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PRODUCT INNOVATION AND CONTESTABILITY

BY

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1 INTRODUCTION

The implications of potential competition have been stressed time and again starting from different perspectives (Clark 1915, Robinson 1933, Harrod 1953 and Demsetz 1968). The concept of investment contestability fits into this tradition. The essential assumption of the contestable market is the dominance of the threat of potential entry. Investment contestability introduces entry-deterring investment in a free entry framework (Van Witteloostuijn 1988 and 1989). Investment contestability is inspired by the literature on workable competition (Clark 1940 and Sosnick 1958), entry barriers (Bain 1956 and Stigler 1968) and contestable markets (Baumol 1982 and Baumol *et al.* 1982).[1] This note elaborates on perfect contestability by introducing product innovation. Suppliers employ the manipulation of product quality (as well as price) as a way to deter entry.

This means that this note's argument proceeds along the lines of Kim (1987). Kim (1987) examines a contestable *multi*-product *monopolist* which is choosing *once and for all* an optimal set of quality varieties to be offered. This note departs from Kim's model by focusing on firms' decisions on *single*-product, *incremental* quality improvements in a *non-monopoly configuration.* In line with Kim, it will be shown that zero-profit pricing and a strategy of consumers' utility maximisation are necessary conditions for sustainability of a contestable market configuration. However, a non-monopoly configuration introduces additional sustainability requirements since both of the preceding conditions fail to be sufficient. Moreover, this note identifies the source of potential entry in a two-market (or two-country) setting.

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1 Moreover, reference must be made to the literature on pre-emptive strategy (Gilbert and Newberry 1982 and Gilbert 1986) and innovation (Dasgupta and Stiglitz 1980 and Kamien and Schwartz 1982).

In effect, three arguments are outlined: (i) profit is *just* sufficient to reward investment in (product) innovation (Proposition 1); (ii) incumbent firms are forced to introduce product improvements that maximise buyers' utility (Proposition 2); and (iii) product innovation increases the likelihood of both temporary and intertemporal unsustainability (Proposition 3). The propositions are derived from economic intuition. The article is organised as follows. Section 2 briefly indicates the essentials of investment contestability. Section 3 presents an illustrative model of product innovation. Section 4 examines sustainability features. Section 5 offers final observations.

2 INVESTMENT CONTESTABILITY

2.1 *Perfect Contestability*

The essential feature of a perfectly contestable market is vulnerability to 'hit-and-run' entry (Baumol 1982, pp. 3–4), wich follows from the absence of barriers to entry and exit. Baumol uses the definition that '[a] contestable market is one into which entry is absolutely free, *and exit is absolutely costless*' (1982, p. 3). Successful entry is associated with positive entry profits, because the entrant 'can go in, and, before prices change, collect his gains and then depart without cost' (Baumol 1982, p. 4). This means that Bertrand-Nash expectations are imposed. The pervasive fear of entry forces incumbent single-product firms to adopt (minimum) average cost pricing in order to deter entry (*irrespective* of prevailing market structure).

The contestability framework endogenises market structure: number and size of firms depend on cost and demand properties. Although perfect contestability implies Pareto-optimal (minimum average cost) price setting at a point in time, its optimal properties over time are questionable, because a contestable market is incompatible with sunk investment (Schwartz and Reynolds 1983, Shepherd 1984 and Stiglitz 1987). Moreover, 'in the intertemporal case unsustainability can come closer to being the rule rather than the exception' (Baumol *et al.* 1982, p. 405), where intertemporal unsustainability follows from entry and/or exit movements over time. Aside from intertemporal unsustainability, sunk investment can induce temporary unsustainability, where temporary sustainability indicates an integer number of incumbent firms in equilibrium.

2.2 *Sunk Investment and Free Entry*

Investment contestability introduces sunk investment in a free entry framework (Van Witteloostuijn 1988 and 1990), which raises the important question of whether an assumption of a positive sunk cost is compatible with a free entry condition, since the literature suggests that any positive sunk cost erects an entry barrier (Baumol and Willig 1981, Grossman 1981, Baumol *et al.* 1982, Farrell 1986, Stiglitz 1987 and Dasgupta and Stiglitz 1988). The key point is that entry barriers only emerge when sunk costs introduce a *disadvantage* for (potential) entrants relative to incumbent firms. The investment contestability framework applies to those cases where incumbent firms assume that the sunk cost incurred *ex ante* does *not* raise an entry barrier *ex post* to *all* potential entrants. The case of innovation can illustrate this point.

