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Aggregate Demand, Aggregate Supply and Economic Growth

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ABSTRACT *While mainstream growth theory in its neoclassical and new growth theory incarnations has no place for aggregate demand, Keynesian growth models in which aggregate demand determines growth neglect the role of aggregate supply. By assuming that the rate of technological change responds to labour market conditions, this paper develops a simple and conventional growth model that integrates the roles of aggregate demand and aggregate supply. The model shows how the long-run equilibrium growth rate of the economy, at which the unemployment rate is constant, can be affected by aggregate demand.*

KEY WORDS: Growth, aggregate demand, aggregate supply, technological change, Keynesian growth models, hysteresis.

JEL CLASSIFICATION: O41, O33, E12

Introduction

In most macroeconomic models, aggregate demand and aggregate supply interact to determine the short-run performance of the economy, but when it comes to the long-run analysis of economic growth, aggregate demand usually makes its exit and aggregate supply rules the roost. Mainstream growth theory both in its earlier—neoclassical (Solow, 1956)—form, and its later new or endogenous growth theory (see Barro & Sala-i-Martin, 1995, for a review) incarnation, share this neglect of aggregate demand.[1] These theories imply that the rate of growth of per-capita income in long-run equilibrium depends on supply-side factors.[2] They do not introduce aggregate demand into the analysis at all, assuming that the economy is always at full employment and that all saving is (identically) invested.[3] Thus, for mainstream macroeconomists, aggregate demand is relevant only for the short run and in the study of cycles, but irrelevant for the study of growth. The apparent reason for this is that the market mechanism, in the form of flexible wages working through assets markets, or government policies, solves the

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problems of unemployment and the deviation of aggregate demand from aggregate supply in the longer run.

The neglect of aggregate demand from current mainstream growth theory is ironic, because in Harrod's (1939) growth model—arguably the key pioneering contribution to modern growth theory—aggregate demand plays a central role. Harrod distinguished clearly between saving and investment behaviour, and his warranted rate of growth, at which saving and investment behaviour were mutually consistent, could be different from the natural rate of growth, or the rate of growth of what we can call aggregate supply. Other growth theories in which aggregate demand played a major role, such as those of Robinson (1962) and Kahn (1959) were also earlier considered to be a part of growth theory (see Sen, 1970; Wan, 1971).[4] Growth theories in which aggregate demand plays a role have not disappeared entirely, however. Several heterodox economists, who can be called post-Keynesian or structuralist, give centre stage to aggregate demand.[5] These economists have developed models of aggregate-demand determined growth that imply that the rate of growth of the economy in the long run can be increased by increasing aggregate demand, for instance, government spending. However, these models, while reinstating aggregate demand, appear to jettison aggregate supply, somewhat implausibly implying that the aggregate supply factors, so dear to mainstream growth theorists, are irrelevant for long-run growth.

In short, aggregate demand has disappeared from mainstream growth theory, which focuses entirely on the supply side. Growth theories that focus on aggregate demand, however, ignore aggregate supply considerations. All this raises the question: is it not more sensible to have a growth theory in which both aggregate supply and aggregate demand considerations have roles to play?

This paper attempts to take some steps in synthesizing the roles of aggregate demand and aggregate supply in a growth model by drawing on features of the three growth traditions—Keynesian models of aggregate-demand determined growth, neoclassical models and new growth theory models. In doing so it complements the contributions of others who have sought to synthesize aggregate demand and aggregate supply in growth models: for instance, Cornwall (1972, 1977), Palley (1996, 2003) from the post-Keynesian tradition, and Martin & Rogers (1997) and Blackburn (1999) from the new growth theory perspective.

The next section starts with a simple model of aggregate-demand determined growth. The section following this then introduces aggregate supply considerations by developing a simple model in which aggregate demand plays a role in the short run as in neoclassical-synthesis models, but in which it is irrelevant to the determination of the rate of long-run growth, as in neoclassical growth models. The fourth section introduces endogenous technological change. The fifth section incorporates endogenous technological change into the model of the third section and shows how aggregate demand and aggregate supply factors can be integrated. The penultimate section provides some additional comments on the model, examining its generality, and its relationship with some theoretical and empirical literature, while conclusions are reached in the final section.

Aggregate Demand and Economic Growth

To examine perhaps the simplest of aggregate demand-driven growth models, assume that: saving is a fraction s of real income and output Y so that the ratio of saving S to capital stock K is given by

$$S/K = s\,u, \tag{1}$$

where $u = Y/K$ is a measure of capacity utilization; and that the ratio of investment to capital stock is a positive function of capacity utilization, so that, adopting a simple linear form,

$$I/K = \gamma + \beta\ u, \tag{1}$$

where γ is the autonomous component of investment, and $\beta > 0$ shows the response of the investment rate to changes in capacity utilization. Assuming that there is no government fiscal activity and that the economy is closed, goods market equilibrium is achieved through variations in Y, and hence u, in the standard Keynesian manner, which implies that

$$u = \gamma/(s - \beta) \tag{3}$$

Abstracting from depreciation, the growth rate of capital, is given by $g = I/K$, where

$$g = s\gamma/(s - \beta) \tag{4}$$

Abstracting from technological change, the growth rate of output y (with output given by $Y = uK$), is also given by g since u is determined by (3). Three comments about this model are in order.

