IMPLICATIONS OF AGGREGATE DEMAND ELASTICITY FOR THE PHILLIPS CURVE

Ben L. Kyer* and Gary E. Maggs*

I. INTRODUCTION

Since its introduction in 1958, the Phillips curve has assumed an important position in macroeconomics.[1] The modern analytical approach to the Phillips curve in principles and intermediate level texts relies on the familiar aggregate demand, aggregate supply model to distinguish between demand-pull and cost-push inflation and, within this framework, the role of aggregate supply for the Phillips curve is relatively well established. For example, Mankiw states, "the Phillips curve is a reflection of the short-run aggregate supply curve."[2] Gordon's approach provides a lucid explanation of the strong relationship between both the slopes and shifts of the short-run aggregate supply curve and the short-run Phillips curve.[3]

While the general relationship between the aggregate supply curve and the Phillips curve is recognized, the importance of aggregate demand and, in particular, aggregate demand elasticity, for the inflation-unemployment relationship has been untreated. We believe, however, that the elasticity of aggregate demand with respect to the general price level does have some significance for the short-run Phillips curve since, on a general level, the economy's equilibrium price level, inflation rate, real gross domestic product, and unemployment rate are determined jointly by aggregate supply and aggregate demand. The primary purpose of this paper then is to demonstrate with a graphical analysis the implications of aggregate demand elasticity for the Phillips curve.

The paper proceeds as follows. Section II develops a model of aggregate demand and discusses some relationships between aggregate demand elasticity and the macroeconomy. Section III presents the analysis between the elasticity of aggregate demand and the Phillips curve. Section IV concludes by providing a short summary of our results.

II. A MODEL OF AGGREGATE DEMAND

The elasticity of aggregate demand with respect to the price level is a concept which has been largely ignored in the macroeconomic literature, both theoretically and empirically. From a theoretical

---

The authors are The Benjamin Wall Ingram, III, Professor of Economics, Francis Marion University, Florence, SC, and Professor of Economics, St. John Fisher College, Rochester, NY, respectively. We thank an anonymous referee and the editor for helpful suggestions on an earlier version of this paper. Any errors which remain are our own.

perspective, and from its foundation in the quantity theory of money, the Classical school implied that aggregate demand was unit elastic with respect to the price level.[4] Alternatively, Keynes[5] and his early followers believed that aggregate demand had a variable elasticity and, in the special case of a liquidity trap, could be perfectly price level inelastic. In earlier papers, we have shown the relevance of aggregate demand elasticity for supply-side economics[6,7] and monetary policy rules[8].

Relatively few empirical studies of aggregate demand elasticity are available and perhaps the earliest are found in Green[9]. We have previously estimated this elasticity for the United States[10] and Canada[11], and Apergis and Elestherio have calculated this elasticity for Greece[12]. Because this concept is generally neglected, this section develops a model of aggregate demand and derives expressions for both the slope of the economy's aggregate demand curve and the price level elasticity of aggregate demand.

For simplicity, we assume a private economy with no government. In the product market, real private saving (s) is assumed to depend on real income (Q) and real money balances (M/P), while real investment (i) is determined by the market rate of interest (r). The general price level (P) is defined by the GDP deflator. Total real imports (m) are defined as a function of both real income and the domestic price level while total real exports (x) are stated as a function of only the domestic price level. The product market equilibrium condition may then be stated as:

$$s(Q, M/P) + m(Q,P) = i(r) + x(P) \qquad (1)$$

In the money market, the demand for real balances is a function of both real income and the interest rate. The nominal money supply (M) is assumed to be exogenous. Equilibrium in the money market is then given as:

$$M/P = l(Q,r) \qquad (2)$$

The derivation of the expression for the economy's aggregate demand function begins by differentiating equations (1) and (2) to obtain:

$$s_Q dQ + s_{M/P}(PdM - MdP^2) + m_Q dQ + m_P dP = i_r dr + x_P dP \qquad (3)$$

and

$$PdM - MdP/P^2 = l_Q dQ + l_r dr \qquad (4)$$

where, from standard macroeconomic theory s_Q, l_Q, and $m_P > 0$ and $s_{M/P}$, i_r, x_P and $l_r < 0$. By assuming that the nominal money supply is constant, solving the product market equation (3) for dr and substituting that expression into (4) and rearranging, the slope of the economy's aggregate demand curve may be expressed as:

