The Phillips Curve: Which? Whose? To Do What? How?*

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I. Introduction

Economists have long debated the nature of the determinants of the origin and development of economic theories. Many economists have maintained that these determinants are *internal* to the discipline itself. Economics, they typically have argued, consists of a logical system of laws which predicts the facts. Economics develops as new laws are deduced which encompass additional phenomena. The professionalization of economics enforces standard method while scholarly interaction within the profession prompts the direction of work. Economics consequently is autonomous and objective [85]. Yet other economists have maintained that economics develops in response to extra-scientific or *external* factors. Economists, they have argued, function within a socio-economic, cultural and political context. How economists perceive events in this external context affects their whole approach to economics—their scope of study, definitions, methods, even their facts. Economics as a result is highly subjective [31; 63]. This debate over the autonomy of economics never has been resolved.

Similarly, economists have differed over the process which governs the acceptance or rejection of theories. Most economists have regarded theory appraisal as an objective matter. They have proposed that hypotheses of alternative theories should be tested in terms of their empirical predictions. Economists should reject theories which fail the tests and choose that theory which tests best. If alternative theories test equally well, economists should apply logical criteria, such as consistency and simplicity. Yet, some methodologists have seen theory choice as an extra-scientific, or subjective affair. They have claimed that economists rarely choose theories on the basis of testing, which is difficult in economics, and arbitrarily use logical criteria. In reality, factors such as social forces, rhetorical persuasion or policy relevance decide between theories [15; 60; 87]. Again, this controversy has remained unresolved.

In the recent literature, economists have employed the methodology of scientific research programs to address these issues [7; 15; 50; 91; 96]. This essay applies the research program methodology to a case study of the development of the Phillips curve. This meth-

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odology treats science as a problem-solving activity occurring in scientific research programs (SRPs). Such programs are composed of the following elements:

1. A hard core which is irrefutable and consists of:
   a. *Presuppositions*, metaphysical beliefs, or ideologies. Presuppositions may be implicit or informally stated. They underlie the SRP.
   b. *Heuristics*, or methodological rules, including:
      (i) A negative heuristic which indicates paths of research that would conflict with the hard core and should be avoided.
      (ii) A positive heuristic which indicates broad paths of research to pursue and designates research techniques.
2. A protective belt of the standard corpus of scientific analysis, namely:
   a. *Axioms* setting out the basic functional relations between entities of the system.
   b. *Theoretical models* that break down the axioms to represent real processes.
   c. *Empirical models* designed to test the theoretical models. If tests fail to confirm a theoretical model, researchers may modify the test, empirical model, or the theoretical analysis. [8; 49; 90]

This case study considers in particular those presuppositions in economic SRPs which concern the economic role of government. After all, with the modern economy a main arena of government action, economists employed in a variety of institutions have served to instruct the polity on economic policy. The issue has been the extent of public intervention. Conflicting political ideologies often have provided presuppositions for competing economic SRPs. A conservative, classical SRP essentially has ruled out government intervention, while a reformist, neoclassical and more radical post-Keynesian SRP have aimed to justify moderate or great intervention, respectively.

Moreover, the essay shows that economic policy questions have influenced which problems economists have chosen to research in the protective belt of SRPs. For an SRP's status and resources often have depended on its success in showing how to resolve commonly perceived economic troubles. Economists indeed have argued habitually in the media about the economic problems of the postwar period, slow growth, instability, inflation and unemployment.

Economists have seen the Phillips curve as offering a solution to these four postwar problems. This essay studies the aims, method and coherence of the classical, neoclassical and Keynesian SRPs in incorporating the curve. Part II analyses the neoclassical invention, parts III and IV the classical appropriation, and part V the Keynesian formulation of the curve.

II. Inception and Initial Development

Modern neoclassical economics was constituted by a synthesis of Keynesian economics and classical, Walrasian economics.[1] The revolutionary message of Keynes's *General Theory*

1. The SRP of the neoclassical synthesis included the following:

Hard Core

1. Decision-makers optimize subject to constraints.
2. The price-mechanism that provides signals to decision-makers works imperfectly in modern capitalism.
3. As a result, the nonoptimal situation of unemployment or inflation occurs frequently in a private capitalist economy.

was that macroeconomic equilibrium, persistent excess labor supply and a downwardly flexible money wage rate could coexist [42; 43, 204]. Yet according to Walrasian microeconomics, excess supplies of labor in perfectly competitive markets would be eliminated quickly by downwardly flexible wage rates. However, persistent involuntary unemployment undoubtedly occurs in the modern economy. In the late 1930s and 1940s, Walrasian theorists responded by acknowledging such unemployment. But in their SRP unemployment could only occur in imperfectly competitive labor markets where wage rates exceeded market-clearing rates and were downwardly rigid.[2] Walrasians made this rigidity complete for purposes of mathematical simplicity [62, 48]. The neoclassical synthesis then anomalously contained equilibrating micro-wage rates and a non-equilibrating macro-wage rate. To maintain aggregate demand at full employment, neoclassicists proposed monetary and fiscal measures [79].

Phillips's Conjecture

In the 1950s, Alban William Housego Phillips attempted to resolve the neoclassical anomaly [68–73]. Phillips, who had degrees in electrical engineering (1938) and sociology with economics (LSE, B. A., 1949) [10], was showing how to build a waterflow model as an analogy of the neoclassical income-expenditure model. The latter model usually was represented in mathematical terms, but some economic students had difficulty with mathematics. Both the hydraulic and income-expenditure model contained flows. Also, both could be described by means of differential calculus. The hydraulic machine, however, was visible and comprehensible to students.[3] The machine, described in Phillips's Ph.D. thesis, prompted his appointment as assistant lecturer at the LSE in 1950. In discussing the machine, Phillips focused on changes following a disturbance of equilibrium, which conformed to Hick's

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4. Democratic government, which is rational and foresightful, should enact macroeconomic policies to stabilize the economy at full employment.

Positive Heuristic

1. Connect the Keynesian theory of effective demand to Walrasian price theory to form a general theory.
2. Explain how the market-interrelated circular flow of income generates equilibria without full employment.
3. Construct analytically manageable models of the monetary economy to serve as guides for policies of demand management.
4. Show that successful application of the fiscal and monetary policies validates Walrasian principles of the allocation of fully employed resources.

Negative Heuristic

1. Do not discard the classical analytic tools.
2. But do not use disaggregated models to predict macroeconomic outcomes.

Protective Belt

1. Microeconomics: the laws of supply and demand, marginal productivity analysis.
2. Keynesian (or macro-) economics: the consumer-income equation, marginal efficiency of investment, expenditure multiplier, income-expenditure model, liquidity preference, IS-LM model.

Major exponents of the neoclassical SRP included Alvin Hansen, J. R. Hicks [35], Lawrence Klein, Franco Modigliani, Don Patinkin, Paul Samuelson [79], Robert Solow and James Tobin.

In this essay, the term neoclassical signifies the SRP of the neoclassical synthesis. The term Keynesian designates applied economists who held the macroeconomic tenets of the synthesis without microeconomic underpinnings.

2. In the early neoclassical literature [35; 43; 62] downward wage rigidity explained unemployment, except in the special case of an infinitely elastic demand for money (the liquidity trap). Patinkin [66] showed the real balance effect secured full employment even in the special case.

3. The analogy between economics and mechanics was not unfamiliar: Irving Fisher's Ph.D. thesis [24] developed an hydraulic model. Phillips was inspired by Boulding's mechanical analysis [11]. Also, Samuelson's textbook [78] pictured the income-expenditure flow generated by a pump.