First, if we assume that the rate of growth of labour supply is exogenously given by n, there is no reason why the rate of growth of labour demand is equal to this rate of growth of labour supply. With labour productivity fixed and given at A, the rate of growth of labour demand is equal to the rate of growth of output y, which is equal to g and determined in equation (4) quite independently of n. This implies that unemployment will rise (if $g < n$) or fall (if $g > n$) indefinitely over time.

Second, growth is driven entirely by demand-side factors. The rate of growth of output (and per capita output, if the rate of growth of population and the labour force is assumed to be constant at the rate n), is determined by the parameters such as γ, which represent autonomous investment (and, which in a model with government policy can be more generally determined by monetary and fiscal policies), β and s, and not by supply side factors. A rise in s, usually considered a supply-side factor in new growth theory models, implies a fall in the rate of growth of output and per capita output, as a result of the paradox of thrift. A rise in n, also a supply-side factor, leaves the rate of growth of output unchanged, and reduces the rate of growth of per capita output.

Third, this basic model has been extended in a number of directions to incorporate several features left out of this simple model, including income distribution, differential saving propensities from wages and profits, inflation, financial variables, open economy features and debt of various kinds.[6] One feature relevant for present purposes is technological change. If we assume that that labour productivity A grows at the constant rate a over time, the rate of growth of employment is given by $l = y–a$. There is, again, no reason why this l is going to be equal to n, and hence for the unemployment rate to be constant in long-run equilibrium. Note also that if there is an increase in the rate of technological change, so that a

rises, unemployment will merely rise at a faster rate, leaving the rate of growth of output and per capita output unchanged.[7]

Several criticisms have been made of this model. One is that it allows the rate of capacity utilization u to be endogenous even at long-run growth equilibrium, rather than requiring it to converge to some desired or planned level, which may be considered to be a requirement of long-run equilibrium. Against this criticism, however, it can be argued that there may exist no unique desired level of capacity utilization, but perhaps a range within which investment behaviour may be stable. Moreover, it can be shown that if there is a unique desired level of capacity utilization, but one that is endogenous to take into account the strategic behaviour of oligopolistic firms (see Lavoie, 1995), then a long-run equilibrium in which the rate of capacity utilization adjusts to this endogenous level of desired excess capacity, is entirely consistent with the model of the text (as shown in Dutt, 1997).[8] We therefore leave this criticism aside, not only because of these defenses, but also because the main interest of this paper is to address the roles of aggregate demand and supply. Even if we assume that there is a mechanism that takes the economy to full capacity utilization in the long run, the long-run equilibrium growth rate of the economy would still be determined by aggregate demand and not aggregate supply.[9]

We therefore turn to another criticism of the model, that is, it does not require the unemployment rate to arrive at some equilibrium level in long-run equilibrium. As noted earlier, the model implies that there is nothing to ensure that the unemployment rate does not rise or fall indefinitely at long-run equilibrium. The model may be considered to be problematic, both because one does not observe indefinite increases or decreases in the unemployment rate in reality and also because it seems theoretically implausible to have a long-run equilibrium in which the rate of unemployment does not arrive at some equilibrium value. We now turn to models that introduce such a requirement.

Aggregate Supply and Growth

Models of aggregate supply-determined growth can be developed by completely ignoring aggregate demand right from the start. This, indeed, has been the strategy adopted in neoclassical and new growth theory models. Because the purpose of this paper is to draw on both the aggregate demand and aggregate supply approaches to growth, we cannot follow this route, however. Instead, following the neoclassical-synthesis model, we introduce aggregate demand considerations in the short run, only to render them irrelevant in the long run.

In the standard textbook neoclassical-synthesis Keynesian model there is wage rigidity and unemployment in the short run and wage flexibility and full employment, or at least unemployment at the natural rate, in the long run. In the short run, with a degree of wage rigidity, the labour market does not clear, and output can grow at a rate that does not make the growth of labour demand equal to the growth of labour supply. However, in the longer run, with wage flexibility, this condition cannot persist, and growth can only occur such that the demand and supply of labour grow at the same rate. This treatment of the short and longer runs, of course, is not found only in textbook models, but also in the new consensus and new neoclassical synthesis models thaat introduce explicit longer-run dynamics and a more complex treatment of monetary policy, such as those of Clarida *et al*. (1999), Meyer (2001) and Woodford (2003).

A simple interpretation of neoclassical synthesis Keynesian models allows deviations between labour demand and labour supply growth to occur in the short run, but makes components of aggregate demand adjust to deviations between the two growth rates in the long run.

For the short run, therefore, our model can allow demand-determined growth as in our model of the previous section, which takes saving and investment to be determined by equations (1) and (2). In short-run equilibrium the goods market clears through adjustments in output, so that capacity utilization and the rate of capital accumulation are determined by equations (3) and (4), as before.

