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ABSTRACT

Heterodox economists long complained about having no systematic alternative to neoclassical production and cost theory. This paper deals with this complaint. That is, it presents a theory of production and costs of the business enterprise that is a complete alternative to the neoclassical theory of production and costs of the firm.

KEY WORDS**:** heterodox theory, accounting rules, structure of production and costs, segmented plants, direct costs, shop expenses, enterprise expenses.

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HETERODOX PRODUCTION AND COST THEORY OF THE BUSINESS ENTERPRISE

1. INTRODUCTION

Heterodox economists complain about having no systematic alternative to neoclassical production and cost theory. The complaint seems somewhat inaccurate since over the last seventy years alternatives have been broached, starting with Gardiner Means, Philip Andrews, Joel Dean and Piero Sraffa and more recently Alfred Eichner (Lee, 1986; 1998). However, there is also a reasonable germ of truth to it as long as the alternative theory had to contain or mirror all of what constitutes neoclassical production and cost theory. What the heterodox alternatives failed to do was to adequately delimit themselves from their neoclassical brethren and to clearly articulate what an alternative production and cost theory would cover and what it would not. For example, most heterodox alternatives dismissed marginal products, but they did not extend their arguments to cost minimization, to marginal cost curves, or to constant output factor input demand curves. Moreover, most of the alternatives dealt with short period production and costs, but left open the possibilities for long period production and costs based on, implicitly, neoclassical returns to scale arguments. If any real progress is to be made in developing a heterodox theory of production and costs independently of existing neoclassical theory (and hence beyond critiquing neoclassical theory), it must be accompanied with empirically-based arguments that establishes its theoretical domain and at the same time rejecting the domain of neoclassical theory on the grounds that it is empirically ungrounded and theoretically irrelevant. What follows is a preliminary attempt to do precisely this: to develop a heterodox theory of production and costs of the business enterprise and delineate its domain relative to the domain of neoclassical production and cost theory.

The business enterprise produces an array of outputs, that is, goods and services or product lines. A product line may consist of a single main product with numerous derivatives but secondary and/or by-products; or it may consist of a conceptually distinct product that is a differentiated array of products. In either case, the structure of production of a single product in a product line is hard to isolate because fixed investment goods and labor power skills may be used to produce more than one product; and the costing of the product is difficult because of the problem of allocating various common shop costs. To overcome this, the *product line* is defined in terms of its core or main product—that is, a product line consists of a single homogeneous product. As a going concern, when producing any product line, the business enterprise engages in sequential acts of production through historical time and as a result incurs sequential costs of production also through time. These acts of production and the costs incurred in producing a product line are determined by the underlying relatively enduring structures of production and costs. The structure of production consists of the plant segment, the plant, the shop technique of production, and the enterprise technique of production; and correspondingly, the cost structure of the product line consist of direct costs, shop expenses and enterprise expenses (jointly called non-direct costs). The basic analysis of the structure of production and costs is a two dimensional comparative analysis in which production and costs are examined relative to different flow rates of output (or degrees of capacity utilization). Hence it concentrates on the “virtual” movement of inputs and costs and the flow rate of output. From this it is possible to delineate a time-oriented structure of production and costs with regard to sequential and different variations in the flow rate of output, but it will not be covered in this paper.

Before delving into the theory of production and costs, it is first necessary to delineate and discuss the accounting rules by which enterprises identify, understand, and record their costs. Once this is in place, the ensuing sections deal with the structures of production and costs as they relate to plant segments, plants, and direct costs; the structures of production and costs regarding the shop and enterprise techniques of production, and shop and enterprise costs; and the structure of production and average total costs for the product line. The final section of the paper summarizes the theory by comparing it to and differentiating from neoclassical production and cost theory.

2. ACCOUNTING RULES

The business enterprise adopts and develops cost and financial or, more generally, managerial accounting practices that are necessary for it to be a going concern. So long as the enterprise remains a going concern, its accounting practices remain relatively enduring, although changing in minor ways in light of changes in technology, inputs used in production, and the information needs of management. If an enterprise is not a going concern, it is a terminal venture in that it has a specific starting and ending date. Consequently, accounting for expenditures as deductions or one-time expenses against revenue, and business income is straightforward. Moreover, the question of the value of the fixed investment goods and depreciation never arises. That is, the fixed investment goods are valued at the beginning of the venture and then revalued at the terminal date. Their initial value is their historical costs while their liquidation value at the terminal date is added to the profit account for distribution (Litherland, 1951). An enterprise as a strictly terminal venture is largely incommensurate with a going economy; rather it is compatible with an exchange economy where repeatable and ongoing economic activities and provisioning *processes* are absent. As for the going enterprise, the accounting practices must ensure an accurate delineation of costs which must be recovered if the enterprise is to be a going concern. More specifically, because a going enterprise engages in continuous sequential acts of production, its income or profits has to be calculated periodically, which is denoted as the *accounting period* and is generally taken to be a calendar year, and in a manner that permits distributing part of it as dividends without impairing the enterprise's productive capabilities. This means it is necessary to treat inputs (which are producible and reproducible) that contribute to the production of the output as reoccurring costs as oppose to one-time expenses against total revenue to arrive at profits.[1] In this manner, the expenses of resources, goods, services, labor power skills, depreciation of fixed investment goods used directly and/or indirectly in production are costs that are recouped so that the enterprise can repeat production. This implies that the fixed investment goods are not viewed as commodities to be sold on the market for revenue purposes; rather the going enterprise views them as essential non-commodities for maintaining the going plant whose historical value is considered a recoverable cost to be changed against revenue before determining business income.

