Innovation and Demand

Esben Sloth Andersen

IKE and DRUID
Department of Business Studies, Aalborg University

Email: esa@business.auc.dk

Version: 10-12-2003 09:04

Paper for *The Elgar Companion to Neo-Schumpeterian Economics*,
edited by Horst Hanusch and Andreas Pyka, to be published by Edward Elgar.

Introduction

Economic evolution is an immensely complex phenomenon, so there is an obvious need of simplifying the way we handle this phenomenon. Since Nelson and Winter's (1982) pioneering formalisation of the Schumpeterian vision of innovation-driven evolution, the major simplification has been obtained by modelling the demand-side of markets in the simplest possible way. This strategy has allowed a gradual increase in the sophistication of supply-side aspects of economic evolution, but the one-sided focus on supply is facing diminishing returns. Therefore, demand-side aspects of economic evolution have in recent years received increased attention. The present paper argues that the new emphasis on demand-side factors is quite crucial for a deepened understanding of economic evolution. The major reasons are the following: First, demand represents the core force of selection that gives direction to the evolutionary process. Second, firms' innovative activities relate, directly or indirectly, to the structure of expected and actual demand. Third, the demand side represents the most obvious way of turning to the much-needed analysis of macro-evolutionary change of the economic system.

Individual innovations and demand: The great debate

The distinction between invention, innovation and imitation/diffusion is often attributed to Schumpeter, but actually his approach put on overwhelming emphasis on innovation. For him the core characteristic of innovation is that it is a *difficult* change of some of the routines of the economic system. This conception has several consequences. First, since the function of innovative entrepreneurs is to perform the difficult implementation of 'new combinations', their efforts cannot be seen as simple applications of inventions or other kinds of relevant knowledge. Second, since the initial attempts of imitating a successful innovation is quite difficult, they should also be characterised as innovations. Thus, there is no clear-cut distinction between innovation and imitation/diffusion. Instead the innovative contents of a particular type of change become less and less significant until the change becomes a matter of routine. Third, there is no possibility that market demand can automatically bring about innovation. The demand side of the market is characterised by routine behaviour and limited foresight, so entrepreneurs becomes drivers of innovation even in the sense that they persuade buyers to change their preferences. Thus the Schumpeterian concept of innovation determines a specific view of the relationship between innovation and demand.

Although Schumpeter's concept of innovation became very influential, there were many economists and economic historians who upheld the classical and quite different concept of 'innovation'. According to this concept, incremental innovation is a normal aspect of economic life that is directly influenced by the 'technology push' by available inventions and the 'demand pull' created by increased incomes and changes in tastes. This classical view was renewed by Schmookler in studies of the relationship between the number of inventions and the level of demand in relation to different industries. He demonstrated that 'technology push' is not an independent variable. Instead changes in the number of inventions shows up to be lagged reflections of changes in the level of demand. Thus it is really 'demand pull' that drives inventive activity and, presumably, innovative activity. This emphasis on demand-side factors was seen as a refutation of the supply-side orientation implied by the Schumpeterian concept of innovation. In retrospect, it is however obvious that Schumpeter and Schmookler were analysing different issues. First, Schumpeter excluded incremental and adaptive change from his concept of innovation while Schmookler emphasised these forms of change. Second, Schumpeter cut any automatic links between invention and innovation while Schmookler implicitly assumed such links. Third, Schumpeter argued about individual innovations while Schmookler dealt with aggregates of inventions and innovations. Thus the debate between Schumpeterian and Schmooklerian researchers during the 1960s and 1970s became quite confusing.

