

Discussion Paper No. 9602

May 1996

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Reconsidered

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Aggregate Demand and Supply Reconsidered

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Abstract: This paper defines an aggregate demand function based on portfolio balance with three assets (money, bonds and equities) and an aggregate supply function based on the supply behavior of a representative price-setting firm. The money wage is endogenous but the usual result is a short-period unemployment equilibrium. The model provides explanations of Phillips curve, stagflation and procyclical real wage phenomena. It also allows for the possibility of a continuum of full-employment equilibria.

Keywords: Aggregate demand, aggregate supply, portfolio equilibrium, representative price-setting firm, unemployment equilibrium.

Thanks are due Emmanuel de Dios, Raul Fabella, Joseph Lim, Felipe Medalla and Nimfa Mendoza for helpful discussions or comments on an earlier draft, and the National Academy of Science and Technology, Philippines, for research support. As usual, the author is solely responsible.

Aggregate Demand and Supply Reconsidered

1. Introduction

This paper presents a simple short-period aggregative model where the aggregate demand (AD) and aggregate supply (AS) functions differ from the more usual ones. The AD function incorporates two portfolio equilibrium conditions derived from a 3-asset formulation, and the AS function is based on the supply behavior of the representative monopolistically competitive firm. Although the money wage is endogenous in the model, the typical case is an unemployment equilibrium. The model permits explanations of the Phillips curve and stagflation as well as procyclical real wage phenomena. A continuum of full-employment equilibria is a possibility with an exogenous money supply and an exogenous AD shift parameter.

Section 2 defines equilibrium conditions in the asset and product markets, and Section 3 derives the supply function of the representative price-setting firm. Section 4 describes the aggregative model. Implications are drawn in Section 5, and Section 6 makes concluding remarks.

2. Portfolio balance and output equilibrium

Following the lead of Tobin (1969), we assume three paper assets in the economy: fiat money M , government bonds B and equities E . At the end of the preceding short period, their corresponding amounts are $\bar{M}$, $\bar{B}$ and $\bar{E}$. Each unit of B issued during the present period is redeemed in the next period for one unit of money, so the price per unit of B is $1/(1+r')$ where r' is the nominal rate of interest on bonds. The government's budget constraint is, in real terms,

$$(2.1) \quad G \leq (M - \bar{M})/p + (B/(1+r') - \bar{B})/p + T$$

where G is government spending on output, p the price level, and T taxes.

Assume for simplicity that firms finance their planned investment I by issuing new equities, so $I = (E - \bar{E})/p$, each unit of E being a claim to one unit of physical capital. There is the usual aggregate production function

$$(2.2) \quad Y = F^0(\bar{K}, N)$$

where $\bar{K}$ is the stock of capital at the end of the preceding period and N is employment. The amount of labor supplied, N^s , is given by the usual labor supply function

$$(2.3) \quad N^s = h^0(w/p)$$

where w is the money wage rate. Defining

$$(2.4) \quad Y^h = F^0(\bar{K}, N^s)$$

as the output that can be produced with N^s , we can assume that

$$(2.5) \quad N \leq N^s$$

and therefore

$$(2.6) \quad Y \leq Y^h.$$

Writing $W = (M/p, B/p, E/p)$ and C for consumption, we assume that households in the aggregate have a utility function $U(C, N^s, W)$, W standing for future possibilities after the present period. However, in view of (2.5), U is effectively $U(C, N, W)$ which is maximized subject to the budget constraint

$$(2.7) \quad C + (M - \bar{M})/p + (B/(1 + r') - \bar{B})/p + (E - \bar{E})/p \leq Nw/p + \phi - T$$

where ϕ denotes firms' profits which are paid out to owners of $\bar{E}$. Since $\phi = Y - Nw/p$ and (2.7) will be satisfied as an equality, (2.7) reduces to

$$(2.7a) \quad C + (M - \bar{M})/p + (B/(1 + r') - \bar{B})/p + (E - \bar{E})/p = Y - T.$$