Stiglitz (1987) notes that '[m]ost expenditures on R&D are, by their very nature, sunk costs. The resources spent on a scientist to do research cannot be recovered. Once it is spent, it is spent' (p. 928). However, R&D outlays need not necessarily introduce a barrier. Innovative potential entrants can face free entry and costless exit after the introduction of the innovation. The essential feature of investment contestability is that incumbent suppliers assume that there are potential entrants around which undertake sunk R&D as well. This validates the entry threat. The literature generally assumes that potential competitors face the need to bear *incremental* sunk costs upon entry (Baumol and Willig 1981 and Stiglitz 1987). Investment contestability drops this assumption.

The deviation from perfect contestability follows from the observation that the investment costs incurred *ex ante* introduce *costly* exit to the *incumbent firms ex post* if they leave the market before the sunk investment is fully amortized. If an incumbent firm is retaliated by an entrant, then it fails to recover fully the sunk costs invested. The key point is that sunk capital can give an exit cost. This contradicts perfect contestability. Perfect contestability is compatible with investment if the remaining investment cost can be recouped at any exit data. That is, perfect contestability assumes that firms are always able to benefit from selling or alternative use of the investment outside the market, so that exit cost is zero by assumption, irrespective of the date of exit. This is not the case in a market with investment contestability.[2] If exit occurs before the sunk investment is fully amortized, selling or alternative use of the sunk capital is not cost effective. That is, (part of) the investment is not fully recoupable outside the market. This means that (part of) the investment cost has to be recovered in the market. For the sake of the argument, below sunk cost refers to the unrecoupable part of investment cost (Martin 1989),[3] where R&D outlays are assumed to be completely unrecoupable.

2.3 *Credible Entry Threat*

Van Witteloostuijn (1988) describes five scenarios where the introduction of sunk cost does *not* violate the free entry condition. Recent models that support investment contestability are Kim (1987), Cairns and Mahabir (1988), Calem (1988), Maskin and Tirole (1988),Mills (1988), Rashid (1988) and Van Witteloostuijn and Maks (1988). Here it suffices to point to one illustrative ex-

2 The term contestability is retained, since investment contestability, as perfect contestability, assumes that external competition dominates over internal competition. That is, the pervasive entry threat is still effective. Potential entrants which undertake R&D in a home market can exert a credible entry threat even if sunk investment is positive. Van Witteloostuijn (1988) and Van Witteloostuijn and Maks (1988) use the term barrier market rather than investment contestability.

3 Of course, pure exit cost can be introduced as firms can discount the net present value of pure exit cost (*i.e.*, cost incurred at the date of exit) in current calculations.

ample. Sunk cost does not raise an entry (and exit) barrier if, after entering the incumbents' market, an entrant is able to recover the sunk costs incurred before exiting the market. This means that the response lag of the incumbent firm exceeds the lifetime of the innovation concerned.

Of course, it is necessary to assume that there are potential entrants around which are innovating. Here it is plausible to think that there can be entry from a closely related industry or nearby region (Caves and Porter 1977). For example, Shepherd (1984) and Green (1987) point to the increasing importance of (a fear of) imports. Shepherd argues that '[i]n recent decades, imports have probably provided the most important form of new competition in industrial markets in advanced economies. They may offer the best chances for applying Baumol *et al.*'s approach, even if the concepts may need adapting' (p. 584). Green supports Shepherd's view by asserting that 'one might justifiably question the relevance of the contestable market paradigm for competition policy on the grounds of nongenerality, if it were not for the growing influence of foreign competition' (p. 485).

Cairns and Mahabir (1988) even argue that the validity of an assumption of contestability *increases* if sunk investment is permitted. Here they point to 'an already existing firm in a market which is a prototype of the market to be contested' (p. 270). So, they 'propose that the idea of potential entry as a disciplinary force requires latent excess capacity, latent fungibility, and the ability of firms to alter endogeneously the industry product set through their own strategies. In such a situation the existence of sunk costs may actually *improve* the chances of a firm to contest a market' (p. 272; italics added).