The accounting practices essential to a going concern deal with (1) the tracing of the direct and overhead material, services, resources, and labor skills inputs relevant to the production of a unit of output, (2) the categorization of costs into direct (variable) and overhead (fixed) costs, (3) the determination of the cost of producing a unit of output, (4) depreciation, and (5) the determination of profits associated with a particular product and the business income for the enterprise as a whole. Evidence from archives of business enterprises show that prior to 1700 merchants utilized accounting systems to keep records of purchases and sales; and after that, industrial enterprises drew on these systems to keep records of purchases and sales, and to document the internal movement of inputs in the production process. In particular, sophisticated cost accounting systems for tracking direct inputs and direct costs in the production of a specific good have been in use since the 1700s. At almost the same time, enterprises developed accounting procedures that differentiated between direct and overhead inputs and costs, began identifying and measuring/quantifying them, and devised procedures to allocate the overhead costs among the various goods produced. Thus by 1900 comprehensive accounting systems of various degrees of sophistication were in general use and remain so to the present day. With developed cost accounting systems in hand, enterprises are able to engage in costing of a good, that is, to arrive at its unit (or average) direct or direct plus overhead cost. Costing systems utilized historical-estimated, or standard costs and employed various methods (based on, for example, output, direct costs, direct labor costs, labor hours, or machine hours) for the allocation of overheads. However, changes in technology, the production of new goods and services, the need for new and better product line cost information, and competitive pressures have pushed enterprises to alter their cost accounting and costing systems although not significantly, but their function of collecting cost information and use for estimating product line costs has remained unchanged—as long as enterprises remain going concerns, cost accounting and costing systems will remain relatively stable and hence relatively enduring structures[2] (Chatfield, 1974; Garner, 1954; Jones, 1985; Boyns and Edwards, 1995; Boyns, Edwards, and Nikitin, 1997; Fleischman and Parker, 1997; Lee, 1998, Appendix A; Al-Omiri and Drury, 2007)

Business enterprises have always made financial decisions, such as setting prices, whether to produce a good or close down a product line, or whether to undertake an investment project; and tying costing systems to the financial decisions (which occurred as early as 1700) helped immensely in making the decisions. This long historical emergence was, in part, due to an interlinked problem qua controversy grounded in the nature of a going concern. In particular, profits are defined as the difference between revenue and costs for a particular period of time, such as the accounting period, but whether that definition is consistent with the nature of the going concern depends on how expenditures on fixed investment goods are accounted for. From 1700 into the early 1900s, expenditures on fixed investment goods paid for and expensed out of revenues or profits and not included as a cost component, that is depreciation, of a product. Being treated as a current expense and hence not added to the capital account, the capitalized value of the enterprise did not change. More significantly, it also meant that the enterprise's cost structure did not include all the costs to be a going concern—that is, it did not include the cost of the fixed investment goods needed for ongoing and future production. So when the fixed investment goods wore out or became technologically obsolete and thus needed to be replaced, a 'cost-recovery' fund for their replacement purchase did not exist.

Enterprises dealt with the problem through adopting replacement accounting in which replacement (which could include repairs) investment was charged directly against revenues before profits were determined; having repairs to the fixed investment goods (which is a form of investment) charged directly against revenues before profits were determined; or establishing a depreciation fund of money based on assigned depreciation rates (based on reducing balance, straight line, or some other basis) to different categories of fixed investment goods based on their historical costs, which involved a charge against revenue before profits were determined or directly against profits. However, the demand by shareholders of the enterprise for immediate dividends irrespective of the negative impact on the going concern capabilities of the enterprise to provide an ongoing stream of dividends and hence an ongoing access to the provisioning process resulted in a change in the way expenditures on fixed investment goods were dealt with.[3] Instead of being expenses charged against revenue, they initially are expenditures out of profits that become a cost of production. To include depreciation as a cost of production, it is first necessary to value the fixed investment goods, which is generally done at historical cost (that is in terms of money). Then a method of depreciation, such as straight-line or accelerated, is deployed to determine the amount of depreciation to be allowed as a cost of production. Once depreciation is a cost of production, the accounting working rules of the enterprise ensure that, in principle, all inputs are traceable, all costs identified and allocated, and the determination of business income or profits can be done without affecting the going plant of the enterprise (Edwards, 1980; 1986; 1989; Boyns and Edwards, 1997; Napier, 1990; Tyson, 1992; Fleischman and Parker, 1997; Wale, 1990)

3. TECHNOLOGY, PLANTS, AND DIRECT COSTS

The basic aggregate unit of production is an establishment which houses or encompasses the activities immediately involved in the production of the product line—it is denoted as the *plant*. Given the plant, production can be further delineated in that more than one plant may be used to produce the product line and/or that each plant may consist of a number of plant segments, each also capable of producing the product line. Whether the plant is an emergent technological establishment, divided into separate plant segments, or a hybrid of the two depends on the technology constituting the plant (see Lee, 1986). Although the production of a product line may consist of many processes and stages, the enterprise's cost accounting procedures are capable of tracking each direct intermediate and labor power input and their amount used in production. Consequently, the array of direct inputs used in production of a unit of output constitutes and represents the technology used in production.

