Eastern Economic Journal, Volume XVII, No. 4, October-December 1991

Truth in Teaching Macroeconomics: Mappings of the Aggregate Supply Curve onto the Phillips Curve

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Recently economists have been debating the purpose and content of the economics principles course. Some economists have believed that the principles course, which relies heavily on textbooks, reasonably well characterizes how economists treat the problems of economic growth, inflation, unemployment and income distribution (McConnell 1988, Case 1988, Amacher 1988). Other economists have assessed that the macroeconomics principle course supplies too few of the skills and too little of the insights to prepare students to be economically intelligent citizens (Boulding 1988, Bell 1988, Boskin 1988, Siegfried et al 1991, Colander and Brenner 1992). One of the matters of contention in the debate focuses on how the macroeconomics principles textbooks use graphic analysis. Some economists have considered that the graphic analyses provide a clear and simple way to grasp macroeconomic ideas (McConnell 1988, p. 150). Yet others have thought that some of the graphic models have obscured macroeconomic reasoning (Colander 1992, pp. 158-64). Economists who have acknowledged the limitations of those graphic analyses have reacted differently. Some instructors have responded that it is presumptuous to eliminate models from which instructors for long have extracted considerable mileage. After all all models are simplifications that merely approximate the truth. Other instructors have responded that the graphic analyses oversimplify, or bowdlerize macroeconomic ideas and thus dull the cognitive skills that the principles course aims to sharpen (Saunders 1990; Fels 1990). This essay argues that the mapping of the aggregate supply curve onto the Phillips curve is a case in point.

The Phillips curve relates the rate of inflation to the level of capacity usage. The curve may take one of several related forms. A. W. H. Phillips (1954, 1958) presented the curve, which he supported on the basis of some back-of-the envelope empirical work using British data, either as a positive relation between average price inflation and the real output ratio or a negative relation between average money wage inflation and the unemployment rate (Wulwick 1987). Phillips initially argued that his curve represented *demand-pull* inflation mainly on the grounds that awards of cost of living adjustments resulted from the competitive bidding for labor. Later he (1962) adopted the familiar explanation of inflation as the sum of *demand-pull plus cost-push*. The lag structure let Phillips eliminate money wage inflation (or price inflation) and maintain the proposed relation between price inflation (or money wage inflation) and capacity usage for the purposes of prediction (Wulwick 1989, pp. 182-83).

On the basis of his curve Phillips suggested that stabilization policy maintain the level of capacity usage associated with a stable price level. Economists interested in stabilization policy in the United States swiftly appropriated the Phillips curve. Yet P. A. Samuelson and R. M. Solow (1960) cautioned economists to avoid rashly concluding that the Phillips curve represented *demand-pull* inflation, or movement of the aggregate demand curve along the *static* aggregate supply curve (p. 189). Demand-pull *plus cost-push* inflation represented by the interaction of a shifting aggregate demand curve and an *expectations augmented* aggregate supply curve also could explain the Phillips curve. The latter, dynamic explanation gained popularity after E. S. Phelps (1967) and M. Friedman (1968) introduced their theory of the expectations augmented Phillips

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curve, which denied the possibility of a useable trade-off between inflation and capacity usage. Intermediate macroeconomics textbooks have shown how to map the expectations augmented aggregate supply curve onto the expectations augmented Phillips curve given the assumptions of (1) adaptive expectations and (2) an positive relation between the price level and the level of capacity utilization (Mankiw 1992, pp. 303-04; Hall and Taylor 1991, p. 197; and Dornbusch and Fischer 1990, pp. 490, 513-14).

In contrast, the principles textbooks have mapped the *stable* aggregate supply curve onto the *stable* Phillips curve. In particular, the textbooks have claimed that

> [a] downward-sloping Phillips curve implies that an aggregate supply curve will be upward-sloping (Arnold 1989, p. 324).

The interpretation appears in the textbooks by E. Mansfield (1992, p. 274), K. E. Case and R. C. Fair (1992, pp. 829-31), R. T. Byrnes and G. W. Stone (1992, p. 358), H. Kohler (1992, pp. 501-2), C. R. McConnell and S. L. Brue (*op. cit.*), R. A. Arnold (*op. cit.*), R. T. Froyen and D. F. Greer (1989, pp. 247-8), and older editions of R. Lipsey and P. Steiner (1979, p. 377). The typical mapping by those textbooks of the aggregate supply curve onto the Phillips curve appears in Figure 1.