Writing $\bar{W} = (\bar{M}/p, \bar{B}/p, \bar{E}/p)$ and $X' = (r', Y, \bar{W})$, suppose X' is given. Since N is determined by Y in (2.2), the maximization problem includes only four choice-variables, viz. $C, M/p, B/p$ and E/p . Because of (2.7a), there are only three degrees of freedom, so if (say) M/p and B/p are also given, the U-maximizing value of C would be determined. In other words, the optimal C can be expressed as a function of $X', M/p$ and B/p . Noting that

$$(2.8) \quad 1 + r = (1 + r')/(1 + \pi^e)$$

where r is the expected real rate of interest on bonds and π^e is the expected inflation rate between the present period and the next, the optimal C can also be expressed as a function of $X = (r, Y, \bar{W})$, M/p and B/p with the exogenous π^e suppressed:

$$(2.9) \quad C = c(X, M/p, B/p).$$

More generally, any particular choice-variable can be expressed as a function of X and any two of the other three variables.

We can therefore write the asset demand functions as

$$(2.10) \quad M/p = m^0(X, B/p, E/p)$$

$$(2.11) \quad B/p = b^0(X, M/p, E/p)$$

$$(2.12) \quad E/p = e^0(X, M/p, B/p).$$

Using (2.12) to eliminate E/p in (2.10),

3. The representative firm's supply function

In line with the recent literature on monopolistic competition as a basis for an aggregative model (see e.g. Startz (1989) and, for a survey, Dixon and Rankin (1994)), we assume that the production sector of the economy consists of a large number of monopolistically competitive firms whose differentiated products are measured in the same units. Let $x = x(p, \alpha)$, $x_p < 0$, $x_\alpha > 0$, be the demand for the product of the representative (or average) firm; p is the price set by the firm--it is also the price level--and α is a demand shift parameter for the firm's output x .¹ Writing w for the money wage rate and $\beta > 0$ for an exogenous cost parameter, let $k(x, w, \beta)$ be the cost of producing x ; $k_x > 0$, $k_w > 0$, $k_\beta > 0$, $k_{xw} > 0$ and $k_{x\beta} > 0$. Taking α , w and β as given, the firm maximizes $px(p, \alpha) - k(x, w, \beta)$, so

$$(3.1) \quad (p - k_x)x_p + x = 0$$

$$(3.2) \quad (p - k_x)x_{pp} + 2x_p - k_{xx}x_p^2 < 0.$$

We assume enough competition to make $p - k_x > 0$ relatively small and $k_{xx} > 0$. Total differentiation of (3.1) gives

$$(3.1a) \quad Ddp + ((p - k_x)x_{pa} + (1 - x_p k_{xx})x_\alpha)d\alpha - x_p k_{xw}dw - x_p k_{x\beta}d\beta = 0$$

where D is the left-hand side of (3.2). Therefore

$$(3.3) \quad \partial p / \partial w = x_p k_{xw} / D > 0$$

$$(3.4) \quad \partial p / \partial \beta = x_p k_{x\beta} / D > 0$$

$$(3.5) \quad \partial p / \partial \alpha = -((p - k_x)x_{pa} + (1 - x_p k_{xx})x_\alpha) / D > 0$$

with $p - k_x$ sufficiently small. The price is thus set higher if w , β or α is higher.

Consider the demand curve in the usual diagram with x on the horizontal axis and p on the vertical. Since a higher α shifts the demand curve and the marginal revenue curve rightwards, the latter will intersect the marginal cost curve at a higher value of x . The firm's supply curve, which tells the optimal p as a function of the output x supplied (which depends on α), is accordingly generated by varying α , given w and β . It is upward sloping as usual and can be written

$$(3.6) \quad p = f^0(x, w, \beta), \quad f_x^0 > 0, \quad f_w^0 > 0, \quad f_\beta^0 > 0.$$

