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RETHINKING CAPACITY UTILIZATION CHOICE: THE ROLE OF SURROGATE INVENTORY AND ENTRY DETERRENCE

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ABSTRACT

This paper presents a macroeconomics-friendly Post Keynesian model of the firm describing both an inventory theoretic approach and an entry deterrence approach to choice of excess capacity. The model explains why firms may rationally choose to have excess capacity. It also shows the two approaches are complementary and reinforcing of each other. Analytically, the paper makes three principal contributions. First, it provides a simple framework for understanding the microeconomics of capacity utilization choice. Second, it reframes the Post Keynesian discussion of capacity utilization by making excess capacity choice the key to understanding normal capacity utilization. Third, it implicitly challenges Neo-Kaleckian wage-led growth theory as the model shows choice of the optimal excess capacity rate is independent of the level of demand.

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Rethinking capacity utilization choice: the role of surrogate inventory and entry deterrence

Abstract

This paper presents a macroeconomics-friendly Post Keynesian model of the firm describing both an inventory theoretic approach and an entry deterrence approach to choice of excess capacity. The model explains why firms may rationally choose to have excess capacity. It also shows the two approaches are complementary and reinforcing of each other. Analytically, the paper makes three principal contributions. First, it provides a simple framework for understanding the microeconomics of capacity utilization choice. Second, it reframes the Post Keynesian discussion of capacity utilization by making excess capacity choice the key to understanding normal capacity utilization. Third, it implicitly challenges Neo-Kaleckian wage-led growth theory as the model shows choice of the optimal excess capacity rate is independent of the level of demand.

Keywords: Capacity utilization, excess capacity, surrogate inventory, entry deterrence, wage-led growth.
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1. Introduction

Capacity utilization is a critical construct in Post Keynesian growth theory and the source of significant controversy. Neo-Kaleckian (NK) growth theory (Rowthorn, 1982) argues steady state capacity utilization is endogenous with respect to aggregate demand (AD). Cambridge (Robinson, 1962) and supermultiplier (Serrano, 1995; Serrano and Freitas, 2017) growth theory argue it is exogenous with respect to AD and settles at a normal rate of capacity utilization. The issue is of central importance as demand driven endogenous capacity utilization is a necessary condition for NK wage-led growth, whereby increases in the wage share raise growth.

This paper examines the economics of choice of capacity utilization and presents two simple macroeconomics-friendly models of excess capacity choice. In the first model

excess capacity serves as a form of surrogate inventory. Instead of holding actual inventory to meet positive demand surprises, firms hold "idle" (excess) capacity. Consequently, "actual" capacity utilization is less than "installed" capacity (i.e. the rate of capacity utilization is less than 100 percent).

In the second model firms hold excess capacity as a deterrent to entry. That is a different rationale for excess capacity, but it produces similar economic predictions. The two models show that the two rationales for excess capacity are fully consistent, which reinforces the case for understanding capacity utilization choice in the way suggested.

2. Some antecedents

Before turning to the formal models it is worth noting some antecedents to the proposed inventory theoretic approach. With regard to the surrogate inventory model, the closest antecedent (cited in Lavoie, 1992, p.330) is contained in Amadeo (1987, p.79) and Ciccone (1987, p.97) who argue that the main determinant of normal capacity utilization is the variance of demand which induces firms to hold excess capacity as a precautionary measure.

A second more distant antecedent is with Setterfield (2019), who builds on suggestions contained in Hein et al. (2012, p.146-148) that are in turn derived from Hicks (1974, p.19). Setterfield frames the argument terms of "satisficing" behavior, whereby it is claimed satisficing firms will tolerate – within limits – deviations of actual capacity utilization from desired target utilization (i.e. normal utilization). The satisficing perspective tacitly holds there are costs to adjustment which justify living with small deviations from target.

The satisficing perspective can be given an inventory interpretation by recasting it

in terms of an [S,s] inventory model, whereby the optimum rate of capacity utilization is a range rather than a point. In the presence of capacity utilization adjustment costs, sales uncertainty, and productivity uncertainty, optimum capacity utilization might be a range and subject to dynamics similar to [S, s] inventory dynamics. That [S, s] interpretation does not need satisficing, but it does connect the satisficing within limits explanation of endogenous capacity utilization to the inventory story developed below.