In the long run, however, we assume that

$$\hat{\gamma} = -\theta[l - n] \tag{5}$$

where l is the rate of growth of employment and $\theta > 0$ is a speed of adjustment parameter, and where from now on the 'hat' denotes the rate of growth. As noted earlier, two mechanisms can explain this adjustment, which shows how a faster rate of labour supply than labour demand, which increases the unemployment rate, increases the autonomous investment rate. First, an increase in the unemployment rate reduces wages and prices, increases real money supply, reduces the interest rate and increases investment. Second, a rise in the unemployment rate induces expansionary monetary and fiscal policies, which increase the investment rate. These mechanisms are not explicitly incorporated in the model for simplicity, which does not contain the interest rate or fiscal policy, but can be modified to do so.[10]

Assuming that the productivity of labour is constant, the rate of growth of output, $y = l$. From the definition of u, we have

$$y = \hat{u} + g \tag{6}$$

Differentiating equation (3) and substituting from equation (6) into (5) we obtain

$$\hat{\gamma} = [\theta / (1+\theta)][n - s\gamma / (s - \beta)] \tag{7}$$

This equation of motion for the model implies that the long-run equilibrium rate of growth of the model, at which $\hat{\gamma} = 0$, is given by

$$g = n, \tag{8}$$

and is stable.[11] In long-run equilibrium, since $g = y = l$, the rate of unemployment is constant, and output grows at the rate of growth of labour supply, implying no growth in per capita income.

If we introduce technological change, reflected in a constant rate of labour productivity growth, a, $y = l + a$, equation (7) must be modified to

$$\hat{\gamma} = [\theta / (1+\theta)][(n + a) - s\gamma / (s - \beta)] \tag{7'}$$

In long-run equilibrium—which is again stable—the unemployment rate becomes constant and we have $y = g = n+a$. The rate of growth of per capita income is a, as in the Solovian neoclassical growth model with exogenous technological change.

One distinction between this model and the standard neoclassical synthesis model is that its long-run equilibrium rate of unemployment is *some* constant, rather than at a *particular* exogenously specified full employment rate.[12] The reason why this model does not result in an exogenously-specified unique unemployment rate is that it assumes that investment changes as a result of *changes* in—and not *levels* of—the unemployment rate. Dependence on changes can be explained by what has been called hysteresis in labour markets.[13] A high level of unemployment need not exert downward pressure on wages and lead to increases in investment because outsiders in the wage negotiation process may have no influence on wage bargains, and because workers who lose their skills are not relevant to the wage determination process. It is only when unemployment increases that wages will tend to fall, because it takes time to lose skills or become outsiders and this exerts downward wage pressures. Fiscal and monetary policy may also change only when there are changes in the unemployment rate, with policy makers getting used to any level of unemployment by calling it the natural rate of unemployment consistent with price stability. We will return to this issue later.

Before we conclude our discussion of growth models determined by aggregate supply, we point out that the property of the models that makes the economy grow at the rate determined by aggregate supply is that components of aggregate demand change in response to labour market conditions. For the market-mediated adjustment, this requires both that wages and prices are flexible in the long run, and that changes in the price level lead to increases in investment spending (as a result of, for instance, changes in the interest rate or, alternatively, the real balance or wealth effects). That such an adjustment may be aborted by a variety of factors, including wage and price rigidity, the endogeneity of credit money, uncertainty that prevents investment from responding to a reduction in the rate of interest rate, and debt deflation, has been pointed out by Keynes (1936) and many Keynesian and post-Keynesian economists (see Dutt & Amadeo, 1990). Furthermore, the government policy argument may also be aborted by the unwillingness—for instance, for political reasons (see Kalecki, 1943)—or the inability (as suggested by the recent experience of Japan, for instance) of governments to adjust aggregate demand to aggregate supply. These problems may well interfere with the economy converging to positions of full employment or a constant unemployment rate. In this case, it is possible for the economy to grow—for considerable lengths of time—with a rate of growth of output determined by aggregate demand, as in the model of the previous section. However, what if these problems are exceptional and most of the time the economy does converge to an equilibrium with full employment or at least a constant unemployment rate?

Endogenous Technological Change

The analysis of the previous section either abstracted entirely from technological change, or assumed that labour productivity grows at an exogenous rate.

We now endogenize technological change by assuming that the change in rate of growth of labour productivity depends on the difference between the rates of growth of labour demand and labour supply, so that

$$\hat{a} = \alpha[l - n], \qquad (8)$$

where $\alpha > 0$.[14] In this approach an expansion in aggregate demand leads to a faster rate of growth of employment, which results in a faster rate of labour-augmenting technological change, allowing an increase in the rate of growth without creating a labour shortage.[15] This view is different from that of mainstream growth models that do not distinguish between employment and labour supply and that focus on research and development activities, human capital accumulation and learning by doing. How plausible is this view of technological change?

In the view adopted here, firms are assumed to increase the rate of labour productivity growth in response to shortages of labour by adopting at a faster rate technology that economizes labour use (see Bhaduri, 2003).[16] The approach follows Marx's analysis of technological change—which involves the adoption of labour-displacing machines—as a weapon in the hands of capitalists in class struggle (see Marx, 1976, ch. 15, sect. 5). It is also consistent with the views of Robinson (1956) who argues that even more important than speeding up discoveries is the speeding up of the rate at which innovations are diffused. When entrepreneurs find themselves in a situation where potential markets are expanding but labour is hard to find, they have every motive to increase productivity (Robinson, 1956, p. 96). This view of technological change differs from the new growth theory approach in two ways. First, it draws attention to the demand side of the economy: technological change occurs in response to labour shortages caused by the growth of employment—formalizing the old adage that necessity is the mother of invention—rather than the supply side, which focuses on the research and development process. The speed of technological change is essentially determined by pressures and bottlenecks in the economy, or disequilibria.[17] Second, it stresses the process of diffusion of technological change among firms who are driven to adopt the technology by labour shortages, rather than the process of invention (although it is also consistent with a simple innovation view). It is not so much new innovation, but the technological diffusion owing to adoption of techniques already known theoretically, which is the primary determinant of technological change. To the extent that demand-side factors and diffusion are important factors in the process of technological change, this approach can be argued to be a plausible one.[18]

Aggregate Demand, Aggregate Supply and Economic Growth

We now introduce endogenous technological change as discussed in the previous section and depicted in equation (8) into the model of aggregate supply-determined growth with a role for aggregate demand in the short run of the third section, formalized in equation (5).

