

Neo-Schumpeterian Price Theory with Sraffian and Post-Keynesian Elements*

by

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Abstract

This paper contributes to the development of a neo-Schumpeterian price theory by combining elements of Sraffian and post-Keynesian price theory with elements drawn from Schumpeter's own theory of prices. The result is an integrated heterodox approach to price theory incorporating the realism of post-Keynesian pricing rules and the rigour of Sraffa's formal modelling, along with Schumpeter's insight that capitalism develops "from within" in a disruptive and uneven manner.

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1. Introduction

The objective of this paper is synthesising elements of several approaches to price theory to obtain a hybrid theory that is appropriate for analysing an evolving capitalist economy. From Schumpeter comes the insight that development is driven by innovation, along with his theory that this implies uneven change over time in the form of the business cycle. From the classical tradition comes the long-period approach to price determination as formalised by Sraffa (1960). From post-Keynesian, theory comes cost-plus pricing for final product along with having short-period adjustment through quantities rather than prices. From modern evolutionary modelling of competition as a process of differential firm growth comes the link between pricing and investment leading to structural change.

Schumpeter presents his theory of innovation-driven development in *The Theory of Economic Development*, Schumpeter (1961 [1934]), and *Business Cycles*, Schumpeter (1939), as a complement to the Walrasian theory of competitive general equilibrium. He draws a sharp distinction between the circular flow of economic life (to which the Walrasian theory applies) and economic development (to which his own theory applies). Yet, he argues that Walrasian equilibrium prices provide the theoretical norm for a developing economy, albeit only when the economy is in the neighbourhood of equilibrium at the transition between business cycles. Otherwise, prices are subject to the disruptive influence of clusters of innovation, which generate cyclical movements in the price level and structural change in the price system.

Schumpeter's use of perfectly competitive Walrasian general equilibrium as determining the theoretical norm for a developing economy has been widely criticised (see Bloch, 2016b for a review of the criticisms). Kurz (2008) provides an analysis of the impact of innovation on prices based on replacing competitive Walrasian general equilibrium with Sraffa's framework of reproduction prices for characterising the price relations. I start from the same price relations when an economy is stationary and competitive, but modify the framework to analyse innovation and creative destruction through introducing firm heterogeneity, imperfect competition and obsolescence of assets.

Innovation disturbs markets making perfect competition impossible as Schumpeter recognises, particularly in *Capitalism, Socialism and Democracy* (see Schumpeter, 1950,

Chapter VIII). However, while acknowledging the likelihood that prices often exhibit rigidity in such circumstances, he does not further pursue developing a theory of pricing to apply to markets experiencing disruption from innovation. Bloch and Metcalfe (2014) argue that modern post-Keynesian theories with administered prices provide a theoretical framework consistent with both imperfect competition and disruption and are thus suitable for use in analysing the impact of innovation and creative destruction.

Two key concepts in post-Keynesian pricing are cost-plus pricing rules and price leadership. The cost-plus pricing rules are such that prices vary with the prices of raw materials and wage rates, but not capacity utilisation (except in extreme boom conditions). Importantly, profit margins are rigid. Price leadership is used to explain how price uniformity is achieved in markets characterised by cost heterogeneity, which is a common phenomenon in markets experiencing disruptive innovation.

Post-Keynesian pricing rules are usually applied to short-run contexts, particularly to examining the impact of changes in effective demand on output and capacity utilisation with profit margins and prices unchanged. Schumpeter's theory implies structural change over the course of the business cycle, with innovators displacing established firms. Incorporating the post-Keynesian rules into Schumpeter's theory thus requires a mechanism by which market shares are altered to determine the impact on aggregate levels of unit cost, profit margin and price.

The analysis of differential firm growth as a selection process developed by Metcalfe (1994, 1998) links the dynamics of market shares to firm heterogeneity. Variation across firms in fitness characteristics, such as unit production cost, impacts on relative firm growth through investment strategies, which in turn affects the concentration of market shares. Within the post-Keynesian approach, Steindl (1976 [1952]) provides a related analysis that incorporates changes in pricing strategies.

In the next section there is a brief synopsis of Schumpeter's price theory. This is followed by a discussion of the Sraffian and post-Keynesian approaches to price determination. The fourth section discusses the impact of innovation on obsolescence, while the fifth deals with its impact on direct costs and profit margins. Section 6 discusses models of

differential firm growth from both evolutionary and post-Keynesian approaches. The proposed neo-Schumpeterian price theory is then outlined in Section 7, while Section 8 concludes.

2. Schumpeter's price theory

Schumpeter (1961 [1934], 1939) argues that innovation follows an endogenous cyclical pattern under capitalism. When innovation is low and previous innovations have largely diffused through the economy, actual prices are close to their theoretical normal values. Such prices provide reliable information for entrepreneurs and their financiers in determining the potential profitability of particular innovations and, hence, encourage a new wave of innovation. However, a wave of innovation enabled by an expansion of bank credit disturbs prices and makes at least some price information unreliable for calculating future profits. Innovation slows and recession ensues, usually followed by depression and recovery as the economy tends to overreact. Only when the endogenous cyclical pattern of disruption and adjustment is completed are the conditions ripe for the emergence of a new wave of innovations.¹

The cyclical pattern of development through innovation implies a cyclical pattern of prices.