With regard to the second model, the antecedent is from the microeconomic field of industrial organization where it is has long been argued firms may hold excess capacity as a deterrent to new entry (Wenders, 1971; Spence, 1977; Salop, 1979). Skott (1989, p.54) notes that argument has potential relevance Post Keynesian growth theory.

3. Excess capacity as surrogate inventory: model I

The intuition behind the first model is as follows. Firms hold excess capital stock, over and above that needed to satisfy known demand, as a form of surrogate inventory. The excess serves as a way of meeting positive demand surprises. The benefit to holding excess capacity is the addition to profit from additional sales. The cost of holding excess capacity is the cost of capital associated with it. Profit maximizing firms choose a level of excess capacity such that the marginal benefit of that excess equals the marginal cost.

3.a) Production and capital stock accounting identities

The production process and definitions of capacity are given by

(1) $Y = \text{Min}[aL, bK]$ $\quad a > 0, b > 0$

(2) $K = U + X$

(3) $U = D/b$

(4) $X = xU$ $\quad 0 < x < 1$

Y = output, L = employment, K = capital stock, a = output-labor ratio, b = output-capital ratio, U = active (utilized) capital, X = idle (excess) capital, D = level of known demand, x = excess to active capital ratio.

Equation (1) is a Leontieff production function. Equation (2) decomposes the capital stock into active and idle components. Equation (3) determines the active capital stock as a function of known demand. Equation (4) determines the excess capital stock as a proportion of the utilized capital stock.

Dividing equation (2) by K yields

(5) $1 = u + e$

u = capacity utilization rate (U/K), e = excess capacity rate (X/K). Substituting equation (4) into (5) and manipulating yields

(6) $u = 1/[1 + x]$

(7) $e = x/[1 + x]$

The critical determinant of the capacity utilization mix is firms' choice of the excess (idle)-to-utilized (active) capital ratio (x).

3.b) Costs of capital

The cost of capital is given by

(8) $C = [r + \delta]pK$

C = cost of capital, r = interest rate, δ = depreciation rate, p = price level. Equation (8) can then be re-written as

(9) $C = [r + \delta][1 + x]pU$

Differentiating with respect to x yields

$dC/dx = [r + \delta]pU > 0$

Holding additional excess capital as surrogate inventory has a cost which is determined by the total cost of capital, as determined by the interest rate and depreciation rate.

3.c) Benefits of capital

The benefit from capital derive from the additional revenue net of variable costs, which are determined by the following equations.

(10) $R = pY - wL$

(11) $Y = D + S$

(12) $p = [1 + m]w/a$

(13) $S = \sigma(x)D$ $\quad 0 \leq \sigma(x) < 1, \sigma(0) = 0, \sigma_x > 0, \sigma_{xx} < 0$

R = revenue net of variable (labor) costs, p = price, w = nominal wage, S = average surprise sales, m = mark-up. Equation (10) determines revenue net of variable costs. Equation (11) defines output as consisting of known demand and surprise demand. Equation (12) is the familiar Kaleckian mark-up pricing equation whereby price is a mark-up over unit labor costs (w/a). Equation (13) determines average surprise sales as a fraction of known demand. The level of surprise sales depends positively on the excess capacity rate which enables firms to meet surprise demand.[1]

3.d) Profit maximization and choice of excess capacity

[1] Average surprise sales are always positive. The logic is as follows. The firm cannot lose sales from having excess capacity (x), but it can gain sales. *Ergo*, average surprise sales are always positive. Moreover, they are increasing in x because excess capacity enables the firm to harvest more surprise sales when there is a large positive demand shock. Analytically, all equation (13) says is that there are positive net revenue benefits to having some excess capacity, which seems a reasonable assumption. The modelling is a simplification intended to highlight the economic message regarding the "surrogate" inventory role of excess capacity. In the real world there would positive and negative demand (D) surprises. The standard way of representing that structure would be to invoke a subjective probability distribution governing surprise demand and assume firms maximize expected profit. That would make the model significantly more mathematically complex. It would also introduce probability theory which is anathema to many Post Keynesians on grounds that the world is non-ergodic. The above modelling simplification side-steps those tangles.