In a famous paper by Mowery and Rosenberg (1979) the results of the debate were evaluated. A series of empirical studies had tried to support the Schmooklerian view, but they had run into serious conceptual difficulties. Thus it was obvious that there is no automatic relation between inventions and innovations. But the most important problem was the confusion about the concept of demand. Schmookler's studies had upheld the standard definition of observed market demand, but the subsequent studies had included a much broader view that included expected demand as well as attention to basic wants of the buyers. Even Schumpeter would have admitted that considerations on the latter issues were crucial to any innovation, so the demand push theory seemed to have led to a dead end. This does not mean that the debate was without results. First, it drew attention to the fact that there are both radical and incremental innovations that may show different patterns of causation. Second, it emphasised the need of studying the role of user needs in innovative activities, for instance in terms of the innovative role of ‘lead users’ and ‘user-producer interaction’. Third, it drove researchers to move from ‘linear’ models of innovation to the study of the complex interaction of the different determinants. Fourth, it pointed to the difficult process of ‘market creation’ with its standardisation and networking processes among buyers as well as suppliers. Fifth, it became obvious that there was a need of studying innovation as an aggregate phenomenon instead of only focussing on individual innovations. Thus it seems somewhat misleading when McMeekin et al. (2002, p. 8) suggest that the debate has largely vanished. Instead it has branched into a number of sub-debates, and these debates have become more technically demanding because of the increased application of explicit models and econometric analysis. Thereby, much of the freshness (and naivety) of the original debate has disappeared—especially in relation to aggregate analysis. But this kind of study is not without fascinating research problems.

Accounting for the effects of selection and innovation

The great debate on the innovation–demand relationship took place at a time when the modern analysis of economic evolution had not yet been developed. This analysis may shortly be characterised as ‘population thinking’ (Metcalfe 2001). According to this form of thinking, evolution takes place within heterogeneous populations whose average characteristics are changed by selection. In the case of a population of firms that produces a good for a particular market, selection is, directly or indirectly, performed through the buyers’ choices based on prices and qualities. Thus the basic function of demand is to select between the varieties that are made available by innovation. But there are additional contributors to this selection—like the banks that to some extent determine to degree to which profits can be transformed into expansion.

We may measure the effectiveness of selection with respect to some quantitative characteristic (e.g. productivity) in terms of a regression coefficient ($\beta_{\rho,A}$). This coefficient measures how selection with respect to the characteristic (A_i) influences the firm's expansion coefficient (ρ_i). If this expansion coefficient is 1, then the capacity of the firm is unchanged. Since we are mainly interested in relative change within the population, we also need to take into consideration the average expansion coefficient ($\bar{\rho}$). Thus we may find how selection transforms a firm's characteristic into change of share of the industry's capacity.

To produce any results, a selection mechanism of a given efficiency needs that firms vary with respect to the characteristic under study. The degree to which 'fuel' is available for the selection is shown by the industry's variance with respect to the characteristic, and the relevant measure is the capacity-share weighted variance ($\mathrm{Var}(A)$). Selection uses this fuel by expanding firms with above-average performance with respect to the characteristic. At the same time some of the fuel is used, so that variance after selection has taken place is smaller than before. Innovation largely serves to restore variance. But it also has an immediate effect that is comparable to that of selection. This is most obvious if we measure the change in the average level of the characteristic between two points of time ($\Delta\bar{A}$). Selection has an obvious effect of this change, but so does innovation. The size of the contribution of an innovation in any particular firm depends on the size of the change brought about by innovation, the capacity share of the firm and the degree to which this capacity share is changed due to super-normal growth during the period ($\Delta A_i(s_i\rho_i/\bar{\rho})$).

It is of much importance to bring together the contributions of the selection effect and the innovation effect to the change of an average characteristic like average productivity. This may be done in different ways, but recently evolutionary economists have become aware that evolutionary biologists have for quite some time had a very elegant and efficient way of doing so (Frank 1998). This is George Price's formula for decomposing evolutionary change. In the present interpretation, this formula may be expressed as

$$\Delta\bar{A} = \text{Selection effect} + \text{Innovation effect} = \frac{\beta_{\rho,\mathrm{A}}\mathrm{Var}(A)}{\bar{\rho}} + \frac{\mathrm{E}(\rho\Delta A)}{\bar{\rho}}.$$