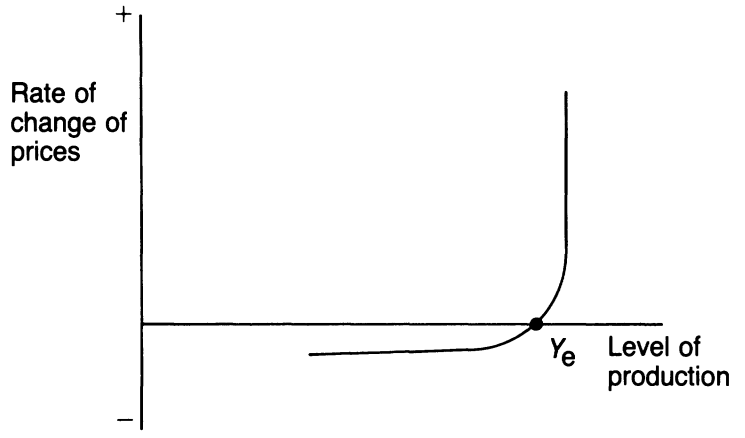

Figure 1. The 1954 Phillips Curve

contemporary trade cycle theory. In addition, Phillips used engineering systems terminology, viz., closed loop systems, production errors, negative and positive feedback, correction factor, automatic regulation and control. The economics of all this came from the neoclassical IS-LM model. Phillips specified the equations of the expenditure-income relation (or savings-investment identity) with investment depending on the interest rate and the accelerator, inventory adjustment, and liquidity preference. The supply of labor depended on the money wage rate, the usual Keynesian formulation. Yet the question was should he make the money wage level flexible downwards as well as upwards?

After all, the Marshallian neoclassicist A. C. Pigou attacked the fix-wage convention [74]. According to Pigou, there was a notable responsiveness in money wages—even if monopolist entities made this slow and only partially followed by a fall in real wages—because the fall in nominal values could have a real balance effect on savings, which would lead to a rise in investment. Also, neoclassical Keynesians recognised that a fall in nominal values, when liquidity preferences were not infinitely elastic, would cause a fall in the money rate of interest (the LM curve shifting right) and a rise in investment [43, 200]. Either way, the economy would have a unique equilibrium with full employment.

In 1954, Phillips, perhaps owing to his interdisciplinary training, dared to break from the convention of the neoclassical synthesis. He described "a relationship between the level of production and the rate of change of factor prices, which is probably of the form shown in Figure II". That Figure II is reproduced here as Figure 1. The product price rather than the money wage level appeared on the vertical axis since, given constant productivity, there was a one-to-one relation between proportional money wage and price changes.[4] The economy was at equilibrium, defined by a stable price level, at Y_e. Because firms erred in how much to produce relative to equilibrium demand, the economy could be in disequilibrium. Price changes would take effect, somewhat like the Samuelson-Hansen linear model

$$\dot{p} = v(Y_a - Y_e)$$

that is, the rate of change of product prices $\dot{p}$ was proportional to the deviation of actual production from the equilibrium level. (The smaller the production error, the better this

4. See note 26 below.

linear equation would approximate his nonlinear curve signifying greater money wage rigidity in the unemployment range) [69, 308]. Then the price change either changed the interest rate in the same or real balances in the opposite direction. To increase the speed of error correction, "a monetary policy based on the principles of automatic regulating systems would be adequate" [69, 315].

The original Phillips curve, like a bold conjecture that initiates development of a theoretical model in mathematics or the physical sciences, was arrived at by deductive guessing stated in naive, atheoretical terms [48]; what neoclassical paths between micro and macroeconomics it promised to free! Before that could occur, however, the Phillips conjecture needed analytical testing (part II below) and theoretical proof (part III).

Empirical Analyses

When Phillips sketched the 1954 curve which indicated that money wage rate adjustment in deflation and inflation was asymmetrical, he was trying to incorporate an old, popular observation into a theoretical structure. Phillips gave an example of this observation:

> When demand for labor is high and there are very few unemployed, we should expect employers to bid wage rates up quite rapidly . . . On the other hand it appears that workers are reluctant to offer their services at less than the prevailing rates when the demand for labor is low and unemployment is high so that wage rates fall only very slowly [72, 283].

Predictably, Phillips's research on an empirical model objectifying this popular observation had its precedents [5]. The closest research was by Professor Arthur J. Brown [88]. Phillips and Brown both studied the history of wage changes, using the same orthodox data sources and taking the pre-World War I period as a base. Both researchers had the same statistics (i.e., the annual rate of change of money wage rates and unemployment percentages) recorded on statistical scatter diagrams covering the pre-World War I, interwar and post-World War II periods. They defined the same relation between product price and money wage changes. Both perceived an inverse relation between inflation and unemployment within each pre-World War I cycle. But unlike Phillips, Brown emphasized that the precise inflation-unemployment relation varied markedly from cycle to cycle. Moreover, Brown perceived that cost changes unrelated to the level of aggregate demand were the major cause of inflation during the post-World War I and II periods; Brown's *Great Inflation* therefore advocated policies of cost reduction [13]. In contrast, Phillips concluded that there had been a stable century-long, inverse relation between the rate of change of money wage rates and unemployment, and stated that the price level would be stable if unemployment were kept at a "little under 2–1/2 percent" [72, 299], as shown by Figure 2.

The same experiment by two researchers led to conflicting conclusions—a common event in the history of science in which each experimenter interpreted the empirical data according to his own a priori, theoretical perspective. Furthermore, the conclusions had immediate policy implications. In the mid-1950s, there was a heated debate between "demand-pull" and "cost-push" factions about the cause of inflation and the policies against inflation.[5]

5. The demand-pull faction was dominated by monetarists but included right-wing Keynesians such as Frank Paish [64]. This faction advocated deflationary measures to reduce the mid-1950s "creeping" inflation. Post-Keynesians dominated the cost-push faction and advocated incomes policies [21]. See note 15 below on demand-pull and cost-push inflation.

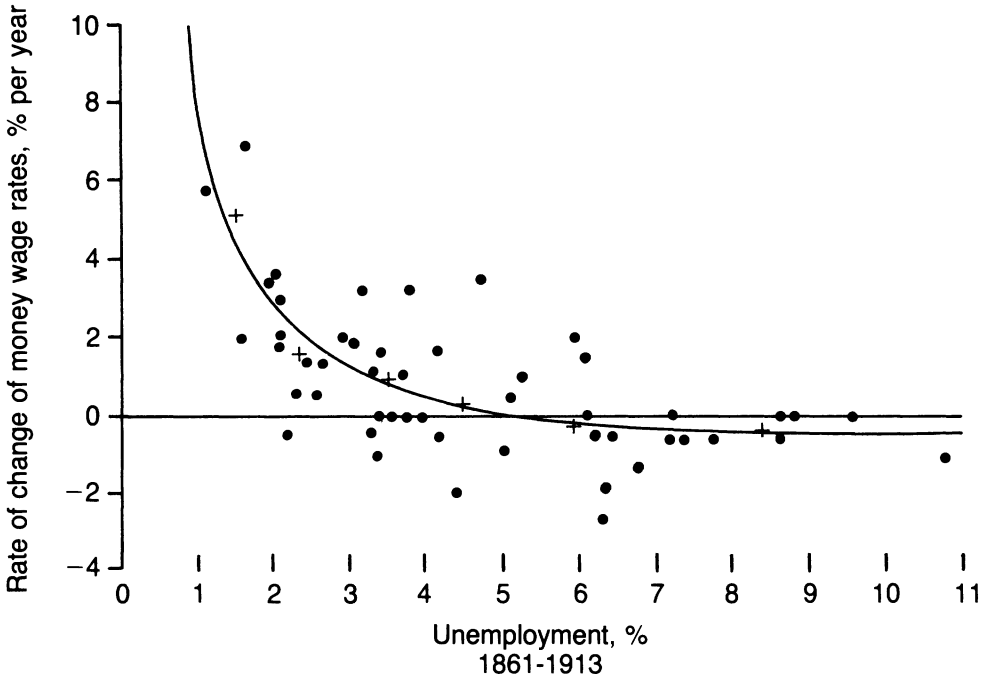

Figure 2. The 1958 Phillips Curve

Brown, a cost-push Keynesian, and several colleagues of Phillips aware of his ongoing research actively participated in this [47]. Phillips's 1958 article greatly promoted the demand-pull case.