3.1 Plant segment, plant, and the structure of production

For the segmented plant (SP), the primary unit of production is the *plant segment* (PS) which is defined as the technical specifications of direct intermediate inputs of resources, goods, and services and labor power skills needed to produce a given amount of output, *g*, of a product line in a specific period of time. This usage of direct inputs is, in turn, uniquely determined by the specifications of the plant segment and underlying fixed investment goods, and the social/labor conditions surrounding production. Moreover, the fixed investment goods used in production of *g* are uniquely related to it in that they are specifically tailored to produce *g* per period of calendar time. The period of time used in the specification of the PS is called the *production period* and it denotes the amount of calendar time needed to produce *g*, starting with the first input and ending with the output. Therefore, given the fixed investment goods and their operating specifications, the unit of output, and the production period, the structure of production at the plant segment level can be formally delineated as follows: [4]

Plant segment (PS): $g \leftarrow \mathbf{a_i} \oplus \mathbf{l_v} : \mathbf{k}$ (1)

where g is the flow rate (or amount) of output per production period, $\mathbf{a_i}$ is a 1×h row vector of direct intermediate input technical coefficients, $\mathbf{l}_v$ a 1×z row vector of direct labor power input technical coefficients, $\mathbf{k} = (k_1, \ldots k_k)$ the vector of fixed investment goods associated with PS; ⊕ means both inputs are need to produce the output and ":" means "given".[5]

Since each PS is a recipe of rigidly fixed ingredients for producing a single batch or amount of output—that is each technical coefficient is fixed, it is impossible for any one PS to produce more than *g* per production period. Consequently, to increase flow rate of output of a product line at a point in time, the enterprise must bring on line additional PSs complete with their specific complement of fixed investment goods, implying that the plant consists of more than a single PS to produce the product. This characterization of production and of the flow rate of output means that the PS is not particular to any production period, but exists for all production periods, thus making it a component of the structure of production; and that the PS is unaffected by the passage of time or by repeated usage through time even though it must exist in time. As a result, this relatively enduring structural property permits the PS to be used over and over again under the guise of sequential production. In this manner, the fixed technical coefficients are flow coefficients and *g* is a flow of output denominated in terms of a single production period.

Consider the case for the segmented plant (SP) when the PSs of a plant are not identical, meaning that each PS consists of different amounts of the same inputs or of different inputs. If *m* plant segments are being used, where $1 \leq m \leq$ maximum number of PSs in the plant, then we have:

$$\text{Segmented plant (SP): } q_m = \sum_{j=1}^{m} g_j : \mathbf{k_{sp}} \tag{2}$$

where q_m is the plant's aggregate flow rate of output for *m* plant segments, $\mathbf{k_{sp}} = (k_{1m}, \ldots, k_{km})$ the vector of fixed investment goods associated with the SP, and k_{km} the quantity of the *k*-th fixed investment goods associated with the *m* plant segments that constitute the SP.

It follows that the average amount of direct intermediate and labor power inputs used to produce a unit of output at a given flow rate of output is:

$$\text{Average plant segment (APS): } \frac{q_m}{q_m} = \mathbf{a_i^*} \oplus \mathbf{l_v^*} : k_{mu} \tag{3}$$

where $\mathbf{a_i^*} = \mathbf{a_i}/q_m$, $\mathbf{l_i^*} = \mathbf{l_v}/q_m$, $k_{mu} = q_m/q_{max}$, and q_{max} is the plant's maximum flow rate of output when all PSs at utilized.

The average plant segment (APS) and its production coefficients (which are input-output ratios) represent the plant's structure of production at different flow rates of output or capacity utilization. If PSs are different, then production coefficients will vary, as will the APS, as capacity utilization increases. However, if PSs are identical, the intermediate and labor power production coefficients do not vary with the flow rate of output, thus making them equal to their respective technical coefficients of the individual plant segments. Consequently the plant's structure of production, as represented by the APS, does not vary with capacity utilization. [6]

To summarize, the basic aggregate unit of production is the plant and production is a recipe of fixed ingredients that results in fixed technical coefficients. Hence, the intermediate and labor power inputs are not individually productive; instead to be productive all inputs must be used together along with the associated fixed investment goods. When the capacity utilization of the plant increases, the resulting production coefficients may increase, decrease, or remain constant, even though the underlying technical coefficients are fixed; and the changes are a result of the technology embodied in the plant, not the outcome of some law of production. So how a plant's structure of production, as represented by APS, varies with changes in the capacity utilization can only be determined by empirical investigations, not by assumption (Lee, 1986; Dean, 1976; Eichner, 1976).

3.2 Plant segment, plant, and the structure of average direct costs

With the introduction of intermediate input prices and wage rates, the PS becomes the direct costs of the product line produced by the plant (PSDCP) and the segmented plant average direct costs (SPADC) can be derived accordingly.

$$PSDCP = \mathbf{a_i p_i} + \mathbf{l_v w_v} \tag{4}$$

$$SPADC = \frac{1}{q_m} PSDCP = \mathbf{a_i^* p_i} + \mathbf{l_v^* w_v} \tag{5}$$

where $\mathbf{p_i}$ is a h×1 vector of direct intermediate input prices, and $\mathbf{w_v}$ a z×1 vector of wage rates.

If PSs differ and assuming that the lowest PSDCP is used first, then SPADC will vary as the degree of capacity utilization (k_{mu}) varies since the production coefficients vary and will increase as k_{mu} increases. In contrast if all PSs are identical, then SPADC will not vary as k_{mu} increases since each production coefficient will not vary. Thus the plant's structure of costs, represented by SPADC will vary and increase or remain constant as k_{mu} varies, depending on its underlying structure of production (Lee, 1986).