The formula shows that short-term change of the average of a characteristic (say, productivity) is determined by two effects. The first is the selection effect that exploits the variance of the productivities ($\mathrm{Var}(A)$). If this variance is large, then average productivity may increase quickly because firms with super-normal productivity are selected to obtain increased capacity shares. The effectiveness of this selection is influenced by the degree to which the relative expansion coefficients of firms reflect their productivities, and this degree is measured by regression of the expansion coefficients on the productivities ($\beta_{\rho,\mathrm{A}} / \overline{\rho}$). Thus, selection efficiency is an empirical question that we have to confront for each period in the analysis of economic evolution. The second term in the equation is the innovation effect (which may also include imitation). To see why this name is appropriate in the present context, we have to consider the meaning of the expected market-share weighted value of the firms' expansion coefficients times their productivity changes ($\mathrm{E}(\rho\Delta A)$). If there is no change in the productivity of any of the individual firms ($\Delta A_i = 0$), then this value is zero. If some firms innovate or imitate ($\Delta A_i > 0$), then the expected aggregate effect is influenced by the capacity shares of these firms at the end of the period. Since innovative performance is to some extent determined by the size of firms, the innovation effect may be quite important.

As soon as we have grasped the logic of Price's decomposition, we recognise that it may be used in a multi-level way. For instance, large firms are often composed by a set of plants that vary with respect to productivity. Therefore, we may also apply Price's equation for selection and innovation within these firms. If this is the case, we may consider the overall productivity change of a firm (A_i) as an aggregate that may be decomposed into a firm-level selection effect and a plant-level innovation effect. The firm-level selection effect changes the average productivity of the firm by promoting super-normal plants and demoting sub-normal plants. The size of the plant-level innovation effect depends both on the size of process innovations (and imitations) and their spread across plants of different capacities.

The short-term accounting for evolutionary change must be complemented by considerations of long-term evolutionary outcomes. Here it is important to note that the selection effect may become zero for two reasons: either there is no productivity variance or the existing productivity variance has no effect on the change of capacity shares. The former situation is the long-term consequence of the selection effect in isolation: this effect simply increases average productivity by decreasing the productivity variance and increasing the concentration of the industry. However, in the Nelson–Winter model an increased monopoly power changes the regression of expansion rates on productivities. The reason is that a firm with a large capacity share increases profits by restraining output expansion. As a result, the industry may end up as a relatively stable oligopoly. An important question is what happens to the innovation effect in such an oligopoly. Although the Nelson–Winter model is not designed for a thorough answering of this question, it is obvious that the innovation effect comes to dominate over the selection effect. Oligopolistic firms are still motivated to increase their productivity, but they may also give raise to perverse selection effects, where the productivity leader periodically decreases its capacity.

Simple relationships between innovation and demand

The Nelson–Winter model was designed to clarify the confusing Schumpeterian heritage. As it was pointed out above, one of the controversial issues concerns the relationship between innovation and demand. The confusion was partly due to the fact that Schumpeterians and Schmooklerians were treating the issue from different perspectives and at different levels of aggregation. Evolutionary economic analysis helps to clear up much of this confusion. The simple Nelson–Winter model of process innovation provides some insights, but we shall soon need to move toward more complex models.

The two views of the innovation–demand relationship show up to be closely related to endogenous and exogenous changes in aggregate monetary demand (D) in the Nelson–Winter model. In the basic model the aggregate monetary demand for the output is the industry, so that price changes inversely with aggregate supply ($P = D/Q$). Let us instead assume that monetary demand is elastic to price in the sense that a lowering of the price in present period increases monetary demand in the next period. In non-monopolistic situations both the selection effect and the innovation effect increase average productivity as well as output. This leads to a lower price in the present period and an increased aggregate demand in the next period. Thus we have the Schumpeterian pattern of process innovation preceding increasing demand. However, if aggregate demand changes for exogenous reasons, we see the Schmooklerian pattern of increased demand leading to invention and process innovation. Let us consider a situation of a relatively stable oligopoly and increase significantly the level of monetary demand. Then all firms experience increasing profits and start to expand their production. This expansion is most rapid for high-productivity firms, so the selection effect is restored by an increased regression of expansion on productivity. However, due to the routines for determining R&D efforts, an increase in employment also means an increase in innovative activities. This means that the chances for invention and innovation are increased, and the results show up in subsequent periods. If we allow for adaptation of the fraction of labour that is used for R&D, we see an increase in R&D intensity. The reason is that R&D productivity increases because the probabilistic cost of innovation can be spread over a larger output. There are thus several reasons why the Schmooklerian pattern emerges.

