NEW TECHNOLOGY AND THE ECONOMIC ORGANISATION OF THE CLOTHING INDUSTRY

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FOREWORD

The ability to make product variations and to respond to demand fluctuations as well as to changing market needs is said to be one of the key issues behind the competitive power of a modern company. Thus economies of scope -- or simply flexibility -- are usually believed to be one of the driving forces behind modern production automation, such as FMS and other forms of CIM. They are, of course, technological means of creating flexibility in production and design.

In the literature economies of scope or flexibility are usually described either in terms of business strategy or in very general economic terms. The latter type of studies are directly connected to technology and to technological and organizational design of flexible production. What is missing is a real economic theory of flexibility, which could explain costs and benefits and the relationships between different inputs and outputs. One of the aims of the CIM projects has been to develop a cost-benefit model to acquire an understanding of the economic factors of flexibility.

The clothing industry is a typical case, where the ability to make variations and to respond to seasonal fluctuations in demand is a critical factor for a successful company. Therefore, the ability to make new designs and to implement them rapidly in the production process are of crucial importance. Thus, design systems as well as production automation have been essential for the clothing industry in the industrialized countries.

One of the main sectors to be studied by the Finnish TES-program is the clothing industry. It is also one main focus of the bilateral cooperation between the Finnish and Bulgarian TES-programs.

Dr. Geoffrey Wyatt, from the Heriot-Watt University, UK, has prepared a research report for the Finnish TES-program, which explains the sources of flexibility in the clothing industry as well as the organizational and technological means of achieving flexibility. The paper is also a starting point for an understanding of flexibility and especially of design as an economic production factor. It is highly relevant to the IIASA CIM Project.

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OUTLINE

1. Introduction

Apart from being an important determinant of general living standards, the state of technology determines many important features of the economy, such as the cost of transforming inputs of factors of productions into output, and the extent of substitution between outputs and between inputs. It also strongly influences the demand for factors of production, the location of production and the appropriate economic organization of the industry. When technology changes, therefore, there is a substantial catalogue of economic consequences to be anticipated.

This essay attempts to provide a framework for a coherent discussion of the economic effects that might be expected to follow from impending changes in technology used in the clothing industry. Needless to say, it is not possible to discuss the details of the technologies and changes in technology as well as their economic effects. Instead, these are given a rather broad-brush treatment in the account that follows. It will also soon be apparent that the economic effects of certain supposed broad changes in technology can only be sketched out as speculations of a rather general type at this stage. Rather, what the essay attempts to contribute is a drawing-together of various strands of economic analysis that appear to have particular relevance to the topic in hand.

The initial intention was to focus on only one element of changing technology: namely that affecting the design function within the industry. It soon became apparent that such a restricted view would distort the overall picture, and that in any event the changes in technology come as a package, so that focussing on design alone would be misleading. Even so, there is still a certain residual emphasis on design in the paper, and this hopefully reflects its pivotal role in the clothing industry. It will be argued that product differentiation is the essence of the clothing industry, and design of course is all about the creation of such differentiated products.

The plan of the paper is as follows. Section 2 discusses the economic structure of the clothing industry, emphasising the role of technology in determining its structure, and pointing to the kinds of changes that new technology is expected to bring to the industry in the foreseeable future. Section 3 is a self-contained account of a simple economic model of the firm in which design is treated explicitly as a decision variable. Section 4 concentrates on the industrial organisation of product-differentiated industries, and relates the theoretical analysis to the clothing industry where possible. Finally Section 5 presents an outline of what might be predicted for the clothing industry on the basis of the foregoing analysis.

2. The clothing industry

The clothing industry is rather vulnerable to cyclical fluctuations in income, and in the prices of its material inputs. This could be thought surprising since clothing, along with food and shelter, is often designated as a necessity, at least when all clothing types are lumped together and treated as a single "commodity". Such a designation suggests rather low income and price elasticities of demand for clothing, taken as a whole, which in turn imply that the industry should be somewhat insensitive to cyclical fluctuations. There are, however, at least two reasons why this is not so. First, clothing is a semi-durable commodity, and the demand facing the industry represents the sum of replacements and additions to the stock held by consumers. Although consumers' demand for the flow of services from their stock of clothing assets may respond inelastically to fluctuations in its underlying determinants, the semi-durable nature of clothing amplifies and bunches the response in time as far as it concerns the effective demand that producers face for their output. Added to this, the second reason for the proneness of the industry to cyclical fluctuations is that a large and variable fraction of the stock of clothing held by consumers is prone to obsolescence as a result of changes in fashion. Despite the fact that the demand for fashion can to a degree be explained by economic variables (Stigler and Becker, 1977), changes in fashion are difficult to predict. However, predicting such changes on a year-by-year basis - or on an even shorter time horizon - is one of the major tasks of the designers who define the products which the industry produces.

2.1 The structure of the traditional clothing industry

Where a significant clothing industry exists in a market economy, it is highly fragmented. Typically, around three-quarters of plants have 50 employees or less, and only one in a hundred has over 1000 employees (Rush and Hoffmann, 1987). This structure is essentially determined by the technological characteristics of the industry's products and production. The products are extremely heterogeneous and the production process is remarkably homogeneous. The product heterogeneity is partly intrinsic -

reflecting combinations of different garments, shapes and sizes - and partly due to the demand for variety or individuality that typifies the product ("Kleider machen Leute"). The homogeneity of the production process is due to the fact that it is organised around a simple and stable technology that has for many years been the least cost form of production irrespective of factor prices - namely the sewing-machine/operator workstation. Scale economies in production are almost negligible with this traditional technology, and entry costs are extremely low - indeed part of the industry competes with household production of essentially the same goods using essentially the same technology.