The firm's problem is to choose x so as to maximize profits, which are given by

(14) $\underset{x}{\text{Max}}\ \Pi = p[D + S] - wL - [r + \delta]pK$

$= mw[1 + \sigma(x)]D/a - [r + \delta][1 + m]w[1 + x]D/ab$

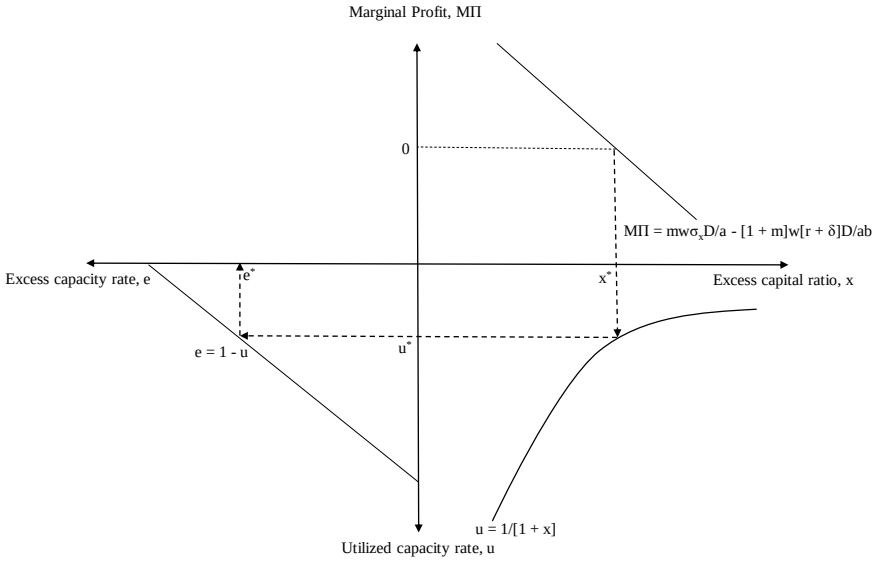
Differentiating with respect to x and setting equal to zero yields the first-order condition which is given by

(15) $d\Pi/dx = mw\sigma_x D/a - [1 + m]w[r + \delta]D/ab = 0$

Equation (15) describes the marginal profit (MΠ) as a function of the excess capital ratio (x). The left-hand term ($mw\sigma_x D/a$) represents the marginal revenue from increasing the excess capital ratio, while the right-hand term ($[r + \delta][1 + m]wD/ab$) represents the marginal cost. Marginal revenue is declining owing to the declining marginal benefit of having excess capital to meet surprise sales ($\sigma_{xx} < 0$). Marginal cost is constant and represents the cost of holding an additional unit of excess capital.

The determination of the optimal excess capital ratio is shown in Figure 1. The northeast quadrant shows marginal profit as a function of the excess capital ratio. The optimal excess capital ratio corresponds to the ratio at which marginal profit is zero. The southeast quadrant then determines the utilized capacity rate, given the excess capital ratio. Lastly, the southwest quadrant determines the excess (idle) capacity rate, given the utilized capacity rate.

Figure 1. The determination of the mix of utilized and excess capacity in the surrogate inventory model.



3.e) Comparative statics

Solving equation (15) for σ_x yields

(16) $\sigma_x^* = [1 + m][r + \delta]/mb$

The comparative statics are as follows:

$d\sigma_x^*/db < 0$. An increase in the output - capital ratio (b) lowers σ_x^*, which implies an increase in x. Capital is more productive so firms hold more excess capital on hand to meet surprise demand, which increases the excess capacity rate.

$d\sigma_x^*/d[r + \delta] > 0$. An increase in the cost of capital ($[r + \delta]$) increases σ_x^*, which implies a fall in x. Capital is more costly so firms reduce excess capital holdings, which reduces the excess capacity rate.

$d\sigma_x^*/dm < 0$. An increase in the mark-up lowers σ_x^*, which implies an increase in x. Surprise sales are more profitable so firms therefore hold more excess capital to meet them, which increases the excess capacity rate.

$d\sigma_x^*/dD = 0$. An increase in known demand has no impact on the optimal excess capital ratio or the utilization rate. However, it does increase the capital stock ($K = [1 + x]D/b$]) and total capacity.

Lastly, an increase in the sensitivity of realized surprise sales to excess capital (σ_x) shifts the marginal profit function up by increasing marginal revenue. That raises the optimal excess capital ratio, lowers the utilized capacity rate, and increases the excess capacity rate. The economic logic is there is increased value (in terms of harvesting surprise demand) to having more excess capital.

3.f) Implications for Neo-Kaleckian (NK) growth theory

The above model has significant implications for NK growth theory. The starting point is the comparative static result showing the rate of utilization is unaffected by known demand ($d\sigma_x^*/dD = 0$). That result is contrary to NK theory and gets to the core of the issue. The NK model assumes that strengthening of demand permanently increases the rate of normal capacity utilization. An inventory theoretic formulation of capacity choice challenges that claim.

