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Waiting Time: A Factor in Export Demand for Manufactures

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I. INCLUSION OF WAITING TIME IN THE THEORY OF DEMAND

To a great extent, manufacturers of durable goods — goods which account for a large and growing proportion of the value of the world's exports — meet current demand out of future production. As a result, there may often be a significant delay between the placing of an order and the shipping of the product. This delay, or "waiting time," will be costly if the purchaser does not perfectly anticipate his own needs and therefore cannot arrange for delivery at the ideal time. If, for example, the purchaser cannot get delivery as rapidly as he desires, he pays not only the quoted price but also the imputed cost of waiting. Waiting time has two important implications for the study of international trade. First, the length of time to delivery constitutes an additional factor which, together with such considerations as price, quality, and terms of credit, determines the competitiveness of a country's products in world markets. Second, the length of delivery time represents the minimum amount of time that must elapse before there is an observable response in the level of a country's export shipments to a change in the exchange rate or in any of the other determinants of export demand.

The role of length of delivery time in export demand was first examined in an empirical study by Steuer *et al.* (1966), who found waiting times to be highly significant variables and relative prices not significant in the explanation of foreign new orders for British machine tools. Their paper sparked subsequent research. Bispham (1970, pp. 45–49) included a measure of order backlog in equations explaining export new orders for the aggregate of British engineering industries. His estimates suggested that, as measured by the beta coefficients, relative delivery dates typically account for three times as much of the variation in export orders as do relative prices, although both effects are considerably less important than the level of total world demand. In a later report, Artus (1971) confirmed that British export orders for machine tools and for all machinery were favorably influenced by long waiting times in a competing country, Germany. He also noted that long waiting times in the exporting country had an unfavorable influence for the British and American machinery industries as well as for the American machine-tool industry. Gregory (1971) concluded that American buyers consider domestic (but not foreign) terms of delivery when choosing between domestic and foreign suppliers and suggested that a 50 per cent increase in waiting time is equivalent to an 8 per cent increase in actual price.

These studies are useful in that they present preliminary findings to suggest that waiting time, a long-forgotten factor in empirical studies, may indeed be an important determinant of export demand. Unfortunately, their authors failed to draw upon general price theory to obtain an understanding of precisely how terms of delivery affect demand. As a result, their estimation procedures suffer from misspecification, and the theoretical underpinning for subsequent work is never laid out.

The procedures used in these earlier studies were based on largely empirical rather than theoretical considerations. Steuer *et al.* (1966) admitted that it would be desirable to relate orders for machine tools theoretically to the explanatory factors they included in their estimating equations, but they felt that it was not feasible to do so. Instead, they examined a wide range of possible relationships, using single-equation, least-squares regressions (p. 394). These relations included either the ratio of two countries' waiting times — the formulation presumed to be the more appropriate — or countries' waiting times as separate arguments — an approach designed to accommodate waiting-time estimates for more than two countries. Neither of these approaches proved to be entirely satisfactory statistically. Although their regression estimates improved when waiting times were entered separately, Steuer *et al.* suspected that at least one of the waiting-time arguments was not capturing the effects of fluctuations in delivery times but, rather, was standing in as a measure of world demand (pp. 397–398). Artus (1971) found that, when waiting-time estimates were entered separately, multicollinearity between these estimates was frequently so serious that it was difficult to isolate statistically the independent importance of any one of them (p. 27).

Nevertheless, a theoretical approach for introducing waiting time into empirical export-demand equations can easily be derived and has been suggested by the variety of analyses that treat time as an economic good.[1] Becker (1965), in his general treatment of the allocation of time, analyzes a case that closely anticipates the approach used in this study. Initially, he assumes that no time is required to purchase a particular market good.

[1] Apart from Becker's (1965) work, described below, Stigler (1961) stressed that the search for the lowest price is expensive in terms of both time and money; Mincer (1963) explicitly included in the demand function the buyer's opportunity cost of time spent consuming a product; and Contini (1968) concluded that in labor negotiations the bargainer who is more anxious to reach agreement may have to settle for a relatively less advantageous solution.

Then he posits a price ceiling on that good (below the market price) and a production subsidy sufficient to maintain the same level of output. Because of the cut in price, more is demanded than is supplied, and the good must be rationed. If the good is distributed on a first-come first-served basis, a queue of prospective customers will develop and grow until the expected cost of joining the line is so high as to discourage the excess demand. In other words, the total cost of the commodity remains unchanged, but indirect time costs are substituted for direct goods costs.