The organisation of activities within firms in the clothing industry is more or less standardised. It can be described as a sequence of stages following an annual or seasonal cycle. The first stage in the process is the design of the made-up products, which in turn gives rise to a plan for the purchase of raw materials, production and eventual marketing. The first stage, design, includes not only the conception of the products, but also the creation of prototypes and of templates in the subsequent pre-production activities of "grading" and "marking". Grading is the process of adjusting the master patterns to the various sizes that will be produced, while marking involves the fitting together of the graded patterns on the cloth in preparation for cutting. The production process involves a sequence of cutting, sewing and finishing activities. Cutting is normally done in batches, and here there are considerable possibilities for substitution between capital and labour. The traditional sewing activity has allowed little scope for substitution between capital and labour, being organised around the sewing-machine/operator workstation, as already indicated. But, over time, advances in technology have led to faster and more productive sewing machines becoming available, so that it might not be unreasonable to characterise the sewing production function as one which has exhibited zero substitution possibilities at a moment of time, but with labour-saving technical progress taking place over time. The final element of the production process, finishing, is an activity that requires highly skilled labour.

These observations about the production process may help to explain trends in the international organisation of the industry. Thus in countries where wages are high relative to the cost of capital, firms have an incentive to invest in cutting machines with high throughputs, while in low wage countries cutting might be done predominantly by hand. If, as mentioned above, the sewing function does not allow much substitution between capital and labour, and if the cost of capital is similar in different countries - which is increasingly the case as international capital markets have become free of restrictions - then sewing is more efficiently carried out in countries with low wages. Indeed, because of the preponderance of sewing in total costs, it has been the case for many years that the most competitive producers are found in low wage countries.

These are the underlying forces which have led to the substantial changes that have taken place in the international location of the industry over the last half century or so. Relative factor prices have been favourable to clothing manufacture in the less developed countries, and the location of activities has changed to reflect this changing competitiveness. As the clothing industry in developed (OECD) countries has become less and less price competitive, so its survival has depended more and more on 'non-price factors' such as quality and design. At the same time there have been strenuous efforts by the developed countries to cushion the necessary adjustment of their industries by the implementation of various protectionist policies, of which the most internationally comprehensive is the multi-fibre agreement of the GATT. Even so, the trend in competitiveness has been reflected in a recent tendency for clothing firms in Europe and North America to do the design and finishing at home but subcontract the middle stages of manufacture to partners in more competitive locations, such as the Far East. As would be expected, this trend has been particularly strong at the "low end" of the market.

As far as the industrial organisation of the clothing industry is concerned, it seems reasonably accurate to describe the clothing industry as being composed of multi-product firms in monopolistic competition. Usually, however, it is assumed that monopolistically competitive firms produce just a single product. The essence of monopolistic competition is that the products of these firms are differentiated in some way from each other. A summary of the theory of monopolistic competition for the purposes of this paper is presented in Section 4 (multi-product firms are considered in 4.3).

2.2 New technology and the emerging clothing industry

The new technology under consideration here is that arising from the electronic "information revolution" which encompasses computers, robotics, communications and so on. More specifically, when it is applied in manufacturing contexts, it assumes various forms, each with its own acronym. Thus we have "computer aided design" (CAD), "computer aided manufacturing" (CAM), "computer integrated manufacturing" (CIM), "flexible manufacturing systems" (FMS), "just in time" (JIT) delivery systems, and so on.

The clothing industry has not been to the forefront in the adoption of such new technologies, and for good reasons. The new technologies were applied initially to those areas of manufacturing where they were most likely to be profitable - that is to say, where the benefits anticipated from their application were large and/or the costs of development were small. The latter consideration has in practice been dominant because of the truism that solutions to simpler problems are found earlier - and indeed may be required as inputs into the solutions of more difficult problems. Thus there has been, in the application of these new technologies, a "learning by doing" phenomenon on a grand (industrial) scale. Hence the initial applications of the new technologies were to industries in which the problems were both reasonably standard, implying large markets for solutions, and relatively straightforward, implying a low cost to produce them.

Thus CAD found early application in the electronics and the building and civil engineering industries, followed by metal-using manufacturing industries such as cars and shipbuilding. The common feature of these industries is that the geometry of design is reasonably straightforward, largely because the products are made from rigid materials, and the uses to which the products are put are relatively well-defined. The same factors led to the initial implementation of numerically controlled machine tools in the metal-working industries already in the 1960s, while the more recent integration of such automated cutting and assembly with CAD techniques at the design stage is an important part of what is understood by "computer integrated manufacturing".

The clothing industry has presented various difficulties for the application of these new technologies. Perhaps the main one is that the materials it uses are soft and pliable. But additional problems are that "shape" is difficult to pin down (!) in simple geometric terms, and that an essential yet difficult-to-describe aspect of clothing concerns how it moves and how it allows the wearer to move. Nevertheless, some aspects of clothing production have already been automated in some firms - notably the pre-assembly activities involving grading, marking and cutting, where the principal gains are in the utilization of materials (Rush and Hoffmann, 1987). It can, moreover, be argued that the clothing industry will soon be in a position to make further innovations involving the new technologies. As an example, it appears that the potential exists to relate a customer's exact measurements, themselves produced by an electronic imaging system, to the appropriate cut of the garment (Bell, 1987).