A further reference is Calem (1988). Calem offers a model of penetrable markets. A penetrable market shows a close resemblance to the investment contestability assumption: 'The potential entrant may be a firm producing an identical product but operating in a geographically distinct market, in which case ease of entry would derive from low transport costs; or it may be a firm producing a distinct but technologically related product, in which case ease of entry would derive from substitutability in production. A market faced with entry as such may be deemed a *penetrable market*. It is plausible that a firm in a penetrable market would be unable to adjust its total output as rapidly as a potential entrant could transfer some of its product into the market. ... the rivalry between a firm in a penetrable market and a firm threatening to enter that market may be reciprocal. As these firms operate in related markets, each may be a potential entrant into the other's market' (Calem 1988, p. 171; Calem's italics). It is essential that incumbent firms and potential entrants decide on output *simultaneously*. That is, '[a] novel feature of our model is that the monopolist in a market, and the firm threatening entry into the market, *both* make strategic choices (choose their total outputs) during the pre-entry stage' (Calem 1988, p. 172; Calem's italics).[4]

4 A major result of the model is that '[i]n a penetrable market, as in a contestable market, a threat of entry can limit the exercise of monopoly power' (Calem 1988, p. 173).

3 PRICE AND PRODUCT INNOVATION

3.1 *Two-Period – Two-Market Model*

Investment contestability can be illustrated with a two-period – two-market model: period $t = 0, 1$ and market $f = i, e$. R&D takes one period of time: that is, R&D outlays have to be incurred up-front in period $t = 0$, whereas the firm can introduce the innovation in period $t = 1$. The firm sets a price (p) for the new product by adding a markup (m) to average variable and fixed cost (c)

$$p_1 = c_1 + m_1 \tag{1}$$

so as to permit the recovery of sunk R&D cost. That is, the markup in period $t = 1$ should be sufficiently large so as to recover the cost incurred in period $t = 0$.

The essential feature of investment contestability is that incumbent firms anticipate the entry threat by innovative potential entrants which capture a zero profit in the incumbents' market if they refrain from entry. In a two-market framework this means that incumbent firms (superscript i) in market $f = i$ take notice of the strategies of potential entrants (supercript e) in market $f = e$ (and *vice versa*) by assuming that $s_0^e = s_0^i$ and $\pi_1^e = 0$ if entry is abandoned (where s represents sunk R&D expenditures and π denotes the payoff derived from market $f = i$). The products traded in market $f = i$ and $f = e$ are perfect substitutes. Both markets are characterised by localised demand. That is, only firms are mobile between markets. Here it can be plausible to consider a two-country setting, where potential entrants reflect the fear of imports (Bulow *et al.* 1985, Pinto 1986 and Calem 1988). The model is described from the perspective of an incumbent firm in market $f = i$ which does not consider entry into market $f = e$ (potential entrants being aware of this attitude).[5]

3.2 *Two-Stage Game with Product Innovation*

Incumbent firms and potential entrants play a two-stage Bertrand-Nash game on innovation. In the first stage ($t = 0$) firms decide on product innovation, which can be effectuated in the second stage ($t = 1$). In the second stage firms compete over prices. In accordance with theoretical and empirical research

5 For example, Calem (1988) introduces the assumption of one-sided entry (threat) by arguing that the incmbent firms' entry cost is sufficiently large to keep it from entering the potential entrants' market (p. 175) or, alternatively, by supposing that there exist legal or regulatory barriers which prevent incumbent firms from being potential entrants into market $f = e$ (note 5, p. 182). Reciprocal entry (threats) introduce(s) complicated strategic interactions. For example, non-binding (excess) capacities imply a threat of reciprocal dumping (Pinto 1986), whereas binding productive capacities introduce a home market disequilibrium if entry is undertaken (Cairns and Mahabir 1988). These complications are ignored by assuming, first, zero opportunity cost of entry and, second, one-sided entry threat. Bulow *et al.* (1985), Pinto (1986), Calem (1988) and Van Wegberg and Van Witteloostuijn (1989) drop one or both assumption(s).

(Kamien and Schwartz 1982, pp. 64–70 and 194) innovative activity is assumed to yield decreasing returns. That is,

$$v_1 = V(s_0), \tag{2}$$

where v denotes product quality, $\partial V/\partial s_0 > 0$ and $\partial^2 V/\partial {s_0}^2 < 0$. Sunk investment in period $t=0$ raises price [equation (1)] *and* quality [equation (2)] in period $t=1$. Following the introduction of an innovation the profit (ignoring discounting)

$$\pi_1 = (p_1 - c_1) \cdot q_1 - s_0 \tag{3}$$

accrues to a firm in period $t=1$ (where q denotes output).