To examine the effect of the increase in w on the supply curve, let us assume that $k(x, w, \beta) = n(x)w + \beta x$ where $n = n(x)$ is the amount of labor required to produce x , so $k_x = n'(x)w + \beta$. A Taylor linear approximation at any particular optimal price-output point (x^*, p^*) gives

$$(3.7) \quad x(p, \alpha) = x^* + (p - p^*)x_p^* + (\alpha - \alpha^*)x_\alpha^*$$

where α' is the existing value of α and the partials are evaluated at (p', x') . To simplify the notation, write $A = x' - p'x_p - \alpha'x_\alpha$ and $b = -x_p$, and choosing units so that $x_\alpha = 1$, (3.7) becomes

$$(3.7a) \quad x = A - bp + \alpha.$$

Then, writing $a = n'(x')$ and using (3.7a), (3.1) can be written

$$(3.1a) \quad p = (A + \alpha)/2b + (aw + \beta)/2.$$

We now assert

Proposition 1. The supply curve will shift upwards proportionately less than a dw increase in w , i.e. at any given x and the corresponding p on the supply curve, if δp is the vertical shift, then $\delta p/p < dw/w$.

Proof. The δp shift can be thought of as the sum of two components: (i) δp_1 , due to dw , which decreases output by (say) dx , and (ii) δp_2 , due to a rise in α that increases output by the same amount dx .

(i) $\delta p/\delta w = a/2$ from (3.1a), so $dw = 1$ gives $\delta p_1 = a/2$ which reduces output by $dx = ba/2$ since the slope of the demand curve is $1/x_\alpha = -1/b$. (ii) $\delta p/\delta \alpha = 1/2b$ is the slope of the supply curve, and therefore $\delta p_2 = (1/2b)(ba/2) = a/4$. Thus $\delta p = \delta p_1 + \delta p_2 = 3a/4$, and $\delta p/p = 3a/4p$ can be compared with $dw/w = 1/w$. Since $p > k_x = aw + \beta$ so $p/a > w$, one gets $4p/3a > w$ whence $\delta p/p < dw/w$.

In view of Proposition 1, the representative firm's supply function (3.6) can be written

$$(3.6a) \quad p/w = f^1(x, w, \beta), \quad f^1_x > 0, \quad f^1_w < 0, \quad f^1_\beta > 0$$

where $f^1 = f^0/w$. Since Y is x times the number of firms, (3.6) and (3.6a) imply the aggregate relationships

$$(3.6b) \quad p = f^2(Y, w, \beta), \quad f^2_Y > 0, \quad f^2_w < 0, \quad f^2_\beta > 0$$

$$(3.6c) \quad p/w = f^3(Y, w, \beta), \quad f^3_Y > 0, \quad f^3_w < 0, \quad f^3_\beta > 0$$

respectively. It is then possible to have a lower p/w at a higher output level if w is higher, a result which will play a later role.

4. An aggregative model

The model consists of the following relationships from the preceding sections, renumbered here for convenience:

$$(1) \quad Y = F^0(\bar{K}, N)$$

$$(2) \quad p = f^2(Y, w, \beta)$$

$$(3) \quad Y^d = g^2(r, Y, M/p, B/p) + \gamma,$$

$$(4) \quad M/p = m^5(r, Y)$$

$$(5) \quad B/p = b^5(r, Y)$$

$$(6) \quad Y = Y^d$$

$$(7) \quad N^s = h^0(w/p)$$

$$(8) \quad Y^h = F^0(\bar{K}, N^s)$$

$$(9) \quad Y^d \leq Y^h.$$

Equation (1) = (2.2), (2) = (3.6b), (3) = (2.13), (4) = (2.10d), (5) = (2.11d), (6) = (2.14), (7) = (2.3), (8) = (2.4), and (9) = (2.15).

Equations (3)-(6) suffice to determine r , p , Y and Y^d . Then, with p and Y in hand, (1)-(2) give N and w , and (7)-(8) give N^s and Y^h . The model is just determinate in the eight endogenous variables $\bar{Y}$, N , r , p , w , Y^d , N^s and Y^h , given the exogenous variables $\bar{K}$, M , B , β and γ .

