Real Business Cycle Theory

Paul Scanlon

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1 Introduction

The emphasis here is on technology/TFP shocks, and the associated supply-side responses. As the term suggests, all the shocks are real, not nominal. As we know from the Solow model, total factor productivity, A, was central to maintaining sustained economic growth. This theory takes the view that if A is so important in the long-run, then surely, isn't it likely A will be important in the short run too? Recall from the Solow model how we assumed A grew at some constant rate, say 2%, in the long run. But why should the growth of A be so smooth? Imagine A starts growing above trend, say at 4%, for a couple of years. How should this affect the economy? This is the question RBC theory addresses. Remarkably, temporary but somewhat persistent fluctuations in technology, A, *lead to exactly the kind of business cycles we see in the data.* The real business cycle model can replicate business cycle fluctuations without *any* reference to demand, Keynes, sticky prices, or the money supply.

1.1 Introduction

As in the last model, I will only restrict myself to the case of a boom, but, by symmetry, the opposite occurs in a recession. For attaining intuition, I think it's useful to think of A being constant at potential and then rising for a few periods.

In the model, the constant returns to scale production function is Cobb-Douglas:

$$Y = A_t K_t^{\alpha} L_t^{1-\alpha}.$$

The main player in the model is technology, A (as is ultimately the case in the Solow model). Yet A should be interpreted broadly. It is anything that changes the level of production, Y, for any given K and L. For instance, it could incorporate inventions, oil shocks, weather, regulation, financial intermediation, and so on. Formally, A is a random variable that follows a stochastic process: A is related to its previous value, but there is some random element added on. This causes shocks to A to be *persistent*; i.e., a high A today will lead on average to a high A tomorrow. For example, the steady state value of A might be 1. Then this period A might rise to 1.5; then next period it will be 1.3, then 1.2, and so on; after a few periods A will revert to its steady state value of 1 again.

Ignoring government and net exports, in the model we have

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} = C_t + I_t.$$

Here, the sources of demand are C_t and I_t. As A_t varies, so does potential. In stark contrast to the previous model, demand will always sum to potential output (and the interest rate will always equal its natural rate.) According to the model, prices are flexible so all prices adjust to clear the goods market; hence demand always equals supply. Yet how the composition of output changes over the business cycle *is* important. To give an example, suppose there is a once-off rise in A, but

A will revert to trend next period. Clearly the rise in A causes output, Y_t, to rise. Now ask yourself? By the permanent income hypothesis, what will happen? *Because the change is temporary, most of the output will be saved in accord with the permanent income hypothesis.* As in the Solow model, those savings are then used for investment. So what will happen is consumption will rise a little, but investment will rise a lot. For this reason, the model predicts moderately procylical consumption, but highly procyclical investment. Moreover, because investment rises this period, the capital stock will be higher *next period.*[1] This then will lead to more consumption and more investment next period, and so on. For this reason as well, economic fluctuations will be *persistent,* as they are in reality.

There is more. As we shall see, the wage will equal the marginal product of labour, $\frac{\partial Y}{\partial L}$. But this is increasing in A_t. As a result, the temporary rise in A will also lead to a rise in the marginal product of labour: in turn, this raises labour demand and the real wage. This induces the intertemporal substitution of labour, causing labour supply to increase. So from the production function, Y gets another "kick" from this increase in L.

Another important feature of the model is the fact that the jump is A is temporary but modestly persistent. Say A usually grows at a rate of 2%. Then a "technology shock" would (say) cause A to grow at 4% in year one, 3% in year two, but would revert back to 2% in year three. Why do shocks have to be persistent? See, if shocks were just completely once-off, then almost all of the extra income would be saved when the shock hit. Remember the consumer is maximizing lifetime utility, so a temporary shock would only increase lifetime wealth—which, by the PIH, is what determines consumption in each period by the PIH—by a little. To generate fairly procyclical consumption, as in the data, lifetime wealth must increase modestly.

[1]Recall that $K_{t+1} = I_t + (1 - \delta)K_t$. In the first period, the capital stock is *predetermined.*

This is why the shock to A must be persistent; namely, it must make the consumer feel moderately richer, but not *that* much richer. I should add that, in reality, it does seem to make sense that any change in A would last a few years. Whether the change is from innovation or a government policy, it seems plausible shocks to A would last a few periods.

