exists a threshold value of

²⁸Exogenous growth factors are often assumed in research for a deeper understanding of the role of technological progress in various phenomena; see, for instance, Lucas and Moll (2014) and Benhabib et al. (2017). Given that our goal in this paper is to investigate the cause of innovation, our extended model still has the endogenous component, $R^N(t)$, which is more in accordance with Anderlini et al. (2013), who consider endogenous and exogenous growth factors in the process of technological progress.

²⁹See, for example, Middendorf (1981) for more details on this type of innovation.

³⁰If $\eta > 1$, the new good, $N(t)$, autonomously expands without the help of endogenous new product development. Given the focus of our paper, we should restrict the exogenous growth factor to be lower than 1; $\eta < 1$.

³¹To ensure feasibility, such that $\rho(t+1) \in (0, 1)$ for any $n(t)$, it would suffice to assume $\beta(\mu-1)\kappa L - ((\beta(\mu-1) + \kappa/\varepsilon^{\sigma-1}) + 1) < \eta\varepsilon^{\sigma-1} < \beta(\mu-1)\kappa L$.

³²We also use $A(t+1) = A(t)$ for $n(t) < \varepsilon^{\sigma-1}/\kappa$ and $N(t+1) = \eta N(t)$ for $n(t) > \varepsilon^{\sigma-1}/\kappa$. To ensure $n(t+1) > 0$ for any $n(t) > \varepsilon^{\sigma-1}/\kappa$, we impose an upper bound of ε , such that $\varepsilon < [(\kappa/\eta)\beta(\mu-1)L]^{1/(\sigma-1)}$.

³³A formal proof is available upon request from the authors.

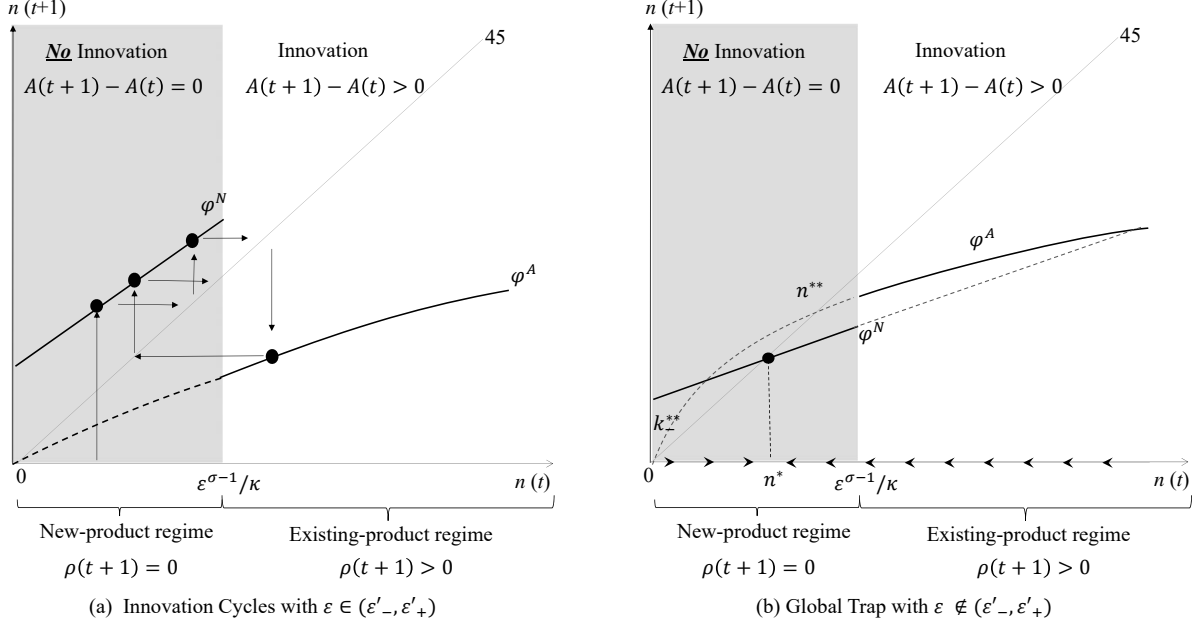


Figure 4: Cycles and Global Traps

ε , ε'_+ , such that $\Theta/(1-\eta) > \varepsilon^{\sigma-1}/\kappa$ holds for $1 < \varepsilon < \varepsilon'_+$, and $\Theta/(1-\eta) \leq \varepsilon^{\sigma-1}/\kappa$ for $\varepsilon \geq \varepsilon'_+$.³⁴ This shows that if (and only if) the consumer's love of novelty ε is sufficiently strong, there is a *locally* stable trap, n^* . Once the economy falls into the new product development regime, the economy is trapped and converging to the situation, n^* , in which there is no innovation.