The way the Schumpeterian relationship between innovation and demand is produced in a simple Nelson–Winter model is hardly reflecting Schumpeter's original vision. This vision is much better handled by a model that includes product innovation. In their history-friendly model of the computer industry, Malerba et al. (1999) for instance include two types of computer users. The first type of users has a need for advanced performance rather than cheapness while the needs of second type of users cannot be fulfilled unless ease of use and cheapness is emphasised. Although the second type of users were always there, it is misleading to say that their demand drove the innovative efforts toward the huge market for small computers. Like in the cases studied by Mowery and Rosenberg (1979), it is much more relevant to consider an innovation-driven evolution that ultimately brought forth an effective demand. In the case of the case of the computer industry model, we may think in terms of two evolving characteristics of the industry: average performance and average cheapness. Before the industry started to produce personal computers, the efficiency of selection was large with respect to performance and small with respect to cheapness. But with the advent of personal computers, the computer industry was practically split into two sub-industries with different selection environments. As long as we study the industry as a whole, both regression coefficients are small. If we, however, study the evolution of two sub-industries separately, it becomes clear that the one is dominated by selection for performance while the second is dominated by selection for cheapness. By following the mature evolution of the personal computer industry, it also becomes clear that cheapness innovations dominate in core firms while performance innovations are more prominent in peripheral firms. This sub-industry seems to have entered a stage that to some extent may be analysed in Schmooklerian terms, but it should be emphasised that innovation is motivated by potential demand and that it went through an extended Schumpeterian phase where only pioneering and very special users were able to give some guidance for innovative activities.

Product innovation and endogenous preferences

Even in its extended versions, the Nelson–Winter model gives rather limited guidance to the debate on innovation and demand. Thus there is a need of a more radical rethinking of the model. This rethinking may start by applying some version of the Lancaster approach to the demand theory (see e.g. Saviotti 1996). According to Lancaster the utility of a good is evaluated by means of the utility effects of a small number of characteristics. In relation to a realistic theory of innovation, the problem is that there are a huge number of characteristics that are of potential relevance to any buyer of the good. For instance, the 'performance' of computers may be split up in a near-infinity of characteristics. Since buyers are boundedly rational, it is likely that they express their preferences for goods in terms of lexicographic orderings of the characteristics. Buyers thus select the variant of a good that is best with respect to the most preferred characteristic. If two variants are equal with respect to this characteristic, they base their choice on a secondary characteristic, and so on. In this way buyers economise their limited amount of attention on a few crucial characteristics. But this behaviour is based on large amounts of individual and social experience. This experience is necessary because the proper functioning of any good presupposes that a large number of characteristics have reached satisfactory quality levels, and these levels cannot be checked in relation to particular choices. Instead they have to be taken for granted. But experience also singles out a few characteristics that buyers would like to change, and thereby they obtain a small and lexicographically ordered checklist. Since this checklist depends on their previous experience, it is obvious that they have endogenously changing preferences. But there are also other reasons for buyers to adapt their preferences to experience (Aversi et al. 1999).

When buyers encounter a new innovation, they evaluate it according to their acquired preferences instead of any fixed and complete preferences. This evaluation defines a selection environment that can be used to discern between what may crudely be called Schmooklerian and Schumpeterian innovations. A Schmooklerian innovation is an innovation that takes place within the agenda defined by the established lexicographic preferences. Thus it has to live up to the conventional requirements of the good as well as to improve it in one of the dimensions that buyers focus upon. In the simplest case such an innovation represents what Lancaster calls vertical product differentiation, i.e. a product that is exactly as its competitor with respect to all characteristics except that it is better with respect to a single characteristic. In contrast, a Schumpeterian innovation is an innovation that transcends the buyers' routine-based decision making. This transcendence has two aspects. First, the innovation is so radical that buyers are not automatically convinced that its many characteristics are so that it has an acceptable functioning. Second, the innovation has a superior performance with respect to characteristics that buyers are not accustomed to apply in their product selection. Such an innovation cannot in any meaningful sense be said to have been called forth by pre-existing demand, and the question is therefore how the innovation becomes selected. The standard Schumpeterian solution is to assume that the innovative entrepreneur persuades buyers to change their preferences (e.g. by marketing efforts). The adoption of the innovation may, however, also require a complex social process that largely takes place among different types of buyers. If we take this social process into account, several Schumpeterian innovations may show up to be reducible to Schmooklerian innovations. Such innovations may originally have been designed according to pre-existing preferences of sophisticated buyers in niche markets dominated, but then a social process changes the preferences of ordinary buyers so that they adopt the innovation (see e.g. Witt 2002; McMeekin et al. 2002).