3.3 Multi-plant production and enterprise average direct costs of production

Business enterprises may employ *p* plants to produce a product line. Thus the number of plants actually used in production depends on the total flow rate of output as well as the flow rate of output of each plant. Assuming full capacity utilization of each plant, the shape of the enterprise's average direct costs (EADC) curve depends on which plants are being utilized. If the plants are identical, then the production coefficients are constant as the degree of capacity utilization increases; but if the plants are not identical then the production coefficients vary as the degree of capacity utilization increases. Thus the enterprise's average direct input structure of production (EADSP) for the product line can be derived (see Equation 6). Adding intermediate input prices and wage rates to EADSP results in the enterprise average direct costs of production (EADC) that is the sum of the enterprise's average direct intermediate input costs (EADMC) and the enterprise's average direct labor power costs (EADLC) for the product line.

$$EADSP = \frac{1}{q_e}\left[\mathbf{a}_{\mathbf{imk}} \oplus \mathbf{l}_{\mathbf{vmk}}\right] = \mathbf{a}^{*}_{\mathbf{imk}} \oplus \mathbf{l}^{*}_{\mathbf{vmk}} \tag{6}$$

$$EADC = \mathbf{a}^{*}_{\mathbf{imk}}\mathbf{p}_{\mathbf{i}} \oplus \mathbf{l}^{*}_{\mathbf{vmk}}\mathbf{w}_{\mathbf{v}} : \mathbf{k}_{\mathbf{d}}; k_{mue} = EADMC + EADLC \tag{7}$$

where $\mathbf{a}_{\text{imk}}$ ($\mathbf{l}_{\text{vmk}}$) is an array of intermediate (labor power) inputs needed to produce $q_{\max}$ for k-th plants, $\mathbf{a}^{*}_{\mathbf{imk}} = \mathbf{a}_{\mathbf{imk}}/q_e$, $\mathbf{l}^{*}_{\mathbf{vmk}} = \mathbf{l}_{\mathbf{vmk}}/q_e$, and $q_e = \sum_{k=1}^{p} q_{\max k}$ is the enterprise's flow rate of output for k plants; $\mathbf{k}_{\text{d}}$ is the array of fixed investment goods across all plants that are directly used, $k_{mue} = q_e/q_{\text{emax}}$ is the degree of capacity utilization of the product line, where q_{emax} is the enterprise's maximum flow rate of output when all plants are used.

As noted above, if the plants are identical, then the production coefficients are constant as capacity utilization (k_{mue}) increases, resulting in constant EADC, EADMC, and EADLC. However, if the plants are not identical, then they will change as k_{mue} changes. That is, if technical and organization knowledge has changed over time, then each plant may be different in terms of intermediate and labor power inputs used and the flow rate of output. Consequently, it is not possible to determine the order in which the various plants are used to produce the output without first comparing their average direct costs (Gold, 1981). Assuming that the business enterprise tries to produce any flow rate of output as cheaply as possible, it will use plants with lower plant average direct costs

(PADC) at full capacity utilization first and plants with higher PADC later. Consequently, as capacity utilization increases and more plants are brought on line, EADC will increase due to the use of more costly plants.

The outcomes of the above analysis of EADC are that (1) under single plant production both EADC and its incremental costs (defined as $PSDCP_{m+1}$) can be constant or increase as k_{mue} increases; (2) under multi-plant production EADC and its incremental costs (defined as the plant direct costs of production at full capacity of production – PDC_{k+1}) can be constant or increase as k_{mue} increases; and (3) average direct intermediate and labor costs can increase or remain constant as k_{mue} increases. These varied outcomes are due to the possibility that plants (and plant segments) can have the same or different technology that generates a structure of production whose production coefficients can vary or remain constant as k_{mue} varies. In particular, over time technical and organizational innovations and changes in capital-labor relationships occur that become embedded in the technological make-up of a plant and, as a result, produces a lower PADC. The lower costs may arise, for example, from large-scale production through the use of specialized equipment, better organization of production flows, and use of different kinds of skilled or unskilled labor power. But the point is that technical and organizational knowledge and capital-labor relationships continually change and supersede the existing knowledge and conventional ways of working. Hence the difference between the technological makeup and work organization of plants is not just time, but a wholly new unforeseen body of technical and organizational knowledge and capital-labor relationships that makes for greater cost reductions per unit of output; thus it is possible to view a plant as a particular time-specific embodiment or 'vintage' of technical and organizational knowledge and capital-labor relationships.[7] Since the older vintage plants have higher PADC, an increasing EADC is a result of technological progress and social change in the workplace; and in contrast, if technological progress is absent and capital-labor relationships stable, then EADC is constant so that vintage plants are the same as new plants. Thus, it is the existence of technological progress and social change which creates vintage plants that makes the EADC increase as k_{mue} increases, not the existence of inefficient technology and out-of-date workplace practices; and an assumption of constant EADC is minimally an assumption of technological stagnation or at least the absence of technological progress (Lee, 1986; Eichner, 1976; Gold, 1981; Salter, 1966).

4. SHOP TECHNIQUE OF PRODUCTION AND SHOP EXPENSES

As noted above, the costs a business enterprise incurs in the production of a product line are divided into direct costs and overhead costs. The former is specified in terms of a production period while the latter is specified in terms of an accounting period which consists of a number of production periods. Overhead costs, in turn, are divided into two categories, *shop expenses* and *enterprise expenses* (which will be dealt with below). Shop and enterprise expenses can be further divided into indirect costs and depreciation. *Indirect costs* consist of the labor power and intermediate input expenses required to supervise and manage the production of a product line; hence they must be able to accommodate many different flow rates of output in a single production period and a succession of flow rates of output over a number of production periods. That is, for a business enterprise to engage in sequential acts of production over time as well as to be able to vary how much it produces in any production period, it must continually incur labor power and intermediate input expenses which permit this. Shop expenses are those non-direct costs associated with the production of a particular product line in a plant and across plants and generally include the salaries of foremen, support staff and supervisors; the intermediate inputs needed to maintain the support staff and the technical efficiency of the plant(s) used directly in production; and the depreciation allowance associated with the plant(s).