As before, using equations (3) and (6), we now have $l = g + \hat{\gamma} - a$, so that equation (5) implies equation (7′)

$$\hat{\gamma} = [\theta / (1+\theta)][(n+a) - s\gamma / (s-\beta)] \qquad (7')$$

Equation (8) implies

$$\hat{a} = [\alpha / (1+\theta)][s\gamma / (s-\beta) - n - a] \qquad (9)$$

The dynamic system is a zero root system with the phase diagram shown in Figure 1, where the $\hat{g} = 0$ and $\hat{a} = 0$ loci are both given by the equation $a = -n + s\gamma/(s-\beta)$. Note that at this equilibrium the rate of unemployment is a constant, since $l = n$.

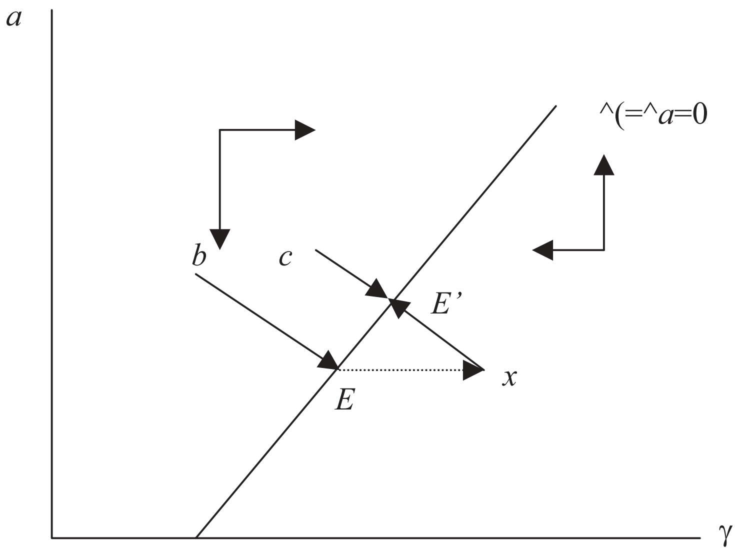

Figure 1. Long-run dynamics in the AD-AS growth model

The stability of the system given by equations (7′) and (9) can be explored with a Liapunov function of the form

$$V(t) = \tfrac{1}{2}[(s\gamma / (s-\beta)) - n - a]^2$$

The global stability of the system requires that $dV/dt < 0$.[19] Differentiating this function with respect to time we obtain

$$dV / dt = [(s\gamma / (s-\beta)) - n - a]\,\{(s / (s-\beta))\, d\gamma \;/ dt - da / dt\}$$

Substituting from equations (7′) and (9) this implies

$$dV / dt = -[(s\gamma(/(s-\beta)) - n - a]^2\;[1/(1+\theta)]\,\{(s/(s-\beta))\gamma\;\theta + a\;\alpha\} < 0,$$

ensuring stability.

Three implications of the model may be noted. First, instead of a unique long-run equilibrium, the economy has a continuum of equilibria along the $\hat{\gamma} = 0$ and $\hat{a} = 0$ loci that happen to coincide. These equilibria are all stable. This implies that the long-run equilibrium position of the economy will depend on where it starts off from. For instance, if it starts from point *b*, it will converge to point *E*, while if it starts from point *c*, it will converge to point *E*′.[20] Second, starting from a long-run equilibrium, say at *E*, an exogenous increase in γ brought about by expansionary fiscal or monetary policy, or by simply an autonomous boost in animal spirits, will imply a move to a position like *x* (since *a* is given in the short run).[21] In the long run there will be a movement along the diagonal arrow to *E*′, implying a higher rate of growth than at the initial equilibrium at *E*. Hence, expansionary policies and other positive aggregate demand shocks have long-term expansionary effects, although not as strong as short-run expansionary effects.[22] Likewise, contractionary policies have long-run contractionary effects. Third, the path of the economy from any point in the diagram will depend on the relative sizes of the two adjustment parameters θ, which denotes the adjustment of investment to deviations of the rate of growth of demand for labour from the supply of labour, and α the response of technological change to the same deviation. If technological change is not very responsive to conditions in the labour market, α will be close to zero, a will adjust very little, so that the economy will move from point x back to a point close to E. If, on the other hand, investment is not very responsive—because of the rigidity of wages and prices or because of slow adjustments in investment to asset market conditions, or because government policy is not contractionary when the economy begins to heat, θ will be close to zero, and γ will adjust very little, and the economy will move from point x to a point on the $\hat{\gamma} = \hat{a} = 0$ line vertically above x. Thus, the path of the economy will depend on the technological responsiveness of the economy (captured by α) and by the policy stance of the government and by labour and asset market characteristics (captured by θ).