Concerning the existing product development regime, there are two possibilities. First, if n^{**} exists outside this regime, the equilibrium behavior of the economy is quite similar to that in the original model. That is, when $n^* > \varepsilon^{\sigma-1}/\kappa$, the economy achieves innovation and growth perpetually through irregular cycles of new and existing product development (Figure 4a). Otherwise, that is, if $n^* < \varepsilon^{\sigma-1}/\kappa$, the economy is fatally caught in a globally stable trap, n^* , called a global trap (Figure 4b).

Second, if n^{**} is included in the existing product development regime, it may work as a globally stable steady state (Figure 5a). This case is for $n^* > \varepsilon^{\sigma-1}/\kappa$. At point n^{**} , the number of new goods, $N(t)$, and that of old goods, $A(t)$, grow at the same rate. Therefore, in this case, any path starting from any initial state converges to point n^{**} that provides the economy balanced growth, similar to the standard growth model. Figure 5b depicts another interesting case where $n^* < \varepsilon^{\sigma-1}/\kappa$. There are two locally stable steady states, and whether the economy converges to a balanced growth path, n^{**} , or a locally stable trap, n^* , depends on the initial condition. So-called path dependence implies that the economy may suffer from a lock-in by virtue of historical events (e.g., Arthur 1989). We call this sort of trap a local trap.

In summary, we demonstrate that the minor change leads to drastically different equilibrium behaviors of the economy such as balanced growth and path dependence; however, the message in our main results does not alter: A too strong love of novelty, and a too weak love of novelty, negatively affect innovation and growth in the long run.

³⁴Notably, ε'_- and ε'_+ are solutions to the quadratic equation in ε , given by $\Theta/(1-\eta) = \varepsilon^{\sigma-1}/\kappa$, noting $n^* = \Theta/(1-\eta)$. They are almost the same as ε_- and ε_+ in Lemma 4.

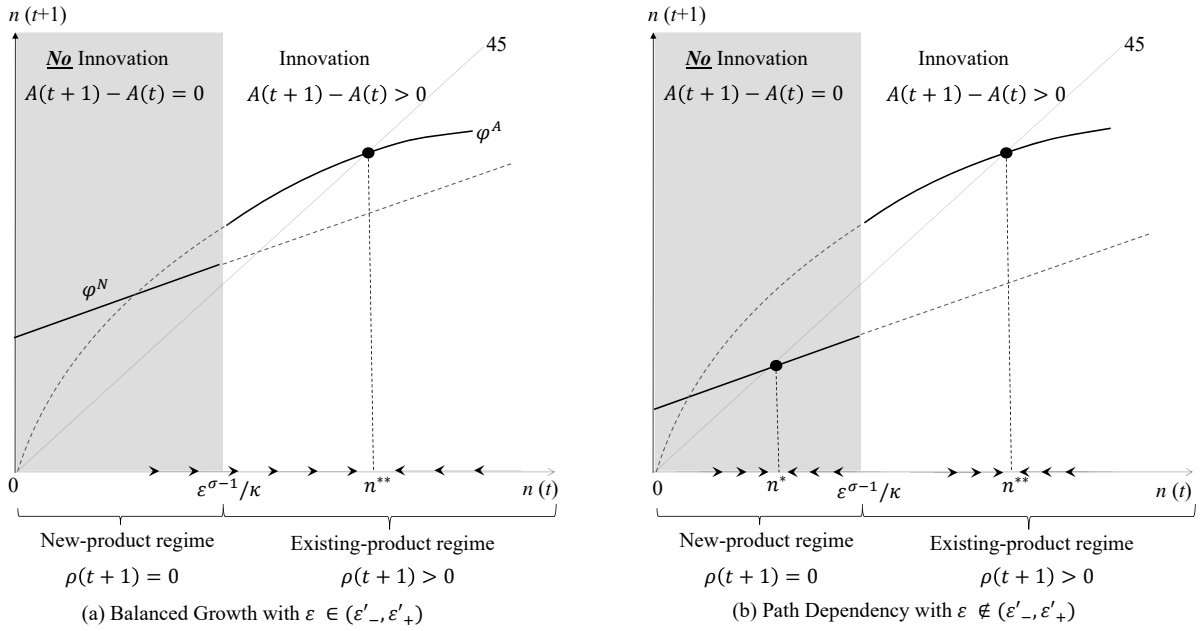


Figure 5: Balanced Growth and Path Dependency

5.2 Departing from a One-period Monopoly

The purpose of the second extension is to relax the assumption of a one-period monopoly. To achieve this goal, we consider a stochastic process through which firms can obtain long-lived monopoly power. Specifically, we assume that if an R&D firm that invents a new good in period t invests $z(t)/A(t)$ units of labor in existing product development,³⁵ it will survive with long-lived monopoly power from period $t+1$ onward at a probability of $s(t+1) = s(z(t)) \in [0, 1]$. At the probability of $1 - s(t+1)$, the firm fails to obtain long-lived monopoly power and exits. We consider a simple linear survival function such as $s(z) = \psi z$ with $z \geq 0$; see Dinopoulos and Syropoulos (2007) and Eicher and García-Peñalosa (2008) for R&D-based growth models with this type of endogenous survival of innovations.³⁶ Here, $\psi > 0$ is a productivity parameter. Because $s(z)$ is a probability, $s(z) \leq 1$ must hold, and thus $z \leq 1/\psi$. The law of motion governing the evolution of the old goods $A(t)$ is, thus, given by