An area of application of the new technologies in which, it is argued, there is substantial scope for the application of innovations based on the new technologies is in the integration of the design and pre-production stages, where "design" includes not only the specification of the product but also the specification and scheduling of the production process. As Rush and Hoffmann point out, design and pre-production are the most "information intensive" stages, and are therefore crucial to the overall automation of production (op. cit.). It seems that the impending changes in technology at this stage of the firm's activities are likely to be quite radical and substantial. In contrast, there have been fairly steady improvements in the productivity of the sewing process due to the introduction of faster and more flexible machinery, and this trend of incremental innovation in sewing is likely to continue. However, the latest manifestation of such improvements is the appearance of "intelligent" sewing-machine workstations, in which the machine is capable of "learning" a sequence of operations by copying those of its operator-tutor. This seems to be a change in the pattern of technical progress experienced hitherto, specialising it from being labour-saving in a general sense to becoming particularly "skill-saving" in character. It means that one skilled operator can, in effect, now operate a number of machines, each one of which is supervised by a relatively unskilled attendant. If it is accurate to portray low-wage third-world countries as having abundant raw labour, but scarce skilled labour, then this innovation confers particular advantages on such countries, and would help to reverse the trend of labour-saving technical change which has been eroding their competitive advantage.

3. A simple economic theory of design and the firm

Design is an activity of the firm that impinges on both its revenues and its costs. Increased design effort aimed at the specification of the product should shift the demand function outwards: by improving the product, or making it more suitable for consumers, a larger quantity should be sold at any given price (or a higher price charged for any particular quantity supplied). But at the same time a greater design effort will affect the firm's cost function. One question of some importance in the sequel is whether the design effort affects variable costs as well as fixed costs (with respect to output). In general it will, and it could do so in either direction: upward or downward. The cost of the design effort itself adds directly to fixed costs, but to the extent that design is aimed at the production process, for a given product specification, it should reduce total costs - although how that splits between fixed and variable costs cannot be said a priori.

Denoting the quantity demanded by q, the design effort by d and the price of output by p, the inverse demand function facing the firm can be written:

$$p = p(d, q) \quad \text{with} \quad p_q < 0$$

while the firm's cost function is:

$$C = C(d, q) \quad \text{with} \quad C_q > 0 \quad \text{and} \quad C_{qq} > 0$$

in which C is total cost and q here represents the firm's output, which is equal to the quantity demanded. The partial derivatives are standard, but in addition we need to consider how the variable d affects the two functions. It would be natural to assume that $p_d > 0$, implying that the product is improved in the eyes of consumers. But if design is focused on saving costs, it could be that the quality of the product is impaired, reducing demand so that $p_d < 0$. However, a profit maximising firm will not be in equilibrium if an increment in design effort both reduces costs ($C_d < 0$) and increases demand ($p_d > 0$) - because it should increase its design activity in that circumstance until the sum of the incremental effects is zero, which can only happen if one of the effects is reversed.

The firm considers the impact of design on both its demand and its cost functions, and chooses q and d so as to maximise profit:

$$\pi = q.p(d,q) - C(d,q).$$

The first order conditions imply the following equalities:

$$p + q.p_q = C_q \tag{1}$$

$$q.p_d = C_d \tag{2}$$

in which (1) is the usual equality between marginal revenue and marginal cost, and where the partial derivatives in (2) must have the same sign in equilibrium - the point made above. These equations apply to competitive firms and firms with market power alike. Firms in a competitive equilibrium face an infinitely elastic demand for their product, so that $p_q = 0$ in (1), implying that price equals marginal cost, while by definition the firm with monopoly power faces a finite elasticity of demand ($p_q < 0$), implying a lower output and higher price than for the competitive firm. But a question of some interest is whether the design effort would differ in these two cases (and more generally as a function of the price elasticity of demand). This turns on how the equilibrium design effort varies with output. If marginal revenue (or, for a competitive firm, price) increases faster or decreases slower than marginal cost with greater design effort, then the equilibrium design effort increases with output, and hence competitive demand conditions enhance the firm's design effort (Schmalensee, 1979).

The set-up here has some formal similarities with a well-known model of advertising or selling costs (Dorfman and Steiner, 1954). However, in that model it is normal to allow for just the direct costs of advertising, whereas here design has both a direct cost effect and an effect on other costs as well. On the other hand, if q_d were set to zero we would have a model in which d could be interpreted as R&D effort aimed at cost-reducing innovations, though normally in such models it is also assumed that marginal costs are constant ($C_{qq} = 0$) to reflect the fact that the long-run case is then most appropriate (Wyatt, 1986).