4.1 Shop technique of production

Each plant involved in the production of a product line utilizes an array of labor power and intermediate inputs in conjunction with an array of fixed investment goods to oversee production for the accounting period which can be thought of as the plant's managerial technique of production (PMTP). Although the technical coefficients that make up the PMTP are not rigid, they are specified at the same time the technology of plant is determined. Assuming the number of production periods in the accounting period to be f, the PMTP for the k-th plant is the following:

$$PMTP_k = \mathbf{a_{rk}} \oplus \mathbf{l_{sk}} : \mathbf{k_{sek}} \tag{8}$$

where $\mathbf{a_{rk}}\,(\mathbf{l_{sk}})$ is the vector of plant managerial intermediate (labor power) input coefficient in absolute amount for the accounting period and $\mathbf{k_{sek}} = (k_{k1}, \ldots, k_{kk})$ the array of fixed investment goods associated with PMTP.

The technical coefficients are made up of flows of inputs over successive production periods that constitute the accounting period and their amount for any *f*-th production period is given and sufficient to manage any degree of capacity utilization of the plant—which implies that incremental variations in the amount of any coefficients have no impact on the degree of capacity utilization. While the flow of the managerial inputs need not be absolutely uniform over the production periods, their variations cannot be too great and in the end they have to add up to the absolute amounts needed for the accounting period. To simplify the analysis, it is assumed that the managerial inputs are uniformly distributed over the *f* production periods; therefore the $PMTP_k$ for the *f*-th production periods and the average $PMTP_{kf}$ can be represented as

$$PMTP_{kf} = \frac{1}{f} PMTP_k = \mathbf{a}_{\mathbf{rkf}} \oplus \mathbf{l}_{\mathbf{skf}} : \mathbf{k}_{\mathbf{sek}} \tag{9}$$

$$APMTP_{kf} = \frac{1}{q \cdot f} PMTP_k = \mathbf{a}^{*}_{\mathbf{rkf}} \oplus \mathbf{l}^{*}_{\mathbf{skf}} : \mathbf{k}_{\mathbf{sek}} \tag{10}$$

Thus, as capacity utilization increases, $APMTP_{kf}$ varies and the average plant managerial production coefficients for the *f*-th production period decline, reaching their lowest value when the plant is at full capacity utilization.

If the enterprise uses more than one plant in the production of a product line, it has more than a single PMTP. As a group they are the shop technique of production (STP) and represent the enterprise's 'technical organization' of its managerial supervision of the production of the product line:

$$STP = \sum_{k=1}^{p} PMTP_k = \sum_{k=1}^{p} \mathbf{a_{rk}} \oplus \mathbf{l_{sk}} = \mathbf{a_{rp}} \oplus \mathbf{l_{sp}} : \mathbf{k_{se}} \tag{11}$$

where $\mathbf{a_{rp}}(\mathbf{l_{sp}})$ is the array of shop intermediate (labor power) input technical coefficient for the accounting period and $\mathbf{k_{se}} = (k_{se1}, \ldots, k_{sek})$ the array of fixed investment goods associated with STP.

Because STP is based on PMTP, its technical coefficients are made up of flows of inputs over successive production periods that constitute the accounting period and their amount for any *f*-th production period is given and sufficient to manage any degree of capacity utilization for the product line. Since managerial inputs are assumed to be evenly distributed over the production periods that constitute the accounting period, the STP for the *f*-th production period is

$$STP_f = \frac{1}{f} STP = \mathbf{a_{rpf}} \oplus \mathbf{l_{spf}} \tag{12}$$

Finally, for any production period, the STP can accommodate variations in the enterprise's flow rate of output (q_e) in terms of bringing a plant (or a plant segment) on line or closing a plant (or a plant segment) down. Therefore the average shop technique of production (ASTP) for the *f*-th production period is

$$ASTP_f = \frac{1}{q_e} STP_f = \mathbf{a^*_{rpf}} \oplus \mathbf{l^*_{spf}} \tag{13}$$

Thus, as capacity utilization at the enterprise level (k_{mue}) increases, $ASTP_f$ varies and the average shop production coefficients decline, reaching their lowest value when k_{mue}

reaches full capacity utilization.

4.2 Indirect costs: Cost of the shop technique of production

With the introduction of intermediate input prices and salaries, the STP_f becomes indirect costs or the cost of the shop technique of production ($CSTP_f$):

$$CSTP_f = \mathbf{a_{rpf}p_r} + \mathbf{l_{spf}w_s} : \mathbf{k_{se}} \tag{14}$$

where $\mathbf{p_r}$ is the vector of managerial intermediate input prices and $\mathbf{w_s}$ the vector of managerial wage rates.

The $CSTP_f$ shows that indirect costs are cost flows over the production periods that constitute the accounting period; but they are also invariant with respect to different flow rates of output in the f-th production period. Therefore, the average $CSTP_f$ and the average intermediate and labor input costs will vary inversely with the flow rate of output (q_e) or degree of capacity utilization:

$$ACSTP_f = \frac{1}{q_e} CSTP_f = \mathbf{a^*_{rpf}p_r} + \mathbf{l^*_{spf}w_s} : \mathbf{k_{se}} \tag{15}$$

Costs of the shop technique production are contractual expenditures; thus, although fixed with regard to variations in q_e within a production period, they are not deferrable over production periods, but have to be paid-out on a regular, sequential basis.