$$A(t+1) = A(t) + s(t+1)N(t). \quad (38)$$

The discounted present value of a new good (or a firm inventing a new good) can be described as the following Bellman equation:

$$V^n(t) = \max_{z(t)} \left[\pi^n(t) - \frac{w(t)z(t)}{A(t)} + s(t+1) \frac{V^a(t+1)}{1+r(t)} \right] \quad (39)$$

subject to $s(t+1) = \psi z(t) \in (0, 1)$. The discounted present value of a successfully survived firm follows the following Bellman equation:

$$V^a(t) = \pi^a(t) + \frac{V^a(t+1)}{1+r(t)}. \quad (40)$$

³⁵Alternatively, if we consider that an arbitrarily chosen outside firm makes this investment, the equilibrium conditions would not alter.

³⁶See also Furukawa (2013) and Niwa (2018) for more recent papers. In this section, we use the modelling specification of firms' endogenous survival developed by these two papers.

Solving optimization in (39), there are three kinds of equilibrium: (i) the value of an old good satisfies

$$\tilde{W}^a(t) \equiv \psi \frac{V^a(t+1)}{1+r(t)} - \frac{w(t)}{A(t)} = 0 \quad (41)$$

for $0 < z(t) < 1/\psi$; (ii) $z(t) = 1/\psi$ holds with $\tilde{W}^a(t) \geq 0$; and (iii) $z(t) = 0$ holds with $\tilde{W}^a(t) \leq 0$. Free entry for new product development ensures

$$W^n(t) \equiv \frac{V^n(t+1)}{1+r(t)} - \frac{w(t)}{A(t)} = 0 \quad (42)$$

for $N(t+1) > 0$.

Here we restrict our analysis to the more interesting interior-solution case, (i), in which new and existing product development coexist; $N(t+1) > 0$ and $1 < z(t) < 1/\psi$. Conditions (41) and (42) imply that the balanced values of new and old goods, $\psi V^a(t) = V^n(t)$, hold as long as $0 < z(t) < 1/\psi$. The following labor market clearing condition closes this extended model:

$$L = \frac{1}{\mu} \frac{E(t)}{w(t)} + \frac{z(t)N(t)}{A(t)} + \frac{N(t+1)}{A(t)}, \quad (43)$$

which is basically analogous to (21) except that the aggregate use of labor for existing product development now depends on each firm's endogenous decision, $z(t)$. Using (38)–(43), we can show that the equilibrium dynamical system in terms of the rate of innovation, $g(t) \equiv (A(t+1) - A(t))/A(t)$, is as follows.³⁷

$$1 + g(t+1) = \frac{\varepsilon^{\sigma-1}}{\varepsilon^{\sigma-1} - \psi} \left[(1 + \psi L + \beta\psi) - \frac{\varepsilon^{\sigma-1}}{\varepsilon^{\sigma-1} - \psi} \frac{\beta\psi(1 + \psi L)}{1 + g(t)} \right]. \quad (44)$$

Using (44), we can straightforwardly prove the following: In the interior case of $0 < z(t) < 1/\psi$, for any given $g(t)$ on an equilibrium path, the equilibrium rate of innovation $g(t+1)$ can be an inverted U-shaped function in the love of novelty ε . To verify this, we define $\tilde{\varepsilon} \equiv \varepsilon^{\sigma-1}/(\varepsilon^{\sigma-1} - \psi)$ and $\varepsilon^* \equiv (1 + \beta + \psi L)(1 + g(t))/(2\beta(1 + \psi L))$ for descriptive convenience. Then, (44) becomes

$$1 + g(t+1) = \tilde{\varepsilon} \left[(1 + \beta + \psi L) - \frac{\beta(1 + \psi L)}{1 + g(t)} \tilde{\varepsilon} \right]. \quad (45)$$

Differentiating (45), $g(t+1)$ increases (decreases) with $\tilde{\varepsilon}$ for $\tilde{\varepsilon} \in (0, \varepsilon^*)$ (for $\tilde{\varepsilon} \in (\varepsilon^*, 2\varepsilon^*)$). Therefore, an inverted U-shaped relationship is observed between $\tilde{\varepsilon}$ and $g(t+1)$, and the maximum point is ε^* . Because $\tilde{\varepsilon}$ is decreasing in ε and the feasible domain of $\tilde{\varepsilon}$ is $(1, \infty)$ (resulting from $\varepsilon \in (\psi, \infty)$), we can straightforwardly show that the relationship between ε and $g(t+1)$ is also an inverted U-shape for the feasible range of ε if $\varepsilon^* > 1$. This inequality holds for any $g(t) > 0$ if $1 + \beta + \psi L > 2\beta(1 + \psi L)$, which holds when, for instance, ψ is sufficiently small. To conclude, in the general case in which a monopoly can last longer than one period, the love of novelty can have an inverted-U effect on innovation and growth. This result confirms our main message that the role of the public's love of novelty in innovation and growth is ambiguous.