‘Expectations from the pure model are so definite as to make it superfluous to elaborate them beyond what has been said in Chap. IV. Price level should rise in prosperity – under the pressure of credit creation, which, under conditions embodied in the pure model, would not be compensated either by an increase in output or by any fall in “velocity” – and fall in the downgrade – under the pressure of autodeflation and of increase in output – *more than it had risen in the preceding prosperity.*’
(Schumpeter, 1939, p. 462, italics in original)

¹ Alternative explanations of the endogenous bunching of innovations are offered by Mensch (1979) and Perez (2002) among others. Mensch (1979, p. 7) attributes the upsurge of innovation to ‘the degree of stagnation of the old technologies and the attractiveness of the new alternatives.’ Perez associates waves of innovations with new techno-economic paradigms, which appear as revolutions rather than continuously because conditions are favorable for emergence only as the prior techno-economic paradigm nears exhaustion and better access to financing for innovative firms becomes available.

Schumpeter adds to the two-phase cycle by allowing for secondary phenomena, especially overreaction in which the downswing turns from recession to depression (and possibly crisis) followed by recovery. In the resulting four-phase cycle, depression adds to the recession-phase fall in the price level, while recovery offsets price declines during the depression phase. Prices of individual goods and services move unevenly over the cycle, reflecting the uneven pattern of innovation and the secondary phenomena.

To Schumpeter, equilibrium is one thing and development is another. ‘Development in our sense is a distinct phenomenon, entirely foreign to what may be observed in the circular flow or in the tendency towards equilibrium.’ (Schumpeter, 1961 [1934], p. 64) Further, development is driven by innovation and, ‘The changes in the economic process brought about by innovation, together with all their effects, and the response to them by the economic system, we shall designate by the term Economic Evolution.’ (Schumpeter, 1939, p. 86) Yet, he insists that the theoretical norms for an economy undergoing development are determined by perfectly competitive Walrasian general equilibrium. This is problematic in the extreme, as equilibrium implies an absence of any tendency towards variation from within and, hence, an absence of evolutionary potential.² An alternative framework for determining theoretical normal prices, without relying on equilibrium concepts, is developed in the next section.

3. Sraffian and post-Keynesian elements

Sraffa (1960) presents the economy as a series of input-output relationships by which commodities are produced through combining commodities and labour. For the simplest case of no joint production and no non-reproducible natural resources, he then shows that for any given production structure there are sets of prices that just cover production costs, including wages and a uniform rate of profit. Further, there is a unique relationship between the wage rate (assuming homogenous labour) and the rate of profit that determines the set of prices in terms of any particular numeraire. Once the wage rate or profit rate is given, the prices of all commodities are uniquely determined. These prices are reproduction prices in the sense that the price of each product is just equal to its

² A detailed review of Schumpeter’s price theory and the criticisms that it has attracted is provided in Bloch (2018).

production costs including labour and the uniform rate of profits on invested capital, so that each producer earns sufficient revenue to undertake the same production activities without expansion or contraction.

Kurz (2008) uses Sraffa's system as an alternative to Walrasian general equilibrium for the framework in which to discuss Schumpeter's analysis of innovations and profits. Labour is the only non-produced means of production (no natural resource inputs) and all intermediate commodities are produced and consumed in the current period (no durable capital). In vector notation, the unit cost of production is given as the sum of unit labour and unit intermediate input cost as follows:³

$$\mathbf{c} = \mathbf{A}\mathbf{p} + \boldsymbol{\gamma}w \quad (1)$$

where \mathbf{c} is the vector of unit production cost for all commodities (the i th element is the unit cost of the i th commodity), \mathbf{p} is the corresponding vector of commodity prices, $\boldsymbol{\gamma}$ is the vector of labour requirements, \mathbf{A} is the matrix of input-output coefficients and w is the wage rate (assumed to be uniform across all employments). The elements of the matrix \mathbf{A} give the direct requirements for each commodity to produce one unit of the commodity in that row, so a_{ij} gives the direct requirements of commodity j used in producing one unit of commodity i .

Kurz starts, as does Schumpeter, with no profits and having all firms that produce a commodity use identical technology. Both of these assumptions are shown to be violated once the process of development is under way. However, they provide a precise starting point for distinguishing Schumpeter's theory of development from the classical theory of the circular flow of an economy in a stationary state.

Under the extreme assumptions of zero profits and uniform technology, the price of each commodity is equal to its cost of production for every firm. The vector of commodity prices can be solved from (1) by setting $\mathbf{c} = \mathbf{p}$ to yield:⁴

$$\mathbf{p} = ((\mathbf{I} - \mathbf{A})^{-1})\boldsymbol{\gamma}w \quad (2)$$

³ The notation and representation of equations differ from that used by Kurz (2008) as this permits post-Keynesian pricing rules to be more readily incorporated into the analysis.

⁴ The equation for determining prices follows the exposition of Pasinetti (1977, p. 75).

where the elements of the matrix, $(\mathbf{I} - \mathbf{A})^{-1}$, when multiplied by the vector of direct labour requirements, give the vector of total (direct and indirect) labour requirements. Multiplying this total labour requirement by the wage rate gives the cost of production and this unit cost is equal to the product price. Here, the vector of commodity prices is determined solely by wage rates and technology in terms of input-output coefficients and labour requirements.⁵

The system in (2) determines prices that are identical to the corresponding perfectly competitive Walrasian equilibrium for a stationary state without profit. However, price is equal to unit production cost for each output as an accounting relationship, with revenues just sufficient to cover production costs. Further, there is no presumption that the accounting relationship is immune to change when there is change in the scale of production, input composition or technology in the form of input-output coefficients or labour requirements. Evolutionary potential in the form of emergent forces can remain to drive changes in technology without any external shock.⁶

According to Schumpeter, a cluster of innovations disrupts normal relationships, creating profits for entrepreneurs and prices move away from their corresponding theoretical norms. The Sraffian system of reproduction prices is not designed to deal with innovation and diffusion, as all producers of a commodity are assumed to use identical technology. Also, if there are profits, they are assumed to be earned at a uniform rate across all producers and all commodities.