The modelling of product innovation under the assumption of endogenous preferences can be made in many ways. Presently, most insight seems to be gained from relatively simple models. If we, for instance, ignore the fact that the potentially relevant characteristics of a differentiated product is never fully known, then we may fairly quickly explore the important co-evolution between supply and demand. If we assume that buyers initially have different lexicographic orderings, then the innovations of the firms of a new industry will target different customer groups. The buyers will select different product variants, and occasionally they consider whether to shift to other variants. If they have for an extended period of time adopted a particular variant, then their preferences will become adopted this variant. The evolution of the model of such a customer market shows many of the characteristics found in real markets, especially if we include directed innovative activity and marketing efforts. However, many issues of long-term evolution are missing. By adding network effects in consumption (like the utility gain from a large user community of a particular computer system), the standardisation of some quality characteristics may be explained. Furthermore, we may model the gradual expansion of the set of characteristics that have become standardised. In such a model the focus of attention of buyers shifts in a step-wise manner from one characteristic to the next. Thereby, the agenda for the innovative activities of the firms of the industry is also shifting. It is obvious that the modelling of such issues presupposes that the innovating firms are operating within a rather limited range of possibilities. Thus the models have been constructed by de-emphasising many aspects of the Schumpeterian story of radical innovations.

Macro-evolutionary transformation and satiation of demand

Although modern evolutionary economics is much inspired by Schumpeter, most contributions have ignored the fact that he was largely confronting the macroscopic aspects of economic evolution. Thus the issue of the innovation–demand relationship has been treated at the level of individual innovations or individual industries rather than at the level of the aggregate economy. This discussion has instead been dominated by Keynesian or neoclassical economists. The reason is largely that the mechanisms through which selection and innovation interact with the macroeconomic state of the economy are immensely complex. At the moment we, therefore, need rather naive models that relates innovation to the macroscopic level without abandoning too many of the Schumpeterian insights. Such models should as a minimum include a microeconomic level at which innovation takes place and a mesoeconomic level that allows us to handle the structural transformation of the economic system. The latter requirement implies that the extension of the Nelson–Winter model into a one-sector growth model is not sufficient. Instead Pasinetti's (1993) abstract multisectoral model of structural economic dynamics in a pure labour economy may serve as a convenient starting point. Although this model is clearly of a post-Keynesian type, it is not without Schumpeterian influence, and it focuses attention on the innovation–demand relationship. In the present context, the main problem with the Pasinetti model is that it operates at the level aggregate sectors without any microfoundation. So the task is to reconstruct it in a way that gives it an evolutionary economic character (Andersen 2001).

The basic intuition underlying the Pasinetti model is that consumers have hierarchically organised preferences. To simplify, we may say that any consumer wants to consume a satisfactory level of one good before consuming anything of the next good in the hierarchy. If the list of goods and their prices and satiation levels are given, then it is clear how any consumer will distribute any given income among the goods. The demand starts from the bottom of the hierarchy and covers as many goods as possible up to their satiation levels. The quantity of last good that is chosen may, however, be only a fraction of its satiation level. Increasing incomes imply that consumers move their consumption frontiers, first by securing that the last good is consumed up to its satiation level, then by moving to the next good in the hierarchy. By assuming a uniform wage rate and uniform preferences, everyone in the economy have exactly the same consumption pattern. On this background, it is not difficult to add an evolving supply side to the economy. The population of firms that produces a particular good competes by labour-saving innovations, and the price of the good decreases. This means that part of the income of consumers can be spent for an expansion of the consumption frontier. However, this expansion is not without problems. First, although the next good in the hierarchy is defined in terms of basic consumer needs, its concrete form will be determined by innovations in firms that operate at the consumption frontier. Second, consumers have to learn about the characteristics and the ways of using new goods. If one of these two requirements is missing, then the consumption frontier cannot move and we see a satiation of aggregate demand. In that case the economy may encounter what may be called technological unemployment. The problem is that increasing productivity and fixed demand in the old sectors necessarily means a reduction in the demands for labour, while the lack of demand for labour means an insufficient absorption. To maintain long-term economic growth it is crucial to have firm innovation and consumer learning at the consumption frontier.