4.3 Depreciation

As noted above, depreciation of fixed investment goods is a cost that is incurred in the production of a product line. To determine it, the fixed investment goods involved in its production have to be identified. From the analysis of direct costs and shop expenses (Equations 1, 2, 7, 8, and 11), the array of fixed investment goods ($\mathbf{k}_{\mathrm{dse}}$) associated with the production of the product line is composed of two types of fixed investment goods: the one is directly used in the production of the production line ($\mathbf{k}_d$), and the other associated with the managerial technique of production ($\mathbf{k}_{se}$). With the fixed investment goods associated with the production of the product line identified, individual values of fixed investment goods are determined based on their historical costs. Then using straight-line or declining charges methods, the depreciation allowance of each fixed investment good for the accounting period (D_{dse}) is determined from whence they are aggregated into a single value amount for the accounting period. Distributing D_{dse} equally across all production periods, depreciation allowance for the f-th production period is

$$D_{dsef} = \frac{1}{f} D_{dse} : \mathbf{k_{dse}} = \mathbf{k_d} + \mathbf{k_{se}} \tag{16}$$

Since D_{dsef} is invariant with respect to variations in the flow rate of output, average depreciation costs and hence the shop depreciation production coefficient varies inversely with as the flow rate of output or degree of capacity utilization.

4.4 Shop expenses

Shop expenses (SE) for the f-th production period is obtained by adding together D_{dsef} and $CSTP_f$:

$$SE_f = CSTP_f + D_{sef} = \mathbf{a_{rpf}p_r} + \mathbf{l_{spf}w_s} + D_{sef} \tag{17}$$

Since $CSTP_f$ and D_{dsef} are cost flows, SE_f is also a cost flow. Thus it cannot be seen as "fixed" even though it is invariant with respect to different flow rates of output. Average shop expenses (ASE) for the f-th production period is:

$$ASE_f = \frac{1}{q_e} SE_f = \mathbf{a}^*_{\mathbf{rpf}}\mathbf{p}_\mathbf{r} + \mathbf{l}^*_{\mathbf{spf}}\mathbf{w}_\mathbf{s} + D^*_{sef} : \mathbf{k}_{\mathbf{se}}; k_{mue} \tag{18}$$

And it is apparent that ASE_f declines, as the degree of capacity utilization increases.

5. ENTERPRISE TECHNIQUE OF PRODUCTION AND ENTERPRISE EXPENSES

Because the going enterprise is generally a multi-product producer and a going concern, it incurs expenses that are common to all of its product lines and necessary if it is to stay in existence as a going concern and hence are identified as enterprise expenses. In general, these costs are associated with those activities that the enterprise must engage in order to co-ordinate the production flows of its various product lines, to sell its various product lines, and to develop and implement enterprise-wide investment and diversification plans and which include the salaries of management, stationary, selling and other office expenses, and the depreciation of the central office fixed investment goods. This array of labor power and intermediate inputs in conjunction with an array of fixed investment goods ($\mathbf{k}_{\mathrm{ee}}$) are used to manage the enterprise as a whole for the accounting period which includes the various degrees of capacity utilization for any one product line and all product lines; and it can be thought of as the enterprise technique of production (ETP):

$$ETP = \mathbf{a}_\mathbf{u} \oplus \mathbf{l}_\mathbf{e} : \mathbf{k}_{\mathbf{ee}} \tag{19}$$

where $\mathbf{a}_{\mathrm{u}}$ ($\mathbf{l}_{\mathrm{e}}$) is the vector of enterprise intermediate (labor power) input technical coefficient for the accounting period and $\mathbf{k}_{\mathbf{ee}} = (k_{ee1}, \ldots, k_{eek})$ the array of fixed investment goods.

The technical coefficients are made up of flows of inputs over the accounting period that are not synchronized with the production periods of the various production lines, which would not be possible in any case since they are not necessarily the same. Therefore, it is not possible, as with the STP, to allocate the flow of the inputs to any and all product lines; rather the allocation is done in terms of money.

With the introduction of intermediate input prices and yearly salaries, the ETP becomes indirect costs or the cost of the enterprise technique of production (CETP):

$$CETP = \mathbf{a_u p_u} + \mathbf{l_e s_e} \qquad (20)$$

where $\mathbf{p_u}$ is the vector of enterprise intermediate input prices and $\mathbf{s_e}$ the vector of yearly salary of labor power input.

Given the CETP for the accounting period, it is allocated to each of the enterprise's *j*-th product lines. Once a given percentage of CETP, αCETP, is allocated to the *j*-th product line for the accounting period, it is then allocated equally over all the production periods. Therefore, the CETP for the enterprise's *j*-th product line and the *f*-th production period is

$$CETP_{jf} = \frac{\alpha_j}{f} CETP = \mathbf{a_{ujf} p_u} + \mathbf{l_{ejf} s_e} \qquad (21)$$

where α_j is the percentage of CETP allocated to the *j*-th product line.

Like with the $CSTP_f$, the $CETP_{jf}$ shows that indirect costs are cost flows over the production periods that constitute the accounting period; but they are also invariant with respect to different flow rates of output in the *f*-th production period. Therefore, the average $CETP_{jf}$ and the average intermediate and labor input costs will vary inversely with the flow rate of output or degree of capacity utilization.

$$ACETP_{jf} = \frac{1}{q_e} CETP_{jf} = \mathbf{a}^*_{\mathbf{ujf}} \mathbf{p}_{\mathbf{u}} + \mathbf{l}^*_{\mathbf{ejf}} \mathbf{s}_{\mathbf{e}} \tag{22}$$

Costs of the enterprise technique of production are also contractual expenditures: thus, although fixed with regard to variations in the flow rate of output (q_e) within a production period, they are not deferrable over production periods, but have to be paid-out on a regular, sequential basis. Because the array of fixed investment goods ($\mathbf{k}_{ee}$) associated with the ETP are known, the depreciation allowance for enterprise expenses (D_e) for the accounting period is determined in the same manner described above in reference to shop expenses. It is then allocated to the various product lines so that the enterprise depreciation allowance of the j-th product line for the accounting period is $D_{ej} = \alpha_j D_e$; and for the j-th product for the f-th production period, it is $D_{ejf} = \frac{\alpha_j}{f} D_e$. Finally, although D_{ejf} is invariant with respect to variations in the flow rate of output, the enterprise depreciation production coefficient for the j-th product line and f-th production period varies as the flow rate of output varies.