$$\frac{dQ}{dP} = \frac{1}{P}\left(\frac{-M/P}{l_r(\frac{\partial r}{\partial Q_{IS}} - \frac{\partial r}{\partial Q_{LM}})} + \frac{S_{M/P}M/P}{i_r(\frac{\partial r}{\partial Q_{IS}} - \frac{\partial r}{\partial Q_{LM}})} + \frac{(x_P - m_P)}{i_r(\frac{\partial r}{\partial Q_{IS}} - \frac{\partial r}{\partial Q_{LM}})} \right) \qquad (5)$$

Equation (5), which can be shown to be unambiguously negative, demonstrates that the total effect of a change in the general price level is the summation of three effects: the Keynes or interest rate effect, the Pigou or real balance effect, and the Mundell-Fleming or international effect. Equation (5) may then be restated in elasticity form as:

$$\xi_{Q,P} = \frac{1}{PQ}\left(\frac{-M}{l_r(\frac{\partial r}{\partial Q_{IS}} - \frac{\partial r}{\partial Q_{LM}})} + \frac{S_{M/P}M}{i_r(\frac{\partial r}{\partial Q_{IS}} - \frac{\partial r}{\partial Q_{LM}})} + \frac{(x_P - m_P)P^2}{i_r(\frac{\partial r}{\partial Q_{IS}} - \frac{\partial r}{\partial Q_{LM}})} \right) \qquad (6)$$

$$\frac{\delta r}{\delta Q_{IS}} = \frac{s_Q + m_Q}{i_r} < 0, \qquad (6a), \qquad \frac{\delta r}{\delta Q_{LM}} = -\frac{l_Q}{l_r} > 0. \qquad (6b)$$

Equation (6) is useful to investigate the relationship between aggregate demand elasticity and important structural parameters in the macroeconomy, while equations (6a) and (6b) make explicit the underlying parameters contained in the IS-LM core of this model. For example, it is clear from equation (6) that aggregate demand is less elastic with respect to the price level the more responsive is the demand for money to changes in the interest rate. In the extreme case of a liquidity trap when l_r approaches infinity, the first term on the right side of equation (6) reduces to zero and aggregate demand elasticity is accordingly decreased.