In the evolutionary version of the Pasinetti model, firms make two types of innovation. First, they engage in process innovation to increase productivity in the production of established goods. This form of innovation can become more or less systematised since there is a permanent pressure for cost reduction. Second, they engage in product innovation. Since this activity is only going on at the consumption frontier and since anticipatory behaviour is unlikely in evolutionary models, this activity is quite sporadic and erratic. Thus it unlikely that the new good becomes available at the exact moment when demand begins to emerge. Furthermore, if we add initially heterogeneous preferences for the new good, further time is needed for establishing a standard version of the good and the appropriate set of preferences. However, these problems are to a large extent the result of the assumption of a uniform wage rate in the whole economic system. If we allow for multiple levels of income, different firms and consumers will meet the satiation constraint at different points of time. The agents that first meet the constraint will try to overcome it and by more or less unavoidable spillover effects, ease the constraint for groups that reach the present-day frontier with a smaller or larger delay. This pattern suggests that the satiation problem is most radically met in a model where labour is totally homogeneous and where there are thus no income differences. There are, however, also problems at the other extreme with a very skew income distribution. Both cases are likely to be more seriously hit by aggregate satiation problems than in-between economies.

The proposed multisectoral model of economic evolution is, of course, only a first and fairly naive step toward an analysis of the interaction of innovation and demand in relation to aggregate economic transformation and growth. Many further ideas may be found in the neo-Schumpeterian analysis of cyclical economic evolution (including the Kondratieff wave literature). But even on the background of the present paper is it obvious that the innovation–demand relationship is both interesting and complex. The complexity is a major reason why researchers tend to apply one-sided views. We need a further development of analytical tools to handle this complexity in a systematic manner.

References

Andersen, E. S. (2001), Satiation in an evolutionary model of structural economic dynamics, *Journal of Evolutionary Economics*, **11**: 143–164.

Aversi, R., Dosi, G., Fagiolo, G., Meccati, M. and Olivetti, C. (1999), Demand dynamics with socially evolving preferences, *Industrial and Corporate Change*, **8**: 353–408.

Frank, S. A. (1998), *Foundations of Social Evolution*, Princeton, N.J.: Princeton University Press.

Malerba, F., Nelson, R. R., Orsenigo, L. and Winter, S. G. (1999), 'History-friendly' models of industry evolution: The computer industry, *Industrial and Corporate Change*, **8**: 1–36.

McMeekin, A., Green, K., Tomlinson, M. and Walsh, V. (eds.) (2002), *Innovation by Demand: An Interdisciplinary Approach to the Study of Demand and its Role in Innovation*, Manchester and New York: Manchester University Press.

Metcalfe, J. S. (2001), Evolutionary approaches to population thinking and the problem of growth and development, in Dopfer, K. (ed.), *Evolutionary Economics: Program and Scope*, Boston, Mass.: Kluwer.

Mowery, D. and Rosenberg, N. (1979), The influence of market demand upon innovation: A critical review of some recent empirical studies, *Research Policy*, **8**: 102–153.

Nelson, R. R. and Winter, S. G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Mass. and London: Harvard University Press.

Pasinetti, L. L. (1993), *Structural Economic Dynamics: A Theory of the Economic Consequences of Human Learning*, Cambridge: Cambridge University Press.

Saviotti, P. P. (1996), *Technological Evolution, Variety and the Economy*, Aldershot: Elgar.

Witt, U. (ed.) (2002), *Escaping Satiation: The Demand Side of Economic Growth*, Berlin: Springer.