A GENERAL THEORY OF HEDONIC PRICING OF CAPITAL AS A FACTOR OF PRODUCTION*

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I. Introduction

Most of the production theory literature considers the capital input to the production process as, in some sense, a physically measurable entity. The vector of machines and structures is taken to b representative of the firm's fixed plant with Ōcm acquiring the plant is the "price" of capital to the firm, expressed as a function of the plant's characteristics.

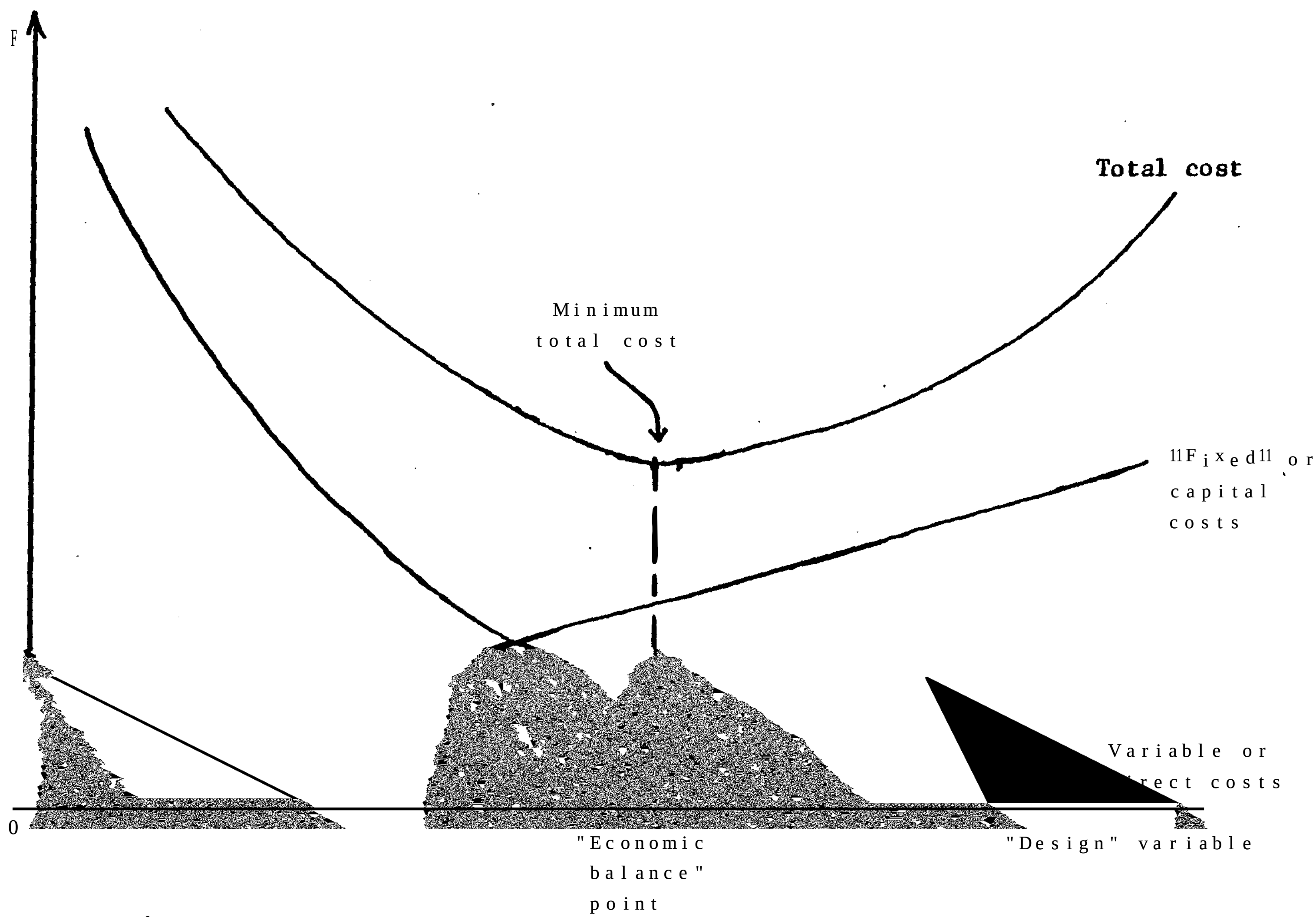
The use of hedonic pricing for production inputs in the economics literature has primarily been in the mdeling of steam electric power generation. The biler-turbine-generator (b-t-g) complex that is the heart of electric power production is well suited to hedonic pricing in that labor is relatively unimportant in the generating process and the ex[illegible] characteristics of the technology are fairly rigid and well known. Hence Stewart (1980) and Cowing (1974) use plant capacity and fuel efficiency, or heat rate, as the main elements in determining the purchase price of capital at the plant level. Since electricity exists only as a flow, plant capacity is defined as the technologically inflexible rate at which electric power is produced by a given b-t-g unit. The amount of fuel, in BTU equivalents, necessary to produce a kilowatt of electricity with a given b-t-g complex is also fairly rigid and well known by the firm's engineers. The ratio of BTUs of fuel to kilowatts of electricity then serves as an efficiency parameter associated with any given b-t-g unit. The cost of obtaining a steam electric generating plant is then determined by its capacity pgernS triiency economic context, while the second requires a sojourn into the practices of engineering economy. We will show that the hedonic pricing of capital is related to the "economic balance" concept used by engineers. It also implicitly restricts the substitutability of subsets of the inputs to the underlying production technology. When this restriction is imposed, the expenditure functions associated with hedonic pricing models yield factor demand relationships that are equivalent to those of neoclassical duality theory.