To illustrate the meaning and implications of the various partial derivatives of the cost function that involve d, it is helpful to make some particular assumptions. For example, it could be assumed that for a given design effort, total cost is linear in output with fixed costs F and variable costs v, but both F and v are functions of design effort d, so that we may write:

$$C = F(d) + v(d).q \ .$$

Now consider the fixed cost element of this cost function in more detail. A component of these fixed costs will be the direct cost of the design effort, $w.d$, where w is the price of a unit of design resource. In addition there will be indirect effects of the design effort on other fixed costs, denoted $G(d)$, and a component of fixed costs that is independent of d, denoted F_0, so that:

$$C = F_0 + G(d) + w.d + v(d).q \ . \tag{3}$$

As an example, consider a firm producing made-up clothing, and suppose that design work has produced a basic template for some item of clothing and that further design activity costing $w.d$ could reduce the amount of stitching and economise on material, both of which are components of variable costs, so $v'(d) < 0$. However, the cutters and sewers would have to learn the new steps involved ($G'(d) > 0$), and the product's appearance on the market would be delayed ($p_d < 0$). The extra design activity would be undertaken as long as the reduction in variable costs exceeds the sum of the extra fixed costs and the loss of profit due to diminished demand. In other words, d increases so long as $\{q.p_d - G'(d) - w\} > v'(d).q$, until equality is brought about, as is required by condition (2).

A useful expression that is derived from both the first order conditions (1) and (2) is the following:

$$d.C_d/p.q = \epsilon \tag{4}$$

in which ϵ is the elasticity of price (inverse demand) with respect to design, which can be decomposed as the ratio of the elasticity of demand with respect to design ($d.q_d/q$) to the usual price elasticity of demand. Assuming that the firm is in production ($p,q > 0$), the equation implies that if design effort has no impact on the demand function ($\epsilon = 0$), then the firm will either set d to zero, ie. not have any design effort, or pursue the design effort until it can no longer decrease costs at the margin ($C_d = 0$). The case of particular interest, of course, is where both d and $\epsilon > 0$. Assuming a positive design effort and finite elasticities, and using the cost function (3), consider the case in which $G'(d) = v'(d) = 0$: then only the direct costs of the design work affect the cost function. In that case $C_d = w$, and equation (4) implies that design costs as a fraction of total revenue will equal the elasticity ϵ.

Other firms' design efforts should have the effect of diverting consumers away, and this can be reflected in the inverse demand function by writing it thus:

$$p = p(q, d, D) \quad \text{with} \quad p_D < 0$$

in which D represents the design efforts of rival firms. The firm's actions will only be affected by this if it thinks that its own decision about d will influence D - that is, if it has a non-zero "conjectural variation" (D_d) for design. Now the equilibrium condition (2) above must be amended to take this interaction into account by including the indirect effects that work through the conjectural variation:

$$q.(p_d + p_D.D_d) = C_d \tag{2a}$$

and the elasticity condition (4) must also reflect firms' conjectures about rivals' responses. Writing ϵ_D for the elasticity of inverse demand with respect to rivals' design efforts ($D.p_D/p$) and ϕ for the conjectural elasticity ($d.D_d/D$), we find:

$$d.C_d/p.q = \epsilon + \epsilon_D.\phi. \tag{4a}$$

It can be seen that if the firm conjectures a null response of rivals to its own design efforts, so that $\phi = 0$, then (4a) specialises to (4). However, a belief that rivals will respond ($\phi > 0$) will tend to reduce the right hand side of (4a) since $\epsilon_D < 0$, implying a reduction in design effort.

There is a normative question concerning the socially optimal input of design resources, because it can differ from that arising from profitability criteria. Ignoring income effects, social welfare is the sum of profits and consumer surplus, $W = \pi + S$ where consumer surplus is:

$$S(d, q) = \int_0^q p(d, v)\, dv - q.p(d, q)$$

and hence

$$W(d, q) = \int_0^q p(d, v)\, dv - C(d, q)$$

Maximising W over q and d, the first order conditions are as follows:

$$p = C_q \quad (5)$$

and

$$\int_0^q p_d(d,v)\ dv = C_d. \quad (6)$$

Equation (5) is the standard welfare injunction that price should equal marginal cost, and comparison with the corresponding condition for profit maximisation (1) demonstrates the familiar result that a firm with market power charges too high a price and produces too small an output for a given design effort. Comparing (6) with (2) reveals that the difference is on the left hand side of the two equations. The comparison implies that it is how design shifts the whole demand curve - not just the extent of the shift at the profit-maximising output level - that determines whether the profit-making firm over- or under-supplies design. The difference in the left hand sides of (2) and (6) is that between the effect of more design on the marginal consumer and the average affect of more design on all the intra-marginal consumers (see Spence, 1975). If the marginal consumer values an increment in design less than the average intra-marginal consumer, then a profit oriented firm will undersupply design, given the output implied in (5). While there is no presumption that this is necessarily so, it may be a common case.

4. Monopolistic competition and product differentiation

Product differentiation can be horizontal or vertical. Horizontal product differentiation concerns the creation of different species of products belonging to the same general type or genus, whereas vertical product differentiation concerns the creation of different qualities of the same basic product. The meaning of quality in this context is that if two products which differ only in the quality dimension are on offer at the same price, then all consumers would prefer one over the other. However, the expression "product differentiation" is usually understood to mean horizontal product differentiation, and this will be understood here until vertical product differentiation is explicitly discussed at a later stage.

4.1 Horizontal product differentiation

A fruitful approach to horizontal product differentiation is that products are considered to be amalgamations of more basic characteristics (Lancaster, 1979). In the simplest case, an amalgamation is just a mixture of these characteristics. Analysis proceeds on the assumption that consumers' preferences are defined in terms of these characteristics, rather than the products themselves. A product innovation is then the creation of a product with a new combination of characteristics.