To support their divergent policies, Brown and Phillips pointed to the "same" facts, annual wage rate changes and unemployment percents. But such facts, as modern methodologists have stressed, were not given but constructed.[6] Phillips indeed honestly criticized the data, which were very inadequate for the base period because the primary source were records of trade unions to which few workers belonged. Also, union wage records were of standard, not effective rates.[7] Moreover, Phillips's treatment of the data was disparaged by economists at the Keynesian National Institute of Economics and Social Research (NIESR) [76][8] and Oxford Institute [45] because (1) Phillips used fixed-weight wage and unemployment indexes instead of vari-weighted indexes which allowed for changes in numbers employed by industry, (2) the unemployment and the wage sample did not include the same in-

6. Traditional philosophies of science (inductivism and logical positivism) sharply distinguished between a theoretical language and an unbiased, observational language. Many modern methodologists believed that a neutral observation language is impossible—that facts, in other words, are theory-laden. Thus Gaston Bachelard described how physical scientists applied instruments (or "materialized theories") and techniques ("phenomeno-technics") to *produce* phenomena [4]. Later examples of this "structural" view are [37; 46; 49, I, 13–15; 75, 107 n.3; 86, 125–91].

7. Standard rates were set by centralized collective bargaining and lasted for years. Effective rates were set locally in the context of changing market conditions. In Phillips's study, the standard rates were not adjusted to reflect effective rates after 1910 [76].

8. The NIESR economist, Guy Routh, was a former student of Henry Phelps Brown at the LSE. Phelps Brown "never believed" the Phillips curve analysis which showed that "the level of unemployment determined the change of wages." Rather, "wage movements . . . depended on the attitudes, organisation, expectations and personalities of employers and the employed." (Letter from Henry Phelps Brown to the author dated 24 January 1986.

dustries, and (3) the wage and unemployment series were not synchronized. By 1960 statisticians had improved Phillips's scatter diagram. Yet they emphasized that the early data could not support a precise numerical relation between wage inflation and unemployment.

But Brown had not even seen a general relation. How had Phillips? Phillips simplified the scatter diagram by applying a regression method. Statisticians when using regression method conventionally followed these steps: (Step 1). Set up a scatter diagram with the independent variable on the horizontal and dependent variable on the vertical axis. (Step 2). Divide the diagram into equal vertical strips according to a rule (of standard deviations) about their width. (Step 3). Mark the mean value of the dependent variable in each strip. (Step 4). Draw a regression line through the graph of averages, smoothing it. (Step 5). Measure the spread around the regression line (the residual error) to show the amount of accuracy of the regression estimates. (Step 6). Perform tests of statistical significance. In Phillips's experiment the independent variable was unemployment (Step 1). He (Step 2) set up six arbitrary intervals at unemployment percents 0–2, 2–3, 3–4, 4–5, 5–7, 7–11 and (Step 3) for each interval marked the mean, or steady-state, wage inflation by a cross, explaining that "the effect of changing (i.e., cyclical) unemployment on the rate of change of wage rates tends to be cancelled out by this averaging" [72, 290]. The highest and lowest crosses figured at 1.5 and 8 percent unemployment, respectively. He next (Step 4) chose a simple geometric function to describe the regression line. This was a hyperbolic curve, which went through the four lower crosses and passed close to the two upper crosses. Phillips then extended the line to the very low and very high employment regions of the graph where there were no crosses; the extensions each were asymptotic to an axis, according to the equation for a rectangular hyperbola. Phillips's critics [45; 76] issued several complaints about his statistical method: the double process of simplification—the averaging to derive six points (Step 3) and the curve fitting (Step 4)—produced an illusory effect of smoothness; the extension of the asymptotes of the hyperbola (Step 4) was purely formal; despite the scatter's large spread (Step 5) no estimate of error was given; and, finally, when the curve for 1861–1913 was fitted to data for later periods, the resulting deviations were explained ad hoc. It was only these special ad hoc procedures which allowed Phillips to see the determinate inflation-unemployment relation [19].

Phillips had measured his hyperbolic wage inflation $\dot{w}/w$ – unemployment U relation (Step 4). Starting with the equation for a hyperbolic curve

$$\dot{w}/w + a = bU^z \qquad a > 0,\ b > 0,\ z < 0$$

where z set the nonlinearity, he specified the loglinear form

$$\log (\dot{w}/w + a) = \log b + z \log U$$

which was easier to measure. Logarithms could not take negative values and two crosses appeared in the negative plane on the graph of averages. Phillips used ordinary regression method to estimate b and z for the four upper crosses. Then a was "chosen by trial and error" to make the curve pass as close as possible to the remaining two crosses [72, 290]. The measurements, which were excessively precise, were not accompanied by an estimate of approximation. Moreover, Phillips's estimating technique was ad hoc and informal [30].[9]

9. The 1978 survey of the Phillips curve literature [82, 500] stated two further criticisms of Phillips's technique: The six intervals (step 2) each contained a different number of raw points and hence the number of raw points averaged into each of the six composite points (step 3) varied; since the composite points were not weighted, the outlying points were given undue significance in the regression. In addition, significance tests (step 6) were not reported.

Since standard techniques ensure repeatability and objectivity, Richard Lipsey, a colleague of Phillips at the LSE, carried out a standard statistical test. The result was a long run curve drawn close to Phillips's curve, but a test of goodness of fit (R^2) indicated that unemployment accounted for only 64 percent of wage inflation. To more fully account for wage inflation, Lipsey included unemployment change ΔU, an expectations variable, and price inflation (a cost-push variable) which left unemployment accounting for 38 percent and cost-push for 69 percent of wage inflation in the postwar period [52]. Lipsey did not specify rejection rules, but on standard criteria his test failed to verify the Phillips relation in respect to either the long run or short run.

Grounds for Acceptance

Economists nevertheless did not drop the Phillips curve as positivist methodology would predict.[10] In the spirit of the methodology of SRPs, economists constructed auxiliary hypotheses which were intended to explain the conflict between the test results and the theoretical model.[11]

Even so, it seems curious that the LSE quickly promoted Phillips to Professor of Economic Science and Statistics [10].[12] More paradoxically, the economic community rapidly institutionalized the long run hyperbola. The rest of part II discusses why the Phillips curve was readily accepted.

There were firm epistemological reasons for accepting the long run curve. Phillips's construction followed the reductive principles of investigation of the classical natural sciences: classical scientists sought simple, constant, quantifiable observational laws in the form of Euclidean functions; when observations were inconsistent on the scatter graph, classical scientists calculated the mean to get the true measures; they ignored error because laws revealed essential uniformity [16; 75]. Indeed, the Phillips curve was hailed by economists as reflecting "natural laws" [95, 43]. Phillips functions, it was thought, might be "immutable" [52, 19]. Cartesian realism plus common sense help explain the "strong dejà vu reaction" of economists to the curve, "the reaction: Oh yes! That puts the whole problem complex in focus, all right" [51, 738]. Indeed, at the 1959 American Economics Association convention, neoclassicists Paul Samuelson and Robert Solow gave the curve an eponymic title, like many a physical law. Years later Solow recounted what a dramatic representation the curve offered during the era of unemployment and "creeping" inflation: "I remember Paul Samuelson asked me when we were looking at the diagram for the first time, 'Does that

10. Logical positivism held that scientific theories were composed of theoretical laws linked to observational statements by correspondence rules. Positivist methodology dominated orthodox (Walrasian and neoclassical) economic thinking in the post-World War II period [41]. Positivist economists thought that an hypothesis should be judged by its predictive power and be rejected once its predictions were contradicted [14; 17; 25]. Strict positivists said to discard an hypothesis after a single failure to pass a statistical test [7, 401].

11. The 1958 steady-state curve had loops around it, each loop coinciding with a trade cycle, while the 1954 conjecture was a monotonic cyclical curve. Researchers saw that loops caused poor statistical tests of the 1958 curve and, to explain them, inserted the expectations variable ΔU into the empirical model or pointed to aggregation of monotonic cyclical curves of markets with unequal unemployment rates (See pp. 847–48 below).