Section II discusses the general issues of plant capacity and efficiency, while section III relates hedonic capital pricing models to dual cost and production function models. Section IV summarizes and concludes.

II. Plant Capacity and Efficiency Measures

The idea of capacity is related to the ability of a firm to use its existing physical plant to produce goods. There are several ways to define the quantity of output that corresponds to the capacity output of a plant. The usual practice in economics is to define capacity output as that quantity that minimizes short run average cost, or as the firm's planned output over the expected life of a plant. These two methods are, however, not the [illegible] planê T the quantity corresponding to the tangency of the short and long run average cost curves.

It can be argued that the minimum point of short run average cost corresponds to the engineer's concept of designed capacity, since for an individual machine the design capacity is the rate of output at which the machine produces a "unit" at lowest average cost in material inputs. Nevertheless, for collections of machines, b r t [illegible] use the capacity rate q0 to represent the


Total cost
Minimum total cost
"Fixed" or capital costs
Variable or direct costs
0
"Economic balance" point
"Design" variable

costs rise with increases in the design variable. A clear optimum exists at the point where the reduction in variable cost just offsets the increase in capital cost, and this corresponds to the minimum point of total cost. The change in variable cost "balances" the change in capital cost at the balance point: the slope of the variable cost curve is the negative of the slope of the capital cost curve. In this way the engineering optimization mirrors the familiar economic marginal conditions.

Smith suggests insulation thickness, conductor size, pipe size, number of evaporators, pump capacity, and the like for the design variable. Electric power generation is an excellent example. For a given capacity b-t-g unit (in kilowatts) increasing thermal efficiency, or declining heat rate BTU/kw, causes the fuel requirements per kw to fall and so reduces fuel costs. Simultaneously, a lower heat rate requires higher temperatures and pressures in the boiler-turbine complex which in turn require stronger and more heat resistant construction. This tends to increase the purchase price of the b-t-g unit. Thus heat rate, or thermal efficiency, serves as the design variable that determines the economic balance point and the optimal design.

Amonia production is a similar case.[4] The first stage involves mixing natural gas with steam and injecting the mixture into tubes filled with a catalyst inside a reforming furnace. This produces hydrogen at which time air is added to produce more hydrogen and nitrogen for later use in the synthesis of amonia. The heat and pressure in the furnace tubes is crucial since higher pressure gives better heat transfer but also reduces the yield per pass. Hence reforming tube pressure may serve as the ammonia industry's equivalent of heat rate in electric power.

These processes do not employ labor directly in the production process and use fairly homogeneous raw materials to produce a chemically well defined product. These factors contribute significantly to the ease with which an efficiency parameter can be identified. Industries such as steel where the input proportions determine the character of the finished metal present a more preplexing problem. Steel production does exhibit relatively fixed labor requirements _ex post_, so further search for a physical efficiency ratio of input and output may be fruitful.

Assembly operations such as automobile production are even more complex in that an efficiency index of tons of inputs per ton of output may not be very meaningful. Short run or _ex post_ labor requirements in assembly operations may also be subject to change or responsible for minor alterations in the use of the fixed plant. Engineers typically figure capital requirements and material inputs by the economic balance method, but assign labor using textbook recommendations. The use of labor is then studied after the plant begins operation and altered as seems fit. This indicates. the process that economists tend to lump into the concept of the learning curve. At any rate, when labor is a signifcant participant in the direct production of the output this learning effect could bias the attempt to observe an efficiency parameter E F _post_. We will continue to base our hedonic

where the optimal ϵ^* is the "economic balance point" in Figure 1.

Both Stewart and Cowing assert a production technology composed of a rate function in terms of capital and the flow inputs

$$(2) \qquad q = G(K, x)$$

and a labor requirement of the form

$$(3) \qquad H = H^*(q)$$

where cummulative output is $Q = tq$, q is the output produced by running the plant at a constant instantaneous rate for the entire period, and t is the fraction of the period that the plant operates. The flow-fund production function in this case is

$$(4) \qquad q = f(K, H, x) = \begin{cases} G(K, x) & \text{if } H \geq H^*(G(K, x)) \\ 0 & \text{if } H < H^*(G(K, x)) \end{cases}$$

Labor requirements are determined by the rate of production alone, and do not depend on the amounts of the other factors used. This is compatible with the engineering practice of setting labor requirements for a particular design by predetermined standards. If the labor requirement is met, the rate of production is determined by the capital employed and material input flow. If the labor present is not adequate, no output is produced.

FIGUR: 2

K

H

21$F CP

have recently confirmed this property for electric power generation. When the technology can be described by (4), and when the observation of capital or its price is difficult, the hedonic pricing approach can be the answer to a problematic investigation.

FOOTNOTES

[1] Cowing lets total capital costs be a direct function of these characteristics, while Stewart posits a price function for units of capacity that depends on b-t-g capacity and heat rate. The two are formally equivalent. since Stewart's price function is conceptually identical to the average capacity cost function used by Cowing for his empirical work.

[2] Georgescu-Roegen suggests a production function of the form

$$q = f(K, H, x)$$

where q corresponds to an instantaneous rate of production sustained for a 24 hour period; K is the number of each type of machine present during the "day"; H is the number of each type of worker present while the plant operates; and x is the flow of material inputs required to produce q.

Then, if t is the proportion of the day that the plant actually operates, the observed total production for the day is given by

$$;F = tq = tf(K, H, x).$$

Klein has shown that a cost function dual to this technology exists.

[3] Either per year, per day, or per hour depending on the sort of process and the magnitude of the units involved.

FOOTNOTES--CoAtinued

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4 See Levin (1977) for a discussion of this and other industries from a process specific point of view.

4F This is also identical to Stewart's (1980) method ... [illegible]

6 These properties are listed in Diewert (1982a).

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