The form of industrial organisation within which product differentiation is usually discussed is monopolistic competition. The current theory of monopolistic competition brings together two strands which originated in the seminal works of Hotelling and Chamberlin in 1929 and 1933 respectively (Lancaster, 1979). In the Hotelling model the products of the competing firms are differentiated solely by their location along a line (a road), and consumers' preferences for these products are simply ordered by the cost of transport. With simple and arbitrary assumptions about the density of consumer demand by location (uniform), and about the cost of producing at different locations (no costs of relocation), Hotelling argued that in a duopoly industry the two firms would be located together "back to back", with each taking half of the market - whereas the socially optimal location, which minimises transport costs, would be at the quartile points along the road. It can be seen therefore that monopolistic competition and product differentiation raise problems of both a positive and normative kind.

The tendency in the Hotelling model for firms to cluster in the specification of their products is at variance with a precept derived from Chamberlin's model, namely that firms will attempt to differentiate their products from each other in order to decrease the elasticity of demand that they face for their output. The clustering prediction persists with different (exogenous) numbers of firms in the industry, and with higher dimensional preference spaces (Lerner and Singer, 1937; Eaton and Lipsey, 1975), though it apparently depends on the finiteness of the product characteristics space, because in models in which preferences are distributed round a circle rather than along a finite line the prediction is that firms will be evenly spaced out. Another peculiarity of the Hotelling model is the fact that a given number of firms serving the market was assumed from the outset, whereas in the absence of nonconvexities in production, and assuming that firms can join or leave the industry freely, a competitive equilibrium will entail production of goods covering the complete spectrum of preferences, like haircuts. Thus the cause of finite product variety in competitive markets is to be found in production nonconvexities - economies of scale.

Chamberlin, in contrast to Hotelling, assumed the existence of economies of scale and allowed the number of firms in the industry to be endogenous. However, Chamberlin's analysis does not involve explicit modelling of the ways in which products are differentiated. Nevertheless, an implication of the Chamberlin model is that product variety is limited by the rate at which average cost declines with output (though the discussion about the supposed welfare implications of this in terms of "excess capacity" has been largely erroneous - see Spence, 1976a and Lancaster). Declining average costs may arise for a variety of reasons, but the simplest case is that in which some fixed cost, like research and development or marketing or advertising or design, is involved.

If it is assumed that the creation of a new product variety (relocation) is itself costly, but there is otherwise free entry to the industry, then firms will necessarily apply some foresight to their location decisions. Each firm contemplating entry into the market in such circumstances would consider how other rational firms, not unlike itself, would react to its own decisions: "No firm mistakenly considers itself a profit maximiser in a world of fools" (Prescott and Visscher, 1977). Clustering of products will not be observed in this case. Rather, firms will aim for gaps in the existing product spectrum. This leads firms to locate themselves in the space of product characteristics in such a way as to leave an insufficient gap in the market to make entry by other firms profitable. If they succeed in so doing then they can maintain a non-zero profit even in the absence of any barrier to entry (Prescott and Visscher op. cit., Lane 1979).

Hence the extent of product variety, and the profitability of firms, are determined by the structure of costs - and not by the ferocity or the mildness of price competition. Consider the position of a potential entrant into the market. It is seeking gaps in the product spectrum, compared to the distribution of consumers' preferences in the space of product characteristics. But these gaps do not depend on the prices that the present incumbents are charging. If the firm actually entered the market with a particular product specification, all its neighouring competitors would adjust their prices to make the best of the new situation. Hence, an attempt to deter entry by means of a threat to engage in a price war will be seen by all rational firms - incumbents and new entrants alike - as an empty threat. The problem with prices in this regard is that they are reversible, and known to be so. The only credible threat or deterrent to new entry is an insufficiently sized gap to make entry profitable at whatever prices might ensue. The reason for this is that, unlike a price decision, a product specification decision involves the commitment of a fixed cost which is irreversible - a sunk cost.

Firms with differentiated products compete, therefore, in two stages. First, they choose whether or not to enter the industry with some particular product specification. Secondly, with a given constellation of products on offer to the market, firms choose the prices of their products to maximise profit, and their optimal prices will be locally interdependent. That is to say, each firm's prices depend, among other things, on the prices set by other firms producing neighbouring products in the product characteristics space. Strategic considerations are of importance in the first of these two stages. It is claimed that it is at this stage that firms in some oligopolistic industries engage in "product proliferation" as a means of deterring entry and extracting surplus profit from their range of products (Hay, 1976; Schmalensee, 1978).

The importance of declining average costs has been emphasised in the foregoing, and the fact that this may be due to the presence of fixed costs. Fixed costs, of which a part are design costs, are therefore of particular importance in the theory of monopolistic competition. Fixed costs "..restrict the number and variety of products that it is feasible or desirable to supply, and therefore force an economy to choose from the large set of all conceivable products" (Spence, 1976b). The question is: how good is the choice generated by the market? In the market the set of products is determined by profitability, which is part of the total surplus. By contrast, in the social optimum it is the total surplus which is maximised, which means consumers' surplus in addition to profits. Compared to this, the market criterion of profitability gives rise to a bias in the selection of goods made available. The bias works against certain kinds of products, which have been characterised as "special interest products". These are products for which there is a wide disparity in consumers' valuations, which is to say that these products have steeply sloped demand curves. The problem is that firms, being unable to price discriminate, are not able to appropriate enough of the surplus to cover the fixed costs of making the product available. Thus consumers with eccentric tastes are driven to conform by consuming the standard product or refraining altogether from this type of consumption, unless some non-market mechanism can be found to supply the goods, such as clubs or cooperatives.