In this study, I first explore the theoretical relationship between demand for a product and alternative terms of delivery. I demonstrate that the relevant consideration for a potential purchaser is the difference — not the ratio — in waiting times offered by competing suppliers, given quoted prices. Since a demand equation that includes the difference in waiting time cannot be transformed into one that is a function of waiting-time ratios, it is not surprising that the separate waiting-time arguments in the Steuer *et al.* equations provided the better results.

My second objective is to extend the work of earlier authors by analyzing the role of waiting time for a wider range of industries and a larger number of countries than have been covered before. The industry groups to be studied are iron and steel, fabricated metal products, and various sectors of the mechanical and electrical engineering groups. The countries to be included are those for which data could be obtained. Waiting-time estimates were calculated for Canada, Germany, Japan, the Netherlands, Norway, the United Kingdom, and the United States. Export-demand equations were estimated for at least one industry in each of these countries (except Canada). Although this group of seven countries does not contain all important suppliers for each of the several industries studied in this paper, these countries — with two members of the European Economic Community, two members of the European Free Trade Area, two countries of North America, and the major industrial nation of the Far East — are probably representative.

The method of calculating waiting times and the procedures used to introduce the waiting-time difference into an empirical export-demand function are discussed in Chapter II. Although it is important to appreciate the limitations of the statistical techniques employed, the reader interested primarily in the results of these experiments might wish to proceed quickly over the technical discussion of this chapter and turn to Chapter III.

Even though the emphasis of this study is waiting time, one should not lose sight of the other nonprice factors that may enter into the demand function for a particular commodity, some of which may be of greater importance. When British companies were asked to give reasons for any changes in their export position during the period 1960–65, better marketing, improved design, and a change in product mix were the most frequently given reasons for improvement. The greatest hindrance to exports, in the opinion of most companies, was presented by tariffs and quotas. Too long delivery dates were considered to be as important as uncompetitive prices only by companies that exported more than half their total output (National Economic Development Council, 1965).

However, delivery dates have been shown to be of crucial importance from time to time. When Cooper *et al.* (1970, p. 100) asked British pottery firms wishing to increase foreign sales what actions they were taking to encourage export orders, the largest group of respondents indicated they were giving export orders priority (see Table 1). The now infamous contract that Rolls Royce had to accept to fill a £1 billion order for their RB211 aircraft engines from Lockheed serves as another example. Lockheed was so concerned that the engines be delivered on time that, as a condition of the contract, it drew up detailed production schedules and required U.S. auditors to determine that the schedules were being kept. The penalties imposed for late delivery were so severe that when, in fact, Rolls Royce was unable to meet the technical requirements by the stated date, it was forced into receivership.

TABLE 1

ACTION TO INCREASE PROPORTION OF EXPORTS TO TOTAL SALES: POTTERY INDUSTRY, UNITED KINGDOM

Action	*Frequency of Response*
Giving priority to export customers	8
Doing all we can already	6
Arranging mix of products to suit export markets	2
Looking for new markets	2
Increasing selling effort overseas	1
Adding production capacity	1

SOURCE: Cooper *et al.* (1970, p. 100).

The Theoretical Model

There have been several attempts to analyze from the supply side the effects of waiting time and other factors on a country's competitive position (see, for example, Ball *et al.*, 1966; Adams *et al.*, 1969; Henry, 1970; and Artus, 1971). The so-called "pressure-of-demand hypothesis" supposes that all forms of nonprice competition are less favorable for a country when, other things being equal, the level of domestic demand is especially high. This hypothesis implies that producers give preference to the domestic market, which is assumed to be the more profitable, and allow delivery terms for export orders to lengthen while they meet the demand at home. The approach taken here is, by contrast, from the demand side.

The principal effect of a delay in delivery is to force the purchaser to wait before he can enjoy the service flow from the commodity in question. The seriousness of this delay will depend on how well the individual purchaser anticipates his needs and in what manner he discounts the value of the product's services in future periods. If the buyer perfectly anticipates his future requirements and the ability of his supplier to meet commitments, he can avoid the inconvenience of waiting simply by placing his order at the appropriate time. But if he does not have the benefit of perfect foresight and he has a positive rate of discount — if he values the good's services in the current period more highly than those in subsequent periods — then the buyer may have to be compensated for any postponement of the service flow. It is the trade-off between waiting time and price that is the focus of this paper.