12. According to Phillips's LSE colleagues Henry Phelps Brown and James Meade, "the famous, or infamous, curve" barely occasioned the promotion. They consider that Phillips's creative skill as an engineer and his brilliant hydraulic machine won him a great reputation at the School. And the LSE made Phillips the Tooke Professor in 1958 in light of his publications, which dealt with a wide range of dynamic macroeconomic problems that involved not only econometrics but also mathematics and control engineering. (Letters to the author from Henry Phelps Brown dated 26 January 1986 and from James Meade dated 3 February 1986.)

look like a reversible relation to you?' What he meant was, 'Do you really think the economy can move back and forth along a curve like that?' And I answered, 'Yeah, I'm inclined to believe it', and Paul said, 'Me too.'" [6, 67; 84]. Though their speech qualified the Phillips relation was loose or inconclusive in respect to America, the President's Council of Economic Advisers were pondering over the "menu of choice between different degrees of unemployment and price stability" by 1962 [81, 147][13]

Economics simply needed a technological law which theory and experiment failed to provide, a not uncommon dilemma of applied science [49, II]. For applied, policy-oriented economists, Phillips's geometry possessed an additional feature, ambiguity. Economists taking up the Walrasian or the neoclassical SRPs claimed the Phillips relation (when applied to a competitive market) incorporated price—or cost—inflation.[14] But other neoclassical economists responded that the labor market was monopolistic, so cost and demand inflation were independent, and thus the curve was just a demand model.[15] Only post-Keynesians saw no association between inflation and demand-deficient unemployment.[16] An anti-inflationary plank based on the curve therefore would catch at least partial support from many political economists.

Even so, why was a rectangular hyperbola chosen? Other simple functions would have gone through Phillips's crosses. First, Phillips's hyperbola was an "eye-catching" hyperbole, which suited his polemical aim [82]. Second, like classical natural scientists, economists preferred the rectangular hyperbola because the product of its coordinates was constant, a useful expository property. For example, classical economists used the hyperbola to signify the tradeoff of two goods, given constant utility; economists would discuss the Phillips curve in terms of a tradeoff between inflation and unemployment, given constant welfare. Third and more to the point, the classical quantity model of inflation was an hyperbola, $M\bar{V} = \bar{Y}/r$ (meaning that, given full employment output $\bar{Y}$ and constant money velocity $\bar{V}$, inflation, or fall in money's value r, was caused by excess money M) and during the 1950s Chicago school economists were reviving that model. Therefore, neoclassical researchers could assert that "instead of being on a Gold Standard, we are now on a Labour Standard" [44, 469], which replaced the monetarist model by the Phillips hyperbola. Fourth, economists found the hyperbola a versatile heuristic device, as their classic textbook on mathematical analysis [1] detailed: An hyperbola could be extended to more than one quadrant and empirical Phillips curves often crossed the positive and negative eastern quadrants. Hyperbolas had

13. Noted instances of the Phillips analysis influencing policy in America were the 1968 surtax and the 1978 Full Employment Act [83; 95].

14. Indeed, in the Walrasian microeconomic mathematical model, the equations for domestic prices, real wage rates and money wage rates were determined simultaneously. This interpretation of the Phillips curve was stated by Phillips [72, 284; 73, 11], was implied in Lipsey's Walrasian proof of the curve [52, 13], and was supported by Archibald [2, 125; 82, 509–10].

15. Keynes's *General Theory* [42] discussed inflation due to demand and cost factors, but it was neoclassicists who sharply distinguished between "demand-pull" and "cost-push" factors [94]. Cost-push inflation denoted inflation which occurred in the presence of nonfrictional unemployment—a phenomenon that conflicted with the classical microeconomic model of competition. Cost-push tendencies arose in imperfect markets with "an institutional framework in which *all* prices and wages were determined as a result of producer, worker, and consumer psychology and administered decisions" [80, 343]. Amongst neoclassicists interpreting the Phillips curve in this light were Klein and Ball [44, 466], Lipsey [52, 31] and NIESR's Dow and Dicks-Mireaux [20, 166].

16. As part V below discusses, post-Keynesians thought that cost factors mainly caused inflation. The British post-Keynesian attack on the Phillips curve was made by Cambridge's Nicky Kaldor. Kaldor criticized the curve in 1959 in two lectures at the LSE (where he taught 1932–47) [40, xviii, 191–97; 59].

different curvatures, a feature Lipsey applied to delineate the heightened response of inflation to unemployment in the 1923–57 data. And an hyperbola belonged to a system so Phillips could simply shift his curve up to fit the 1927–37 scatter.[17]

III. A Walrasian, Long Run Phillips Model

The theoretical proofs of the Phillips curve occurred within the classical, Walrasian SRP, which presupposed the existence of rational, self-interested, optimizing individuals whose voluntary, perfectly competitive exchange of commodities in markets resulted via the price mechanism in general equilibrium without government intervention. Walrasians, including Paul Samuelson, were preoccupied since the mid-1930s with the complex task of demonstrating that the microeconomic system had a general equilibrium solution.[18] To policy-oriented economists, this research seemed trivial when compared to neoclassical or post-Keynesian research that realistically represented economic processes and produced problems of disequilibrium, such as largescale unemployment and inflation. Around the time of Phillips's studies, Walrasians began to elaborate microeconomic systems that produced general disequilibrium [90]. Derivations of Walrasian Phillips curves belonged to this project: One derivation by Lipsey [52, 12–19] aimed for a long run, general disequilibrium model based on orthodox classical microeconomics and implied the efficacy of fiscal intervention, while a second, by Milton Friedman [26–28] produced a short run, general disequilibrium model from revised classical microeconomics and implied the inefficacy of intervention. The two derivations are discussed in parts III and IV respectively.

Derivation of the Phillips-Lipsey Model

Many contemporary economists learned of the Phillips curve from the 1960 proof by Richard

17. In the 1960s Walrasians Milton Friedman [26–28] and Ned Phelps [67] used a system of hyperbolic curves to display "expectations augmented" Phillips models. Seemingly, the competition between SRPs over the Phillips curve required that contenders apply Euclidean geometry.

18. The resulting Walrasian SRP included the following [90; 91]:

Hard Core

1. The agents of the economy are individual households and firms.
2. Economic agents are rational, self-interested, and optimize subject to constraints.
3. Agents make choices in interrelated, perfectly competitive markets where the price mechanism disseminates full information.
4. The result of the competitive process is a general equilibrium with an optimal allocation of resources.
5. Government policies distort the price signals enabling the market system to function efficiently.

Positive Heuristic

1. Construct theories in which economic agents optimize.
2. Establish sufficient conditions for the existence of competitive equilibria.
3. Produce sufficient conditions for the stability of equilibria.

Negative Heuristic

1. Do not construct theories in which irrational behavior plays any role.
2. Preclude theories without general equilibrium outcomes.
3. Expose the inefficacy of government intervention.

Protective Belt

Marginal productivity theory, the law of supply and demand, axiom of gross substitution, Walras's Law, the quantity theory, new classical economics.

Major exponents of the Walrasian SRP included J. R. Hicks [36], Paul Samuelson [77], Lloyd Metzler, Kenneth Arrow, Gerald Debreu, Frank Hahn, and Takashi Negishi.

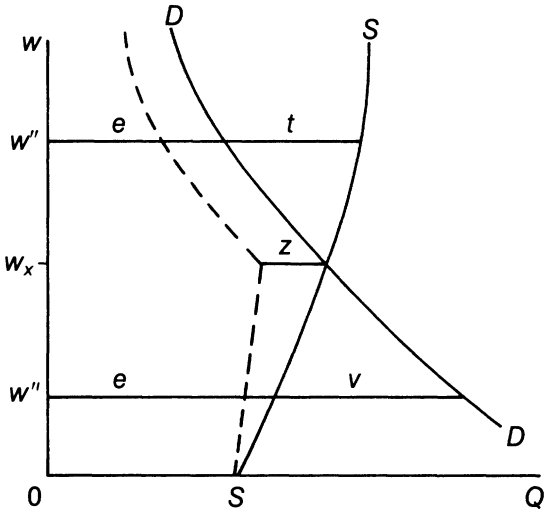

Figure 3. The Supply-Demand Model

Lipsey with the help of Christopher Archibald, who was also at the LSE [29; 82].[19] The proof had three main steps, analyzed below.