4.2 Vertical product differentiation

As was mentioned above, vertical product differentiation concerns products that are differentiated by quality, where quality differences are defined in terms of consumer preferences between pairs of products at a common price. If product A is of superior quality to product B, and they are offered at the same price, then all consumers would choose A over B. In a remarkable series of recent papers it has been demonstrated that the equilibrium configuration of industries characterised by vertical differentiation can vary between a highly fragmented industry and a highly concentrated industry, depending on how the generation of perceived quality differences impinges on fixed and variable costs (Shaked and Sutton, 1982, 1983, and Sutton, 1986). *If the burden of creating higher qualities falls mainly on variable costs, then a fragmented industry providing a spectrum of product qualities can be expected. But if higher qualities require expenditures on fixed costs, there may be an upper limit on the number of firms producing distinct product qualities that can survive at equilibrium.* This has led the authors to describe the industries characterized by such technological conditions as "natural oligopolies".

4.3 Multi-product firms

Much of economic theory assumes that firms produce a single product. This applies in particular to the theories of monopolistically competitive firms in which product specification is central to the analysis. However, as was pointed out in Section 2, the firms in the clothing industry typically produce a range of products, and when we come to consider new technology, it is the essence of flexible automation that it concerns the set of products that a firm can produce. Hence the need to consider firms as multi-product entities. One of the analytical difficulties that multi-product firms present is the interactions between products which affect both costs and revenues. If there were no such interactions the firm could be analysed as a simple aggregation of its various product lines, and in effect nothing would be lost by considering single product firms in such a context. Let us consider the implications of demand and supply interactions separately, beginning with the former.

Because a multi-product firm takes the demand interactions between its products into account in deciding what set of products to bring to the market, its selection of products will be interestingly different from that produced by a collection of single-product firms in monopolistic competition (Spence, 1976a,b). The introduction of a new product affects the profits that can be earned from other products - it reduces those profits if the products are substitutes, and increases them if they are complements. A single-product firm contemplating entry into the market with a new product will be oblivious, or at least unconcerned about these effects on the profits of other firms. If the product is a substitute for some existing products on the market, the demands for these existing products are reduced, diminishing both the profits earned on them and their consumers' surpluses. But since these effects are ignored, there is a presumption that too many substitute products will be produced by single-product firms. At the same time, there will be a tendency to undersupply complementary products, because for such goods the external effects which are ignored are positive. By contrast, when the goods are supplied by multi-product firms the effects are internalised, at least as far as the effects on profits are concerned, and both the overcrowding of substitutes and the undersupply of complements are diminished. The market will, of course, have a mechanism by which this preferred position may be approached: a tendency for firms that produce strongly interacting products to merge, creating a market composed of multi-product firms.

The fact that multi-product firms take the whole set of products into consideration when deciding whether to introduce a new product may not, however, be entirely for the good. A problem arises because firms in this context can have the power to impede the entry of competitors by a judicious positioning of their products in the space of product characteristics, as discussed in Section 4.1. This can occur when a sunk cost is incurred in establishing the position, and the manner in which it is achieved is by ensuring that there is no gap within the range of the firm's products that would yield profits to the new entrant sufficient to cover the sunk cost. (Of course, the new entrant could be an established firm whose current domain is elsewhere in the characteristics space.)

Obviously, it is necessary for the incumbent firm to have a contiguous range of products in the characteristics space in order to be able to employ this strategy of preemptive product creation, and the likelihood that a firm could set up and maintain such a contiguous range of products diminishes with the dimensionality of the relevant characteristics space - though see Schmalensee (1978) for an important case involving at least four characteristics. With a contiguous range of products, the firm's ability to extract profit from its products varies with their position with respect to outside products. On the periphery of its domain, profitability will be set by the intensity of competition, and boundary products will be the least profitable, while within the domain profitability will be greater, being determined by the size of the fixed sunk costs involved in positioning the product. The implication here that incumbent firms with established products can maintain a profitable position by "crowding out" latecomers is an example of a more general phenomenon of "first mover advantage", which often arises in models involving product differentiation and technical change.

Turning now to supply side interactions, the effects of producing a particular product on the cost of producing other products may be referred to as 'interproduct economies' (Lancaster op. cit.) or as 'economies of scope' (Panzar and Willig, 1981). We shall restrict attention to the important case in which these interactions are generally positive, ie. where costs are lowered or at most unaffected for all products produced by the firm, and where it is the fixed costs of producing the various products that are affected. In this case the effect of such economies of scope is on the set of products that the firm produces, and not on the output level of any particular product, given that it is to be produced. The reason for this is that variations in fixed costs do not affect profit maximising output levels, because they leave the equalities between marginal costs and marginal revenue unaffected. But such variations do affect the level of profit on each (potential) product, and the decision whether or not to introduce a product turns only on the question whether the increment in profit arising from its introduction would be positive. But note that it is total profit that matters, so it is conceivable that a product would be introduced even though it could not cover its total costs, so long as the shortfall was less than the amount by which the costs of the firm's other products were reduced. There will therefore be a tendency for multi-product firms enjoying such economies of scope to introduce both a wider range and a denser spacing of products than would a set of single product companies utilising an equivalent amount of resources. To the extent that products are substitutes, this is a force on the supply side offsetting the conclusion above that a wider spacing of products comes about when demand interactions are taken into account by multi-product firms.