³⁷See Appendix B for a proof on the derivations of (44).

6 Concluding Remarks

In this study, we explore the role of people’s love of novelty in innovation and innovation-based growth by developing an innovation-based growth model in which the role of consumers’ love of novelty in aggregate innovation can be addressed. In the model, innovation is the combination of two types of innovations, new product development and existing product development; additionally, the infinitely-lived representative consumer has a particular preference for new products (compared with old products), in addition to the standard love-of-variety preferences. Using this model, we show that the consumer’s love of novelty can be a source of innovation and long-run growth when moderate. Then, we demonstrate a mechanism through which the love of novelty can cause underdevelopment traps that result in less innovations when its level is too weak or too strong. Thus, we conclude that people’s love of novelty might have an ambiguous effect: too weak and too strong love for novelty can depress innovation and innovation-driven growth.

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Appendix A: Cross-country Relationships Between Love of Novelty, Innovation, and Originality

In this Appendix, we document some suggestive evidence regarding the country-level relationships between Love of novelty, Innovation, and Originality.

Data and variables To measure the “Love of novelty” of the people of a country, we use data from Question E046 of the World Values Survey (WVS). This survey question asks respondents to score this statement, “Ideas stood test of time better vs New ideas better.” The score ranges from 1 (“Ideas that stood test of time are generally best”) to 10 (“New ideas are generally better than old ones”). To construct the country-level measure, we collapse the WVS sample with valid responses to E046 into country-level means. This variable is also used by Bénabou et al. (2015) to measure people’s general openness to novelty.

We use patent data from the World Intellectual Property Organization (WIPO) and population data from the World Bank to construct several measures of innovation, including Patent applications per million capita in log, Trademark applications per million capita in log, Industrial design applications per million capita in log, and Scientific and technical journal articles per million capita in log.³⁸ As an alternative measure of innovation, we also use the Global Innovation Index.³⁹

Our “Originality” variable measures a country’s “original” patents relative to the “benchmark” U.S. patent within the same patent class and granting year. Specifically, we use the NBER patent data from Hall et al. (2001) to construct this variable. The NBER patent database contains a measure of originality for each patent granted between 1973 and 1999, defined as:⁴⁰

$$1 - \sum_{j=1}^J \left(\frac{\text{Citations made which belong to patent class } j}{\text{Total citations made}} \right)^2. \quad (\text{A1})$$

This measure takes a high value when a patent cites other patents that belong to a wide range of patent classes but a low value when only citing other patents that belong to a narrow range of patent classes. For each patent class and granting year, we identify the “benchmark” as the median value of the above measure in (A1) for U.S. patents. For each patent, we compute the difference between the patent’s originality measure in (A1) and the U.S. benchmark. Then our Originality index for a country is the average of this difference; when a country has a higher Originality index, then this country’s patents tend to be more original than the U.S. benchmarks.

In the next subsection, we report the unconditional relationships between Love of novelty, Innovation, and Originality. We also estimate several simple ordinary least squares (OLS) regressions with additional country-level controls, including log GDP per capita,

³⁸More specifically, Patent applications per million capita for a country is computed as the sum of the country’s patent applications over 2010–2015 divided by the country’s average population over 2010–2015. The other measures are computed in a similar way.

³⁹For each country, we take the average of non-missing values over 2011–2015 as its Global Innovation Index.

⁴⁰See Bento (2018) for a recent study that also uses Hall et al.’s (2001) originality measure. Notably, his focus is quite different from ours, and particularly on the effects of patent protection on patent originality.

log Population, intellectual property protection, years of tertiary schooling, net inflow of foreign direct investment as a percentage of GDP, and religiosity (share of religious people and share of people believing in God).⁴¹ Data for GDP per capita are from the World Bank; data for the net inflow of foreign direct investment (FDI) as a percentage of GDP are from the World Development Index (WDI); the index of patent rights comes from Park (2008); data for years of tertiary schooling are from Barro and Lee (2013). To construct the two measures of religiosity, we use the survey questions F034 and F050 of WVS. More specifically, F034 asks whether the respondent is a religious person (the survey question is: “Independently of whether you go to church or not, would you say you are ...” with possible answers 1 (“A religious person”), 2 (“Not a religious person”), and 3 (“A convinced atheist”).) F050 asks whether the respondent believes in god (the survey question is: “Which, if any, of the following do you believe in? ... God” with possible answers 0 (“No”) and 1 (“Yes”).) Notably, the control variables are country-level means between 1990 and 2010 except that the two religiosity measures are means between 1981 and 2002. Table 1 reports the summary statistics of the various variables used.⁴²