In order to have a simple diagram, it will be useful to condense the model into an AS/AD schema. Suppressing $\bar{K}$, (1) and (8) can be written

$$(1.a) \quad Y = F(N)$$

$$(8.a) \quad Y^h = F(N^s)$$

respectively. Since (2) implies

$$(2a) \quad p/w = f^3(Y, w, \beta), \quad f^3_Y > 0, \quad f^3_w < 0, \quad f^3_\beta > 0$$

by Proposition 1, we can write

$$(2b) \quad Y = \bar{f}(p/w, w, \beta), \quad \bar{f}_{p/w} > 0, \quad \bar{f}_w > 0, \quad \bar{f}_\beta < 0.$$

Using (4) and (5) in (3),

$$(3a) \quad Y^d = g^1(r, Y) + \gamma.$$

From (4) and (5),

$$(4a) \quad p = m^6(r, Y, M)$$

$$(5a) \quad p = b^6(r, Y, B)$$

respectively. Letting $j^0(r, Y, M, B) = m^6(\cdot) - b^6(\cdot) = 0$, the implicit function theorem gives

$$(10) \quad r = j(Y, M, B)$$

so (3a) can be written

$$(3b) \quad Y^d = g^2(Y, M, B) + \gamma.$$

We assume that $g'_Y < 1$ for stability of Y^* , denoting equilibrium values of the variables by star-superscripts, and it is clear from (3b) that Y^* is unique given M , B and γ . The uniqueness and stability of r^* and p^* then follow from (10) and (4a) or (5a). Since (2) gives

$$(11) \quad w = f^1(Y, p, \beta)$$

the uniqueness and stability of w^* also follow, given β . Using (2b),

(3b) can be written

$$(3c) \quad Y^d = g(p/w, w, \beta, M, B) + \gamma.$$

Finally, with (7) in (8a),

$$(8b) \quad Y^h = h(p/w), \quad h' < 0.$$

To summarize at this point, (2)-(2b) are alternative versions of the aggregate supply function, and (3)-(3c) are alternative versions of the aggregate demand function, but we will refer to (2b) in particular as the AS function and (3c) as the AD function. Putting $w = w^*$ and plotting (2b), (3c) and (8b) gives Fig. 1 which is drawn for the case $Y^d < Y^h$. (Cf. Edwards (1959) for a similar diagram.) Referring to (2b), we note that a higher w^* shifts AS upwards.

The labor market fails to clear in general because p/w^* , which equates Y and Y^d , would only fortuitously equate Y and Y^h also. The extent of involuntary unemployment, measured in terms of the corresponding output, is indicated by the vertical distance between the Y^h curve and the equilibrium point where $AS = AD$. As Keynes (1936, p. 15) put it, "in the event of a small rise in ... $[p/w]$ both the aggregate supply of labor willing to work for the current money wage and the aggregate demand for it at that wage would be greater than the existing volume of employment." This is clear from Fig. 1.

Abstracting from government spending G , notice also that it is only where $AS = AD$ that planned investment I (or Y^d less C) equals saving S (or Y less C), in contrast to the textbook construction of AD based on IS-LM where $I = S$ at every point of the textbook AD.

5. Implications

Preliminaries

In the following discussion of some comparative statics of the model, we assume that the endogenous variables are always at their equilibrium values which will change only as a result of a change in some exogenous variable, and we will omit the star-superscripts denoting equilibrium values unless they are needed for clarity.

We make some assumptions about the possible effects of a higher M or B .

A1. A higher M cet. par. (i.e. other exogenous variables remaining the same) implies that w does not fall (and p does not fall).

A2. A higher B cet. par. implies that r does not fall.

We also assert

A3. A higher M or B cet. par. implies that if p rises but Y falls, p/w is not lower.

The rationale for A1 is that p and w are in monetary terms, and it would be odd if they should fall as a result of an increase in M . The parenthetical "and p does not fall" in A1 is meant to indicate that it can be deleted, for it will be seen below that if w cannot fall, neither can p . A2 seems clear: with more B in the market, it is hard to see how r can fall.

Regarding A3, suppose a higher p , lower Y and lower p/w . Then w rises more than p . The higher w shifts AS upwards, which induces an upward shift of AD. At the same time, the higher M or B has a direct positive effect on AD, so we expect the total shift of AD to be of about the same order of magnitude as the shift of AS since $\partial Y^d / \partial Y$ should be closer to 1 than to 0. Now a lower Y and a lower p/w would mean that the new AS = AD point is southwest of the old. But this is not possible with roughly equal upward shifts of AS and AD. A3 thus seems to be reasonable.