The model thus implies that, in general, autonomous government policy changes will have long-run growth effects, provided that the technological system of the economy is responsive to changes in labour market conditions to some degree. The standard neoclassical-synthesis model in which the economy always returns to the same natural rate of growth unless there is an autonomous change in productivity growth, is a special case in which technological change is not responsive at all, or highly unresponsive in comparison to changes in investment.

Further Discussion

This section discusses three issues related to the model of the previous section. First, it examines the generality of its results by briefly discussing a modification of it. Second, it relates the model to some related theoretical models. Finally, it relates the model to some empirical results.

A Modification

It was noted earlier, in the third section, that the long-run equilibrium in the aggregate supply model did not imply a unique full employment rate of employment, since changes in the investment parameter depend not on the level of unemployment, but on changes in it. This property is also present in the model of previous section, which shares the same assumption about changes in the investment parameter. If the arguments in favour of hysteresis in labour markets and the nature of policy responses in response to changes in the unemployment rate discussed in the third section are not found convincing, we can alternatively assume that the investment parameters depend on the *level* of the unemployment rate rather than its rate of *change*, as assumed in equation (5). Wage and policy changes occur when the unemployment rate differs from the natural rate. In this case we replace equation (5) with

$$\hat{\gamma} = f(e), \qquad f' < 0, \qquad f(e_N) = 0, \tag{10}$$

where $e = L/N$ is the employment rate, with L and N being the levels of employment and labour supply, respectively, and e_N is the natural rate of employment. We also modify the assumption about technological change to reflect labour shortages as measured by the *levels* of labour supply and demand rather than rates of change in the employment rate, so that we have

$$\hat{a} = h(e), \qquad h'(\cdot) < 0, \qquad h(e_N) = 0, \tag{11}$$

where at the natural rate of employment, at which there is no shortage of slack in the labour market, the rate of productivity growth becomes constant.

Because $e = uK/N$, defining $k = K/AN$, we have

$$e = uk. \tag{12}$$

Substituting from equations (3) and (12) into equation (10) we can write

$$\hat{\gamma} = f(\gamma\, k \,/\, (s - \beta)), \qquad f' < 0, \qquad f(e_N) = 0 \tag{13}$$

Equation (11) implies that a changes according to

$$\hat{a} = h(\gamma\, k \,/\, (s - \beta)), \qquad h'(\cdot) < 0, \qquad h(e_N) = 0, \tag{14}$$

The definition of k implies

$$\hat{k} = g - n - a, \tag{15}$$

so that, substituting from equation (4) we get

$$\hat{k} = [s\,\gamma \,/\, (s - \beta)] - n - a \tag{16}$$

We therefore obtain a three-dimensional dynamic system involving γ, a and k given by equations (13), (14) and (16). A glance at equations (13) and (14) reveals that this model again produces a zero-root system with a continuum of equilibria. Provided that h' is not too large it can be shown that the equilibria is stable, and that an initial increase in γ will result in a long-run equilibrium value of γ that will increase the rate of growth of the economy in the long run.[23] The results of our simple model with hysteresis in unemployment therefore carry over to this model. We do not have hysteresis in unemployment, but continue to have hysteresis in growth rates.

Relation to Theoretical Literature

The criticism that mainstream growth theory ignores aggregate demand considerations, and the attempt to introduce such considerations into growth models in which supply factors play a role, for instance, by insisting that the rate of unemployment must be constant in long-run equilibrium, are not new. It is, indeed, commonplace among post-Keynesian economists to denigrate neoclassical and new growth theory for neglecting aggregate demand (see, for instance, Palley (1996), Setterfield (2002, 2003) and Dutt (2003), among others), and some have also been critical of the post-Keynesian neglect of the supply side and tried to introduce it into post-Keynesian growth models (see, e.g. Palley, 2003). Although the recognition of the neglect of aggregate demand is rarer among mainstream growth theorists, there have even been some attempts to introduce demand-side factors into new growth theory models.

Cornwall has made pioneering contributions on the issue from the post-Keynesian perspective. Cornwall (1972) points out that aggregate demand is the proximate source of growth of output, and that supply-determined potential output adjusts to it, through the operation of Say's law in reverse. Cornwall (1977) focuses on the adjustment of labour supply to the growth of demand for labour, in the short run because of changes in the labour force participation rate and in the longer run because of regional migration patterns. Labour allocation across sectors in which the levels and rates of growth of productivity differ can also allow total labour supply in effective units to adjust to labour demand (Cornwall & Cornwall, 1994). While this analysis is insightful, and is in the spirit of the analysis of the present paper, it does not provide an explicit model of growth in which aggregate demand affects the rate of growth of the economy in the long run.[24] Palley (2003) illustrates Cornwall's approach by drawing the aggregate supply growth curve (which shows the dependence of aggregate supply growth on aggregate demand growth) to coincide with the 45° line (which shows aggregate demand growth) for at least a stretch of the aggregate supply growth curve. This shows that if aggregate demand growth is exogenously increased, it leads to a growth in aggregate supply. However, the determinants of aggregate demand and aggregate supply growth are not discussed. The model of this paper explicitly examines the dynamics of how aggregate demand growth changes the rate of actual output growth, and how aggregate supply considerations adjust over time to bring aggregate supply growth in line with aggregate demand growth in long-run equilibrium. The model also shows that aggregate demand factors alone do not determine growth, so that Say's law does not exactly operate in reverse, since aggregate demand expansion may not necessarily bring forth a completely accommodating increase in aggregate supply.