Heterogeneity in the technology utilised by different producers of the same commodity can be accommodated in the Sraffian system by treating the elements of the technology matrix, \mathbf{A} , and the labour requirements vector, \mathbf{y} , as weighted averages of the respective

⁵ Schumpeter emphasises the role of monetary factors, especially credit extended to entrepreneurs, in determining the price level, which implicitly determines the wage rate in (2) for given technology and the zero profit rate. Bloch (2016b) argues this is a shortcoming of Schumpeter's analysis as it denies a role for the institutional arrangements of wage setting, which have been of critical importance in determining the inflationary experience of developed economies in recent decades.

⁶ Evolutionary potential in Schumpeter's theory of development comes from the ideas that could be turned into profitable innovations at prices given by (2), but which have not yet found an entrepreneur who is able to exercise sufficient leadership to overcome ever-present resistance to innovations. Such unexploited profitable opportunities are inconsistent with a competitive Walrasian general equilibrium, which assumes perfect information and profit maximisation.

elements for individual producers. The dimensions of \mathbf{A} and $\boldsymbol{\gamma}$ remain unchanged unless innovations involve introduction of new products, in which case the dimensions expand in proportion to the number of new products. However, heterogeneous input requirements across producers of a commodity facing a common wage imply cost differences across the producers, which then leads to price or profit differences. This suggests the need to replace the price equals cost assumption of the Sraffian system in (2) with a theory of price and profit determination to deal with heterogeneity arising from innovation. For this purpose, I draw on post-Keynesian price theories.⁷

There are a variety of pricing rules used in post-Keynesian theories, but they are all in the general form of cost-plus pricing (see Lee, 1998 for an overview of post-Keynesian price theory). One common pricing rule is mark-up pricing, where price is equal to direct unit cost multiplied by one plus a profit margin. With all costs as in (1) consisting of either labour or purchased commodities used as raw materials or intermediate product, pre-multiplying the unit cost vector by a matrix of price-cost ratios, denoted by $\boldsymbol{\Pi}$, and substituting into (2) yields:

$$\mathbf{p} = \boldsymbol{\Pi}\mathbf{c} = ((\mathbf{I} - \boldsymbol{\Pi}\mathbf{A})^{-1})\boldsymbol{\Pi}\boldsymbol{\gamma}w, \quad (3)$$

The i^{th} diagonal element of $\boldsymbol{\Pi}$, $\pi_{ii} \geq 1$, is the average price-cost ratio for the i^{th} commodity if all producers have different costs but charge the same price, while the off-diagonal elements are each zero. π_{ii} can also be written as;

$$\pi_{ii} = 1 + m_i, \quad (4)$$

where m_i is the average profit margin in the production of commodity i .

The post-Keynesian price determination in (3) reduces to the reproduction price system in (2) if the profit margin equals zero for each production process, which means that the matrix of price-cost ratios, $\boldsymbol{\Pi}$, is replaced by the identity matrix with diagonal elements

⁷ Kurz (2008) directly compares long-period positions where price is equal to reproduction cost and doesn't analyse price setting away from these long-period positions. Haas (2015) adds an examination of differential firm growth, but only within the context of a one-sector scheme.

equal to one and off-diagonal elements equal to zero.⁸ This correspondence is fundamental for interpreting Schumpeter's analysis, with (2) determining prices that would obtain in a competitive, stationary economy and (3) determining the actual prices for a developing economy.

According to Schumpeter, innovations generate transitory profits and drive a wedge between (2) and (3) as well as destroying the homogeneity among all producers of a commodity that is assumed in (2) but need not occur in (3). As the innovations become fully absorbed in the economy, entrepreneurial profits dissipate as do differences between producers of the same commodity. Theoretical normal prices are then once again determined by (2), but the technical coefficients are altered so the structure of prices, the price system in Schumpeter's terminology, is different.⁹

Using the Sraffian system to determine theoretical normal prices becomes more complicated when overheads and durable equipment are considered. If expenditures on overhead only involve the use of intermediate inputs or labour, then the technical coefficients specifying input requirements in (1) and (2) are increased by the amount of each intermediate input and by the amount of labour used in overhead activities each divided by the output level. While the calculation is straightforward for a specific and uniform level of output for each producer of each commodity, there is likely to be variation in the technical coefficients for different output levels as overhead activities are generally thought to be prone to economies of scale.

Variation in technical coefficients for different output levels either for an individual producer (internal economies of scale) or for the total output of a commodity (external

⁸ The expression in (3) is superficially similar to the expression for determining prices in a Sraffian system when the rate of profit is greater than zero (see Pasinetti, 1977, p. 80). However, there are two important differences. First, profit in the Sraffian system is viewed as a return on capital and hence applies to commodities used in production but not to wages, so there is no pre-multiplication of the labour requirements vector, \mathbf{y} , by the price-cost ratio matrix, $\mathbf{\Pi}$. Second, the rate of return on production is treated as uniform across producers of a commodity and across different commodities, which equates to uniformity in the profit margins if wage payments are treated as part of the producer's capital that earns a return.

