Evolutionary economics

Applications of Schumpeter's ideas

Edited by
HORST HANUSCH
University of Augsburg

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Discussion

ALFRED MAUSSNER

Professor Klein's chapter shows brilliantly how ideas from biological evolutionary theory, imaginatively mixed with economic concepts, result in a rich theory of economic progress. The chapter is full of ideas, propositions, and explanations. In my view, its most fundamental contributions are in applying biological evolutionary theory to the study of economic progress and in uncovering the role competition plays in stimulating innovative effort. Hence, in the following, I shall limit my attention to the evolutionary concept underlying Professor

Klein's theory and to the proposed relation between the degree of competition and the average propensity to engage in risk taking (PERK).

I start with the differences between biological evolution and economic progress or, more generally, the evolution of human societies. Two principal differences are mentioned by Professor Klein. These are different driving forces (physical necessity versus survival in competitive markets) and different kinds of inputs (a roughly constant genetic diversity versus an ever increasing diversity of hints for successful innovations). I think there is a third major difference: Only human beings are able to discover what governs both biological evolution and socioeconomic evolution, and the knowledge we have obtained about the world's laws of motion gives us the power to take our own destiny in hand. This is certainly a philosophical argument, but, in as far as it is accepted, it changes the role of competition in socioeconomic evolution. Let me elaborate this point.

From the viewpoint of methodological individualism, competition is a social institution established by agreement of a sufficient number of individuals as a means to deal with scarcity. Individual agreement to this institution hinges on the benefits accruing from it. As Professor Klein has pointed out, in the long run, competition is a positive-sum game, but in the short run, there are winners and losers. Now suppose that people are more concerned with today's gains and losses than with future gains. In this case, competition is less favorable, and there will be efforts to reduce it.[1] Think, for example, of increasing protectionism. As a consequence, the pressure for technological improvement and thus economic progress decreases. At the same time, it is profitable to exhaust the given technological potential to a higher degree. Therefore, dynamic flexibility, as defined by Professor Klein, declines. Hence, the economic system will be more vulnerable to exogenous shocks. Furthermore, if we accept the hypothesis of Uzawa (1968) that increasing prosperity shifts people's attention toward today's events, it will be possible to explain the productivity slowdown during the past decade in most Western industrialized countries as a consequence of the rapid growth after World War II.[2]

What I have just tried to explain is that there is a connection between the outcomes of given market structures (and thus given degrees of competitiveness and the PERK) and the forces determining

[1] I have elaborated this point more precisely elsewhere (Maussner, 1986).

[2] Neumann (1985) develops a theory of long swings in economic evolution based on the interplay between growing prosperity and the favorableness of competition.

these structures. I think that evolutionary economics should take into account the mechanism based on this connection.

Let me now turn to the propositions concerning the relation between necessity brought about by dynamic competition and the PERK, as measured by the innovative performance of a firm. Professor Klein argues that increasing competitive pressure tends to raise a firm's PERK and that without the threat of foreign competition or the entry of more competitive rivals, the PERK will decline.

Both propositions seem strange from the perspective of traditional economic theory. A firm has command over a variety of instruments to protect profits from erosion by competitors. This variety ranges from product prices to advertising to lobbying for protection from competition. Thus, there cannot be a single road from more competition to more innovative effort. Furthermore, in a Nash equilibrium, by its very definition, a firm does not change its strategy as long as its competitors do not do so.

In order to prove these claims, I set up a simple model that includes the main ingredients of Professor Klein's model, namely, competitive pressure, product and process innovation, long-run profit maximization that implies that profits per period fall short of the profits a one-period profit maximizer could acquire, and the concept of a Nash equilibrium; that is, the firm takes (implicitly) the actions of its rivals as given when choosing its optimal strategy.

I consider a firm that seeks to maximize its present value (i.e., the discounted value of its net cash flow).[3] In order to do so, the firm has two instruments: the price of its product p and the degree to which it tries to bring about innovations π, which is a measure of the PERK. The model is entirely deterministic and contains no imaginative entrepreneur. Thus, it cannot compete in richness with Professor Klein's model, but even in this simple model it is by no means clear that an increase in competitive pressure raises the PERK. There are values of the elasticity of demand with respect to product quality $\epsilon_{q,x}$ conceivable for which an increase in competitive pressure will result in lowering the target level of the PERK.

This model may also help to explain changes in the interindustry pattern of the PERK, for its predicts that rising real interest rates (such as we have experienced in the more recent past) will induce firms operating in markets with a high $\epsilon_{q,x}$ to increase the PERK, while firms operating in quality-insensitive markets may find it profitable to reduce the PERK.

[3] The model is described and analyzed in the Appendix that follows.

Finally, I should point out that the firm faces no incentives to change the PERK as long as its rivals do not change their strategy, that is, $\bar{x}$ (competitive pressure) remains unchanged. Thus, only if the number of firms in a market is small, so that collusion is highly possible, is it conceivable that they commonly will agree to lower the PERK.