The first step of the proof started with the classical, statical supply and demand model for an individual market which permitted equilibrium or disequilibrium trade with rationing. The proof described how deviations from equilibrium caused by exogenous changes in supply or demand were eliminated by price changes. Samuelson [77] stated this description in functional form

$$\dot{p}_i = g(d_i - s_i), \qquad g(0) = 0, g' > 0, \tag{1}$$

i.e., the rate of price change $\dot{p}$ of commodity i was an increasing function of excess demand $d - s$. Given certain slope conditions of supply and demand (as in Figure 3) Samuelson proved equilibrium was stable.

In the 1950s Bent Hansen [32], constructing dynamic Walrasian equilibrium models with unemployment, presented a price adjustment function with the same stationary solution as equation (1) plus the capacity to handle indexed data,

$$\dot{w}_i / w_i = k_i (d_i - s_i)/s_i, \quad k_i > 0 \tag{2}$$

where k stood for the speed with which money wages responded to a discrepancy between demand d and supply s. Lipsey, referring to Hansen and Phillips, simply restated "the speed at which wages change depends on excess demand as a proportion of the labor force" [52, 13], and wrote[20]

$$\dot{w}_i / w_i = \alpha_i((d_i - s_i)/s_i)100, \qquad \alpha_i \equiv k_i. \tag{3}$$

19. In a note in his article [52, 12 n.1], Lipsey wrote that "He (Mr G. C. Archibald) should in fact be regarded as joint author of part 1 of this section" entitled "The model: The relation between $\dot{W}$ and U". Archibald later attributed the model to Lipsey alone [2, 124–25], as did the inflation literature. Professor Archibald requested that he not appear as co-author of the model (in a letter to this author dated 26 February 1986).

20. In British economics at the time, proportional change was represented by $\dot{w}/w$, or $\dot{w}$, which also meant derivative. Using $\dot{w}$, the proof meant proportional change [52; 57].

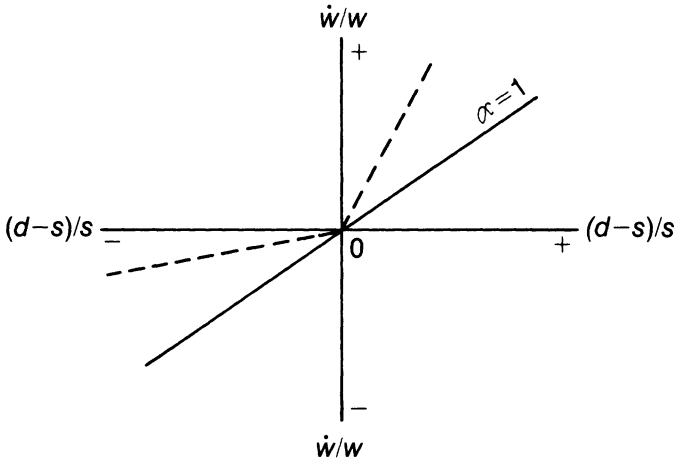

Figure 4. Wage Adjustment Functions

But what was the meaning of α, the slope of the wage flexibility function? In the assumed perfect competition, price flexibility was symmetric; asymmetric price flexibility would involve social or institutional factors outside the scope of Walrasian economics. For example, labor "unions might influence the speed of dynamic adjustment" [52, 17]. Lipsey gave two logical empiricist justifications for keeping uniform price flexibility: simplicity and lack of contrary empirical evidence.[21] Nevertheless, besides a linear function, Figure 4 included a lightly dashed asymmetric function.

Explicitly pursuing the logical empiricist methodology espoused by Samuelson, Lipsey tried to make the linear function "operational" [15]. This meant the function had to be restated in terms of observables. Data existed on wage changes, and quantity of labor supplied (employment e plus unemployment u). As for α, the Walrasian stability literature simply made the adjustment speeds for markets uniform and equal to one. But demand, or employment plus vacancies v, could not be measured because vacancy records were poor. Therefore, in the second step of the proof, Lipsey chose a proxy for relative excess demand, the unemployment percentage U, that is,

$$(d_i - s_i)/s_i = H(U_i). \tag{4}$$

An informal, geometric-algebraic argument for this lemma went as follows [52, 14–15; 53]: Refer to Figure 3. Define the equilibrium point ($d = s$) as one where vacancies equal frictional unemployment z.[22] For wage rates less than the equilibrium rate w_x, there was relative excess demand with merely frictional unemployment, i.e.,

$$(d - s)/s = (\cancel{e} + v - z - \cancel{e})/(e + z), \qquad w < w_x,\ s \equiv e + z,\ d \equiv e + v. \tag{4a}$$

21. Logical empiricism was a modern variant of logical positivism [15]. Unlike the early positivists, logical empiricists required that only some sentences of a theoretical system be translated into observational language for the system to have empirical meaning. They characterized the formal structure of a theory as a mechanical calculus, or hypothetico-deductive system (like Walrasian economics).

22. A Walrasian market strictly was of a homogeneous commodity and efficient, without coexisting positive and negative excess demand, but since the 1940s applied economists accepted that the labor supply was nonhomogeneous and the market had friction.

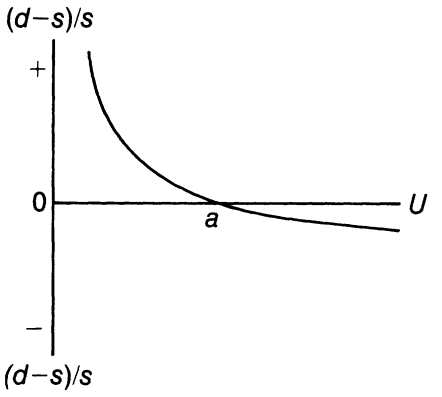

Figure 5. The $H(U)$ Lemma

As the wage rate neared zero, frictional unemployment approached zero and employment became a small number $e_{\min}$:

$$\begin{aligned} &\lim w \to 0 \\ &\lim z \to 0 \\ &H(U) \to v/e_{\min}. \end{aligned} \tag{4b}$$

Accordingly, the $H(U)$ function was negative, nonlinear and had an upper bound in this range (Figure 5, to the left of a). At wage rates exceeding the equilibrium rate, there was unemployment, demand-deficient t plus constant frictional unemployment:

$$(d - s)/s = (\not{e} - u - \not{e})/(e + u), \qquad w > w_x,\ u \equiv t + \bar{z}. \tag{4c}$$

The unemployment percent was defined as

$$(u/s)\,100 = (u/(e + u))\,100 = U. \tag{4d}$$

Hence

$$((d - s)/s)\,100 = (u/s)\,100, \quad \text{(from 4c, 4d)} \tag{4e}$$

meaning as relative excess demand fell, the unemployment percent rose by an equal amount. Hence the $H(U)$ function was linear in this range (Figure 5, to the right of a).[23]

Now the dynamic wage adjustment function could be made operational; this constituted the third step of the proof. In mathematical syntax, there was a composite function made up of $G((d_i - s_i)/s_i)$ plus $H(U_i)$—equations (3), (4)—and written as $G(H(U_i))$ where G was defined for all values of H. Renaming the composite function F and substituting equation (4) yielded

$$\dot{w}_i/w = F(U_i). \tag{5}$$

Thus Lipsey formally deduced Phillips's conjectured, negative relation (Figure 6).

23. This derivation of the $H(U)$ function was odd. There were less rough means of arriving at a negative function: Lipsey footnoted a calculus proof, but it contained an illogical assumption [52, 15 n. 1]; a NIESR study used an hyperbolic vacancy-unemployment relation [22]. More important, an $H(U)$ function need not be negative, as applied economists at the time recognised (e.g., when excess demand rose, job search eased, so the rate of quits might increase which would result in constant or rising unemployment). Later a Marshallian proof yielded a general $H(U)$ relation [38; 39]. It was for instrumental reasons that Lipsey restricted the excess demand function to one which was partly linear and negative (see note 25 below).