⁹ Due to the changing price system, Schumpeter qualifies his use of the theoretical norm for prices and states that it applies only when the economic system is in the neighbourhood of equilibrium when actual prices approach their equilibrium values (Schumpeter, 1939, pp. 68-71). Further, the approach to equilibrium only occurs at the end of the business cycle, when the diffusion of innovations has abated (*op cit.*, p.196).

economies of scale) changes the price vector in (2). Thus, when overhead activities, or any other production activities in which there are internal or external economies of scale, are important, using (2) to determine theoretically normal prices requires specifying a “normal” level of output for each producer. Helpfully, post-Keynesian pricing models generally specify that the unit cost used in cost-plus pricing is based on a “normal” level of output, so that price determination in (3) always implies the use of normal rather than actual output in calculating technical coefficients. There is a corresponding price vector from (2) with the same technical coefficients.

Adjustment of the Sraffian system for durable equipment involves further complications. Sraffa (1960, Ch. X) incorporates durable capital into his system using the device of joint production. Each production process that uses a durable machine is treated as having an extra output, namely a machine one year older than the machine used as input. In the last year of the machine’s life, the machine is an intermediate input and there is no extra output of a year-older machine. If a machine lasts for n years, there are n separate production processes one for machines of each age.

The simplest case involves a machine that has constant productivity over its lifetime, which every year uses the same amount of labour and other intermediate inputs to produce one unit of the same product along with a year-older machine (until the last year when there is no older machine). The price of old machines of all ages then can be solved from the series of n price equations for production processes with machines of various ages. The revenue in each equation is the price of the finished product plus the price of a one year older machine, while the cost is the price of a current machine plus the wage cost for direct and indirect labour. The price of the product and the wage cost are identical across production processes. When there is no interest cost associated with holding machines, the depreciation charge allocated to each year of the machine’s life is then just $1/n$ times the original price of the machine.¹⁰ Thus, the calculation of normal unit cost and normal price can be simplified by having only one production process for

¹⁰ With interest payable, the depreciation charge attributable to each year rises with the age of the machine. This because the total cost of utilising the machine, which is equal to depreciation plus interest on the remaining value of the machine, is constant over time. As the annual interest cost drops over time with the decline in the remaining value of the machine, the depreciation component of the cost of utilising the machine increases (see Sraffa, 1960, Chapter X).

the commodity in which the technical coefficient for the machines is $(1/n)$ times the number of machines employed per unit of output.

4. Innovation and obsolescence

Durable equipment is an important, although often implicit, part of Schumpeter's theory of development. In *The Theory of Economic Development* and in *Business Cycles*, innovation involves more than the rearrangement of this capital equipment as is often assumed in neoclassical analyses of technical change. Rather, innovations are generally embodied in plant and equipment, so that new machines and even new plants are necessary. Writing later in *Capitalism, Socialism and Democracy*, Schumpeter goes further and recognises the prospect of future changes in technology as a factor delaying investment in the latest technology.

‘A new type of machine is in general but a link in a chain of improvements and may presently become obsolete. In a case like this it would obviously not be rational to follow the chain link by link regardless of the capital loss to be suffered each time. The real question is at which link the concern should take action. The answer must be in the nature of a compromise between considerations that rest largely on guesses.’ (Schumpeter, 1976 [1950], p. 98)

Whenever products from new technology are more attractive to buyers because they have lower price or better features, the change in technology disadvantages owners of plant and equipment that embody the old technology. As Schumpeter recognises, this makes investments that embody technology less attractive. To avoid the prospect of losses from “following the chain of improvements”, revenues for firms making investments in new embodied technology need to be sufficient to cover provision for possible obsolescence.

Obsolescence can be incorporated into the system of reproduction prices by replacing the physical lifetime of a machine with its economic lifetime. Suppose the machine becomes obsolete in year m , with $m < n$, then there are only m processes over which the machine is used. Thus, without any change to costs of producing the machine, the reproduction costs of products utilising the machine are increased.

At the time of investment, the economic lifetime of a machine or any other tangible or intangible asset that embodies current technology is unknown. Only after the asset can no longer be profitably employed in a production process due to obsolescence is it possible to determine the reproduction prices that ensure a constant contribution to unit production cost (including interest, if any, on the asset's residual value) over the machine's economic lifetime. Retrospectively, the pattern of unit production cost and price from applying Sraffa's method over the economic lifetime of all fixed assets can be considered "normal" in the sense of providing an amount just sufficient to cover reproduction cost of each fixed asset based on equal contributions to production cost during each year of the asset's economic life.

In a developing economy the future differs from the past so retrospective accounting isn't a reliable indicator of costs in the future.¹¹ Because of differences in the knowledge of firms as well as their unique experiences, firms undoubtedly diverge in their estimation of likely obsolescence, even where the firms use similar processes to produce highly substitutable products. Thus, the notion of a norm for depreciation of fixed assets is problematic in a developing economy, but less so when innovation is low and prior innovations have been largely diffused throughout the economy. In this sense, it is plausible to accept Schumpeter's argument that economy approaches its theoretical norm at the end of a business cycle driven by a cluster of innovations.

The uncertainty associated with the allocation of overheads and depreciation over "normal" output as well as the problems of estimating depreciation helps to explain the predominant use of mark-up pricing rules in post-Keynesian price theory. Direct unit costs associated with labour, raw materials and non-durable intermediate inputs are generally less sensitive to variation in output and less prone to violent changes due to innovation than are overhead and depreciation costs.¹² Applying a fixed gross profit

¹¹ Whenever the price of the commodity differs from its "normal", the use of old machines and their prices as calculated to generate a uniform rate of profit diverge from the normal pattern (see Kurz and Salvadori, 1995, pp. 348-351).