Palley himself has made several attempts to integrate aggregate demand and aggregate supply. Palley (1996) presents models that introduce aggregate demand issues in neoclassical growth models. When aggregate demand is introduced into these models without endogenizing technological change—by introducing an independent investment function and asset market considerations—the steady state rate of growth is given by supply-side factors. These results are comparable to those in the third section, in which despite the introduction of an independent investment function, growth is supply determined, although our analysis is considerably simplified by keeping asset markets behind the scenes. When it comes to models with endogenous technological change, in which aggregate demand affects the steady state rate of growth, Palley does not explicitly relate short-run market clearing with output and employment adjustment in the standard Keynesian manner. Instead, he first treats demand growth as a state variable which drives investment which, through capital accumulation and induced technological change, drives output growth, and then makes demand growth adjust to deviations between actual growth and demand growth.[25] This analysis is problematic because it leaves unclear the relation between output levels and output growth rates,[26] it does not incorporate saving behaviour (seeming to simply reinterpret the mainstream saving function as a Keynesian investment function), does not discuss why aggregate demand deviates from output at a point in time, and does not examine the dynamics of unemployment. The model of this paper overcomes all these problems by explicitly examining short-run market clearing equilibrium and relating it to the rates of output growth, and analyzing how the unemployment rate evolves through time, becoming constant in steady state. The implications of the models are also strikingly different. In Palley's analysis it is not possible to continuously shift the growth equilibrium by demand adjustment, while in the analysis of the present paper, it is.[27] Palley (2003) provides a general discussion of the role of aggregate demand and aggregate supply in a growth context, but confines attention to the rates of growth of aggregate demand and aggregate supply in steady state, leaving the dynamics of the model completely unclear. He then refers to his earlier models discussed earlier, the problems of which have already been discussed.[28] Our model does not make a priori assumptions about steady state aggregate supply and demand growth functions, but examines the evolution of growth paths and analyzes the factors determining the long-run rate of growth at steady state.

Almost all mainstream analyses of growth along neoclassical lines, as mentioned earlier, ignore aggregate demand considerations from the start, assuming that saving and investment plans are identical and that factor prices, including the wage, are perfectly flexible. There are a few exceptions, however. Hahn & Solow (1995) and Ono (1994) develop models that may be called neoclassical because they have optimizing agents of the overlapping generations or infinitely lived types, in which aggregate demand plays a role in determining equilibrium. However, they do not require long-run growth to occur with aggregate supply and aggregate demand growing at the same rate. They also do not incorporate technological change. Martin & Rogers (1997) and Blackburn (1999) develop stochastic growth models with endogenous technological change along new growth theory lines. Martin and Rogers assume that production increases proportionately with the amount of human capital, and that the stock of human capital increases with the flow of effective labour as a result of learning by doing (with non-diminishing returns). Introducing stochastic productivity (or demand) shocks in a model in which workers maximize an infinite horizon expected utility function, by choosing labour and consumption, they show that if future benefits of learning by doing are not fully internalized by workers, opportunities for human capital accumulation are foregone during recessions. Stabilization policy, in which the government budget satisfies an intertemporal budget constraint, is found to increase growth and welfare by avoiding losses in productivity growth during recessions. Blackburn develops a model of an imperfectly competitive economy with nominal rigidities (as in new Keynesian macromodels with nominal rigidities) and endogenous technology in which temporary demand shocks can have long-run growth effects. Productivity growth in this model takes place as a result of learning by doing, which depends on the level of employment. Thus, contractionary stabilization policy can reduce long-run growth by reducing learning by doing. The model of this paper is closely related to these models, especially to Blackburn's, which introduces unemployment owing to nominal rigidities. However, the Martin & Rogers, and Blackburn models focus on the implications of stabilization policy using specific intertemporal choice or new Keynesian models and new growth theory learning by doing assumptions, while our model uses a very simple growth-theoretic formulation in which there are short-run deviations from full employment owing to wage–price rigidities, and in which technology responds to labour shortages.

Empirical Issues

A number of empirical studies are consistent with the theoretical implications of the model of this paper. Models that imply a natural path for output imply that the economy reverts to its normal output path after demand shocks: output is trend stationary in the language of the empirical literature on growth and economic fluctuations. Our model, however, does not imply such a natural path from the economy, because demand shocks can move it to a different path. The large empirical literature tends to support the conclusion of Nelson & Plosser (1982), that is, real output levels feature a unit root and are therefore non-stationary (see Dutt & Ros, 2005, for further discussion). The empirical claim has not gone uncontested, however: there is some evidence that the unit root hypothesis for real output levels is rejected more frequently when allowance is made for a structural break in the deterministic trend, but because the structural breaks could have been caused by occasional demand shocks, these results are not inconsistent with our model either. More direct evidence on the long-run growth effects of aggregate demand changes is provided by Leon-Ledesma & Thirlwall (2002). They use data from 15 OECD countries over the period 1961–1995 to show that their estimated natural rate of growth responds to the actual rate of growth and that input growth is Granger-caused by output growth even when there is no bi-directional causality (as is usually present) between input and output growth.