To derive the role of waiting time in the demand function, I need simply assume maximizing behavior. That is, I assume a purchaser is willing to pay as much as the present value for any given product and that the rate at which he is willing to substitute between two alternatives is therefore the ratio of present values. Consider, for example, two machines identical in every way except that the first can be delivered in period t while the second cannot be delivered until period T, $T > t$. Other terms of sale are the same in both cases. The purchaser, considering these two alternatives, must add to the price of the second machine the present value of its foregone use during the period when the first machine would be available, then subtract the present value of the use of the second machine after the first has worn out. If R_n is the money value of the return from the machine in the nth period, α is the appropriate rate of discount (assumed, for convenience, to be uniform for each period), and k is the life of the machine, a purchaser willing to pay the present value (PV) for each machine would have to contrast

$$PV_1 = \sum_{n=t}^{t+k} R_n A^n, \qquad \text{and} \qquad PV_2 = \sum_{n=T}^{T+k} R_n A^n, \tag{1.1}$$

where $A = 1/(1 + \alpha)$.

The purchaser would be indifferent between the two machines if the difference in quoted prices were equivalent to the difference in present values. In the more specific case where the return to the machine is assumed to be constant over its life and equal to $\bar{R}$, and where the rate of discount is positive (i.e., $A < 1$), it can be shown that the machine with the earlier delivery can command a higher price. For, under these more stringent assumptions, the condition for indifference can be reduced to

$$PV_1 - PV_2 = \bar{R}A^t(1 - A^{k+1}) \sum_{n=0}^{T-t-1} A^n > 0 \,.$$

In most cases, of course, goods traded internationally are not identical in all respects other than length of time to delivery. If we allow for quality differences and unique design specifications, it is no longer possible to determine which of the machines will command the higher price. But the rate of substitution between two machines is easily determined. If, as before, it is assumed for the sake of simplicity that the return to each machine is constant over its life and equal to $\bar{R}_1$ and $\bar{R}_2$, respectively, and, further, that consumers weigh the relative merits of the two machines independently of their time preferences, the rate of substitution (s), equal to the ratio of present values, can be shown (Greene, 1972, pp. 17–19) to reduce to

$$s = PV_2/PV_1 = (\bar{R}_2 A^T \textstyle\sum_{n=0}^{k} A^n)/(\bar{R}_1 A^t \sum_{n=0}^{k} A^n)$$
$$= (\bar{R}_2/\bar{R}_1)A^{T-t} \,. \qquad (1.2)$$

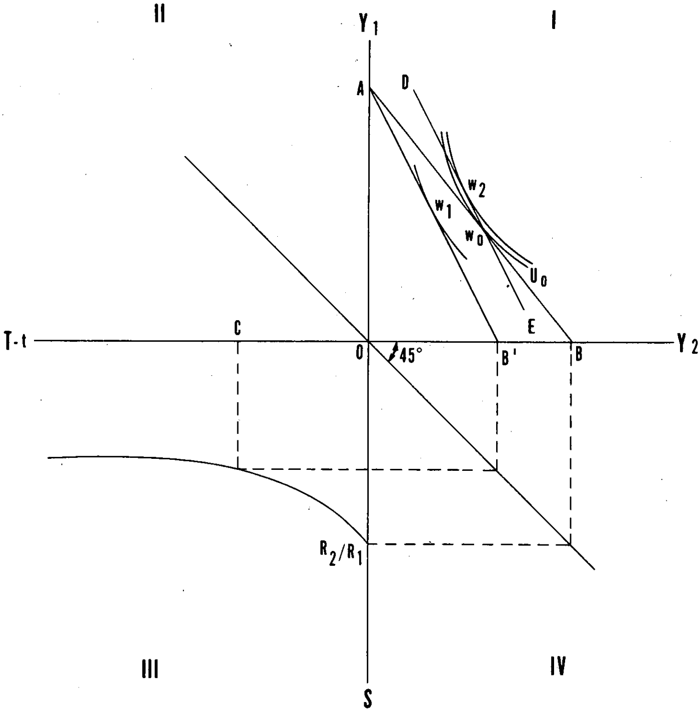
Notice that this ratio of present values involves the difference in waiting times, not the ratio of waiting times.[2] This ratio indicates that, when delivery terms are identical, the marginal rate of substitution reflects only the relative returns of the two machines. But when delivery time for the second machine is longer than for the first, these relative returns are discounted by the *additional* amount of time the consumer must wait to acquire machine 2.

Waiting times can readily be included in the traditional graphical treatment of the theory of demand. The rate at which individuals are willing to substitute between competitive products with different delivery dates, given by equation (1.2), is a downward-sloping function of the variable $T - t$, as shown in quadrant III of Figure 1. When the terms of delivery are identical for both products, $s = \bar{R}_2/\bar{R}_1$ (or 1, if the two goods are perfect substitutes). Quadrant I contains the usual budget

[2] In the event that the machines are perfect substitutes — that is, that $\bar{R}_1 = \bar{R}_2$ — the marginal rate of substitution reduces further to $s = A^{T-t}$.