¹² While technical change affects the amount of labour, raw materials and non-durable intermediates used in production, the effects on depreciation of fixed assets tend to be magnified. For example, machines that have been fully depreciated and taken out of the normal production process due to relatively high operating cost may be used as reserve capacity to meet demand surges, which implies the earlier depreciation charges were excessive.

margin to unit direct cost is less likely to lead to erratic price changes that are out of sync with those of competitors, which is consistent with the post-Keynesian emphasis on stability as a prime objective in business behaviour.

5. Innovation impacts on production cost and profit margin

Embodiment of technology in equipment, processes and organisations affects the process of cyclical adjustment to innovations. In the remainder of this paper, the process of adjustment is examined using the hypothetical example of an innovation that is embodied in a production process, which changes the process uniformly for all periods after its introduction. To simplify the analysis, the process innovation at time t only affects labour requirements, reducing the amount of labour required to produce the i^{th} commodity in future periods. Otherwise, input requirements are unchanged and the input-output matrix, \mathbf{A} , in (3) is unaltered. The innovation affects only the entrepreneurial firm that introduces the innovation. Thus, $\gamma_{i,e,t+1} < \gamma_{i,e,t}$, where e is the entrepreneurial firm, but $\gamma_{i,m,t+1} = \gamma_{i,m,t}$, where m is an established firm. At current prices, this innovation is profitable because it reduces production cost at current wages and prices for intermediate inputs.¹³

How does the reduction in labour requirements from the process innovation affect pricing once output from the new process reaches the market? In post-Keynesian price theory, price leadership is the standard mechanism for dealing with cost heterogeneity among firms producing a homogenous product. The question is then who will be the price leader after a cost-reducing innovation. Here, Schumpeter provides a strong hint by stressing that innovators utilise their advantage to earn profit. This suggests innovators will at least initially choose to follow the lead of established firms, implying no immediate impact of the reduced labour requirements on the price of the affected commodity or on the price level.

With the assumption that innovators follow the price leadership of established firms, the process of adjustment can be analysed in the framework cost-plus prices in (3). The

¹³ The idea that an innovation is embodied in a production process and affects labour requirements without altering intermediate input requirements is perhaps fanciful. However, the advantage is that in the analysis below it is possible to separate the direct impact of the innovation on the unit cost and price of the i^{th} commodity from indirect changes that affect all commodities.

assumption that all producers of commodity i use best-practice technology is no longer applicable. Instead, the i^{th} element of the vector of labour requirements is the weighted average of individual firm labour requirements, with the weights given by the share of each firm in the total production of the commodity as follows:

$$\gamma_{i,t} = \sum_{k=1}^{n+1} \gamma_{i,k,t} (x_{i,k,t} / \sum_{k=1}^{n+1} x_{i,k,t}), \quad (5)$$

where $x_{i,k,t}$ is the output of the k^{th} firm, with n established firms and one entrepreneurial firm, and the term in parentheses is the firm's share in total output of the i^{th} commodity. The labour input requirements vector for the i^{th} commodity has an additional element for the entrepreneurial firm that is lower than that for the established firms. Assuming the entrepreneur starts small, most output still comes from established producers that utilise the old technology and total labour requirements for the industry are not much affected compared to producing the same output without innovation.

If there are heterogeneous labour requirements for firms producing a commodity, then compensating differentials in the price-cost margins are required to ensure that there is a single price in the market. In particular, each firm producing the i^{th} commodity has the same price, p_{it} , at time t , if and only if, the profit margin for each firm producing the commodity is given by:

$$m_{i,k,t} = p_{it} / c_{i,k,t} \quad (6)$$

For consistency in aggregation from the individual firm values in (6) to the industry relationship in (3), the weighting scheme for calculating both $c_{i,t}$ and $\pi_{ii,t} = \sum_1^{n+1} (1 + m_{i,k,t})$ uses output shares for each firm, as shown in (5) for calculating $\gamma_{i,t}$. Profit margins across the full set of firms in the economy are then given by:

$$m_{i,e,t} = c_{i,m,t} / c_{i,e,t} > 0 \text{ and } m_{j,m,t} = 0, \text{ for all } j \quad (7)$$

which implies the weighted average profit margin for the i^{th} industry is given by

$$m_{i,t} = \sum_{k=1}^{n+1} m_{j,k,t} (x_{i,k,t} / \sum_{k=1}^{n+1} x_{i,k,t}) \quad (8)$$

The weighted average profit margin for commodity i exceeds zero, while the corresponding ratio for all other commodities equals zero. If the output share of the entrepreneurial firm is small, the weighted average gross profit margin for the i^{th} commodity is correspondingly close to zero.

6. Differential firm growth, competition and structural change

When an innovation introduces heterogeneity across firms, the “normality” of the price relations in (2) is disrupted. However, disruption to **the** price system in terms of a change in the price vector on the right-hand side of (2) may be temporarily suppressed by price leadership. Price leadership is maintained in post-Keynesian price theories through changes in quantities, implying changes in capacity utilisation. Essentially, established price leaders withdraw output from the market to accommodate the production by the entrepreneurial firm, ceding market share to the entrepreneurial firm and accepting a decline in capacity utilisation.¹⁴

Suppression of disruption to the price system is dynamically unstable as the entrepreneurial firm has a profit incentive to expand by acquiring additional means of production, financed by either credit or retained profits. This emergent instability is a reflection of the evolutionary potential for the population of firms producing the i^{th} commodity. The efficiency (fitness) of the population increases through relative expansion of the innovating firm. What is required is a theory that explains the process by which the improvement in efficiency comes about. Schumpeter provides hints in his discussion of the process of creative destruction, but provides no formalisation.