Incumbents show a first-mover advantage in the sense that entrants can only outperform incumbents if they offer a strictly lower price or better product. For the game on product innovation this means that firms compete over price-quality combinations. In order to illustrate the incumbent firms' first-mover advantage, a four-stage structure is adopted. In t^1 incumbent firms announce prices in their home market. The potential entrants' price responses follow in t^2: that is, the entrants' entry prices are declared *after* the incumbents' announcement of home market prices. In t^3 both the incumbents and the entrants produce/supply output for/in market $f=i$. Supply is equal to the quantity demanded from the firm. So, provided that incumbent firms and potential entrants offer similar quality, for incumbent firms this implies that $q^i > 0$ if $p^i \leq p^e$ and $q^i = 0$ if $p_i > p^e$, whereas (potential) entrants face $q^e > 0$ if $p^i > p^e$ and $q^e = 0$ if $p^i \leq p^e$. The game is closed in t^4, where transactions take place. The game is one which has complete and perfect information. The structure of the game is summarised in Fig. 1.

		Incumbents firms	*(Potential) entrants*
$t=0$		Sunk investment: s_0^i	Sunk investment: s_0^e
$t=1$	t^1	Introduction innovation	Introduction innovation
		Home market prices: p_1^i	
	t^2		Entry market prices: p_1^e
	t^3	Home market output: q_1^i	Entry market output: q_1^e
	t^4	Market transactions	

Figure 1 – Structure of the game

3.3 *Second Stage: Price*

Let p_1^* be the price that yields the revenues just sufficient to reward the investment $s_0^i = s_0^e = s_0$ ($\pi_1 = 0$): that is, p_1^* is the average total cost price. Perfect contestability's assumption of firms' homogeneity is retained. Both incumbent firms and potential entrants have access to the same production and investment (product innovation) technology: $c_1^i = c_1^e = c_1$ and $v_1^i = v_1^e = v_1$. The second-stage game on prices proceeds as perfect contestability theory (although with positive sunk cost) predicts (Knieps and Vogelsang 1982 and Brock 1983). Incumbent firms have two regions of relevant pricing strategies: $p_1^i > p_1^*$ and $p_1^i = p_1^*$. Strategies reflecting $p_1^i < p_1^*$ are dominated, because they generate a negative payoff. Potential entrants are able to reply with the help of two regions or relevant responses: $p_1^e < p_1^i$ and non-entry. Actions yielding $p_1^e \geq p_1^i$ are not worthwhile, since successful entry is then not feasible.

If incumbent firms set prices that earn above-normal profits ($p_1^i > p_1^*$), identical potential entrants are then able to enter profitably by offering a slightly lower price such that $p_1^* < p_1^e < p_1^i$, which yields $\pi_1^e > 0$. Bertrand contestability implies that $q_1^i = 0$ and $q_1^e > 0$ if the entrant offers a price lower than the incumbent (for equal quality). If the incumbent firm adopts zero-profit pricing ($p_1^i = p_1^*$), then successful entry requires a price such that $p_1^e < p_1^i = p_1^*$. However, both the incumbent firm and potential entrant then suffer losses so that the potential entrants' optimal response is not to enter. The incumbent firm's strategy $p_1^i = p_1^*$ is associated with a nonnegative payoff, given the set of optimal replies of the potential entrant. Hence, in order to prevent a potential entrant from being able to profit from a second-mover advantage the incumbent firm adopts zero-profit pricing, which constitutes a unique Nash equilibrium strategy.

So, the distinguishing features of investment contestability determine the way m_1 is calculated. Zero profit implies that

$$m_1^i = s_0/q_1. \tag{4}$$

If condition (4) holds, the price is such that the R&D investment is just paid off. An incumbent firm which sets a price in excess of the one associated with equations (1) and (4) in order to attain above-zero profits, provokes entry. Then, $m_1^i > s_0/q_1$. If the following condition holds, entry is feasible and profitable:

$$m_1^e = m_1^i - \beta, \tag{5}$$

where $m_1^i - s_0/q_1 \leq \beta \leq m_1^i$. The potential entrant is then able to undercut the incumbent firm's price. That is, if the incumbent firm introduces a markup on average nonsunk cost such that a positive profit would be earned if the potential entrant refrains from entry, the potential rival can profitably enter by discounting a slightly lower markup which still permits to capture revenues in excess of production and investment cost. Hence, successful entry is associated with $\pi_1^i = -s_0 < 0$, and $\pi_1^e > 0$, because Bertrand contestability implies that all the incumbent firm's buyers switch to the potential entrant before the incumbent firm can respond or retaliate: $q_1^i = 0$ and $q_1^e > 0$.