FIGURE 1

THE EFFECT OF WAITING-TIME DIFFERENCES ON CONSUMER EQUILIBRIUM



constraint scaled in such a fashion that, for convenience, the distance OB equals the distance $\bar{R}_2/\bar{R}_1$ (or unity). The ratio of quoted prices facing the purchaser is equal to the slope of the line AB. Clearly, if the terms of delivery are identical for both products, the quoted prices will fully reflect the relative costs of the two items, and the buyer will be in equilibrium when his marginal rate of substitution — the slope of his indifference curve — is equal to the ratio of quoted prices (see point w_0).

If, however, machine 2 will be delivered later — that is, $T - t$ is equivalent to a distance such as OC — the effective relative cost of the two machines is not the ratio of quoted prices (the slope of AB) but rather the slope of AB'. The total cost of machine 2 includes not only the monetary outlay but also the delay in the use of the machine. Therefore, the relative cost of machine 2 is higher than that indicated simply by relative quoted prices. The consumer will not be in equilibrium until his marginal rate of substitution is equal to the slope of AB'. In addition, the value of the additional time lost represents a cut in the consumer's real income; the greater his rate of discount, the greater the income loss. In equilibrium, he will consume less of the service flow of machine 2 partly because of the loss of income (compare w_1 with w_0). But even if he were compensated for this income loss (that is, if the new budget constraint were DE), he would prefer to substitute some of the service flow of machine 1 for that of machine 2 (that is, the consumer would move from equilibrium at point w_0 to equilibrium at point w_2).

For simplicity of exposition, it has been assumed that the current period is the optimal time of delivery. If one accounts for the possibility that the optimal delivery time is, instead, some future date, the arguments become more complicated because the purchaser must compare whatever return he would obtain prior to the optimal delivery date against storage, financing, and other costs or inconveniences of too early delivery. Nevertheless, the marginal rate of substitution remains a function of the difference in the two goods' waiting times (see Greene, 1972, pp. 26–27). Moreover, it can always be assumed that, in any data on new orders used in an empirical study such as this, the orders recorded are wanted at least by the date promised, since a prospective buyer could have delayed his order so as to bring delivery more in line with his desired date of receipt.[3]

[3] If optimal delivery is later than the current period but prior to the quoted delivery date for either of the two substitute goods, the marginal rate of substitution is multiplied by a complicated ratio that is greater than unity.

II. INCLUSION OF WAITING TIME IN EXPORT DEMAND: THE EMPIRICAL SPECIFICATION AND ESTIMATING PROCEDURE

As shown in Chapter I, a demand function that takes account of length of time to delivery is similar to that conventionally assumed except that the price term is discounted by the difference in waiting times. Just as demand functions are frequently approximated, empirically, by a constant-elasticity demand function, so, too, the relationship shown in Figure 1 to describe the demand function for commodity χ_2 can be approximated by

$$\chi_2 = cY^{\varepsilon_0}[P/A^{T-t}]^{\varepsilon_1}, \tag{2.1}$$

where Y represents the consumer's income; P, the price of machine 2 relative to that of machine 1; A^{T-t}, the discounted value of the difference in waiting times; and ε_0 and ε_1, the income and relative-price elasticities respectively. This approach is fundamentally different from that adopted by Steuer *et al.* (1966) and Bispham (1970), who included the ratio of waiting times in the principal formulations of their experiments (Greene, 1972, pp. 22, 27–28).

The statistical procedures used to estimate demand equations of this type are similar to those used to estimate demand functions generally. The one difference, of course, is that a new independent variable has been introduced, the difference in waiting times. In this chapter, I describe how the waiting-time data were derived and review other data used. I then describe the actual empirical specification for the export-demand equations and attempt to determine if inclusion of a waiting-time differential would be expected, a priori, to introduce any bias into the estimation.

The Waiting-Time Estimates

Waiting times were calculated from data on new orders, unfilled orders, and shipments by way of a procedure first suggested by Steuer *et al.* (1966, pp. 389–390) and subsequently used by Artus (1971) and Nobay (1970). The procedure is to calculate the amount of time it takes for the first item ordered in a given month to be delivered on the basis of three assumptions: (1) that every recorded shipment appears also as an order on producers' order books;[1] (2) that items are ordered and shipped throughout a month;[2] and (3) that orders keep their place in the order queue, that is, orders are processed on a first-in first-out basis.