Metcalf (1998) formalises the process of differential firm growth for a population of heterogeneous firms producing similar products. In the basic model, firms differ only in their unit cost for producing a single product, with each firm's unit cost fixed in perpetuity and constant with respect to output. The output of each firm is equal to its production capacity and total industry output is constant. Product price is determined to

¹⁴ In a perfect market, the adjustment is solely through quantities with price constant. If the market is not perfect, products are imperfectly substitutable and the entrepreneurial firm captures market share only by some reduction in price or incurring extra cost for marketing. As long as the established firms accommodate entry by maintaining their price and selling cost, the analysis proceeds in parallel to that outlined in the text, which assumes a perfect market.

balance the change in production capacity and sales for each firm. Firms then expand or contract their production capacity in the next period by an amount equal to their current profits or losses.

In this basic model, the evolution of the industry follows the Fisher Principle from evolutionary biology, where the change in average behaviour is related to the variance of behaviour across the population. In this case of variation of unit cost across firms in an industry, the weighted average unit cost for the industry decreases at a rate proportional to the variance of unit cost across the firms in the industry. With low-cost firms expanding their share at the expense of high-cost firms, the industry weighted average unit cost moves towards the lowest unit cost among the firms. Convergence is however at a decreasing rate as the variance of unit cost is also decreasing.

This simple scenario might be adequate for early stage capitalism emerging from stagnation and lacking a history of innovation, but not appropriate for a modern economy with ongoing development. First, in a developing economy, productivity increases mean output is growing over time even with a stable population and capital stock. In Metcalfe (1998), output growth for the innovator's industry implies that price remains above unit cost even in the long run. The difference between price and unit cost generates profits to finance an increase in production capacity across the industry to meet the increase in demand. As a result, some firms with unit cost above the lowest unit cost price remain in operation indefinitely, even though they continue to lose market share.

The growth of market demand impedes the working of the Fisher Principle by weakening the link between cost performance and growth of market share across firms. Other modifications to the basic model in Metcalfe (1998) also interfere with this link. Further, Metcalfe (1994) shows that when the basic model of differential firm growth is modified to consider economies of scale, the weighted average unit cost for the industry actually rises over some intervals in the process of long-run adjustment and that the attractor for the evolution of the weighted average unit cost exceeds the lowest obtainable unit cost.

A second important elaboration is recognising the tendency towards industry concentration implied by models of differential firm growth. Concentration as the end

point of differential firm growth undermines the notion that price equal to lowest possible unit cost is the proper norm for the developing economy. Once a market becomes concentrated, firms tend to recognise their interdependence and alter their investment and pricing strategies, something that is acknowledged in *Capitalism, Socialism and Democracy* (Schumpeter, 1976 [1950]).

Pricing based on recognised interdependence is an essential feature of post-Keynesian price theory. In particular, the profit margin in mark-up pricing rules increases with the degree of monopoly power and industry concentration is recognised as one factor behind monopoly power. Also, adjustment to short-run shocks occurs through variations in capacity utilisation rather than price adjustments, at least in the first instance. However, the analysis is generally static and doesn't deal directly with the process of changing concentration. An exception is Steindl (1976 [1952]).¹⁵

Steindl analyses a model where cost differences lead to differential firm growth across firms in an industry as in the evolutionary analysis of Metcalfe (1998).¹⁶ However, in Steindl's model price is unaffected by the expansion of the low-cost (progressive) firm or firms, at least initially. Only when continued expansion through investment of retained earnings by the progressive firms results in a persistent decrease in capacity utilisation below their desired level do the progressive firms use their low-cost advantage to engage in aggressive competition through price reduction or increased sales effort. This results in relative concentration of the industry as the market share of the progressive firms rises and, eventually, in absolute concentration when high-cost (marginal firms) exit.

With the rise in concentration, Steindl suggests that the industry matures and changes its pricing behaviour once again. The surviving firms in mature industries recognise their common interests and desist from further expanding capacity beyond what is required to maintain their desired capacity utilisation ratios. Price is maintained well above their unit

¹⁵ The relationship between Steindl's analysis and other approaches in post-Keynesian price theory, particularly that of Sylos-Labini (1962) is discussed in Bloch (2016a), which also discusses the connections to Schumpeter of the analyses of both Steindl analysis and Sylos-Labini.

¹⁶ Metcalfe (1998, p.68) acknowledges Steindl (1976 [1952]), 'as a precursor of evolutionary arguments in economics, since it implicitly separated out questions of economic fitness (growth) from questions of viability (survival).'

operating cost and firms accommodate demand fluctuations through variations in capacity utilisation rather than changing price.