PROPOSITION 1 (zero profits). Investment contestability yields profits just sufficient to reward investment. Incumbent firms' compliance with the zero-profit condition constitutes a unique Nash equilibrium strategy.

3.4 *Product Quality*

In a contestable environment, the introduction of product variety can be adopted as a competitive weapon, either to deter entry or to enter (Kim 1987, Cairns and Mahabir 1988 and Rashid 1988). In the literature product differentiation is often simply restricted to a unidimensional quality continuum (Kihlstrom and Levhari 1977). The utility of the buyers depends on the quantities of x other commodities $(q^1, \ldots, q^x)$ and the quality (υ) and quantity of the product involved (q): $u^j = U(q^1, \ldots, q^x, q, \upsilon)$, where u^j denotes utility of buyer j and $\partial U/\partial \upsilon > 0$. For reasons of simplicity, buyers' *homogeneity* is assumed. That is to say, all buyers are characterised by similar utility and demand functions, preference orderings and budget constraints. A representative buyer decides on the basis of

$$u_t = U(q_t^1, \ldots, q_t^x, q_t, \upsilon_t), \quad \text{and} \tag{6}$$

$$\left(\sum_{i=1}^{x} p_t^i \cdot q_t^i\right) + p_t \cdot q_t \leq b_t. \tag{7}$$

Equations (6) and (7) give

$$D_t = D(p_t^1, \ldots, p_t^x, b_t, p_t, \upsilon_t), \tag{8}$$

where b represents budget constraint and D market demand for the product involved. The utility and demand function are subject to the usual assumptions of continuity, convexity and signs of the first-order derivatives. The composition of alternative spending opportunities $(q_t^1, \ldots, q_t^x, p_t^1, \ldots, p_t^x)$ and the budget constraint (b_t) are assumed to be given and constant for $t = 0, 1$.

Suppliers in a market with product innovation have two competitive weapons: price and quality. The free entry assumption is in line with many contributions to the product differentiation literature, from Hotelling (1929) and Chamberlin (1933) to Lancaster (1966 and 1979) and Gabszewicz and Thisse (1980). To reach a position of exit avoidance and entry deterrence an incumbent firm seeks to introduce a product which offers maximum utility to the buyers. Rashid (1988) suggests that '[i]n the long run the only way to stay is by pleasing customers; this requires providing them with the goods they really want, and this long-term dependence of producers upon customers is perhaps the most effective guarantee of quality' (p. 248). In the simple two-period context this result is easily illustrated.

3.5 *First Stage: Product Innovation*

Incumbent firms and potential entrants play a first-stage Nash game on product innovation. Let u_1^* represent the maximum utility of the representative buyer (through a $p_1 - v_1$ combination) which is feasible in period $t=1$, where u_1^* follows from optimal sunk R&D outlays s_0^* in period $t=0$. That is,

$$u_1^* = \operatorname*{Max}_{q_1, v_1} u_1 = U(., q_1, v_1), \tag{9}$$

subject to the feasibility condition that $\pi_1 = 0$ (the binding nature of which follows from the second-stage game). Using Lagrange multipliers transforms the maximisation problem (9) into

$$u_1^* = \operatorname*{Max}_{q_1, v_1, \sigma} L_1 = U(., q_1, v_1) - \sigma \cdot (\pi_1 - 0). \tag{10}$$

Hence, $\partial L_1/\partial q_1 = 0$, $\partial L_1/\partial v_1 = 0$ and $\partial L_1/\partial \sigma = 0$. Moreover, the matrix of second-order derivatives should be negative semidefinite.

Kim (1987) and Van Witteloostuijn and Van Wegberg (1988) solve equation (10) for R&D technology (2) and specified linear forms of the utility function, which gives an optimal sunk R&D outlay s_0^*, average total cost price p_1^* and quality v_1^* [equations (1), (2) and (4)]. To be precise, Kim (1987) uses the utility function $u = v \cdot q - p$, whereas Van Witteloostuijn and Van Wegberg (1988) adopt the simple repackaging model (Deaton and Muellbauer 1980, pp. 260–263). The key point is that the assumption of consumers' homogeneity implies that all buyers select the same quality. For example, the simple repackaging model with buyers' homogeneity predicts that the representative consumer will prefer the product variety which offers the minimum p_1/v_1 ratio.[6]