Results and discussions We first examine the relationship between Love of novelty and Innovation. Figure 6(a) to Figure 6(e) show the scatter plots of the country-level means of E046 of WVS against the five different aforementioned innovation measures. In each scatter plot, the line is a fitted quadratic curve. In these various scatter plots, we observe an inverted-U relationship between Love of novelty and Innovation: Innovation is lower when Love of novelty is either very weak or very strong. These relationships are all statistically significant. The aforementioned relationships are purely unconditional. We also estimate a set of OLS regressions by including various country-level control variables. These results are reported in Tables 2 to 6, respectively. We find that the inverted-U relationship is significant (except when the Global Innovation Index is the outcome variable).

Next, we examine the relationship between Love of novelty and Originality. Figure 6(f) shows a scatter plot of the country-level means of E046 of WVS against our Originality measure. The linear fitted line has a positive slope (but is statistically insignificant). In Table 7, we also estimate a set of OLS regressions. We find that, when other control variables are included (in Columns (2) to (4)), Love of novelty is positively and significantly related to Originality.

Overall, there seems to be an inverted-U relationship between Love of novelty and Innovation and a positive relationship between Love of novelty and Originality. Nevertheless, we are aware of various limitations of the empirical analysis. For instance, one major concern is regarding the measurement of “love of novelty.” In the empirical analysis, we use data from the WVS to construct the country-level love of novelty index. We can argue that answers to such types of survey questions do not necessarily provide an accurate measure of the extent to which consumers love new products. One further question is whether these answers can be compared across countries; this comparison is especially relevant in our case because we cannot control for country-level differences through country fixed-effects in our country-level regressions. An even more challenging concern is whether the relationships we observe are causal. Without a credible instrument that is correlated with people’s love of novelty but is not correlated with other factors that

⁴¹These control variables are also used in Bénabou et al. (2016).

⁴²Notably, this variable has an outlier (for Colombia); its value is 8.210, whereas the maximum value of the remaining countries is approximately 6.185. In the results reported, this outlier is excluded.

can potentially affect innovation activities, we cannot show that love of novelty *causally* affects innovation activities.

Although these empirical concerns are important, it is beyond the scope of this study to address them. Therefore, we emphasize that the empirical results reported in this Appendix should be interpreted as *suggestive* evidence in line with the predictions of the theoretical predictions of our model.