It should be noted that these empirical findings do not unequivocally prove that aggregate demand has long-run growth effects, because the results are consistent with supply-side technological shocks as well. Indeed, much of the empirical work on unit roots is produced by proponents of real-business cycle theories who make the case for technology shocks have long-term effects, rather than resulting in a deterministic trend as argued by mainstream Keynesian models in which output grows at a given natural rate in the long run. However, these findings are certainly consistent with notion that aggregate demand changes have permanent long-run effects on the growth path of the economy.

Conclusion

This paper has developed a simple model with endogenous technological change in which aggregate demand and aggregate supply both have a role to play and in which long-run growth can be affected by aggregate demand.

The model can be thought of as synthesizing the roles of aggregate demand and aggregate supply. The importance of aggregate demand forces in obvious: aggregate demand (in the sense of exogenous changes in investment demand or changes in government policy) affects the long-run rate of growth. The role of aggregate supply can be seen from the fact that if technology is not sufficiently responsive to aggregate demand changes, as shown by a low technology parameter in the model developed here, the impact of aggregate demand expansion will be limited or completely nullified.

The model can also be thought of as synthesizing the contributions of three strands of growth theory, that is, neoclassical, new growth, and Keynesian growth theory. As implicitly done in neoclassical growth theory, there are forces that push the actual growth rate of economy towards the natural rate of growth of the economy determined by labour supply growth, as captured by the equation for investment dynamics. As explicitly done in new growth theory, technological change is endogenized, and this plays a vital role in allowing aggregate demand to affect economic growth in the long run. Following Keynesian growth theory, aggregate demand is explicitly introduced into the model and has a long-run effect on growth.

The main theoretical implication of the paper is to emphasize the role of aggregate demand as a determinant of long-run growth. It is only with extreme assumptions about the nature of technological change that aggregate demand has no effect in determining long-run growth. Thus, the almost complete neglect of aggregate demand in mainstream growth theory is unwarranted. While this neglect was explicitly acknowledged by early neoclassical growth theorists like Solow (1956), new growth theory has ignored it by default. To the extent aggregate demand is an important determinant of long-run growth, we can rely on many of the results of post-Keynesian and structuralist growth theories, which have been ignored in mainstream growth theory, in understanding growth: for instance, it is possible for income distributional improvements to increase the rate of economic growth, as well as for expansionary fiscal and monetary policy to have a positive effect on growth. Moreover, there can be no sharp division between short-run and long-run macroeconomics: for instance, financial crises can have adverse long run consequences.

Because the model of this paper suggests that the long-run growth rate of the economy depends on the dynamic path of the economy, our analysis has the further implication that history and its study should complement theory in the analysis of growth.

The model, especially given its empirical plausibility, also implies that growth policy will have to pay more careful role to aggregate demand. Simple-minded efforts to increase the saving rate and cutting government deficits to increase the rate of economic growth will have to be rethought. The effects of such policies, by reducing aggregate demand, may well be to depress long-run growth. Moreover, contractionary fiscal and monetary stabilization policy in response to crises may well have long-run depressive effects that may exacerbate the effects of the crisis itself. Finally, policies to check the growth of aggregate demand during expansion without clear signs of strong inflationary tendencies may have unnecessary costs in terms of long-run growth rates. This is not to imply, however, that in reality growth can be indefinitely increased by expanding aggregate demand: it is necessary to deal with supply-side factors such as the responsiveness of technological change.

Our analysis suggests a number of directions for future work. First, we have used a simple model in which technical input–output coefficients are given at a point in time, and excess capacity is allowed to prevail even in long-run equilibrium. Allowing factor substitution and endogenously determining desired capital-output ratios may make the model more palatable to those who are troubled by these simplifications. Second, our treatment of asset market considerations has been of a reduced-form type, in which (for instance) labour market conditions are taken to affect investment in the neoclassical synthesis manner without explicitly examining the asset market and the interest rate. It is possible that incorporating asset markets explicitly can yield useful insights. Finally, our analysis assumes a particular type of endogenous technological change, without explicit formalization of the mechanisms by which it occurs. Future work can analyze and explore these mechanisms more carefully, both theoretically and empirically, and analyze whether other related ways of endogenizing technological change will yield similar results.