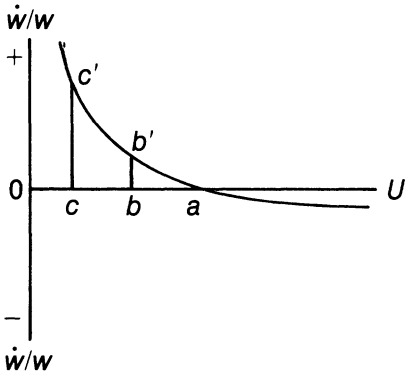

Figure 6. The Phillips-Lipsey Curve

Interpretations and Criticisms

Let us now consider Lipsey's disequilibrium interpretations of his theoretical model.

In light of the Walrasian derivation, the Phillips-Lipsey model represented a stable micro-labor market. *Ceteris paribus*, any disequilibrium would disappear, represented by movement along the curve from point b' to equilibrium point a in Figure 6. Removing the *ceteris paribus* assumption, disequilibrium states could persist; the market would stay at b' or move to c' if exogenous changes in demand or supply occurred more rapidly than the wage adjustment mechanism worked. The Walrasian heuristic however concerned infinite time when exogenous, or random, changes caused equal amounts of positive and negative excess demand: In this Walrasian context, the sole issue regarding historical time was that markets tended to clear. Pragmatic Walrasian economists nevertheless were concerned with the fact that in reality markets may rarely clear [77; 90]. In this context Lipsey's critique was pertinent. The presence of disequilibrium states in an *isolated* market nonetheless could not be a *problem* in this SRP of a market *system*. According to the axiom of gross substitution, labor in market i was a substitute for labor in markets j, so when excess demand and price rose in i, demand spilled into markets j—$(\partial(d - s)_j/\partial p_i > 0$. At least in the two-market case, disequilibrium at anytime would be less than without substitution [34]. Lipsey would comment later that "linkages between such markets were not specified in my theoretical treatment, and clearly were on the agenda for subsequent more formal treatment" [53, 62].

The Phillips hypothesis really pertained to aggregate labor. Lipsey aimed to show that aggregation of stationary, stable Walrasian micro-markets was sufficient to produce persistent macro-disequilibrium. He posited an economy composed of two equally large markets i and j, each with identical Phillips-Lipsey curves. The markets were in disequilibrium. Unemployment in i exceeded, and in j was less than, but on average equalled the aggregate equilibrium value ($z = v$). Because the Phillips-Lipsey curve was nonlinear, according to the Euclidean theory of ensembles, the macro-curve would lie above the micro-curves.[24] At the macro-"equilibrium" unemployment level, wage inflation would be positive but when wage inflation was at the "equilibrium" value, unemployment would be excessive. Thus when markets had imbalanced demand, the macro-Phillips-Lipsey curve apparently had no equilibrium point. Yet, the researcher erred: The wage reaction function in figure IV was linear

24. The aggregation hypothesis required that unemployment in region i and/or j was less than amount a (figure VI). In other words, at least one region had to be positioned on the nonlinear portion of the curve (to the left of a).

and identical for each market ($\alpha_i = \alpha_j$) so the degree of inequality in the distribution of labor demand could not affect aggregate wage inflation which would be zero in equilibrium. The apparent contradiction of figures IV and VI was easy to explain: Unemployment observed on the Phillips-Lipsey model when the wage was constant corresponded to unobserved vacancies in submarkets [33]. Unemployment evidently was not a proxy for excess demand. Walrasian microeconomics would yield a negatively sloped, *linear* Phillips curve with a determinate equilibrium.[25]

What caused Lipsey and Archibald's oversight? Perhaps they were merely careless with the geometry. Or it might have required too deliberate an effort to detect weaknesses in their favorite mode of explanation. A still graver difficulty remained: Walras's axiom stated that the total demand for commodities (including labor) and money was identical to the total supply of commodities and money [55]. But the proof ignored the money and other non-labor markets, which implied these markets were in equilibrium. This meant the labor market was in equilibrium. A Walrasian proof of Phillips's law would have to assume at least one non-labor sector was in long run disequilibrium, greatly disrupting the presuppositions of the program.

More inconsistencies between the 1954–58 Phillips curve elaborated in the neoclassical macroeconomic framework and the Phillips-Lipsey curve derived from a classical microeconomic theoretical model remained. Phillips's curves related *money* wage inflation to (un)employment. At equilibrium, the money wage grew at the productivity trend and the price level was constant so the *real wage was rising.* If the productivity trend rose, the Phillips curve fell.[26] Now consider the Phillips-Lipsey curve based on the Walrasian supply-demand model stating the quantity of labor supplied and demanded depended on the *real* wage (Lipsey used the term "wage rate" since in Walrasian economics money wage change led to real wage change in the same direction.) At equilibrium the *real wage was stable.* To represent productivity growth, the labor demand curve shifted out and the Phillips-Lipsey curve *rose.* Furthermore, the real wage *grew* at the productivity trend along the whole Phillips curve; for an economy historically situated at successively higher points of the Phillips-Lipsey curve, the real wage *level was falling.* The time dimension of the Phillips curve plainly was dynamic, that of the Phillips-Lipsey curve, static. Consider further: The Phillips curve signified price or money wage *inflation rose as employment rose* to capacity level (in the 1954 version) or as unemployment fell (in the 1958 version). On the Walrasian supply-demand graph, disequilibrium trade occurred along the lesser of the curves; at wage

25. The unsuccessful Walrasian proof of the long run curve had a practical spinoff. The Phillips hypothesis was restated as follows: Inflation varies inversely with unemployment and directly with imbalance in the regional distribution of unemployment—given, in the case of two regions, both did not show demand-deficient unemployment t, which corresponded to the *linear* range of the Phillips-Lipsey curve ($U > a$). Symptomatically, Britain had a low and a high unemployment region! Moreover, removing unemployment t in the latter would not be inflationary, which was an argument for regional equity [2, 124]. Further research in Keynesian regional economics [61; 65] supported this hypothesis and in 1967 a fiscal policy was enacted to lower/raise unemployment in the high/low unemployment regions and reduce national inflation [96].

Bent Hansen, using the supply-demand model with asymmetric price flexibility, generated a negative relation between inflation and imbalanced demand to suit the Swedish regional economy [33].

26. Phillips defined the price level by taking a markup k on wage-cost W/A, i.e., $p = k\ W/A$ (A, productivity), as have post-Keynesians (see p. 852 below). The definition implied the following relations in growth terms:

(i) $\dot{p}/p = (\dot{w}/w) - (\dot{A}/A)$, (ii) $\dot{r}/r = (\dot{w}/w) - (\dot{p}-p)$ (r, real wage rate),

(iii) if $\dot{w}/w = \dot{A}/A, \dot{p}/p = 0$, (iv) $\dot{r}/r = \dot{A}/A$, from i, ii.

rates below the equilibrium rate, when excess demand and *inflation rose, employment fell* —as the Phillips-Lipsey curve signified. Referring to the lower segment of a Phillips curve, in the Walrasian SRP the unemployment was *voluntary* while in the neoclassical SRP the unemployment was *involuntary*. The neoclassical and Walrasian Phillips curves looked identical but signified very different phenomena.

IV. Friedman's Short Run, Walrasian Phillips Model

Walrasian economics could not yield Phillips's long run curve, Milton Friedman perceptively observed in his 1967 AEA presidential address. Yet, short run disequilibrium had been on the Chicago school agenda since the early 1950s when researchers defined dynamic quantity models.[27] Deriving a short run curve certainly would advance this disequilibrium project. Friedman naturally worked from the classical supply-demand model but astutely avoided virtually all of Lipsey's troubles [26–28].