Incumbent firms have two regions of relevant strategies: $u_1^i < u_1^*$ and $u_1^i = u_1^*$ (where $u_1 < u_1^*$ follows from $s_0 \neq s_0^*$ and u_1^* is associated with s_0^*). A potential entrant's set of replies contains two relevant regions: $u_1^e > u_1^i$ and non-entry. Actions yielding $u_1^e \leq u_1^i$ are not worthwhile, because then the potential entrant is unable to outperform the incumbent.[7] If an incumbent firm fails to offer a product which yields u_1^* to buyers, then a potential entrant is able to push aside the incumbent firm by supplying a product which offers $u_1^i < u_1^e < u_1^*$ yielding $\pi_1^e > 0$, which follows from the observation that $u_1^i < u_1^e$ permits the potential entrant to increase price above average total cost up to the point where the entrant's price-quality combination is just preferred to the incumbent's. If $u_1^i < u_1^e$, all buyers immediately switch from the incumbent firm to

6 Only the accidental case where a number of varieties share the minimum p_1/v_1 ratio, gives more than one quality in equilibrium. For the current argument the (non)uniqueness feature of the optimal product innovation does not matter.

7 Entry with $u_1^e = u_1^i$ is assumed not to be worth the bother. Since buyers have no preference for either equally-equipped supplier, it is likely that they will follow their buying routines rather than switch to the entrant. Of course, a similar argument underlies Baumol *et al.*'s contestable market. There it is assumed that successful entry only occurs for $p_1^e < p_1^i$.

the potential entrant, given the assumptions of Bertrand competition, investment contestability and buyers' homogeneity. When the incumbent firm adopts $u_1^i = u_1^*$, a potential entrant's reply $u_1^e > u_1^i$ is not possible. The strategy combination $u_1^i = u_1^*$ and non-entry is a *unique* Nash equilibrium.

In line with Kim's (1987) result it appears that entry deterrence (or exit avoidance) requires zero-profit pricing in combination with a strategy of investments in product quality so as to maximise consumers' utility. This means that behaviour in the market yields (partial) *Ramsey optimality*. Ramsey optimality implies that buyers' utility is maximised, subject to the financial viability of the firms (Baumol *et al.* 1982, p. 6). By adopting $u_1^i = u_1^*$ the incumbent firm takes advantage of being the first mover. To uphold the pervasive threat of entry it is required that incumbent firms assume that there are potential entrants around which are able to leapfrog over an incumbent firm's innovation if the incumbent deviates from the optimal product innovation (Fudenberg *et al.* 1983).

PROPOSITION 2 (maximisation buyers' utility). Investment contestability implies that incumbent firms are forced to maximise buyers' utility in order to deter entry. This behaviour constitutes a unique Nash equilibrium strategy.

4 UNSUSTAINABILITY

4.1 *Efficient Scale*

Maximisation of buyers' utility is however not sufficient for entry deterrence or exit avoidance. The point is that unsustainability of market configurations can interfere. Baumol *et al.* (1982) illustrate the contestability framework with the help of the special case of a flat-bottomed U-shaped average nonsunk (*i.e.*, variable and fixed) cost curve.[8] The constant returns interval is of crucial importance in providing (temporary) sustainability of contestable markets (Ten Raa 1980 and Baumol *et al.* 1982). A flat-bottomed average nonsunk cost curve is associated with switching of type of returns:

$$c_t = C(q_t), \tag{11}$$

with $\partial C/\partial q_t < 0$ if $q_t < q_t^L$ (increasing returns), $\partial C/\partial q_t = 0$ if $q_t^L \leq q_t \leq q_t^R$ (constant returns) and $\partial C/\partial q_t > 0$ if $q_t > q_t^R$ (decreasing returns) for $t = 0, 1$.

The switching returns property of the average nonsunk cost curve can result, *ceteris paribus*, in exit or entry as soon as product quality improvement is introduced. This proposition is related to the (un)sustainability of market configurations. This result is even enhanced if the average cost function is of a usual U-shape with a unique minimum, which is the case when sunk cost is

8 The assumption that average cost is minimal over a range of output levels is not in conflict with the results of empirical research (Shepherd 1979 and Scherer 1980).

positive (Van Witteloostuijn and Van Wegberg 1988). Sunk cost by definition introduces increasing returns in production. Unlike a monopolist (Kim 1987) a firm is now *not* facing nondecreasing returns over the whole range of quantities offered.