Implicit in the reasoning above is the idea of strong and weak income and substitution effects. To induce a rise in both labour supply today and saving today, the income effects associated with the technology shocks must be small. In contrast, the substitution effects must be large; this is what prompts the consumer to "make hay while the sun shines." By analogy with savings, if the wage rose permanently, then labour supply could in fact *fall* as a result of the technology shock (i.e., if the income effect was sufficiently strong). Again, the temporary nature of the shocks attenuates the strength of the income effects and reinforces the substitution effects.

Particularly important are the two key propagation mechanisms in the model: the *intertemporal substitution of labour* and *capital accumulation*. What I mean by a propagation mechanism is the model's internal way of amplifying the shock. In the New Keynesian model, what amplified shocks—and hence acted as a propagation mechanism—was the fact prices were sticky.[2] Analogously, there are two key mechanisms here. First, consumers increase labour supply in response to a rise in the real wage. Because the technology shock also raises the marginal product of

[2]The so-called *financial accelerator* acts as another propagation mechanism in the New Keynesian literature (though not in the simple version we studied.) Namely, increases in asset values in booms—as a result of lower interest rates—led to increases in consumers' net worth, which then induced banks to increase lending. This imparted a "multiplier effect" to any fall in interest rates. As we also say, for firms that were borrowing, this also attenuated the rise in firms' marginal costs in booms. For this reason, the financial accelerator increased the degree of real rigidity in the economy.

capital—and hence the natural rate of interest—consumers will also worker since they can now earn a greater return by purchasing capital and renting it out *next period.*[3] Second, because investment today leads to more capital tomorrow, it causes higher output again tomorrow. In turn, this leads to more investment. In addition, as we know from last year, a greater capital stock raises the real wage, so this was induce more labour supply next period.

2 The Model

The representative consumer (or household) maximizes

$$E_0 \sum_{t=0}^{t=\infty} \beta^t \left(\log C_t - \frac{l_t^{1+\sigma}}{1+\sigma} \right)$$

where $\beta = \frac{1}{1+\rho}$, and ρ is *the rate of time preference.* The flow budget constraints each period are

$$w_t l + r_t k_t = C_t + i_t$$

$$k_{t+1} = (1-\delta)k_t + i_t$$

Everything above is in real terms. I have implicitly normalized the price level to one. Here, all saving is achieved through accumulating capital. The consumer receives income from renting out capital and from supplying labour. Note that, in any period t, the level of capital is predetermined. Investment today changes the capital stock next period. For this reason, when the consumer saves, he considers

[3] In any *given* period, the capital stock is predetermined.

the rental rate on capital *next* period, not this period. It's common too to explicitly impose a time constraint such as

$$l_t + h_t = 1,$$

where l_t refers to labour supplied in period t, and h_t (by a process of elimination) refers to leisure. Here, l refers to labour *hours*, not bodies.[4] These must add up to available time, which I assume is simply 1. Taking the the expected paths of wages and interest rates as given, the consumers maximize lifetime utility.[5] Ignore the expectation sign for now; this just arises from the fact that A is uncertain in the future, which causes uncertainty about all future variables such as C, w, and r (since, as we shall see, all variables will be functions of A.) Because this uncertainty has no qualitative effects on the dynamics, I will mostly ignore it.

Combining both constraints above gives

$$w_t l_t + r_t k_t = C_t + k_{t+1} - (1 - \delta) k_t$$

$$w_t l_t + r_t k_t = C_t + k_{t+1} - k_t + \delta k_t$$

$$w_t l_t + (1 + r_t - \delta) k_t = C_t + k_{t+1}$$

$$\underbrace{w_t l_t + (1 + r_t - \delta) k_t}_{sources} = \underbrace{C_t + k_{t+1}}_{destinations}$$

[4] *Realistically*, though, there is more than one person in any economy, so the proper measure of labour supply is lN, where l denotes labour hours per person, and N the number in employment. To derive the theoretical results, I will assume only a single person, but keep in mind that lN is the true variable that represents labour supply at the aggregate level.

[5] This just means that when a worker increases labour supply, he doesn't internalize the fact that the increase in supply will tend to lower the real wage at the national level. Pretty realistic, I think.