The reason for the difference is excess capacity. The NK model focuses exclusively on utilization, and excess capacity is a residual. An inventory theoretic approach views excess capacity as a choice variable which is optimally chosen by firms. Changes in demand that impact utilization implicitly also impact available excess capacity. That impact triggers subsequent further changes as firms seek to adjust back to their desired excess capacity. It is desired excess capacity that drives the adjustment, but that dimension is absent in the NK model which treats excess capacity as a residual of no economic consequence.

A second implication comes from the comparative static result that shows increases in the mark-up lower capacity utilization ($d\sigma_x^*/dm < 0$). From a NK perspective, that would suggest the economy is wage-led. However, it has nothing to do with the character of the demand regime (i.e. whether the economy is wage- or profit-led). Instead, it is due to supply-side considerations.

In an inventory model of capacity utilization the mark-up works through the supply-side, via its impact on the firm's optimal organization of production (i.e. excess capacity choice). That channel is absent in the NK model which lacks a theory of long run optimal production.

4. Excess capacity as a deterrent to new entry: model II

As mentioned earlier, another rationale for excess capacity is entry deterrence. This rationale has a long history (Wenders, 1971). Modern microeconomic theory (Spence, 1977; Salop, 1979) has reformulated it in game theoretic terms. Existing firms may hold excess capacity as a credible commitment device that signals to potential entrants the firm will increase output and lower price should a new firm enter. Installing excess capacity is both a signal and a credible commitment, which together can deter entry. Excess capacity is the signal, and it is also a sunk cost which renders credible the threat of retaliatory action against new entrants.

The entry deterrent role of excess capacity is easily incorporated in the above model by making price a positive function of excess capacity, as follows

(17) $p = [1 + m + z(x)]w/a \qquad z_x > 0, z\sigma_{xx} < 0$

z = extra mark-up generated by excess capacity. For simplicity, surprise demand (S) is assumed zero so there is no need for surrogate inventory. That assumption helps identify

the pure effects of entry deterrence as a factor in choice of capacity utilization.

In that case, the firm's profit maximization problem becomes

(18) $\underset{x}{\text{Max}}\ \Pi = pD/a - wD/a - [r + \delta]pK$

$= [m + z(x)]wD/a - [1+ m + z(x)]w[r + \delta][1 + x]D/ab$

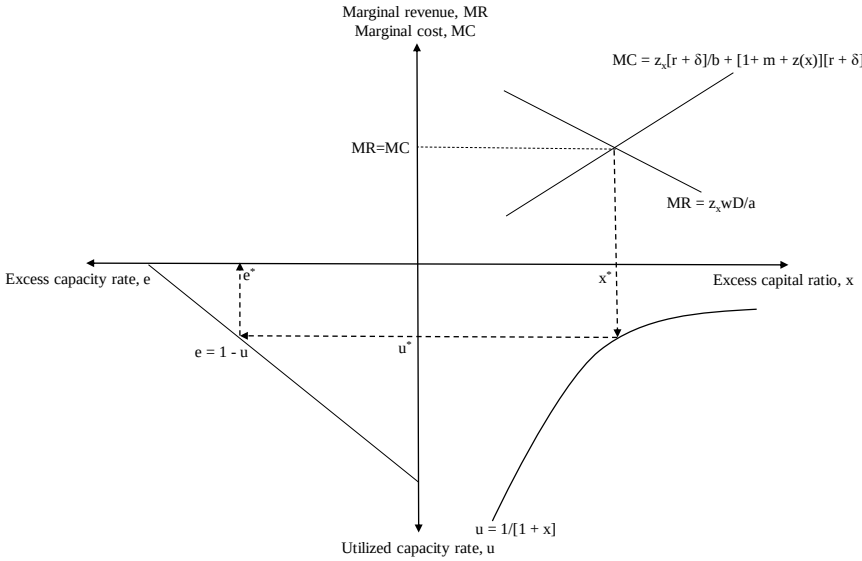
Differentiating with respect to x and setting equal to zero yields the marginal condition which is given by

(19) $d\Pi/dx = z_x wD/a - z_x w[r + \delta][1 + x]D/ab - [1+ m + z(x)]w[r + \delta]D/ab = 0$

The first expression ($z_x wD/a$) represents the marginal revenue from increasing the excess capital ratio, which adds to revenue by increasing the mark-up. The two other terms constitute marginal cost. The first of those terms ($z_x w[r + \delta][1 + x]D/ab$) reflects the fact that a higher mark-up raises the price of capital, which adds to the direct cost of installing excess capacity. The second term ($[1+ m + z(x)]w[r + \delta]D/ab$) reflects the cost of capital associated with installing an additional unit of excess capacity.