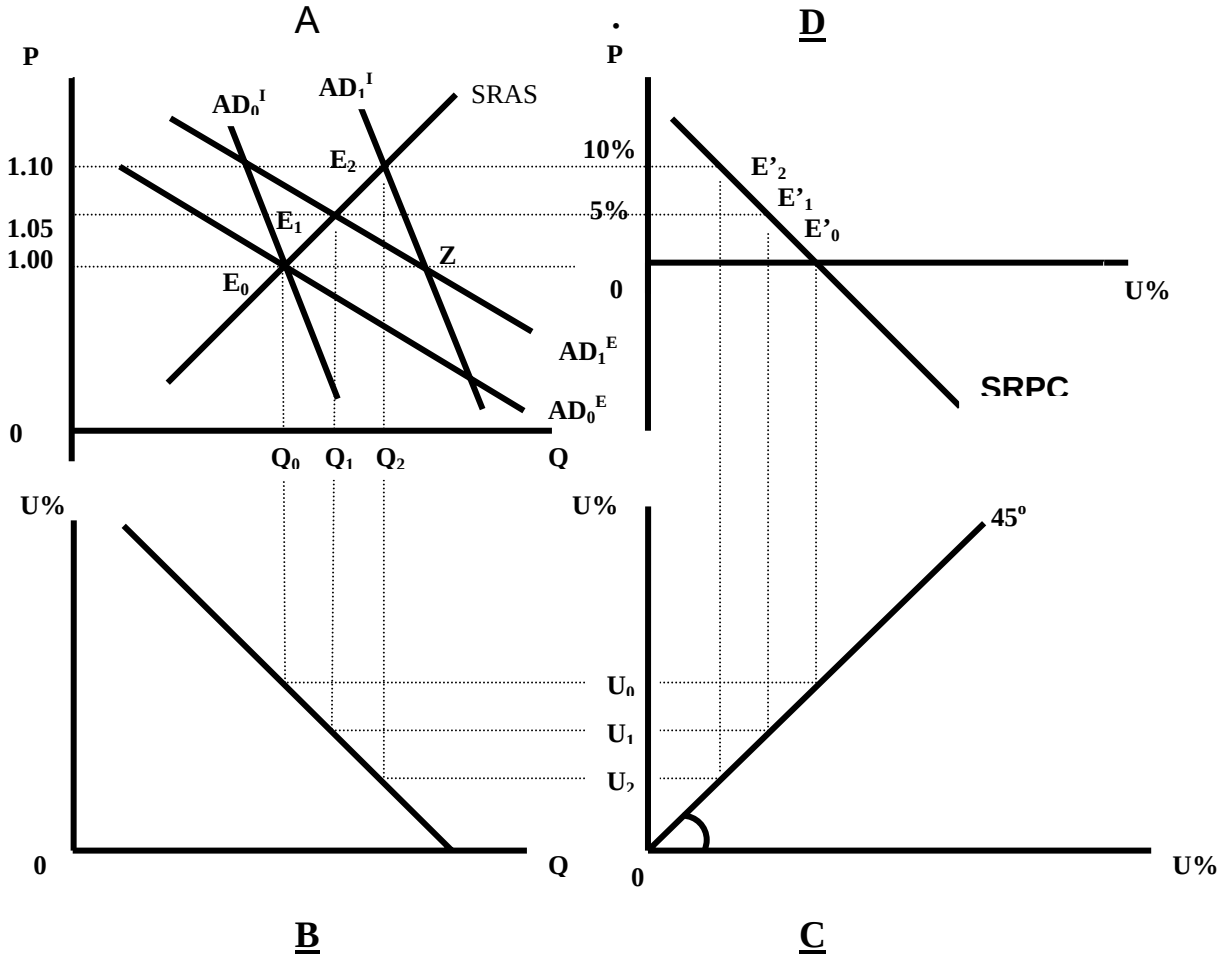
It is also rather evident from equation (6) that aggregate demand elasticity is reduced as the responsiveness of investment spending to changes in the interest rate decreases. In the special case when $i_r = 0$, the first term on the right side of equation (6) again reduces to zero and decreases the elasticity of aggregate demand.

III. AGGREGATE DEMAND ELASTICITY AND THE PHILLIPS CURVE

A. Demand-Pull Inflation

Our analysis of the relationship between aggregate demand elasticity and the Phillips curve is conducted with the four-quadrant diagram system shown in Figure 1.

Figure 1



Panel A is the aggregate demand, aggregate supply model with the customary positively-sloped short-run aggregate supply curve SRAS. Two distinct aggregate demand curves are drawn to pass through common point E_0. Thus, the flatter of the two linear schedules is more elastic with respect to the general price level and is labeled accordingly as AD_0^E while the steeper or relatively more inelastic aggregate demand curve is labeled AD_0^I. Regardless of aggregate demand elasticity, macroeconomic equilibrium occurs at point E_0, with the price level P_0, for convenience equaling 1.00, and the level of real gross domestic product Q_0.

Panel B demonstrates the general principle of Okun's law, or specifically the inverse relationship between the unemployment rate (U%) and the level of real gross domestic product. Given the exact nature of the relationship depicted by the negatively sloped function in this quadrant, the value of Q in panel A determines the unemployment rate ($U\%_0$) in panel B.