An implication of the foregoing is that *a change in technology that enables firms to enjoy increased economies of scope in the form of diminished fixed costs with respect to the set of product specifications, facilitates the establishment of a contiguous range of products permitting long-term profits to be earned which are impervious to outside competition.* The multi-product firm in such circumstances would have an even greater first mover advantage than hitherto.

4.4 Application to the clothing industry

Product differentiation is the norm in the clothing industry. It is sometimes the case that clothing can be considered to be a homogeneous commodity, but, other than in the China of Mao Ze Deng, that mainly applies where it serves the purpose of a uniform. The dimensions in which clothing is differentiated include the following: type of garment, size, style, quality, colour or pattern, and material. Of these six attributes, the first two - type and size - reflect an element of inherent product differentiation, due to the fact that the market is unavoidably segmented. Even in Mao's China there had to be garments of various types (jackets and trousers, say) and sizes. But, while the demand side of the market is thus compartmentalised, it is interesting to note that the organisation of supply is rather different regarding the attributes type and size. Thus, whereas a firm's output will typically span a range of sizes, it is not unusual for firms to specialise in a very limited set of types of garment. Why this difference? It is obviously to do with the fact that economies of scope (inter-product economies) apply more strongly to size-differentiated products than to type-differentiated products. The same design, material buying and marketing apply to products differentiated only in size. Also, where the same firm produces clothing of different types, that too is because of economies of scope. In this case, however, the economies of scope are likely to arise because of interaction with some other attributes - thus a firm produces clothes of different type because they "match", or reflect some wider design concept, or use the same special materials.

The essence of product differentiation among clothing producers is therefore in the remaining four attributes: style, quality, material and colour/pattern. They are of course intercorrelated, but the important point is that the four variables contribute in particular ways to the two 'principal components', namely horizontal and vertical product differentiation. Products are horizontally differentiated in terms of style, colour/pattern and, to some extent, material; whereas they are vertically differentiated by quality, material and, to some extent, style (in the sense of the adjective "stylish"). The firm positions itself in both aspects of product differentiation by its design and marketing activities.

Since there is an annual cycle for the clothing industry, with new product ranges appearing every season, which occurs twice or possibly four times a year, the firms in the industry can reposition their products in the characteristics space with the same frequency. Thus product locations can, and do, vary regularly. But within the season, product location is fixed. It is not feasible, given the lead time from initial design to final marketing, to switch designs - product locations, that is - midseason. This has led to a situation in which some firms stake out an early product location by announcing to the world what their designs for the forthcoming season will be. The firms that do this would be in a vulnerable position if latecomers could simply position their own products optimally in the characteristics space with regard to given positions staked out by the leaders. But there is another dimension to it, namely the design leaders are actually defining the appropriate characteristics space - by determining what is fashionable. In this way, the leaders' designs become the standard by which others' products are judged, and consumers would always prefer clothes with a "designer label" over some anonymous design, *ceteris paribus*. Thus high fashion design is tantamount to vertical product differentiation. With this interpretation it is possible to explain the oligopolistic structure of the "top end" of the fashion clothing market. The key is in the costs required to position a firm at the top end of such a vertically differentiated market. The creation of quality in this sense falls mainly on fixed costs - design and marketing, including the expensive shows and publicity. Of course the clothes themselves are typically hand-made and use expensive materials, which imply higher variable costs. *But it is the relative importance of fixed costs in the production of quality which tends to make the market oligopolistic.* For comparison consider the top end of the men's non-fashion clothing market, which is traditionally one of bespoke tailors. Here the creation of quality falls mainly on variable costs - labour and materials - and the market is quite highly fragmented, which is as the theory predicts (Sutton, 1986).

However, the ostentatiously visible top end of the clothing market is rather atypical of the industry as a whole. Design matters for the bulk of the industry, not as a device for vertical product differentiation, but for horizontal product differentiation. It still involves the incurring of costs which are both fixed and sunk. These cost attributes are, in other contexts, a possible source of local monopoly power because they encourage competitors to distance themselves from an established firm. However, with an annual cycle of new product specification, no firm in the clothing industry is necessarily committed to a particular position in the product characteristics space for the following season. *The only way a firm can get established or be considered as an incumbent is by creating a "design image" that is consistent over a period of several seasons.* That is one strategy that a firm can adopt - such firms might be considered "leaders" in the design game. They do, however, face a risk that fashion has moved demand away from their chosen location. Another strategy is to wait until the last possible moment, when the uncertainty about demand might be somewhat diminished, and to position the firm's products accordingly. Since firms adopting the latter strategy are necessarily delaying their design decisions, they may be considered "followers". But they are far from passive in this role; rather, their strategy is aggressive and rests on their ability to move quickly to areas of high demand.

Whether leaders or followers, all firms have an incentive to discover how their competitors plan to position their products - their design intentions in other words. This of course presents designing firms with a problem because design, being a form of information, has the same public goods properties that other kinds of information share. In the clothing industry the only effective ways to appropriate the value of design work are either to keep it secret until it can no longer be of use to the competition, or to make it specific to the firm by linking it to a distinctive image, possibly through advertising.