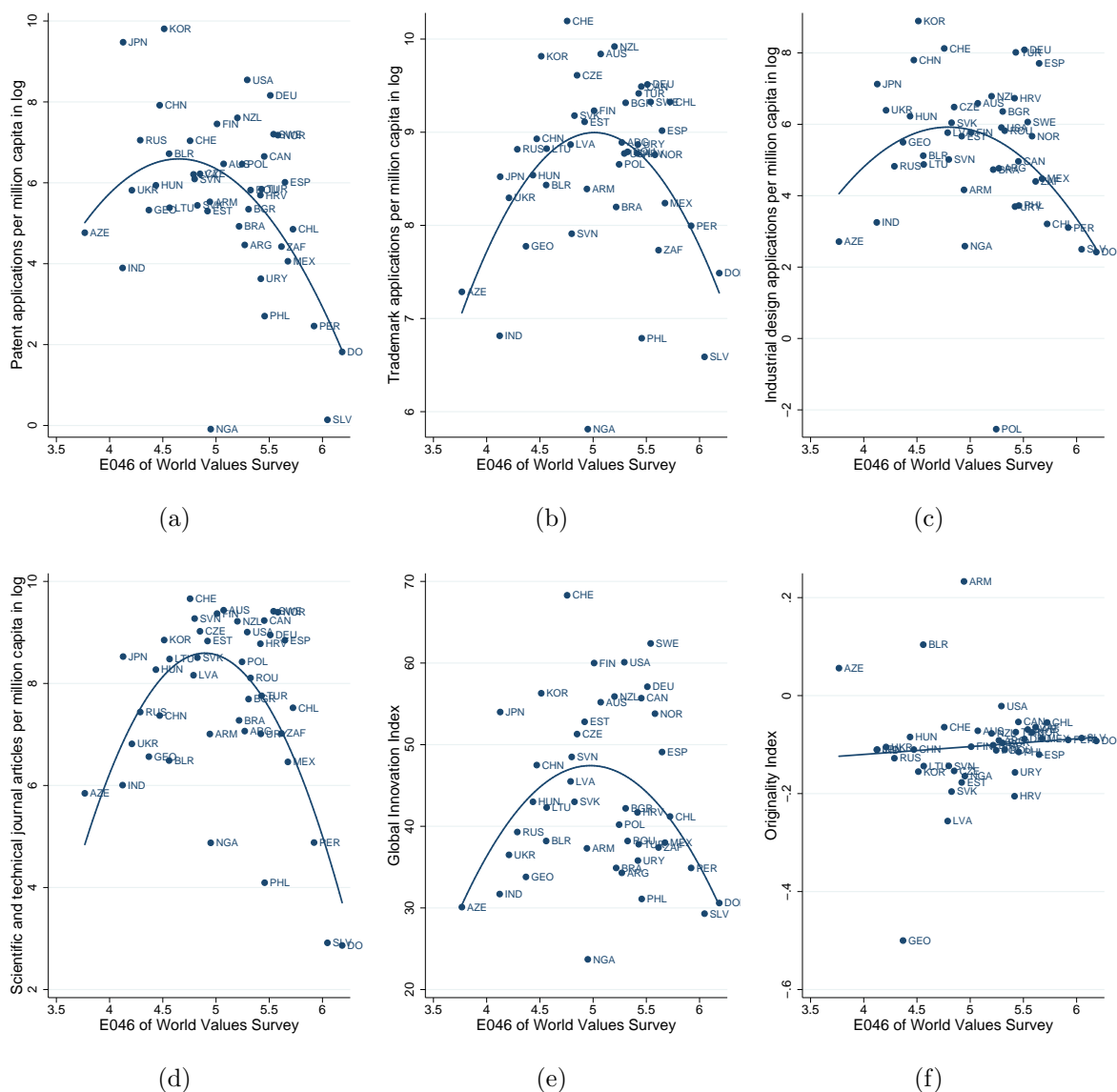


Figure 6: Scatter plots

Table 1: Summary statistics

Variable	<i>N</i>	Mean	S.D.	Min.	1st Q.	Median	3rd Q.	Max.
Patent applications per million capita in log	43	5.622	2.092	−0.090	4.766	5.820	7.039	9.807
Trademark applications per million capita in log	43	8.606	0.950	5.812	8.198	8.790	9.316	10.194
Industrial design applications per million capita in log	43	5.245	2.061	−2.540	4.163	5.667	6.483	8.894
Sci. and tech. journal articles per million capita in log	43	7.599	1.719	2.865	6.816	8.108	8.950	9.661
Global Innovation Index	43	43.721	10.521	23.700	35.800	41.700	53.800	68.300
Originality	43	−0.103	0.100	−0.500	−0.144	−0.101	−0.075	0.233
E046 of WVS	43	5.065	0.563	3.767	4.563	5.201	5.457	6.185
GDP per capita in log	43	9.140	1.150	6.713	8.163	9.098	10.222	11.275
Population in log	43	2.997	1.644	0.343	1.644	2.717	4.146	7.133
Index of patent rights	35	3.458	0.673	2.382	2.936	3.250	4.074	4.840
Years of tertiary schooling	31	43.868	20.138	10.280	28.860	40.300	59.700	79.640
FDI (as % of GDP)	43	3.768	3.473	0.142	1.860	2.921	4.293	21.356
% religious people	43	0.659	0.195	0.160	0.556	0.708	0.804	0.949
% people believing in God	41	0.811	0.166	0.424	0.672	0.856	0.960	0.996

Table 2: The relationship between Love of novelty and Innovation (1)

	(1)	(2)	(3)	(4)
Love of novelty	18.756*** (6.579)	7.912 (5.023)	12.661** (5.018)	9.268* (4.792)
(Love of novelty) ²	-2.016*** (0.655)	-0.942* (0.496)	-1.362*** (0.502)	-1.024** (0.477)
GDP per capita (log)		0.843*** (0.316)	0.687** (0.284)	0.738*** (0.254)
Population (log)		0.411** (0.166)	0.469*** (0.123)	0.323** (0.128)
Index of patent rights		0.537 (0.401)	0.318 (0.392)	0.479 (0.345)
Years of tertiary schooling		0.018 (0.012)	0.023** (0.009)	0.019** (0.009)
FDI (as % of GDP)		0.042 (0.104)	0.001 (0.081)	-0.072 (0.079)
% religious people			-2.841*** (0.829)	
% people believing in God				-2.958*** (0.927)
Constant	-37.030** (16.351)	-21.679* (12.432)	-31.195*** (11.737)	-22.430** (11.265)
Observations	43	31	31	29
R^2	0.265	0.842	0.881	0.900

Note: The dependent variable is Patent applications per million capita in log. Robust standard errors are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 3: The relationship between Love of novelty and Innovation (2)