According to the economic reasoning behind the Figure 1, the goods market remains in equilibrium as the aggregate demand curve shifts along the aggregate supply curve relating the actual price-level P_t to the actual real output ratio Y_t,

(1) $P_t = bY_ta, \quad b, a > 0.$

Taking logarithms of both sides,

(2) $\log P_t = \log b + a(\log Y_t),$

and differentiating $\log P_t$ in respect to $\log Y_t$ yields

(3) $d(\log P_t)/d(\log Y_t) = a,$

or, as an approximation in the discrete terms of Figure 1, given that the subscript n refers to the capacity level written in terms of a fixed index number,

(4) $(P_t - P_{nt})/P_{nt} = a(Y_t - Y_{nt}).$

As the caption for Figure 1 indicates, the principles textbooks in question treat equation 4 as the Phillips curve in inflation-real output space. The principles textbooks use Okun's law to arrive at the Phillips curve in inflation-unemployment space. According to Okun's law the relative gap between the actual and the capacity levels of real output, $(Q_t - Q_{nt})/Q_{nt}$, $Q_t/Q_{nt} \equiv Y_t$, depends on the difference between the capacity and actual rates of unemployment $U_{nt} - U_t$, that is,

(5) $(Q_t - Q_{nt})/Q_{nt} = c(U_{nt} - U_t), \quad c\ 0,$

or

$$Y_t = 1 + c(U_{nt} - U_t).$$

Equations 4 and 5 imply that price inflation is inversely related to the rate of unemployment, that is,

(6) $(P_t - P_{nt})/P_{nt} = a\,(1 + c(U_{nt} - U_t)) - Y_{nt},$

which the Phillips curve in inflation-unemployment space according to Figure 1. It is obvious that the mapping of the stable Phillips curve from the stable aggregate supply curve according to Figure 1 requires the *unstated restriction* that all movements of the macroeconomy start from some *fixed* real output ratio and *fixed* price level Y_{nt}, P_{nt}.

In the absence of that restriction, it is untrue *in general* that the stable Phillips curve implies a stable aggregate supply curve. Instead of *arbitrarily* restricting the movements of the macroeconomy along the aggregate supply curve in order to derive a Phillips curve, this essay asks **what conditions must be satisfied by the aggregate supply curve in order that one can map it onto the Phillips curve.**

The definition of price inflation, I, is the proportionate rate of change of the price-level per unit of time, $T \equiv (1/P_t)(dP_t/dt)$. How has that definition of inflation applied when economists have treated the Phillips curve as a transformation of aggregate supply, which is timeless as in Figure 1? Given that the aggregate supply curve is continously differentiable, changes in the price-level occur in terms of continuous time, or are a monotonic function of time which permits the elimination of time as an explicit independent variable (Dreyfus 1960, p. 235). Accordingly the mapping of aggregate supply onto the Phillips curve implies that inflation is modelled as

(7) $$T_t \equiv \frac{1}{P_t(Y_t)} \frac{dP_t(Y_t)}{dY_t}$$

The Phillips curve satisfies the condition that

(8) $$\frac{dT_t}{DY_t} > 0$$

or, from the definition in equation 1,

(9) $$\frac{d}{dY_t}\left[\frac{1}{P_t(Y_t)} \frac{dP_t(Y_t)}{dY_t}\right] > 0$$

Expanding the terms on the right-hand side gives

$$\frac{1}{P_t}\left[\frac{d}{dY_t}\left(\frac{dP_t}{dY_t}\right)\right] + \frac{dP_t}{dY_t}\left[\frac{d}{dY_t}\left(\frac{1}{P_t}\right)\right] > 0$$

or

$$P_t\ P_t^{11} - P_t^{12} > 0$$

where

$$P' \equiv \frac{dP_t(Y_t)}{dY_t}, \quad P_t'' \equiv \frac{d^2P_t(Y_t)}{dY_t^2}$$

Equation 9 is the mathematical condition that must be satisfied by any curve in price level-output ratio space that can be mapped onto a stable Phillips curve.