5. The implications of changing technology

The changes in technology outlined in section 2.2 and elsewhere above have a number of implications for the firms in the clothing industry, and for the industry as a whole. The new technology simultaneously offers several changes: it makes possible the substitution of capital for labour, and hence has implications for the industry's demands for factors of production; it enables manufacturers to produce a far greater range of products, and to switch between them in a flexible manner; it shortens the whole process from initial conception of a design to its final sale to the customer; and it allows feedback from the final consumers to the initial design stage, so that modifications can be brought about within a season. These changes will impinge heavily, not only on the organisational structure of the firms, but even more importantly on the structure of the industry and the nature of competition in the industry.

Firms which innovate by adopting the new technologies will have a much greater integration of the design, production and marketing functions than hitherto. These functions have, up to now, been separable. For example, it has sometimes made commercial sense to do the designing in Europe and subcontract the production activities to low wage countries. The logic of the new technologies, however, is to bind the stages of production, from the initial conception of the product to its final destination with the customer, together. It is, therefore, evident that, in addition to requiring a substantial investment commitment, such innovation will have a considerable impact on the structure and working practices of the adopting firms. In fact, *in adopting the new technology the firm will also need to make substantial organisational and managerial innovations.* It is quite possible that these concomitant changes to working practices, hierarchical structures, location of production, and so on will be the deciding factors as to which firms will be early adopters and which will delay. The new technology also has implications for the strategies that are open to the firm, and hence for the competitive environment that firms are likely to find themselves in - these are discussed in more detail below.

The international location of the industry will be quite strongly influenced by the advent of the new technology, because of its impact on comparative advantage. With the forward integration from design to marking, grading and sewing, the variable cost of a given batch of clothes produced to a new design should be less than would have been the case with the traditional technology. The saving of variable factor inputs, which are mainly labour costs, will encourage firms in the high-wage countries to innovate with the new technology. It is in these countries that the labour force is most highly educated, and hence most likely to supply the necessary new skills for the new technology. Thus *the incentive to innovate should be greatest for the firms which still carry out the bulk of their productive activities in the high wage countries.* Firms which have subcontracted their production activities to low wage countries have a double obstacle to innovation: the savings in production costs will not appear so large to them, and the necessary reorganisation of their activities will be more costly to them.

At the design end of the production process, the new technologies should entail a substantial decrease in the marginal cost of a new design. The reduced cost of new designs should lead to a much greater proliferation of designs - probably in the sense of more variations on the basic theme which is currently in fashion. There will be a tendency towards custom-made clothing, and there should also be a greater availability of speciality clothing as the fixed costs attributable to such products will have been diminished. This greater product variety will be created in a smaller number of firms than hitherto because to achieve the economies of scope that the new technology makes possible will require a substantial investment in plant and equipment. These larger fixed costs imply a greater range of declining average costs and hence a larger minimum efficient scale for the firms in the industry once the new technology is established. Consumers can benefit from a reorganisation of production into larger multi-product firms: such producers take more account of interactions between the demands for different products, and are therefore more willing to supply complementary products.

Despite a tendency for fewer firms to populate the industry, each producing a greater range of products, it cannot yet be inferred that competitive pressure between firms will be thereby diminished. Although the considerable investment required to realise the greatly enhanced overall economies of scope means a commitment of fixed costs, the costs relevant to the positioning of a particular product in the characteristics space will be much less than before, even though such costs may be described as "sunk" - that is, specific to the product. Hence the ability to use sunk costs to crowd out the competition will be correspondingly reduced. In these circumstances product proliferation by "incumbents" will not be a viable strategy to fend off the opposition and maintain profits. Instead, all the conceivable product niches will have become "contestable" (see Baumol et al, 1982). This contestability of the various product niches places a premium on the ability to move quickly so as to "steal a march" on the opposition.

The capacity to produce a new range of clothes quickly will be one of the characteristics of the new technology. The firms that innovate first will therefore be in an advantageous position in the industry. However, it was argued above that the innovators are likely to be firms whose production takes place in high wage countries, because the new technology offers them the greatest savings in cost. These firms have in the past typically been the design leaders, and have extracted quasi-rents on the basis of their design work. By contrast, firms which are either based in the low-wage countries, or which have subcontracted production to those countries, have been the price-competitive design followers. It is the latter which have the experience, organisation and management style that would most benefit from the advantages of speed and flexibility. Hence, it could be counter-argued that these may be in the vanguard of innovation. In the face of such conflicting possibilities, it is perhaps reasonable to predict that the complementary synergies between firms of these two broad types may encourage pairs of them to combine so as to extract the most profit from innovation.

In the long run, the industry will have adapted to the new technology, and firms will be competing on the same footing. The industry will be composed of larger firms, each producing a greater variety of products. As was argued above, the logic of the technology makes even more competitive behaviour likely, despite the more oligopolistic structure of the industry. In addition, the technology may have consequences for the behaviour of the industry at the macro level. The greater integration of the industry and the increased flexibility of production will enable producers to get feedback from the market place within the season, and thereby to correct previous errors. Producers will have the ability to modify designs, to increase the production of popular models and to switch production away from designs that are not profitable. This points to a much diminished reliance on inventories compared to the present situation, and a consequently reduced exposure to market risk. The adaptability of production with the new technology should further reduce the importance of pre-season buying by retailers, and their end-of-season sales at reduced prices. So retailers, as well as producers, should face lessened demand risk and consequent output price variability. Moreover, the lessened dependence on inventories in the system could point to a radically different channelling of supply to the market, with much less reliance than hitherto on wholesaling services. Furthermore, it is possible that the reduced need for stocks may attenuate the conjunctural cycle of the clothing industry.

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