	(1)	(2)	(3)	(4)
Love of novelty	12.526*** (2.953)	9.278*** (2.900)	11.232*** (2.924)	10.330*** (2.885)
(Love of novelty) ²	-1.250*** (0.298)	-0.948*** (0.283)	-1.120*** (0.286)	-1.033*** (0.282)
GDP per capita (log)		0.503** (0.228)	0.439* (0.231)	0.458** (0.221)
Population (log)		0.021 (0.089)	0.044 (0.071)	-0.015 (0.077)
Index of patent rights		-0.266 (0.286)	-0.356 (0.283)	-0.310 (0.276)
Years of tertiary schooling		0.006 (0.006)	0.008 (0.006)	0.008 (0.006)
FDI (as % of GDP)		0.098 (0.074)	0.081 (0.067)	0.056 (0.069)
% religious people			-1.168** (0.472)	
% people believing in God				-0.989 (0.628)
Constant	-22.391*** (7.210)	-17.986** (6.999)	-21.900*** (6.686)	-19.595*** (6.558)
Observations	43	31	31	29
R^2	0.230	0.698	0.735	0.748

Note: The dependent variable is Trademark applications per million capita in log. Robust standard errors are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 4: The relationship between Love of novelty and Innovation (3)

	(1)	(2)	(3)	(4)
Love of novelty	16.938*** (6.250)	6.281 (10.277)	16.384** (7.566)	18.186*** (5.579)
(Love of novelty) ²	-1.766*** (0.607)	-0.739 (1.007)	-1.632** (0.759)	-1.847*** (0.552)
GDP per capita (log)		0.747** (0.363)	0.416 (0.319)	0.501 (0.323)
Population (log)		0.072 (0.211)	0.195 (0.164)	0.067 (0.163)
Index of patent rights		0.940* (0.540)	0.475 (0.396)	0.474 (0.384)
Years of tertiary schooling		-0.030 (0.019)	-0.019 (0.016)	-0.016 (0.014)
FDI (as % of GDP)		0.001 (0.149)	-0.086 (0.134)	-0.103 (0.119)
% religious people			-6.044*** (2.232)	
% people believing in God				-3.351** (1.404)
Constant	-34.685** (15.812)	-16.371 (24.429)	-36.613** (17.903)	-41.421*** (12.661)
Observations	43	31	31	29
R^2	0.136	0.369	0.530	0.665

Note: The dependent variable is Industrial design applications per million capita in log. Robust standard errors are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 5: The relationship between Love of novelty and Innovation (4)

	(1)	(2)	(3)	(4)
Love of novelty	28.827*** (4.930)	19.842*** (4.053)	20.307*** (4.105)	19.741*** (4.309)
(Love of novelty) ²	-2.944*** (0.494)	-2.061*** (0.395)	-2.102*** (0.398)	-2.041*** (0.419)
GDP per capita (log)		1.053*** (0.309)	1.038*** (0.309)	1.039*** (0.296)
Population (log)		0.171* (0.101)	0.177* (0.097)	0.164 (0.103)
Index of patent rights		0.054 (0.377)	0.032 (0.377)	0.058 (0.362)
Years of tertiary schooling		0.001 (0.007)	0.001 (0.007)	-0.000 (0.007)
FDI (as % of GDP)		0.139** (0.070)	0.135* (0.070)	0.121* (0.068)
% religious people			-0.278 (0.551)	
% people believing in God				-0.595 (0.551)
Constant	-61.975*** (12.171)	-50.279*** (9.381)	-51.210*** (9.500)	-49.606*** (9.950)
Observations	43	31	31	29
R^2	0.427	0.905	0.906	0.910

Note: The dependent variable is Scientific and technical journal articles per million capita in log. Robust standard errors are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 6: The relationship between Love of novelty and Innovation (5)

	(1)	(2)	(3)	(4)
Love of novelty	116.348*** (28.577)	13.917 (26.129)	34.502 (28.068)	14.254 (23.452)
(Love of novelty) ²	-11.693*** (2.812)	-1.755 (2.533)	-3.573 (2.669)	-1.699 (2.223)
GDP per capita (log)		5.201*** (1.225)	4.528*** (1.453)	4.985*** (1.261)
Population (log)		0.224 (0.797)	0.475 (0.702)	-0.533 (0.672)
Index of patent rights		5.799*** (1.827)	4.851*** (1.676)	5.735*** (1.590)
Years of tertiary schooling		-0.003 (0.069)	0.018 (0.079)	0.020 (0.064)
FDI (as % of GDP)		0.357 (0.631)	0.180 (0.485)	-0.068 (0.480)
% religious people			-12.315** (5.419)	
% people believing in God				-3.404 (5.654)
Constant	-241.981*** (71.391)	-49.802 (64.658)	-91.048 (67.642)	-45.619 (57.965)
Observations	43	31	31	29
R ²	0.164	0.846	0.875	0.889