In concluding, I must stress that these results are derived from a simple model and thus have to be taken with care. Nevertheless, I hope they will stimulate the discussion of Professor Klein's ingenious chapter.

Appendix: Price and product policy of a profit-maximizing firm – a simple example

Consider a firm facing a linear, downward-sloping demand curve for its output q. If the firm does not try to improve the quality of its product via R&D effort, it will lose customers to its more innovative rivals. This is formally captured by shifting the demand curve toward the origin. Denote the firm's product price by p, and the shift parameter by x. Then the demand function can be written as[4]

$$q = q(p, x), \qquad q_p, q_x < 0, \qquad q_{pp}, q_{xx}, q_{px} = 0 \tag{1}$$

The change in x is given by the differential equation

$$\dot{x} = \bar{x} - \pi x, \qquad \bar{x} > 0 \tag{2}$$

where $\bar{x}$ measures the competitive pressure on the firm to improve the quality of its product, and π is a measure of successful innovations per unit of time t. If $\pi = 0$, $x(t) = \bar{x}t$, and the demand curve shifts smoothly toward the origin.

In addition to preventing the firm from losing customers, innovative activity decreases unit production costs c in successive periods of time according to

$$\dot{\tilde{c}} = -\pi\tilde{c} \tag{3}$$

Unit costs at a given time t are assumed to be independent of total production and are given by

$$c = a + \tilde{c}, \qquad a > 0 \tag{4}$$

Finally, assume that bringing about innovations costs $R(\pi)$, $R(0) = 0$,

[4] I denote partial derivatives of the function $f(y, z)$ by f_y, f_z, f_{yy}, f_{zz}, and f_{yz}. Derivatives of a function in one variable are denoted by prime. Derivatives with respect to time are denoted by a dot. All variables depend on time. For notational convenience, this is not made explicit.

0, R', $R'' > 0$. Hence, profit at time t is

$$(p - c)q(p, x) - R(\pi) \tag{5}$$

The firm seeks a price and product policy that will maximize the discounted value of its profits. Assuming a constant discount rate $r > 0$, this policy is found as the solution of the following optimal-control problem:

$$\max_{\{p, x\}} \int_0^\infty [(p - c)q(p, x) - R(\pi)]e^{-rt}\, dt$$

where

$$\dot{x} = \bar{x} - \pi x, \qquad \dot{\tilde{c}} = -\pi\tilde{c}, \qquad x(0) = x_0, \qquad \tilde{c}(0) = \tilde{c}_0$$

This solution[5] satisfies the following conditions:

$$q(p, x) + (p - c)q_p = 0 \tag{6a}$$
$$R'(\pi) = -\psi_1\tilde{c} - \psi_2 x \tag{6b}$$
$$\dot{\psi}_1 = \psi_1(r + \pi) + q(p, x) \tag{7a}$$
$$\dot{\psi}_2 = \psi_2(r + \pi) - q_x(p - c) \tag{7b}$$
$$\dot{x} = \bar{x} - \pi x \tag{7c}$$
$$\dot{\tilde{c}} = -\pi\tilde{c} \tag{7d}$$

The equations (6) determine at every $t \in [0, \infty]$ for given values of the state variables x and $\tilde{c}$ and the costate variables ψ_1 and ψ_2 the optimal values of the control variables p and π. These determine, in turn, via the equations of motion (7), the state and costate variables of the next period.

Obviously, equation (6b) implies that intertemporal profit maximization requires $\pi > 0$, and hence profits per period are lower than they were under short-run profit maximizing ($\pi = 0$).

A rest point of the system described by equations (6) and (7) is an equilibrium where $\dot{\psi}_1 = \dot{\psi}_2 = \dot{x} = \dot{\tilde{c}} = 0$. The values for the optimal instruments p and π in this equilibrium are the solutions of[6]

$$q\left(p, \frac{\bar{x}}{\pi}\right) + (p - a)q_p = 0 \tag{8a}$$

$$-R''(\pi) - \frac{\bar{x}q_x(p - a)}{\pi(r + \pi)} = 0 \tag{8b}$$

[5] Because $(p - c)q(p, x) - R(\pi)$ is strictly concave in (p, π), and $\dot{x} = \bar{x} - \pi x$ and $\dot{\tilde{c}} = -\pi\tilde{c}$ are linear in π, a solution exists if $(p - c)q(p, x) - R(\pi)$ and the two equations of motion (7c) and (7d) are continuous and bounded with bounded derivatives. (Kamien and Schwartz, 1981, p. 203).

[6] For my linear demand curve, this solution is unique and satisfies $0 < \pi < 1$, $p > a$.

It can be shown that a sufficiently low elasticity of demand with respect to product quality $\epsilon_{q,x}$ implies that there is only one path converging to this equilibrium.[7]

From the equations (6) it can be inferred that along that path, successful innovations may have opposite effects on the product's price: In as much as they lower unit costs, they induce a price decrease, but in as much as they lower competitive pressure, they induce a price increase. The innovative effort decreases with decreasing costs and decreasing competitive pressure.[8]

Now, consider a sudden change in the firm's environment brought about by either a rise of the discount rate r or competitive pressure $\bar{x}$.