Panel C serves only as a reflection locus, i.e., the 45^0 line transfers the predetermined unemployment rate from the vertical axis to the horizontal. This value is then projected upward to panel D, where the Phillips curve is constructed to later demonstrate the impact of a change in the elasticity of

aggregate demand. Hence, reading counterclockwise through the system from point E_0 in panel A to panel D, we arrive at point E_0', the initial point on the short-run Phillips curve SRPC.[13]

Now suppose that an external factor leads to an increase in aggregate demand. More specifically, assume that this increase is applied to both aggregate demand curves in panel A causing a rightward shift of equal amounts, shown by E_0Z. As long as aggregate supply is positively sloped, the general and unambiguous outcome of the increase in aggregate demand is a higher price level and inflation, higher real gross domestic product and a lower unemployment rate that yields the familiar downward sloping Phillips curve. It is apparent, however, that the amount of inflation, the decrease in unemployment, and the corresponding movement along the given short-run Phillips curve is determined by the elasticity of aggregate demand with respect to the price level. That is, if aggregate demand is elastic, the economy moves to point E_1 in panel A, where the price index has risen to, say 1.05, and real GDP has increased to Q_1. Tracing counterclockwise through the four quadrants, we generate point E_1' on the SRPC, with an inflation rate of five percent and a lower unemployment rate $U\%_1$. If aggregate demand is less elastic, the same rightward shift of aggregate demand results in macroeconomic equilibrium at E_2 in panel A and point E_2' on the Phillips curve in panel D. The inflation rate and real GDP are greater, ten percent and Q_2, respectively, and the unemployment rate is lower, $U\%_2$. The conclusion is straightforward: for identical increases in aggregate demand, the leftward movement along a given short-run Phillips curve is greater (less) the less (more) elastic is aggregate demand with respect to the price level.[14] It follows that equal shifts in aggregate demand and the resulting movement along a given short-run Phillips curve have a correspondence to but are not deterministic with respect to changes along a stationary short-run aggregate supply curve.[15]