Steindl's analysis of the process of industry concentration has three phases of pricing behaviour, an initial phase of price rigidity followed by aggressive competition and then price leadership in maturity. In the long run, the process of concentration stops before all firms with unit cost higher than the lowest obtainable are driven from the market and price remains above the weighted average unit cost. A similar long-run outcome occurs in Metcalfe's evolutionary theory of differential firm growth modified to allow for industry output growth. In both analyses, the end of the process of adjustment to innovations stops well short of yielding reproduction prices based on zero profits, suggesting abandonment of the zero-profit outcome as the end point of the price cycle. Nonetheless, the improvement in average labour productivity and resulting reduction in average unit production cost exceeds the impact of any rise in the average price-cost ratio, so prices fall relative to wage rates implying a rise in the real wage rate although perhaps of a smaller magnitude than would result with zero profits at the end of the business cycle in Schumpeter's analysis.

7. Neo-Schumpeterian price theory

The neo-Schumpeterian price theory proposed here follows Schumpeter's cyclical pattern starting with prices at "normal" levels. However, normal prices are higher than the reproduction prices from the Sraffian system as shown in (2) or the equivalent equilibrium prices from the Walrasian perfectly competitive system used by Schumpeter. Instead, normal prices are determined by the post-Keynesian modification of the Sraffian system in (3) to incorporate price-cost ratios greater than or equal to one and allow for variation in unit production cost and profit margins across producers of the same commodity. Also, the unit production cost reflects potential obsolescence from technical change and exceeds allowances for physical depreciation in traditional cost accounting.¹⁷

¹⁷ The gap between price and cost in post-Keynesian theories is not simply an expropriation of surplus for profit as in Sraffa's framework for representing the classical approach to price theory. Rather, as Eichner (1976) explains, the gap between price and unit production cost can be thought of as a "corporate levy", which is used for multiple purposes, including expenditures on new plant and equipment (both replacement

Schumpeter's argument that having prices at "normal" levels encourages entrepreneurial activity still has merit after changing the notion of what is "normal". The new "normal" is a set of prices based on price-cost ratios exceeding one. These ratios may be the attractors for Metcalfe's evolutionary process of differential firm growth or the outcome of industry maturity as in Steindl's analysis. When innovations have largely diffused so that heterogeneity among firms is low, prices determined by (3) with this "normal" set of price-cost ratios can be used by entrepreneurs to calculate potential profits from their innovations and convince banks to provide credit for finance. This sparks an upswing in innovations.

Next, in Schumpeter's time sequencing of the innovation-driven business cycle, the entrepreneurial firms acquire means of production in the form of labour and commodities to use as raw materials or intermediate inputs. Demand for labour increases directly and indirectly through higher output of commodities used by the entrepreneurs, leading to a rise in the wage rate. This leads to a proportional rise in the price vector, \mathbf{p} , in (3), which conforms to Schumpeter's argument that increased innovation initially leads to a rise in the price level.¹⁸

Output from the entrepreneurial firms doesn't directly affect relative prices according to post-Keynesian theory when there is price leadership by established firms. Established firms absorb any reduction in their own output through variation in capacity utilisation. The relative expansion of the entrepreneurial firms reduces the weighted average unit cost across all firms in the industry as shown in (9), but there is an exactly offsetting increase in the weighted average profit margin calculated according to (12).

Suppression of price changes through quantity adjustments is unstable in the circumstances of innovation. Steindl's (1976 [1952]) post-Keynesian analysis of differential firm growth points to an eventual outbreak of aggressive competition due to capacity expansion by the low-cost entrepreneurial firms reinvesting their profits, putting

and expansion), advertising, research and development, managerial salaries and dividends to shareholders. Only the last category clearly constitutes a return to capital in the classical price theory.

¹⁸ Other changes that affect prices are ignored at this point to simplify the analysis and show its correspondence to Schumpeter's analysis. For example, it is assumed that technical coefficients aren't affected by changes in output, which holds only if there are constant returns to scale in production.

downward pressure on profit margins and prices. A smoother process of decline in prices and individual firm profit margins occurs in Metcalfe's (1998) evolutionary analysis of differential firm growth with balanced growth in supply and demand. In both analyses, this decline in prices is accompanied by continued growth in output, just as in Schumpeter's process of creative destruction. This phase corresponds to the downswing of Schumpeter's two-phase cycle or the recession phase of his four-phase cycle.

Price decreases in the analyses of Steindl or Metcalfe are driven by differential expansion of firm capacity, which depends on the variance of cost across firms. In both cases, the differential expansion reduces cost variance, thereby reducing pressure for further price decreases. Also, in Steindl's analysis increased industry concentration leads to recognition of interdependence and a cessation of aggressive competition, while in Metcalfe's analysis the growth of industry output requires financing from profits so the price decline ceases before price equals lowest unit cost. Thus, in either Steindl's or Metcalfe's analyses, further diffusion of innovation and the price cycle end with a price-cost ratio for the innovating industry that exceeds the "normal" level.

Compared to the situation before the innovation, the weighted average profit margin for the innovative industry in (8) is lower than what is necessary to offset declines in the weighted average labour requirements in (5), leading to a decline in p_i relative to other elements in the price vector, \mathbf{p} , in (3). As Schumpeter suggests, innovation eventually brings change to the price system. There is also downward pressure on the aggregate price index from the decline in p_i , which means the real wage rate clearly rises with the diffusion of the innovation.¹⁹

The fall in p_i reduces the cost of production for other commodities that use the i^{th} commodity as an input in their production process.²⁰ Production cost may also fall in

¹⁹ Under Schumpeter's conception that the price level is a social construct, the price level need not fall. The distinction between changes in aggregate price indices and changes in the price level is clearly articulated by Schumpeter (1939, p.468-9) when, in discussing the problems of using aggregate price indices as measures of the price level, he states, 'It cannot be too often repeated, however, that mere shifts in the price *system*, though they do not per se influence our price level, do influence the indices we have. Hence individual prices may, beside their legitimate influence, acquire an illegitimate one as well.'