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Notes

1. Just a few new growth theory models, referred to later, have some role for aggregate demand.
2. The difference between the two types of theories lies in *which* aggregate supply factors affect the long-run rate of growth of the economy. Thus, the saving rate affects the long-run growth rate in new growth theories, but not in the Solow model.
3. Unemployment can occur in the economy even without any distinction being made between saving and investment plans, for instance, with the rigidity of the real wage. In this paper the essence of the aggregate demand problem relates to the distinction between planned saving and investment, which brings about adjustments that take the economy away from its supply constrained growth rate.
4. In recent textbooks, including Barro & Sala-i-Martin (1995), Aghion & Howitt (1998), and Jones (1998), however, models incorporating aggregate demand are non-existent. Indeed, the Harrod model is transformed into a Solow model with fixed coefficients!
5. These models have been called neo-Keynesian (see Marglin, 1984; Dutt, 1990), post-Keynesian (see Lavoie, 1995), and structuralist (see Taylor, 1991, 2004).
6. See, for instance, Dutt (1984, 1990), Lavoie (1992), Rowthorn (1982) and Taylor (1991, 2004).
7. Some models—see Rowthorn (1982) and Dutt (1990), for instance—assume that investment depends positively on technological change. In these models an increase in the rate of technological change can—but need not, if the response of investment to technological change is small—increase the rate of growth of per capita output. But it does so by increasing aggregate demand, and not because it increases aggregate supply. We abstract from these considerations for simplicity. Our subsequent analysis of the dual-sided relationship between investment and technological change dynamics would not be qualitatively affected by its incorporation.
8. Lavoie (2003) discusses a variety of other mechanisms by which actual and desired or targeted rates of capacity utilization can be brought into equality while allowing the actual (and desired) rate of capacity utilization to be endogenous in the long run.
9. Take this mechanism to be income distributional changes, and assume, as in Kaldor–Pasinetti models that there are different saving propensities out of wage and profit income. For simplicity, assuming that wage income is entirely spent, and the fraction of profit income saved is s_π, and the profit share is σ, saving is given by $S/K = s_\pi \sigma u$, and investment by $I/K = \gamma + \beta u$. With u being at an exogenously given full capacity utilization level, u^*, $g = I/K = \gamma + \beta \beta u^*$, to which S/K adjusts because of variations in σ. This is basically Robinson's (1962) growth model. Thus output growth depends on the parameters of the investment function, and there is no reason for output growth and hence employment growth to be equal to the rate of growth of labour supply.
10. These do not exhaust possible mechanisms. An alternative mechanism is suggested by Kaldor (1959), who assumes that, in the long run, changes in output and income result in a larger change in investment than in saving, so that excess demand leads to a cumulative increase in output till full employment is reached.
11. A rise in γ reduces $d\gamma/dt$, as required for stability.
12. Full employment here can be generalized to a natural rate of unemployment or a NAIRU rate.
13. See for instance, Blanchard & Summers (1987), Price (1988), and Dutt & Ros (2006).
14. An alternative expression of this given by the equation $a = \zeta(L/N)^\alpha$, where ζ is a positive constant, and where L and N refer to employment and labour supply, which shows that labour productivity growth depends positively on the employment rate. I am grateful to Jaime Ros for this interpretation.
15. Technological change, of course, can be endogenized in a number of alternative ways, including Kaldor's (1957) technical progress function. The implications, however, are not always the same, as pointed out in note 22 below.
16. Although we do not introduce the wage rate explicitly into the analysis, it is consistent with the notion that labour shortages exert an upward pressure on the wage, which leads to labour saving technological change. For empirical analysis using US data consistent with this view, see Marquetti (2004).

17. I am grateful to Robert Blecker for pointing out that these ideas are supported by the research of Rosenberg (1994).
18. The model can easily be extended to incorporate profit-seeking research and development expenditures and learning by doing, as in standard new growth theory models, without altering the conclusions. The approach is also consistent with a human capital interpretation. A more rapid rate of growth of labour demand exerts upward pressure on the real wage (which is not explicitly incorporated in the model), inducing workers to obtain more education to take advantage of the higher wage of skilled workers who have more effective units of labour, thereby increasing the rate of technological change.
19. See Gandolfo (1971), for instance. I am grateful to Amit Bhaduri for suggesting this method of analyzing stability.
20. This is clearly not the only zero root model or even growth model available in the literature. Within the post Keynesian tradition, see Dutt (1997) for a discussion of two models, one involving the interaction between changes in short and long period expectations, and one involving the endogeneity of the desired rate of accumulation owing to the threat of entry of firms. These models, however, do not address the issue of the long-run constancy of the unemployment rate, which is the main issue of the present model.
21. It is implicitly assumed that γ has two (multiplicative) components, one of which is a parameter, and the other adjusts according to (5).
22. Other ways of endogenizing technological change can also have similar implications (see Dutt, 2005). The Kaldorian technical progress function, which makes the rate of labour productivity growth depend on the rate of growth of the capital–labour ratio (that is, on capital deepening), however, does not have the implication that aggregate demand affects the long-run rate of growth as long as the function has a slope of less than one, as assumed by Kaldor (1957). With a slope equal to one (so that there are no diminishing returns to capital deepening) aggregate demand does affect long-run growth.
23. The trace of the system is given by $f' \; k/(s–\beta \; \beta) < 0$, and the sum of the principal diagonal minors is given by $[\gamma \; /(s–\beta \;)][h'–f' \; (s/(s–\beta \; \beta))]$. Since stability requires that this is positive, we require h' to be small. Note that the determinant is zero, which makes the system lack a unique equilibrium. The model is discussed in more detail in Dutt (2005).
24. Allowing both a and n to adjust (the latter as a result of labour inflow from the subsistence sector) can provide some interesting insights. A large response in n will slow down the response in a, reducing the impact of an increase in aggregate demand on the rate of growth of per capita income.
25. A more complex version of the model presented in Palley (1997) proceeds along essentially similar lines and suffers from the same problems.
26. One version of the model in Palley (1996) attempts to introduce excess demand levels into the analysis by making excess demand affect investment and technological change, but it is unclear what determines output and aggregate demand, and hence excess demand in the first place.
27. Palley's models also implies that Kaldorian technological change assumptions can imply that aggregate demand affects growth in the long run. Our analysis can be shown to imply that this is not the case—see Dutt (2005).
28. Palley (2003) also discusses a balance of payments constrained model. This model leaves unclear many issues, but because it departs from the closed economy framework of the present paper, is not discussed here.

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