[7] The Jacobian of (7) evaluated at the rest point is

$$J = \begin{bmatrix} \frac{\psi_2 x}{R''} - \pi & \frac{\psi_1 x}{R''} & 0 & \frac{x^2}{R''} \\ 0 & -\pi & 0 & 0 \\ \frac{q_x}{2} - \frac{\psi_1\psi_2}{R''} & \frac{q_p}{2} - \frac{\psi_1^2}{R''} & \pi & -\frac{\psi_1 x}{R''} \\ \frac{q_x^2}{2q_p} - \frac{\psi_2^2}{R''} & q_x - \frac{\psi_1\psi_2}{R''} & 0 & \pi - \frac{\psi_2 x}{R''} \end{bmatrix}$$

with $\operatorname{tr} J = 0$ and

$$\det J = -\pi^2\left(-\pi^2 + \frac{\psi_2 x}{R''}\pi - \frac{q_x^2 x}{2q_p R''}\right)$$

Sufficient for $\det J > 0$ is

$$\frac{\psi_2 x}{R''}\pi - \frac{q_x^2 x}{2q_p R''} < 0$$

Because the stationary value of ψ_2 from equation (7b) is $\psi_2 = q_x(p - a)/(r + \pi)$, some manipulations of the foregoing inequality yield [notice that, from (8a), $(1 - a/p) = 1/\epsilon_{q,p}$]

$$\epsilon_{q,p} < \frac{4\pi}{r + \pi}$$

where $\epsilon_{q,p} := -q_p p/q$ ($\epsilon_{q,x} := -q_x x/q$) is the elasticity of demand with respect to the price (product quality).

If $\det J > 0$, J must have two positive and two negative eigenvalues, because $\operatorname{tr} J = 0$. Thus, the stationary equilibrium is a saddlepoint.

[8] The analytical expressions derived from equations (6) are

$$\frac{\partial p}{\partial x} = \frac{-q_x}{(2q_p)} < 0, \quad \frac{\partial p}{\partial \tilde{c}} = \frac{1}{2} > 0, \quad \frac{\partial \pi}{\partial x} = \frac{-\psi_2}{R''} > 0, \quad \frac{\partial \pi}{\partial \tilde{c}} = \frac{-\psi_1}{R''} > 0$$

From equation (8), the following formulas for the direction of change of the target levels of p and π can be derived:

$$\frac{\partial \pi}{\partial r} = -2\Delta^{-1}\frac{q_p q_x x(p - a)}{(\pi + r)^2} \tag{9a}$$

$$\frac{\partial \pi}{\partial \bar{x}} = \Delta^{-1}\frac{q_x q(\epsilon_{q,x} - 2)}{\pi(\pi + r)} \tag{9b}$$

$$\frac{\partial p}{\partial r} = -\Delta^{-1}\frac{q_x^2 x^2(p - q)}{\pi(\pi + r)} \tag{9c}$$

$$\frac{\partial p}{\partial \bar{x}} = \Delta^{-1}\left(\frac{q_x R''}{\pi} + \frac{q^2{}_x x(p - a)(1 - 2 - r)}{\pi^2(\pi + r)}\right. \tag{9d}$$

$$\Delta := -2q_p R'' + \frac{q_x q x}{\pi(\pi + r)}[\epsilon_{q,x} - 2(r + 2\pi)], \qquad \epsilon_{q,x} := -q_x x/q$$

Hence, the target level of π declines when r rises, if the demand is not too sensitive with respect to changes in the quality of the product ($\epsilon_{q,x} < 2r + 4\pi$). In this instance it is better to increase the target price level. For a sufficiently large $\epsilon_{q,x}$ (so that Δ becomes negative), it may be optimal to increase innovative efforts and to lower the price. An increase in competitive pressure increases π, if $\epsilon_{q,x} < 2 < 2r + 4\pi$. This also holds true if $\epsilon_{q,x}$ is sufficiently large, so that both Δ and $q_x q(\epsilon_{q,x} - 2)$ become negative. But there are constellations of $\epsilon_{q,x}$, r, and π conceivable that will result in a decline in π when $\bar{x}$ rises. No clear-cut answers can be given with respect to price changes as a result of increased competitive pressure.

Because, in this example, the firm disregards possible reactions of its competitors, the solution concept implicitly employed assumes a Nash equilibrium.

If one firm reduces its innovative effort as a result of a higher interest rate, and so do its competitors, the necessity to bring about innovations $\bar{x}$ will decline, reducing π even more.

In conclusion, this example aims to demonstrate (1) that in a Nash equilibrium there is no incentive for a profit-maximizing firm to reduce π (and thus the PERK) as long as its environment remains unchanged, (2) that increasing necessity might not result in more innovative effort, and (3) that given a certain environment, the degree of using prices or product quality as competitive instruments depends on the relative effectiveness of the two instruments.

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