The entry deterrence model is illustrated in Figure 2, the main difference from the earlier model being that marginal cost now increases with x. The reason is the term z(x) which increases with x. As firms add more excess capacity, that increases the mark-up which increases the total cost of installing an additional unit of excess capital.

Figure 2. The determination of the mix of utilized and excess capacity in the entry deterrence model.



The comparative statics are easily understood by simplifying the first-order condition given by equation (19), which reduces to

(20) $z_x = z_x[r + \delta]/b + [1+ m + z(x)][r + \delta]/b$

Inspection then shows:

$dx/db < 0$. An increase in the output-capital ratio lowers MC and increases x. The logic is as follows. Entry deterrence works by having potential output available for sale. An increase in b lowers the capital-output ratio so that firms hold less capital for each unit of excess available output, which lowers the cost of holding excess capacity. That gives firms an incentive to increase the excess capital ratio, lower the utilization rate, and increase the excess capacity rate.

$dx/dm < 0$. An increase in the mark-up increases MC and lowers x. The economic logic is a higher mark-up increases the price of capital, which increases the capital cost associated with holding excess capital. That gives firms an incentive to lower the excess capital

ratio, increasing the utilization rate, and decreasing the excess capacity rate.

$dx/d[r+\delta] < 0$. An increase in the cost of capital increases MC and lowers x. The economic logic is a higher cost of capital increases the capital cost associated with holding excess capital. That gives firms an incentive to lower the excess capital ratio, increasing the utilization rate, and decreasing the excess capacity rate.

$dx/dD = 0$. The excess capital ratio is independent of the level of known demand. The logic is as earlier, with firms picking an optimal excess capital ratio. Increases in known demand increase the capital stock and installed capacity, but they do not change the optimal usage ratio.

5. A combined model

The surrogate inventory and entry deterrence models of excess capacity choice can be combined. In that case, the firms profit maximization program is given by

$$(21)\ \underset{x}{\text{Max}}\ \Pi = p[D + S] - wL - [r + \delta]pK$$
$$= [m + z(x)]w[1 + \sigma(x)]D/a - [r + \delta][1 + m + z(x)]w[1 + x]D/ab$$

Now, there are two benefits to having excess capacity. First, there is the surrogate inventory benefit of harvesting surprise sales, as reflected in the term $\sigma(x)$. Second there is the entry deterrence benefit of a higher mark-up, as reflected in the term $z(x)$.

Furthermore, the benefits enter as a product in equation (21). That means not only are they consistent, they also reinforce each other. Excess capacity does triple duty. First, it enables firms to harvest surprise sales. Second, it generates a higher mark-up. Third, it generates a higher mark-up on surprise sales.

6. Conclusion: implications for Post Keynesian growth theory

This paper has presented a Post Keynesian macroeconomics-friendly model of the firm

that describes both an inventory theoretic approach and an entry deterrence approach to choice of excess capacity. The model endogenizes capacity utilization choice and explains why firms may rationally choose to have excess capacity. Moreover, it also shows that the two approaches are complementary and mutually reinforcing.

Analytically, the paper makes three principal contributions. First, it provides a simple framework for understanding the microeconomics of capacity utilization choice.

Second, it reframes the Post Keynesian discussion of capacity utilization. The existing discussion frames capacity utilization in terms of an exogenously determined normal rate versus a floating rate that is endogenously impacted by AD. The current model reframes the discussion in terms of a choice between “active” and “idle” (excess) capacity. Excess capacity is not a residual, and the normal situation involves positive excess capacity which is held for reasons of surrogate inventory and entry deterrence. Choice of excess capacity is the key to understanding normal capacity utilization.

Third, it implicitly challenges Neo-Kaleckian wage-led growth theory which requires that demand impact capacity utilization. Advocates of wage-led growth have loosely invoked both the surrogate inventory and entry deterrence stories to justify the assumption of demand driven variable normal capacity utilization. However, the models presented in the paper do not support that assumption as they show choice of the optimal excess capacity rate is independent of the level of demand.

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