Consequently, the enterprise expenses (EE) for the accounting period consist of $CETP_{jf}$ and D_{ejf}. That is,

$$EE_{jf} = CETP_{jf} + D_{ejf} = \mathbf{a}_{\mathbf{ujf}} \mathbf{p}_{\mathbf{u}} + \mathbf{l}_{\mathbf{ejf}} \mathbf{s}_{\mathbf{e}} + D_{ejf} \tag{23}$$

Since each of its components is a cost flow, the EE_{jf} is also a cost flow. Thus it cannot be seen as "fixed" even though it is invariant with respect to different flow rates of output. Average enterprise expenses (AEE_{jf}) for the j-th product line and f-th production period can be constructed accordingly.

$$AEE_{jf} = \frac{1}{q_e} EE_{jf} = \mathbf{a}^*_{\mathbf{ujf}} \mathbf{p_u} + \mathbf{l}^*_{\mathbf{ejf}} \mathbf{s_e} + D^*_{ejf} \tag{24}$$

6. STRUCTURE OF PRODUCTION AND COSTS OF A PRODUCT LINE

The average structure of production for the business enterprise's *j*-th product line in terms of the *f*-th production period and for a flow rate of output (q_{je}) can be thought of the structure of production for a product ($ASPP_{jf}$) (derived from Equations 6, 13, and 22).

$$ASPP_{jf} = \mathbf{a}^*_{\mathbf{ijf}} \oplus \mathbf{a}^*_{\mathbf{rjf}} \oplus \mathbf{a}^*_{\mathbf{ujf}} \oplus \mathbf{l}^*_{\mathbf{vjf}} \oplus \mathbf{l}^*_{\mathbf{sjf}} \oplus \mathbf{l}^*_{\mathbf{ejf}} : \mathbf{k_z} = \mathbf{k_d} + \mathbf{k_{se}} + \mathbf{k_{ee}} \tag{25}$$

The enterprise's ASPP consists of an array of material and service inputs and labor power (skills) whose production coefficients are jointly determined by technology and the flow rate of output. So while the structure itself remains stable in face of variations of the flow rate of output, the production coefficients can vary: (1) production coefficients associated with STP and ETP decline as the flow rate of output increases; and (2) production coefficient associated with direct material and labor power inputs can remain constant, increase, or decrease as output increases. Hence the ASPP changes only when the underlying technology and social/labor relationships change, resulting in changes in the material and labor power inputs. This generally occurs when new plants (or plant segments) are brought on line and as vintage plants (plant segments) are dropped as well as when managerial and enterprise techniques of production are altered; but it can also occur after a failed (or successful) strike.

When considering the structure of costs for a single product, we are essentially considering the enterprise's average total costs of production (EATC) for the *j*-th product line, f-th production period, and flow rate of output (q_{je}) (derived from Equations 7, 18, and 24):

$$EATC_{jf} = EADC_{jf} + ASE_{jf} + AEE_{jf} \tag{26}$$

Restricting the structural analysis to a single production period, the relationship between $EATC_{jf}$ and the flow rate of output can be shown in the following manner:

$$\frac{\Delta EATC_{jf}}{\Delta q_{je}} \begin{cases} > 0, \text{ if } PADC_{jk+1} > EATC_{jf} \\ = 0, \text{ if } PADC_{jk+1} = EATC_{jf} \\ < 0, \text{ if } PADC_{jk+1} < EATC_{jf} \end{cases}$$

Thus we find that the specific forms of the relationship depend on a tug-of-war between the rising incremental costs and the falling ASE_{jf} and AEE_{jf}. Since there is no necessary reason for the relative dominance of one side over the other, a positive, negative, or U-shaped $EATC_{jf}$ is possible. The empirical evidence does suggest, however, that $EATC_{jf}$ is declining as the flow rate of output increases. Still, it should be noted that whatever the shape of the average total cost curve is, the shape is solely due to technological and organizational change and changes in capital-labor relationships and hence is solely an empirical issue (see Lee, 1986, Appendix).

7. CONCLUSION

The beginning point of heterodox production and cost theory is not the business enterprise *per se*, but a circular production, surplus producing economy. For such an economy, production and the surplus are delineated in terms of a Leontief-Sraffa input-output model completed with industry or market level production coefficients. However, what is lacking is a connection between the business enterprise which actually does the production and the industry level coefficients. The heterodox theory of production and costs of an enterprise's product line delineated above fills this gap by developing the theoretical 'micro' foundations of the industry production coefficients that consisted of a product-based input-output structure, an explanation of the movements of production coefficients, and finally an explanation of average and incremental cost curves.