On the basis of these assumptions, a measure of waiting time can be calculated using any benchmark value of unfilled orders and time-series data on net new orders and shipments. The first item ordered in period t will not be delivered until all the items on order at the end of period $t - 1$ have been processed. Waiting time, therefore, will equal the number of months it takes for shipments, beginning at time t, to cover completely unfilled orders on the books at the end of period $t - 1$ as well as the first item ordered in period t.[3] Waiting times are always positive, and a value less than 1.0 indicates that shipment occurred within a month after the order was received.

This concept of waiting time (which differs from both the traditional measure of order backlog — the ratio of unfilled orders to deliveries — and that derived from a distributed-lag relationship between deliveries and new orders)[4] is based on assumptions which, to be sure, are not particularly realistic. Orders and shipments are not necessarily evenly spaced: purchasers often order several items at one time, with the result that orders

[1] Items sold from producers' inventories would be treated as being ordered and delivered simultaneously.

[2] My estimates of waiting time were based on monthly data wherever possible. However, when only quarterly data were available, I had to assume, as did Steuer *et al.* (1966), that items were ordered and shipped at equal intervals throughout each quarter.

[3] Mathematically, the waiting-time estimate (W_t), derived from data on the level of unfilled orders at some initial period (U) and time-series data on shipments (S_t) and net new orders (N_t), can be described as $W_t = (n - t) + (1/S_{n+1})$, where n is that value satisfying the condition $U + \sum_{i=1}^{t} N_{t-1} - \sum_{i=1}^{n} S_t = 0$. In most cases, the basic data are not independent series and, by calculating the estimates in this fashion, I use all the information contained in these three series.

For example, if unfilled orders at the end of December 1959 were 100 and shipments in the first three months of 1960 were, respectively, 45, 46, and 30, waiting time for the first item ordered in January 1960 would be $2\frac{1}{3}$ months.

[4] The ratio of unfilled orders to deliveries is satisfactory only if the rate of delivery does not change much; the procedure used here, by contrast, takes into account subsequent fluctuations in shipments. The distributed-lag model, unlike the Steuer *et al.* method, allows for the fact that work may be in process simultaneously on orders received in different periods, and that orders booked in a particular period may therefore be delivered before some previously placed orders. However, in all other respects the distributed-lag procedure requires the same assumptions as this one and is much more cumbersome to use when estimates for many industries are required, as in this study.

and subsequent shipments may be bunched up. In addition, orders do not always keep their place in the queue: purchasers who do not wish to take delivery at the earliest possible date may give up their place in the queue, while rush orders may jump their place in the queue and be handled more rapidly than the waiting-time estimates would suggest. But even if some orders are processed at rates different from the waiting-time estimate, under most circumstances there is little reason to expect a systematic bias to result from this method of calculation. The most serious problems occur when there are unusually large or unusually long-term contracts, or when there are sizable modifications and cancellations of orders previously placed. In any of these cases, there might be a distortion in the waiting-time series for several periods (Greene, 1972, pp. 32–33), causing serially correlated errors that may introduce additional problems in the subsequent estimation of export-demand equations.

As for the actual calculation of waiting times, the net new-order and shipment data are from monthly or quarterly series, whichever were available, before seasonal adjustment and for the period I 1960 through II 1970.[5] (Where the most recent data were not yet available, a somewhat shorter period had to be used.) The benchmark value of unfilled orders is end-1959. In some cases, data on unfilled orders were not available for any period, and an initial value of waiting time had to be assumed. In these instances, a variety of calculations were made, based on alternative assumed initial values. The series chosen was the one that best satisfied criteria established to ensure a "well-behaved" series throughout the estimation period,[6] and, in this respect, these are partly arbitrary.

Waiting-time estimates were obtained for several durable-goods industries and industry groups in seven countries (in one case, also the European Community). Coverage varies for each country according to the availability of data. Within each country, the different industrial sectors represent various degrees of aggregation. The industries for which estimates could be obtained represent from 12 to 42 per cent, individually, of these countries' exports in 1965, the midpoint of the period covered in this study: Canada, 12.1; Germany, 42.1; Japan, 18.1; the Netherlands, 18.9; Norway, 15.8; the United Kingdom, 35.4; and the United States,

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[5] Sources for all data are given under Data Sources at the end of this paper. Problems of comparability, coverage, and availability are described in Greene (1972, Appendix I).

[6] See Greene (1972, pp. 34–36) for the criteria used to choose the best series in these instances.