In combination with production technology (11) a positive sunk cost implies that product innovation introduces a unique cost-minimizing scale (q^*) in period $t=1$, where $q_1^* > q_0^R$: that is, period $t=1$'s efficient scale exceeds period $t=0$'s. Contestability predicts that entry deterrence (or, to be precise, exit avoidance) requires the adoption of q_1^* and associated minimum average total cost price p_1^*. It is only by accident that $n_0 \cdot q_1^* = D(.,p_1^*, \upsilon_1^*)$, where n_0 is the number of incumbent firms in period $t=0$. This follows not only from increased efficient scale (*scale effect*), but also from the demand change that follows upon the introduction of the product innovation (*demand effect*).

4.2 *Demand Change*

Recall that perfect contestability's assumption of firms' homogeneity is retained: both incumbent firms and potential entrants have access to the same production and R&D technology. That is, the average nonsunk cost curve is assumed to be equal for all incumbent firms and potential entrants. Moreover, all incumbent firms and potential entrants offer the same product quality. The key point is that product innovation exerts influence on demand through both price and quality [equation (8)]. Demand shifts can introduce intertemporal unsustainability. *Ceteris paribus*, two cases can be distinguished as to the direction of demand change.

First, the quality improvement can be associated with decreasing demand: $\partial D/\partial \upsilon < 0$. The reason can be that the same utility level can be reached with less quantity. For example, if the product innovation implies that washing can be done with less detergent, satisfaction of the washing need in period $t=1$ can be reached by making use of a quantity of washing powder below period $t=0$'s level. Second, the product innovation can induce increasing demand: $\partial D/\partial \upsilon > 0$. This is the argument that increased quality can bring about a re-allocation of money resources (within the budget bound) from other commodities to the new product variety. For example, the innovation of record to compact disc can spur demand in period $t=1$ for sound recording mediums.

The scale and demand effect together indicate two potential sources of intertemporal unsustainability. The key argument is that the product innovation can increase efficient scale and change demand such that either $n_0 \cdot q_1^* > D(.,p_1^*, \upsilon_1^*)$ or $n_0 \cdot q_1^* < D(.,p_1^*, \upsilon_1^*)$, which indicates unsustainability. The first scenario emerges if product innovation goes hand in hand with either decreased demand or increased demand which cannot offset the scale effect. The second case occurs if demand is increased such that the scale effect is dominated.

4.3 *Exit*

Suppose that the product innovation introduces $n_0 \cdot q_1^* > D(., p_1^*, \upsilon_1^*)$. If $n_0 = 1$, then a potential entrant is unable to avoid the incumbent firm's diseconomies of scale without suffering losses. This market configuration is a monopoly (Baumol *et al.* 1982). For $n_0 > 1$ the prevailing market configuration is unsustainable, because the quality improvement induces (probably negative) market growth insufficient for all incumbent firms to produce and sell at efficient scale. Then, either some incumbent firms exit or all incumbent firms are outperformed by a smaller number of potential entrants. As it stands, the theory is unable to predict which alternative adjustment mechanism occurs (Schwartz and Reynolds 1983). Moreover, if some incumbent firms exit, it is unclear which incumbent firms will be the victim of unsustainability. None of the incumbent firms can be indicated as the canditate that has to exit on any *a priori* argument, since all firms are alike.

Nevertheless, equilibrium is reached when $D(., p_1^*, \upsilon_1^*)/n_1^* = q_1^*$, where $n_1^* < n_0$. It is here where the implications of the flat bottom of the average cost curve come in. The existence of an equilibrium market configuration is promoted by an increasing length of the flat bottom of the average cost curve (Baumol *et al.* 1982, pp. 36–40). If R&D sunk outlays remove the flat bottom from the scenery, the probability of temporary unsustainability (in the sense of a noninteger equilibrium number of firms) is increased. Market equilibrium can be retained if, for example, a niche incumbent or entrant is allowed to serve residual demand at an average cost price (so as to deter further entry) in excess of p_1^*.