Given this, how does heterodox production and cost theory stand relative to neoclassical theory? First, because it is based on the going business enterprise with its relatively enduring (but not unchanging) accounting rules and unceasing sequential acts of production, the theory cannot be located in the short or long period. Rather the relevant time periods for theoretical purposes are the production period and the accounting period, both of which are calendar/real time periods and not solely analytical time periods defined in terms of fixed and variable inputs. Secondly, the going enterprise is also predicated on reproducible, differentiated intermediate inputs and differentiated labor power, implying the rejection of inputs being characterized as relatively scarce factors of production and of the 'linear' reduction of intermediate inputs to an objective or subjective quantity of homogeneous labor power or effort. Finally, the role of a going enterprise's accounting rules in determining what constitutes the reoccurring costs of a product line makes costs a socially constructed concept as opposed to an unambiguous, unmediated objective concept. These three points fundamentally differentiate heterodox from neoclassical production and cost theory: the former is in the theoretical universe of historical time, reproducible inputs, non-reductionism, and social knowledge whereas the latter is in a universe of analytical time, relative scarcity, reductionism, and socially unmediated knowledge.

Heterodox theory also differs from neoclassical theory on the particulars. That is, the heterodox characterization of production as a recipe embedded in a plant is incompatible with intensive rent qua the productivity of individual inputs qua marginal products, fixed-variable input distinction, and the full utilization of a fixed input requirement for the existence of marginal products; and without marginal products (and relative scarcity), the law of diminishing returns does not exist as well as cost minimization, marginal cost curves and their upward slope, the marginal rate of technical substitution, and constant output factor input demand curves. Since vintage plants differ by knowledge and capital-labor relationships that are historically contingent, factor substitution via changes in relative factor input prices, and returns to scale have no substantive meaning. Finally, the inclusion of depreciation solely as a money cost and the rejection of the rate of interest or normal profits as a cost make the meaning of heterodox and neoclassical average total costs quite different. Therefore, the choice between neoclassical and heterodox production and cost theory is based on the empirical validity and theoretical superiority of the latter.[8]

Although fundamentally different at the theoretical level, heterodox and neoclassical production and cost theory are similarly organized. Both theories start with a structure of production in which inputs are connected to outputs, although the actual production processes are left unarticulated; and from the structures, the movement of production coefficients (average products) and ‘incremental’ plants (marginal products) are delineated. In short, both theories see production as a technological, organizational, and (at least for heterodox economists) social activity central to understanding the business enterprise. The transformation of production into costs is carried out in a similar manner by both theories, giving rise to similar looking cost curves. Since their theoretical content is, for both theories, located in the theory of production, the curves' superficial resemblance obscures their profound theoretical differences. This tight connection between production and cost theory means for both theories that it is illegitimate to discuss the costs of the business enterprise independent of its structure of production. This point can be further extended for heterodox economics in that it is illegitimate to aggregate structures of production and costs across product lines. That is, heterodox production and cost theory is predicated on an input-output relationship of a well-defined product line. So long as the production of the goods and services needed for social provisioning require distinct and differentiated reproducible inputs, labor power inputs, and fixed investment goods, it is not possible to aggregate the different product lines and their corresponding structures of production into a single homogeneous input-output (such as in a corn model or a labor-based production model). Therefore the input-output relationship is the foundation of both the going capitalist economy and the going business enterprise. From this, it can be inferred that production and cost theory provides, in part, the foundation from which all heterodox theory emanates.

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NOTES

[1]That is, costs are defined in terms of the going enterprise, so that what constitutes costs are reoccurring expenses derived from the use of reproducible intermediate inputs, labor power skills, and fixed investment goods. Such costs are objective and irreducible to a homogeneous unit such as labor or subjective disutility. Moreover, non-produced items that are not utilized on a reoccurring basis are not costs but expenses that are charged against revenue. Therefore, scarce factor inputs are not costs in the context of the going enterprise, which means that the category of costs of the going enterprises is conceptually distinct from the category of costs in neoclassical theory in that the former is not based on relative scarcity (Kurz and Salvadori, 2005).

[2] In recent decades various studies have noted the relative stability in accounting practices used by enterprises. They show that enterprises slowly make marginal changes while retaining basic practices, even when faced with a changing environment (Emore and Ness 1991; Bright et. al 1992; Granlund, 2001).

[3] There was another controversy which involved whether ‘interest’ on the paid in ‘capitalized value’ of the enterprise was a cost or not. In some partnerships, interest charges were included as costs in order “to ensure that individuals were properly remunerated for differential capital contributions rather than to produce a more accurate costing of business operations’ (Edwards 1989: 312; also see Stone 1973-74; Hudson 1977). While this case seems to be the basis of mainstream arguments that includes normal profits as costs, generally interest charges are not considered costs.

[4] In neoclassical economics, firms choose the quantities of factor inputs, the ratio between inputs, and/or technology (that is, a production function) based upon relative input prices so as to optimize production and costs. By contrast, from a heterodox viewpoint, there are no alternative techniques to choose between based on changes in relative prices; technology (an input-output ratio) is given to a business enterprise. The only ground for choosing a new technology is that the business enterprise needs to *reduce* production costs, rather than to minimize costs in the neoclassical sense. It implies that what is conceptually and empirically relevant is the cost reducing technical choice along with technical and managerial innovations over time (see Section 3.3 for this account).

[5] Mathematical notations used in this paper follow the convention in matrix algebra (see, for example, Kurz and Salavdori, 1995). That is, lower/upper case italic letters are scalars and lower case bold letters are vectors.

[6] We can extend this to the emergent plant (that is a single plant segment plant) and the hybrid plant (which takes many technological forms) but it is not discussed here.

[7] This differentiation between plants is not compatible with the neoclassical economies of scale which is based on proportional increases in the inputs and the absence of technological change and new knowledge (Gold, 1981).

[8] It should be noted that heterodox theory is empirically valid in its own right (irrespective of any empirical evidence that supports neoclassical theory) and that it is theoretically better because it is not theoretically problematic as is neoclassical production and costs theory which is based on the assumption of scarce resources and the partial equilibrium analysis.