Effects of higher M

Suppose M is higher. There are five cases to consider.

(i) If p falls, then M balance (4) and B balance (5) say that Y must be higher. Looking at (2a), the higher Y means that p/w is higher, so w must be lower on the supposition that p falls. Since a lower w is ruled out by A1, p cannot fall.

(ii) If p remains the same, then M balance requires lower r or higher Y . If r is lower, a higher Y is needed to maintain B balance, so Y must rise. For the same reason as in (i), p/w must be higher, which requires w to fall. Thus p cannot remain the same.

(iii) If p rises proportionately more than M , then portfolio balance requires Y to fall. This means a lower p/w by (2a), so w must rise more than p , contradicting A3. Thus p cannot rise more than M .

(iv) If p rises in the same proportion as M , then B balance requires lower r or Y . A lower r means a lower Y in order to maintain M balance, so Y must fall. Repeating the argument in (iii), p cannot rise like M .

(v) If p rises less than M , then M balance calls for lower r or higher Y , and B balance calls for lower r or Y , so r must fall. We have seen in (iii) that A3 rules out a lower Y with higher p , and therefore B balance requires a lower r . Ignoring the

null-probability event that the value of r for B balance will also balance the M market without a higher Y , r will fall and Y will rise.

Since only case (v) remains as a possibility, to summarize we have

Proposition 2. Under assumptions A1 and A3, a higher M cet. par. implies that p rises proportionately less than M (so M/p increases), r decreases, and Y increases.

Effects of higher B

Suppose a higher B (but M is maintained). There are five cases:

(i) If p falls, B balance needs a higher r or Y , and M balance means lower r (ruled out by A2) or higher Y , so Y must rise. Again ignoring the null-probability event that the value of Y that gives M balance will also balance the B market without a higher r , r and Y will both increase.

(ii) If p is unchanged, B balance requires higher r or Y . To maintain M balance, Y must be higher if r is higher, and conversely. Thus r and Y must rise.

(iii) If p rises more than B, then M balance calls for a lower Y since a lower r is ruled out. But as in case (iii) of a higher M, A3 is violated, so p cannot rise more than B.

(iv) If p rises like B, then M balance requires a higher r since like (iii) a lower Y is ruled out by A3. However, to maintain B balance, a higher r implies that Y must fall. Thus, p cannot rise like B.

(v) If p rises less than B, then B balance requires higher r or Y , and since a lower Y is ruled out with a higher p , M balance requires higher r . Thus r and Y will both rise.

Cases (i), (ii) and (v) remain as the only possibilities, and we summarize with

Proposition 3. Under assumptions A2 and A3, a higher B cet. par. implies that the proportionate change in p is less than that of B, and both r and Y will increase.

The Phillips curve

Consider an increase in M. The larger the increase, we expect from Proposition 2 that the greater is the percentage change $\Delta p/p$ and the larger is Y . This means a positive correlation between $\Delta p/p$ and Y , hence a negative correlation between the inflation rate and the unemployment rate, which is the Phillips curve.

Stagflation

Consider an increase in the cost parameter β , which shifts AS downwards. This induces a similar shift of AD, but since $g_y^2 < 1$ in (3b), the downward shift of AD will be smaller than that of AS. The new AS and AD will therefore intersect at a point southeast of the old equilibrium, hence at a higher p/w and lower Y . Unless p falls and w falls more than p (which there is no reason to suppose), this means higher p and lower Y which is the stagflation phenomenon.

A procyclical real wage

Suppose that a higher M raises w as well as p and Y ,² so that AS and AD are shifted upwards. If the AD shift is smaller, maybe because of a concomitant change in γ , the new AS and AD will intersect at a point northwest of the old equilibrium, so at a lower p/w and a higher Y . Hence the possibility of a procyclical real wage. It is important that there be no necessity about this, for the empirical evidence is that there are times when the real wage is procyclical and times when it is countercyclical; see Sumner and Silver (1989).