Starting with Walras's axiom, he imagined that the authorities unexpectedly supplied excess money which resulted in general excess demand. According to the orthodox quantity theorem, the price level would rise to eliminate the excess demand instantaneously (presupposing perfectly rational individuals). Researching the adjustment process, Friedman weakened this presupposition by eliminating uniform and perfect foresight. In its place, he substituted an expectations mechanism (and this just when post-Keynesians began to emphasize expectations). Then he proposed this scenario: Workers, who notice demand rising, bid up their money wage rate w_i while expecting a stable price level p to permit a rise in their real wage w_i/p_i; simultaneously each employer, perceiving the new demand as special and expecting a stable price level, bids up his product price p_i so his real wage cost w_i/p_i falls. Consequently, the rise in nominal wage rates prompts an increase in the effective quantity of labor supplied *and* an increase in the effective quantity of labor demanded for any *expected* real wage; in other words, in respect to the expected real wage, trade occurs off the *two long-sides* of the market. This let Friedman derive the top half of a Walrasian Phillips curve signifying employment and inflation increase together which made more common sense than Lipsey's construction. Unfortunately, if we reverse the above process given an unexpected shortfall of money, workers expect w_i/p_i to fall, causing a decrease in the effective quantity of labor supplied and in the amount of (voluntary) unemployment during deflation, which was not what the lower half of any Phillips curve was supposed to mean. Notwithstanding, Friedman generalized that deviations of unemployment (Figure 7, u', u'') from Walrasian equilibrium, or "natural" unemployment (U_n, similar to frictional unemployment), depend on the difference between actual money wage and expected price inflation $((\dot{w}/w) - (\dot{p}/p_{exp}))$. In time, agents correct their errors with the result that (1) expected price inflation equals actual wage inflation, (2) relative prices w_i/p_i, p_i/p return to equilibrium levels so agents restore optimal real plans and (3) natural unemployment is consistent with new inflation. Friedman predicted just before the long period of stagflation that further

27. For example, *Money, Interest and Prices* by Chicago's Don Patinkin [66] applied the real balance effect to explain how the quantity model behaved out of equilibrium. LSE conducted a seminar series on Patinkin's book. Stimulated by the seminar discussion, Lipsey and Archibald wrote a critique of the book [55; 56], which stated that the quantity theory had no interpretation in a state of disequilibrium.

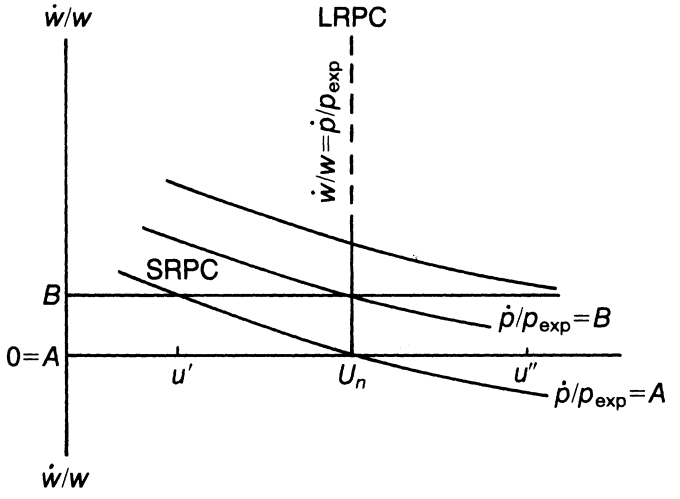

Figure 7. Friedman's Phillips Curves

money supply shocks result in short run curves at successively higher inflation rates, thereby preempting the 1970s empirical, unstable, neoclassical short run Phillips models. In the long run, inflation is a purely monetary phenomenon represented by a vertical "Phillips" curve set at U_n, calling for steady money growth and noninterventionism.

Policy-adviser Friedman claimed that the realism of his theory depended solely upon the accuracy of its predictions. Researchers tested several auxiliary hypotheses, notably the determination of long run expectations. Statistical tests of the monetarist expectations hypothesis were undertaken using the equation

$$\dot{w}/w = a + b\dot{p}/p_{\text{exp}} + F(U)$$

or

$$\dot{p}/p = a + b\dot{p}/p_{\text{exp}} + F(U).$$

In respect to the long run, monetarists predicted that unemployment $F(U)$ had no effect on current inflation $\dot{w}/w$ (or $\dot{p}/p$) and that current inflation equalled expected inflation $\dot{p}/p_{\text{exp}}$; therefore monetarists set $F(U) = -a$ and expected that $b = 1$ [27, 25]. But sometimes b did not measure 1. This implied that agents did not have long run perfect foresight and the curve was not vertical. Now, if a favored prediction went unconfirmed, natural scientists normally would suspect the test was faulty. So did the monetarists. The fault seemed to be the proxy for unobserved price expectations $\dot{p}/p_{\text{exp}}$. The proxy presupposed that economic agents in the short run systematically erred. To replace this proxy, Friedman referred to research of the new classical economists who were developing models of rational expectations, given surprise policy changes. The new classicists assumed such policy changes made information incomplete and decisions suboptimal only in the very short run, after which markets cleared.

The Friedman-Phillips research surely advanced the empirical side of the Walrasian SRP [82].[28] But Friedman's Phillips curve not only saved orthodoxy. It outdid the neoclassical synthesis. Milton Friedman won a Nobel prize and the Phillips curve with the quantity theory provided the basis of the new monetarism of current conservative administrations.

28. Empirical success was enough for the new American post-Keynesian journal to present an explanation of a vertical Phillips model [89].

V. Keynesian and Post-Keynesian Inflation Models

The post-Keynesian SRP presupposed a decentralized private economy in which economic decisions occurred in an institutional context and pertained to an uncertain future. Post-Keynesians studied income distribution and expectations, and postulated inherent economic instability. A macro-price theory with microfoundations appeared at the top of their agenda. Their general strategy was to develop the potential latent in Keynes's economics, especially his *General Theory* [42].[29]

This book started by assuming constant prices in order to expose the basic general system and then incorporated price changes. Their major cause was money wage instability arising in collective bargaining. Since trade unions became stronger as aggregate demand rose, money wage rates moved with demand. Demand inflation was asymmetric because each group of workers resisted a relative decrease in their money wage but not an increase. Also, if political forces favored the trade unions, money wage gains would exceed productivity increases, which would cause a rise in the price level (or cost-push inflation). Keynes warned that the connection between demand and inflation was discontinuous and complex, hence unsuited to "pseudo-mathematical methods of formalising" [42, 297].

The General Theory defined equilibrium by the intersection of an aggregate demand and an aggregate supply (or Z) function. Later, this definition would prompt geometrical formalization. American Keynesians in the 1950s and 1960s countered neoclassical fixprice geometry with a Z curve, while apologizing for the pseudo-continuity of the curve. The Z curve related employment (on the abscissa) needed to produce real output to expected money revenues (the ordinate axis) needed to cover the money cost of output. The slope of Z signified that the money cost of output rose faster than real output. Z shifted up with cost-push inflation [18; 92]. Neoclassical, post-Keynesian and monetarist textbooks since the

29. The post-Keynesian SRP included the following:

Hard Core

1. The economic system consists of a set of social institutions.
2. Large corporations are the dominant economic agents.
3. The economy grows without limits in the long run.
4. Income distribution is of fundamental importance.
5. Agents make decisions in respect to an uncertain future.
6. Decisions are monetary in nature.
7. The monetary economy produces unemployment and instability.
8. The democratic government should enact micro- and macroeconomic remedies.

Positive Heuristic

1. Analyze disequilibrium processes.
2. Explain how "unemployment develops because people want (money)" [42, 235].
3. Integrate pricing, distribution and growth.
4. Develop a theory of oligopoly.
5. Describe institutional behaviors.
6. Develop microfoundations for macroeconomics.
7. Justify interventionist policies.

Negative Heuristic

1. Reject orthodox, equilibrium theory.
2. Reject the neoclassical synthesis.

Protective Belt

Consumer sociology, theory of effective demand, fixed-coefficient model of production, the megacorp model, markup pricing, macroeconomic theory of income distribution, financial instability hypothesis, Harrodian growth theory.

Major exponents of the post-Keynesian SRP included Sidney Weintraub, Hyman Minsky, Paul Davidson, Alfred S. Eichner, G. L. S. Shackle, Joan Robinson, Nicholas Kaldor, Pierangelo Garegnani.

1970s contained an analogous, simplified aggregate supply AS curve. This showed the price index (on the ordinate axis) accelerating as real output (on the abscissa) rises. The AS curve also shifted upwards with cost-push inflation. The textbooks of each SRP then roughly mapped their respective short run Phillips curve off their corresponding AS curve [58]. The *AS-SRPC* picture obscured the differences among the three programs and promoted the illusion of a shared Phillips curve convention.