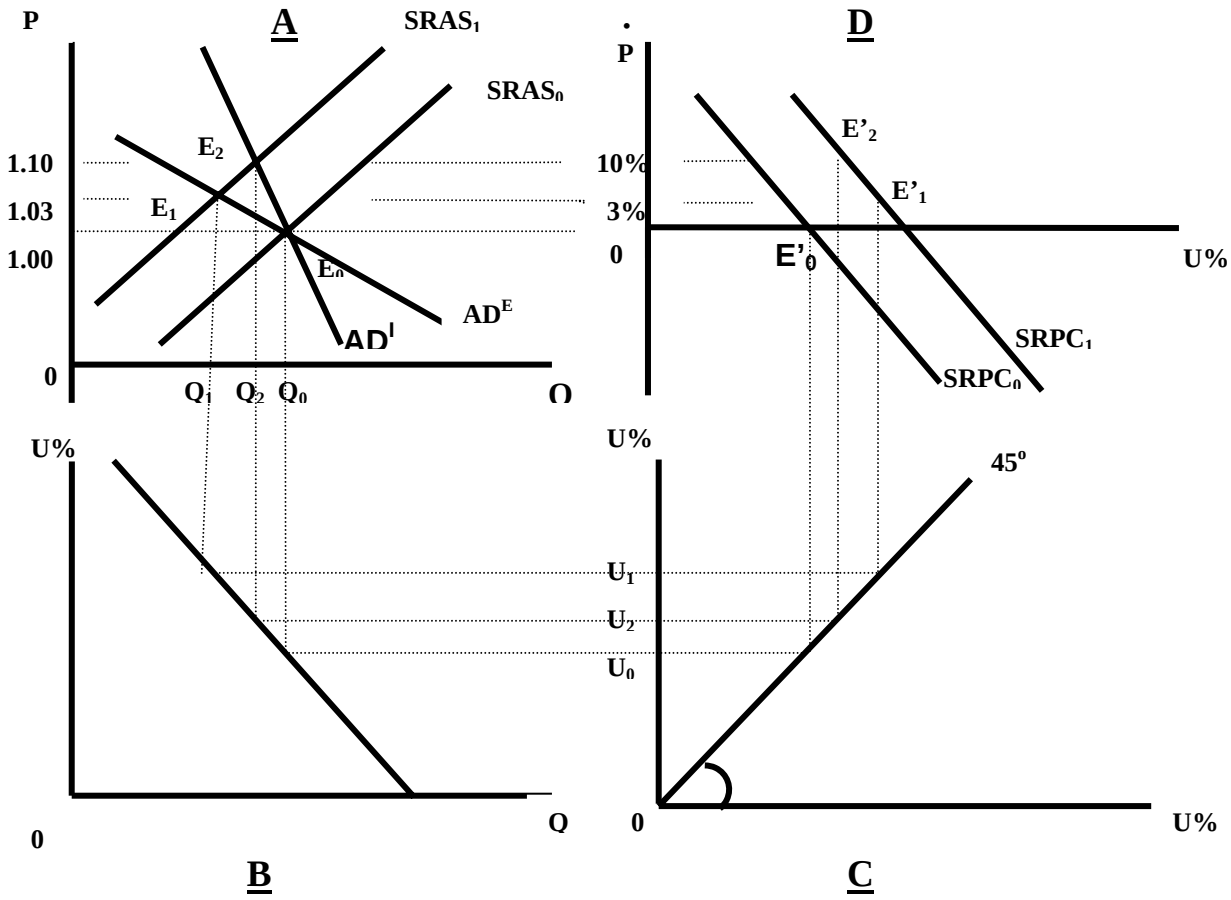
B. Cost-Push Inflation

Figure 2 demonstrates the relevance of aggregate demand elasticity for the short-run Phillips curve when a decrease of aggregate supply occurs. As before, two linear aggregate demand curves with different elasticities are constructed to intersect the original aggregate supply $SRAS_0$ at point E_0, which gives point E_0' on the original short-run Phillips curve, $SRPC_0$. Then, if aggregate supply decreases to $SRAS_1$, as long as aggregate demand is negatively sloped there will unambiguously be higher inflation and unemployment rates and a corresponding rightward shift of the short-run Phillips curve. In this case, although the amount of the rightward shift of the Phillips curve depends only on the leftward shift of aggregate supply[16], the increase of inflation and unemployment and therefore the path or movement from one Phillips curve to the other is determined by the price level elasticity of aggregate demand.

If aggregate demand is elastic, the decrease of aggregate supply in panel A moves the economy to point E_1 with the price level rising to the assumed value of 1.03, and real GDP decreasing to Q_1. Then, tracing counterclockwise through the system, we arrive at the corresponding point E_1' on the new Phillips curve, $SRPC_1$ in panel D. If aggregate demand is more inelastic with respect to the price level, however, the same decrease of aggregate supply moves the economy to points E_2 and E_2', with a larger increase in inflation and a smaller decrease in output. The conclusion is again straightforward: for decreases of

aggregate supply, the vertical (horizontal) movement from one short-run Phillips curve to another is greater the less (more) elastic is aggregate demand with respect to the price level.[17]

Figure 2



IV. CONCLUSION

The relationship between aggregate supply and the Phillips curve is well known. A concept forgotten within macroeconomics in general and in analyses of the short-run Phillips curve in particular is the price level elasticity of aggregate demand. We have found that aggregate demand elasticity influences the inflation-unemployment tradeoff in scenarios involving both demand-pull and cost-push inflation. More specifically, we obtain two results. First, for equal horizontal shifts of aggregate demand, the increase in inflation and decrease in unemployment are greater the less elastic is aggregate demand with respect to the general price level. Stated alternatively, the lower the price level elasticity of aggregate demand, the greater is the leftward movement along a given short-run Phillips curve for demand-pull inflation. Second, for experiences with cost-push inflation, the upward or counterclockwise

movement from one SRPC to another is greater the less elastic is aggregate demand with respect to the price level. Alternatively, with cost-push inflation, the increase in inflation is greater and the increase in unemployment is smaller the lower the price level elasticity of aggregate demand.

While the conclusions obtained in this paper are theoretical in nature, the actual relevance of aggregate demand elasticity for the economy and, specifically, the Phillips curve is an empirical issue. In this vein, our earlier research[18] indicates that aggregate demand does indeed demonstrate a variable elasticity over time, as this paper has assumed, and that for most of the examined time period of 1955 to 1991 aggregate demand was price level elastic in the United States. More specifically, our estimated aggregate demand elasticity coefficient exceeded unity for eighty percent of the total one hundred forty eight quarters of time series data. This historical responsiveness of aggregate demand to changes in the price level implies that demand shocks, such as in Figure 1 would, ceteris paribus, most often result in relatively small movements along a given Phillips curve. Additionally, an elastic aggregate demand function suggests that cost-push inflation, as in Figure 2, should manifest as a relatively more horizontal rather than vertical movement from one Phillips curve to another, ceteris paribus.