Note: The dependent variable is Global Innovation Index. Robust standard errors are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 7: The relationship between Love of novelty and Originality

	(1)	(2)	(3)	(4)
Love of novelty	0.016 (0.029)	0.032*** (0.011)	0.022** (0.009)	0.013* (0.008)
GDP per capita (log)		0.009 (0.006)	0.012* (0.006)	0.012** (0.006)
Population (log)		0.009* (0.005)	0.007* (0.004)	0.007* (0.004)
Index of patent rights		0.012 (0.009)	0.017* (0.009)	0.016* (0.008)
Years of tertiary schooling		-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
FDI (as % of GDP)		0.004 (0.002)	0.004** (0.002)	0.006*** (0.002)
% religious people			0.058** (0.023)	
% people believing in God				0.112*** (0.022)
Constant	-0.184 (0.158)	-0.426*** (0.098)	-0.438*** (0.084)	-0.462*** (0.080)
Observations	43	31	31	29
R^2	0.008	0.397	0.488	0.611

Note: The dependent variable is Originality. Robust standard errors are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Appendix B: Proof for (44)

Solving the maximization problem in (39), the first order condition gives rise to

$$\psi \frac{V^a(t+1)}{1+r(t)} = \frac{w(t)}{A(t)}, \quad (\text{B1})$$

which must hold in the interior-solution equilibrium where $z(t) \in (0, 1/\psi)$. Incorporating (B1) for (39) and (40) yields

$$V^n(t) = \pi^n(t) \quad (\text{B2a})$$

and

$$V^a(t) = \pi^a(t) + \frac{w(t)}{A(t)}, \quad (\text{B2b})$$

respectively.

Together with these conditions on innovation values, we will derive the equilibrium dynamical system of the extended model (for the interior-solution case). First, substituting (B2a) and (B2b) into the balanced value condition $\psi V^a(t) = V^n(t)$, we obtain

$$\frac{E(t)}{w(t)} = \frac{\psi}{\varepsilon^{\sigma-1} - \psi} \frac{\mu}{\mu - 1} \frac{A(t) + \varepsilon^{\sigma-1} N(t)}{A(t)}, \quad (\text{B3})$$

which uses (12), (14), and (20) for the expressions of profits, $\pi^n(t)$ and $\pi^a(t)$. To proceed, we need to assume $\varepsilon^{\sigma-1} > \psi$ since $E(t)/w(t)$ must be positive. Second, substituting (B2a) into the free entry condition (42), we obtain

$$\frac{E(t)}{w(t)} = \frac{1}{\beta \varepsilon^{\sigma-1}} \frac{\mu}{\mu - 1} \frac{A(t+1) + \varepsilon^{\sigma-1} N(t+1)}{A(t)}, \quad (\text{B4})$$

which uses the Euler equation (9), (12) and (20). Finally, incorporating (38) for the labor market equilibrium condition (43), with $s(t+1) = \psi z(t)$, we obtain

$$\frac{E(t)}{w(t)} = \mu \left[L - \frac{1}{\psi} \frac{A(t+1) - A(t)}{A(t)} - \frac{N(t+1)}{A(t)} \right]. \quad (\text{B5})$$

These three conditions, (B3)–(B5), govern the equilibrium dynamic behavior of our economy in the interior case of $z(t) \in (0, 1/\psi)$. Specifically, these determine $E(t)/w(t)$, $A(t+1)$, and $N(t+1)$ as a function in $A(t)$ and $N(t)$.

Since our interest is in the dynamics of the growth rate, $g(t) \equiv (A(t+1) - A(t))/A(t)$, we rewrite (B3)–(B5) as follows. First, we use (B4) and (B5) to express $N(t+1)$ as a function of $g(t)$ and $A(t)$:

$$N(t+1) = A(t) \frac{1}{\psi} \left[\frac{(\psi L + 1)(\beta(\mu - 1))}{\beta(\mu - 1) + 1} - \frac{\beta \varepsilon^{\sigma-1}(\mu - 1) + \psi}{\varepsilon^{\sigma-1}(\beta(\mu - 1) + 1)} (1 + g(t)) \right]. \quad (\text{B6})$$

Using (B3) and (B4), then, we express $1 + g(t)$ as a function in $A(t)$, $N(t+1)$, and $N(t)$:

$$1 + g(t) = \frac{\beta \psi \varepsilon^{\sigma-1}}{\varepsilon^{\sigma-1} - \psi} \left(1 + \varepsilon^{\sigma-1} \frac{N(t)}{A(t-1)} \frac{1}{1 + g(t-1)} \right) - \varepsilon^{\sigma-1} \frac{N(t+1)}{A(t)}, \quad (\text{B7})$$

which uses $A(t) = A(t-1)(1 + g(t-1))$. To eliminate $N(t+1)$ and $N(t)$ from (B7), we use (B6), yielding (44).