Full employment equilibria

Proposition 2 says that a higher M implies higher p and Y . Suppose that for some M and γ the point $AS = AD$ lies on the Y^n curve so there is full employment. Then a further increase in M must raise w in order that more labor can be hired to produce higher Y . The higher w shifts AS upwards, and some value of γ would put the new $AS = AD$ at a higher point on Y^n where Y and the real wage are higher. Thus we have

Proposition 4. Appropriate combinations of γ and M give a continuum of full-employment equilibria.

We might note that Cottrell and Darity (1991) obtain the possibility of multiple full-employment equilibria on the assumption of increasing returns. McDonald (1987) gets a continuum of equilibria from a discontinuity in the representative firm's marginal revenue function, and Dixon (1988) from relative demands in a 2-sector model, but their equilibria are not full-employment ones.

6. Concluding remarks

The aggregative model presented in this paper is different from the standard Keynesian model in two important respects. First, there are two independent asset-equilibrium equations (one for bonds in addition to the usual one for money) derived from a 3-asset formulation which includes equities. This feature endogenizes the money wage but an unemployment equilibrium remains as the typical case. The AD function is based on portfolio equilibrium, which has the consequence that it is only where $AD = AS$ that planned investment I equals saving S . In contrast, $I = S$ at every point of the usual AD construction based on the IS-LM framework.

Second, instead of the profit-maximization condition for price-taking firms that equates the marginal product of labor to the real wage, the AS function derives from the supply function of the representative price-setting firm. This supply function has the property that a higher money wage makes the price-wage ratio smaller at any given output level, which thus allows for the possibility of a higher real wage at a higher output. The observation that the real wage is sometimes procyclical can then be explained. Also, a continuum of equilibria with full employment is possible with an exogenous AD shift parameter and increases in the money wage resulting from increases in the stock of money. Finally, Phillips curve and stagflation phenomena find straightforward explanations in the model.

Notes

1. One might write $x = x(p, \bar{p}, \alpha)$ where $\bar{p}$ is the average price set by firms, but since $p = \bar{p}$ for the representative firm, we can simply write $x = x(p, \alpha)$.

2. This will be the case if $\Delta Y > f_{p/w}$ which implies that the new Y is on a higher AS resulting from a higher w , for we expect AS to be concave in p/w .

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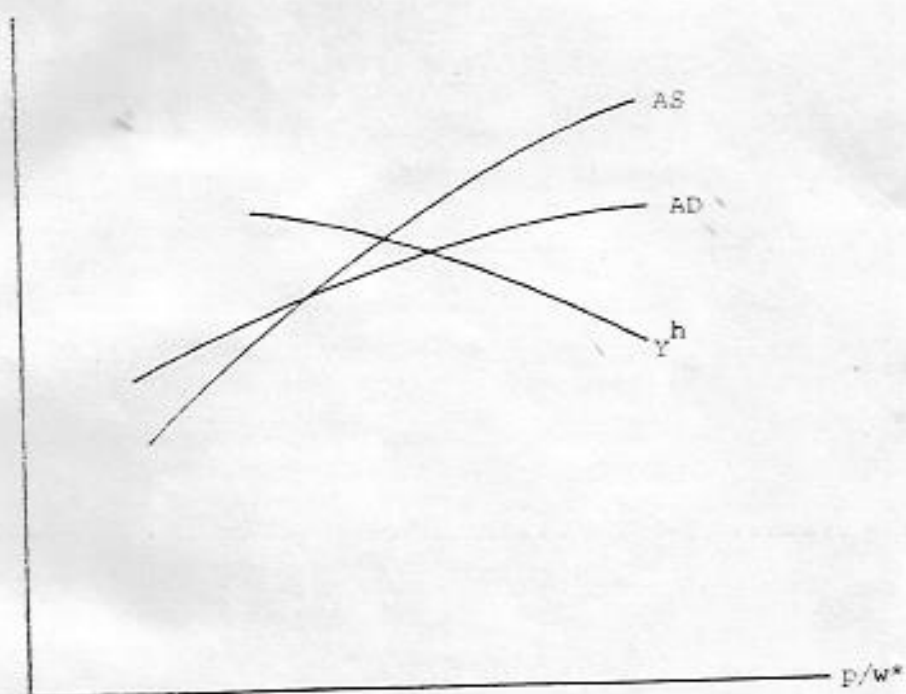


Fig. 1