²⁰ Sraffa's distinction between basic and non-basic commodities is relevant. A basic commodity is used directly or indirectly in the production of all other commodities (for example, electricity) so that a decline in the price of a basic commodity leads to at least some decline in cost and price for all other commodities.

these other industries with falling aggregate labour demand and the nominal wage rate due to the shift in output in the innovating industry from established to entrepreneurial firms with lower labour requirements. If the non-innovating industries follow post-Keynesian pricing with a fixed profit margin, their prices will decline along with that of the innovating industry. Overall, these changes in other industries contribute to a decline in the aggregate price index using price determination according to (3) and due to their widespread occurrence satisfy Schumpeter's requirements for a fall in the price level.

Price movements following from the innovation and diffusion process in the neo-Schumpeterian price theory as outlined so far don't depend directly on changes in aggregate output, although the increased wage rate stimulating the rising price level in the upswing does assume that there is at least a temporary rise in the aggregate demand for labour. Thus, the price cycle that is generated by innovation and diffusion doesn't depend on Schumpeter's assumptions concerning the expansion and contraction of credit and money in the process of financing innovation.²¹ Neither are the overshooting and recovery that feature in Schumpeter's four-phase cycle a necessary part of the analysis.

If, as Schumpeter argues, there is secondary expansion of production across commodities, fuelled by the increase in credit to finance entrepreneurs, then the demand for labour further increases in the upswing of the business cycle with more upward pressure on the wage rate and the price level. Further, if the downswing of the business cycle is accompanied by autodeflation arising from the contraction of credit as entrepreneurs turn to repaying the loans taken out for their establishment and early expansion, there would be a corresponding decline in labour demand, the wage rate and the price level. Finally, fluctuations in output due to overly optimistic or pessimistic expectations or other secondary phenomena of the business cycle need not influence prices under post-Keynesian price theory nor alter the course of competition associated with the diffusion of innovations, although some impact on timing is plausible.

In contrast, a non-basic commodity enters into production of only a limited subset of other commodities, so a decline in the price of a non-basic has limited impact on the remainder of the price system.

²¹ Introduction of innovations still requires the shift of means of production to the innovative production process. This may occur through internal reallocation in large-scale firms, otherwise some market mechanism that potentially involves expansion of credit is still necessary.

So far it is assumed that all industries set prices according to post-Keynesian price theory with a profit margin that is fixed at least in the short run.²² Also, it is implicitly assumed that technical coefficients remain unchanged aside from the innovating industry. However, the analysis can be expanded to incorporate industries with prices determined by market clearing and with firms having rising cost curves in the short run that imply rising technical coefficients for at least some inputs.²³ The complication that arises is that price movements for these industries depend on changes in profit margins and technical coefficients resulting from variation in demand conditions facing the industries as well as from the cost changes attributed to the introduction and diffusion of innovations in the analysis above. The movement over the course of the cycle for prices in these industries with market clearing and rising supply curves then depends on changes in firm and industry output as well as on the influences that impact on all industries. Little definite can be said in general about the direction or magnitude of changes in prices in these industries.

8. Conclusions

The neo-Schumpeterian price theory proposed in this paper starts with a Sraffian structure of production of commodities by means of commodities in which price is determined to cover reproduction cost without profit. This structure is modified to incorporate post-Keynesian theory of cost-plus pricing, allowing analysis of the effects of innovation that introduces variation in unit cost and price-cost ratios across firms. The dynamic impact of diffusion of the innovation is then analysed using differential firm growth models from, alternatively, post-Keynesian and evolutionary traditions.

The theory is used to explain the appearance of price cycles following clusters of innovations as outlined in Schumpeter's *Theory of Economic Development and Business Cycles*. Importantly, the theory allows the analytical separation of impacts on relative prices, which Schumpeter designates as changes in the price system, from impacts across all prices, which he designates as changes in the price level. This separation is

²² Markey-Towler (2016) provides an evolutionary analysis that treats firm price strategies as routines that don't immediately respond to demand variations, as is standard in post-Keynesian price theory. However, he focusses on the distribution of pricing strategies across firms rather than the distribution of unit costs.

²³ Nelson (2013) argues forcefully for including such industries in the scope of evolutionary price theory.

emphasised, but not formalised, in Schumpeter's discussion of price theory in *Business Cycles*. Likewise, the relationship between the wage rate and prices is expressed in terms of technical coefficients and price-cost ratios, providing an analytical basis for evaluating Schumpeter's arguments about the impact of innovation on real wages.

Overall, the analysis leading to the proposed theory undermines Schumpeter's argument that the values of variables associated with perfectly competitive Walrasian general equilibrium provide the theoretical norm for a developing economy. Yet, his argument that innovation-driven growth necessarily leads to cycles in the price level and structural change in the price system is fully supported. His argument that innovation leads to a downward trend in the price level also holds, at least if it is reinterpreted in terms of implying a downward trend in the price level relative to the wage rate, in other words a rising real wage rate. Thus, it is shown that none of Schumpeter's important insights on price theory depend on assumptions that are inappropriate for a developing economy.

We can continue to learn from Schumpeter, especially if we are willing to critically reevaluate and build on his important contributions.

Compliance with Ethical Standards:

Conflict of Interest: Harry Bloch declares that he has no conflict of interest.

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