ENDNOTES

1. Phillips (1958)
2. See Mankiw (2003), page 359.
3. See Gordon (2003), pages 227-230.
4. For more detail see Gambs (1974).
5. Keynes (1936).
6. Kyer and Maggs (1994)
7. Kyer and Maggs (1996)
8. Kyer and Maggs (1995)
9. Green et. al., (1991).
10. Kyer and Maggs (1997).
11. Kyer and Maggs (1999)
12. Apergis and Elestherio (2000)
13. Panel D is constructed in Figures 1 and 2 such that, together with the initial price level of 1.00, the absolute changes of the price level in panel A translate neatly to the inflation rate plotted vertically in panel D.
14. Alternatively, the aggregate demand curves having differing elasticities may be viewed as shifting up vertically by the same amount. In this case, the conclusions are reversed, i.e., the inflation rate is higher, the decrease in unemployment is larger, and the resulting leftward movement along a given short-run Phillips curve is greater the higher is the price-level elasticity of aggregate demand.

15. Although a given shift in the aggregate demand curve has a systematic effect on the resulting movement along the Phillips curve, the magnitude of this relationship will be variant because of the stochastic nature of the Okun relationship.
16. This conclusion is easily demonstrated with our graphical framework.
17. If aggregate demand were perfectly inelastic, the decreased aggregate supply would cause only inflation, i.e., no increase in unemployment. The economy would therefore move upward from one short-run Phillips Curve to another. Conversely, if aggregate demand were perfectly elastic, a negative supply shock would leave the price level unaffected and only raise unemployment, moving the economy horizontally from one SRPC to another.
18. For more detail, see Kyer and Maggs (1997).

REFERENCES

Apergis, Nicholas and Elestheriou, Sophia. "Measuring Price Elasticity of Aggregate Demand in Greece: 1961 – 1995", *Public Finance Review*, September 2000, pp. 452-467.

Gambs, Carl. M. "A Note on Macroeconomic Textbooks: The Use of the Aggregate Demand Curve", *Journal of Economic Literature*, September 1974, pp. 896 – 898.

Gordon, Robert J. *Macroeconomics*, Ninth Edition, Reading, MA: Addison-Wesley, 2003.

Green, R. Jeffrey; Hickman, Bert G; Howrey, E. Phillip; Hymans, Saul H.; and Donihue, Michael R. "The IS-LM Cores of Three Macroeconomic Models", *in Comparative Performance of US Econometric Models*, Lawrence R. Klein, editor, 1991.

Kyer, Ben L. and Maggs, Gary E. "A Macroeconomic Approach to Teaching Supply-Side Economics", *Journal of Economic Education*, Winter 1994, pp. 44 – 48.

Kyer, Ben L. and Maggs, Gary E. "Monetary Policy Rules, Supply Shocks, and the Price Level Elasticity of Aggregate Demand", *Journal of Economic Education*, Fall 1995, pp. 364 – 372.

Kyer, Ben L. and Maggs, Gary E. "Supply-Side Economics and the Price Level Elasticity of Aggregate Demand", *Public Finance Quarterly*, January 1996, pp. 88-98.

Kyer, Ben L. and Maggs, Gary E. "Price Level Elasticity of Aggregate Demand in the United States: Quarterly Estimates, 1955 – 1991", *International Review of Economics and Business*, June 1997, pp. 407 – 417.

Kyer, Ben L. and Maggs, Gary E. "Aggregate Demand Elasticity in Canada", unpublished manuscript, 1999.

Mankiw, N. Gregory. *Macroeconomics*, Fifth Edition, New York, NY: Worth Publishers, 2003.

Phillips, A.W. "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861 – 1957", *Economica*, November 1958, pp. 283 – 299.