4.4 *Entry*

Suppose that period $t = 0$'s investment induces $n_0 \cdot q_1^* < D(., p_1^*, \upsilon_1^*)$. The prevailing market configuration is unsustainable, because entry can be undertaken so as to satisfy contingent demand $D^r = D(., p_1^*, \upsilon_1^*) - n_0 q_1^*$. This holds both for monopoly and non-monopoly configurations. For illustrative purposes, a specific example of an entry mechanism is examined. The supply of period $t = 0$'s incumbent firms amounts to

$$Q_1^i = n_0 \cdot q_1^*. \tag{12}$$

Incumbent firms now leave residual demand D^r unfulfilled;

$$D^r = D(., p_1^*, \upsilon_1^*) - Q_1^i. \tag{13}$$

Potential entrants are able to enter profitably by absorbing residual demand. The entry process can easily be illustrated when sequential entry is assumed. An entrant offers q_1^e. Hence, post-entry residual demand is

$$D_a^r = D^r - Q_1^e, \tag{14}$$

with,

$$Q_1^e = \sum_{e=1}^{a} q_1^e, \tag{15}$$

where a denotes the number of actual entrants and D_a^r the residual demand which incumbent firms plus actual entrants leave unsatisfied. A potential entrant's decision making proceeds as follows: if $D_1^r \geq q_1^*$, then $q_1^e = q_1^*$; otherwise $q_1^e = D_a^r$. After successful entry $a = a+1$. If $D_a^r = 0$, then the profitable entry opportunities are exhausted; otherwise history is repeated. It should be noted that the first entrant facing the entry decision is confronted with $Q_1^e = 0$. A concluding remark is in order with regard to the supply of the last entrant (superscript S). It may be that $q_1^S < q_1^*$. Then, the last entrant's price exceeds the one of the incumbent firms and preceding entrants.

4.5 *Increased Probability of Unsustainability*

The analysis of the entry or exit adjustment mechanism shows that market structure is endogenised. Given demand, cost and quality properties, an equilibrium in the number and size of incumbent firms results. However, sunk product innovation increases the likelihood of both temporary and intertemporal unsustainability. Three effects explain this result. First, positive sunk cost introduces an increased and unique efficient scale. Second, improved quality exerts influence on demand. This means that a further sustainability condition is that $n_0 \cdot q_1^* = D(., p_1^*, v_1^*)$, which implies that market growth (so $\partial D/\partial v$ has to be positive), *precisely* outbalances the effect of increased efficient scale. The scale and demand effect together can induce intertemporal unsustainability. Third, a positive sunk cost introduces a unique cost-minimizing scale of production, which increases the probability of temporary unsustainability.

An integer number of firms in equilibrium can be supported by permitting a niche incumbent or entrant to satisfy residual demand at an (although not minimum) average cost price in excess of p_1^*. That is, if residual demand does not permit further entry with efficient scale ($D_a^r < q_1^*$), equilibrium can be reached by allowing one niche firm (either incumbent or entrant) to satisfy residual demand at inefficient scale ($q_1^S = D_a^r < q_1^*$). If the niche firm offers an above average (total) cost price, entry cannot be deterred.

PROPOSITION 3 (unsustainability). Investment contestability with product innovation implies that the likelihood of both temporary (scale effect) and intertemporal (scale and demand effect) unsustainability is increased.

5 FINAL OBSERVATIONS

The concept of investment contestability seeks to offer a benchmark case of competition by introducing entry-deterring sunk investment in a free entry framework. Although the models are based upon strict assumptions, they provide a framework to study the implications of deviating assumptions on the static and dynamic aspects of performance. It remains to be seen under what relaxed assumptions the results can be sustained. For example, the study of a framework with consumers' heterogeneity (so that competing product varieties can co-exist) deserves priority.

Except for monopoly, perfectly contestable market configurations are associated with Pareto-optimal price setting, because incumbent firms are forced to adopt minimum average (and marginal) cost pricing in order to deter entry. In the case of a monopoly the second-best solution prevails, given monopolist's average cost pricing. In the single-product case, average cost pricing implies (partial) Ramsey optimality. However, existing contestable market models deal with the case where sunk investment cannot occur.

It is in this context that investment contestability is relevant. Investment contestability is based upon the introduction of sunk investment in a free entry framework. In this way, dynamic economies of market behaviour are introduced. The investment cost has to be rewarded by means of a markup on average variable cost. Ramsey optimality is guaranteed, because incumbent firms are forced to introduce a markup such that the cost of investment is precisely rewarded. The introduction of higher product quality reflects a Pareto improvement, because incumbent firms are forced to maximise expected buyers' utility in order to avoid exit.

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Summary

PRODUCT INNOVATION AND CONTESTABILITY

This article deals with the introduction of product innovation in a contestable market model. Investment contestability describes a benchmark case of competition by introducing sunk entry-deterring investment in a free entry framework. Aside from careful price setting, suppliers adopt investment in product quality in order to deter entry. Zero-profit pricing and increased quality point to a partial second-best outcome of market behaviour.