Let us experiment with some stable aggregate supply curves to see if they satisfy the mathematical condition of the Phillips curve. The fixed linear aggregate supply curve

(10) $P_t = aY_t + b, \qquad a > 0, \quad b \neq 0.$

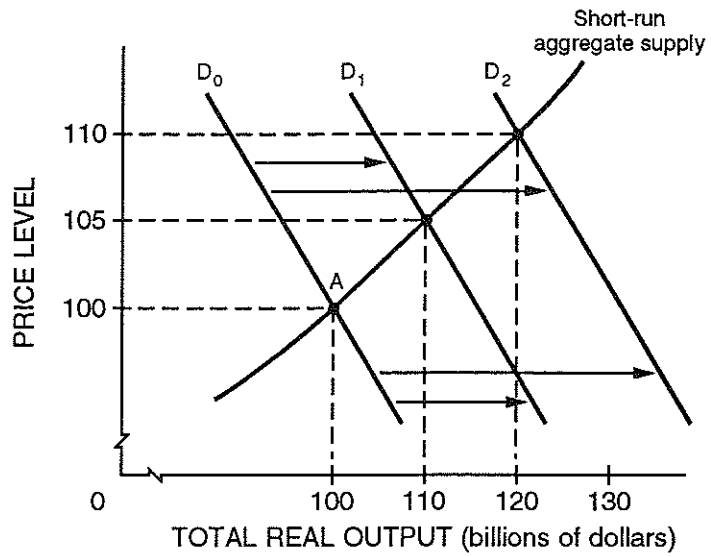
does not satisfy the condition of the Phillips curve, for

substituting the results $P_t' = a, P_t'' = 0$ into equation 9 gives $[(aY_t + b)0 - a^2] > 0$, which is impossible. Alternatively, let us suppose the fixed exponential curve,

(11) $P_t = bY_ta \qquad b > 0.$

Figure 1
Mansfield's Figures 13.2 and 13.3

The Phillips Curve. If all inflation is demand-side inflation, one might expect the inflation rate to be inversely related to the unemployment rate. (Expected inflation is assumed to be constant.)



Effects of Rightward Shifts in the Aggregate Demand Curve (from D_0 to D_1 or D_2) on Total Real Output and the Price Level. If the aggregate demand curve shifts from D_0 to D_2, there will be a greater increase in total real output and a greater increase in the price level than if the aggregate demand curve shifts from D_0 to D_1. Specifically, total real output increases from \$100 billion to \$120 billion if the aggregate demand curve shifts from D_0 to D_2, but it increases only from \$100 billion to \$110 billion if the curve shifts from D_0 to D_1. The price level increases from 100 to 110 if the aggregate demand curve shifts from D_0 to D_2, but it increases only from 100 to 105 if the curve shifts from D_0 to D_1.

where $P_t' = abY_ta\text{-}1$ and $P_t'' = a(a\text{-}1)bY_ta\text{-}2$. Substituting these results into the condition expressed in equation 9 gives $-ab^2Y_t2(a\text{-}1) > 0$. It follows that $a < 0$, which means that the curve (whatever it may represent) in terms of levels P_t and Y_t is *downward*-sloping (which is the case when inflation increases from negative to zero values as the output ratio rises). In contrast, the Phillips curve can be mapped off a fixed aggregate supply curve of the double exponential form,

$$(12) \qquad P_t = c_1 e^{c_2 e^{\alpha Y_t}} \qquad \alpha, \beta > 0$$

because that curve satisfies the condition:

$$P_t \; P_t^{11} - P_t^{12} = k_1 e^{k_2 e^{\alpha Y_t}} \; e^{ar} > 0, \text{where } k_1 \equiv a^2 c_1 2 c_2, \quad k_2 \equiv 2c_2$$

Economic theory offers no rationale for the fact that the Phillips curve can be mapped off the double exponential aggregate supply curve in equation 12, but not from the linear and exponential aggregate supply curves in equations 10 and 11.

CONCLUSION

This essay shows that the stable Phillips curve can be mapped off a stable aggregate supply curve that is double exponential in form but not an aggregate supply curve which is linear or exponential. Clearly economists who attempt to model the stable Phillips curve as a mapping of a stable aggregate supply curve encounter the problem of inconsistency. Yet many principles of economics books claim that the stable Phillips curve is a mapping of a stable aggregate supply curve. Treating the stable Phillips curve mechanically as a mapping of the stable aggregate supply curve discourages the skill of logical reasoning that the principles course intends to develop.

NOTES

1. The idea for this essay arose in a conversation with R. L. Basmann. "Truth in Teaching Macroeconomics" was the title of a paper presented by D. Colander at the conference *Educating Economists*, Middlebury College, Spring 1990. The Jerome Levy Economics Institute at Bard College financed this research.

2. R. L. Basmann pointed out the double exponential curve to the author.

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