Post-Keynesians strenuously opposed the Phillips models. In the first place, a geometrical function could not represent the inflation-unemployment connection which, in any event, was theoretically less important than cost-push inflation. Second, their social philosophy excluded unemployment as the answer to inflation [94]. Third, the Phillips models had not tested well [82]. Finally, post-Keynesians had a price-level determination model that was consistent with the Z curve and rival to the quantity theorem. The wage-cost markup (WCM) model $p = k\ W/A$ said price increases depended on money wage relative to productivity A increases, given a fairly fixed markup k (the reciprocal of the wage share in income). Wage increases depended on union bargaining power, which was influenced by high and low unemployment rates. Tests of the macro-WCM law were in the main impressive [3; 93], while descriptive studies bore out a micro-relation. The model spurred theoretical and empirical research, and formed the basis of proposals for interventionist, national income policies effected at the micro-level. Nonetheless, post-Keynesians were so weak institutionally and politically in America that they could only publicly remonstrate that incomes policy would lower the Phillips curve [95].

British post-Keynesians had no such need to compromise. However, a right-wing Keynesian at the LSE, Frank Paish, offered a non-geometric argument for Phillips's conclusion. This argument was extracted from *The General Theory* and put in growth terms [64]. The argument premised two states—

A. With ample involuntary unemployment, money incomes grew as fast as real output and thus the price level was stable, whatever capacity growth,
B. With little involuntary unemployment, money incomes grew faster than real output, constrained by capacity, and thus the price level rose, and syllogistically concluded that
C. At any time there was a minimum margin of unused capacity at which money incomes grew as fast as capacity, which was the necessary condition for long run price stability that defined equilibrium.

Paish sought to measure this margin of unused capacity for the postwar era.[30] He naively charted annual growth of (1) capacity, (2) money incomes, (3) the price level, and (4) the proportion of capacity in use. In the one year when capacity and money incomes grew at the same rate, the price level actually was stable. Then capacity usage was 93–95 percent, roughly corresponding to employment of a little over 97.5 percent. According to this primitive estimation, the economy was in long run equilibrium when unemployment was a little under 2.5 percent, which was precisely Phillips's policy conclusion. After a political defeat of the full-employment, post-Keynesian faction in 1967, the British government implemented the Paish doctrine. Because the metrical concept failed to interest neoclassical or post-Keynesian theorists, this version of the Phillips hypothesis was short-lived.

30. *The General Theory* [42] gave reasons why the price level rose before full employment (where output became inelastic) was achieved. Paish argued that keeping the economy currently at less than full employment eventually would permit a small margin of unused resources [64, 322].

VI. Summary and Conclusions

This study of the Phillips curve reminds the author of a case-study methodologists have related to exemplify mathematical proofs, which are analogous to theoretical explanations in the sciences [9; 48]: Early modern geometers, having defined polygons, sensed one relation described polyhedra (i.e., solids bounded by polygons). The Cartesian, Euler, constructed a formula, which he empirically confirmed. Afterwards, a Leibnizian, a Kantian and a nonEuclidean mathematically each proved it. The end result: one formula, but three theorems of three different Euler polyhedra. Similarly, modern economists sensed some relation between inflation and unemployment. Interested, neoclassicist Phillips conjectured a geometrical form, which he tested. Then a Walrasian-*qua*-neoclassicist (Lipsey), a pure Walrasian (Friedman) and a Keynesian (Paish) did proofs. The result: one curve, but three models of three different inflation-unemployment relations! The main events of the development of the Phillips curve may be summarized as follows:

Phillips and others saw that the neoclassical SRP was beset by two contradictions, the first between the short run micro-flexprice equilibrium and the macro-fixprice disequilibrium analyses, and the second between these analyses and the conventional observation of asymmetric price flexibility. In the context of the neoclassical, IS-LM macro-model, Phillips made price flexibility asymmetric and, thereby, capable of slowly equilibrating the market. Twenty years later, an IS-LM model with market clearing is common.

Lipsey's proof sought to ground a Phillips curve in pure Walrasian microeconomics, granting orthodoxy to the former and practical utility to the latter. Interpreting the curve as points of long run disequilibria (either inflation or unemployment) the proof failed; it was unable to subvert Walrasian theorems and axioms that led to general equilibrium.

Realizing that the pure Walrasian SRP could not yield a Phillips curve, Milton Friedman straightaway weakened the program's presupposition of perfect foresight and assumed exogenous monetary shocks. This permitted a short run Phillips model and long run equilibrium consistent with inflation caused by the central bank. Combining orthodox reasoning, confidence in capitalism's efficiency and policy diagnosis, this proof boosted the Walrasian program.

Economists have all but forgotten Frank Paish's Keynesian proof which applied existing macroeconomic concepts to construct a metrical tool that corroborated Phillips's policy conclusion instead of his conjecture. Anyway, post-Keynesians had a model to explain inflation, based on the very definition of price Phillips would borrow.

Positivist methodologists at this point would protest that economics is not like mathematics but like the physical sciences, founded on indubitable fact—note Phillips's famous law! There were two empirical curves, in fact. The law, constructed by means of Cartesian mathematical principles, represented a steady-state inflation-unemployment relation with little bearing on the real economy. Econometricians then constructed statistical models, but tests of these failed to verify an inflation-unemployment relation. Moreover, the degree of confirmation of the post-Keynesian wage-push inflation law looked at least as good. Now, positivist methodologists would predict that economists would eliminate their Phillips models. But SRP methodologists would deliberate that this was not necessary: Initially tests could not falsify a model because the fault might be found anywhere, from the axioms to the testing devices, which admittedly are unsophisticated in economics.

The Phillips curve indeed has remained lodged firmly in economics. There's more than

conventionalism to this. In the theoretical realm, the Phillips conjecture was connected to a core of problems involving disequilibrium; proving a Phillips function prompted economists to rethink axioms and pose new lemmas, thereby advancing disequilibrium economics. In the policy realm, the Phillips conjecture pertained to arguments among economists and policy-makers about government intervention, and the developers of each Phillips model promoted particular policy measures. The Phillips thesis then acted as one of those nodal points where theory intersected with policy. Inevitably partisan, economists set about their proofs; when they came out with a novel research finding or mode of public presentation, the aftermath was either to counter, repel, outdo or discredit other economists. Proofs ricochetted about and undoubtedly this case-study will have a sequel.

Of course upon retrospect, only two formulations, Phillips's first and Friedman's curve, advanced economic inquiry. Nevertheless, practitioners of other disciplines have wasted time. Mathematicians have made mistakes in proofs; physicists have come out with ad hoc statistical formulae; still other scientists have tried to save degenerating orthodox programs by illegitimate means. What was unique about the Phillips curve competition (in contrast to cases in mathematics of the physical sciences) was the *ultimate* lack of consensus about the relative explanatory power of the rival models. Such discord is common in economics. Critics usually blame the failure of economists to test their theories [8; 23], but the different Phillips models were tested many times. The point is that the test results were inconclusive, but economists were hardly noncommittal about the Phillips models. Rather each economics program tenaciously adhered to a rival model. In the Phillips curve case, the answer concerns the *grounds of rivalry* between economists: A basic stimulus to research came from their hard core, external beliefs about the economic role of government. Their heuristic hinted how to state policy problems in terms of their methodology. Economists then applied their analytic tools to develop Phillips models with fitting policy implications. And they kept their respective models, however inherent and poorly corroborated, to serve both their theoretical and policy interests. Thus that *interplay of external with internal considerations* explains economists's failure to agree on one Phillips curve from which to progress to fresh research problems.[31]

31. This study of the history of the Phillips curve took a novel perspective in the methodology of SRPs. Previously SRP methodologists focused on internal, "autonomous", "rational" history. Lakatos's histories of physics relegated external history to footnotes. To emphasize the external history of economics, Blaug argued, one must produce instances of "weak scientific ideas which were in fact accepted for specific external reasons" [7, 431]. This essay argued that the Phillips curve is one of those instances and, furthermore, that economics is a science in respect to which "historians and philosophers . . . must make the best of the interplay between internal and external factors" [49, I, 138; 14].

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