The Lagrangian is then

$$L = \sum_{t=0}^{t=\infty} \beta^t \left(\log C_t - \frac{l_t^{1+\sigma}}{1+\sigma} \right) + \sum_{t=0}^{t=\infty} \lambda_t \left(w_t l_t + (1+r_t)k_t - C_t - k_{t+1} \right)$$

Maximizing w.r.t C_t gives

$$\beta^t \frac{1}{C_t} - \lambda_t = 0 \Rightarrow \beta^t \frac{1}{C_t} = \lambda_t. \tag{1}$$

Maximizing w.r.t C_{t+1}

$$\beta^{t+1} \frac{1}{C_{t+1}} - \lambda_{t+1} = 0 \Rightarrow \beta^{t+1} \frac{1}{C_{t+1}} = \lambda_{t+1} \tag{2}$$

Maximizing w.r.t l_t gives

$$-\beta^t l_t^\sigma + \lambda_t w_t = 0 \Rightarrow \beta^t l_t^\sigma = \lambda_t w_t \tag{3}$$

Maximizing w.r.t l_{t+1} gives

$$-\beta^{t+1} l_{t+1}^\sigma + \lambda_{t+1} w_{t+1} = 0 \Rightarrow \beta^{t+1} l_{t+1}^\sigma = \lambda_{t+1} w_{t+1} = 0 \tag{4}$$

Maximizing w.r.t k_{t+1} gives

$$-\lambda_t + \lambda_{t+1}(1 + r_{t+1}) = 0 \tag{5}$$

Finally, we have the usual transversality condition:

$$\lim_{t \to \infty} E_0 \beta^t u'(C_t) k_t = 0$$

Basically, if we value consumption at “the end” (i.e., $u'(C_t) > 0$), then we shouldn’t leave capital left over. Instead, we should eat it.

2.0.1 Solution under Certainty

It is convenient to to set $\delta = 0$, so you can think of r_t as the real return *net of depreciation*. Maximizing this via Lagrangians gives the usual Euler equation and the labour/leisure optimality conditions. Combining (1), (2), and (5) gives the Euler equation

$$u'(C_t) = E_t\beta(1 + r_{t+1})u'(C_{t+1}).$$

And since $u(C_t) = \log C_t$

$$\frac{1}{C_t} = E_t\beta(1 + r_{t+1})\frac{1}{C_{t+1}}.$$

Implicitly gives C_t and savings in each period (which in turn will determine the consumer's level of investment). Temporary rises in interest rates will cause consumption to fall and savings to rise, leading to more investment. This implicitly gives the household's optimal consumption path, and hence savings. Note that the interest rate that appears here is r_{t+1}. In this model, the household earns income by investing and then renting out the capital *next* period. In any given period, you see, the level of capital is predetermined. But if the rental rate rises next period, the household will respond to that *today* by reducing consumption and investing. Keep in mind, then, that the Euler equation above gives us information about savings and *investment*. For a given level of income, if consumption falls, for example, then investment must rise.

Combining (1) and (3) gives the labour/leisure optimality condition

$$w_t u(C_t) = v'(l_t)$$

Or more explicitly

$$\frac{w_t}{C_t} = l_t^{\sigma} \tag{6}$$

Implicitly, this gives labour supply (or leisure demand, $h_t = 1 - l_t$.)

2.1 Intertemporal Substitution of Labour

Iterating forward (6) (or combining (2) and (4)) gives

$$\frac{w_{t+1}}{C_{t+1}} = l_{t+1}^{\sigma}$$

Then dividing this by

$$\frac{w_t}{C_t} = l_t^{\sigma}$$

gives

$$\frac{l_{t+1}^{\sigma}}{l_t^{\sigma}} = \frac{w_{t+1}}{w_t}\frac{C_t}{C_{t+1}} \tag{7}$$

Ignoring uncertainty, the Euler equation is

$$\frac{1}{C_t} = \beta(1 + r_{t+1})\frac{1}{C_{t+1}}.$$

To see the idea here, set $\beta(1 + r_{t+1}) = 1$. Then (7) becomes

$$\frac{l_{t+1}^{\sigma}}{l_t^{\sigma}} = \frac{w_{t+1}}{w_t},$$

and finally we get

$$\frac{l_{t+1}}{l_t} = \left(\frac{w_{t+1}}{w_t}\right)^{\frac{1}{\sigma}}.$$

This has a nice interpretation. Before going on, note that the consumer likes to smooth labour over time (as with consumption) due to increasing marginal disutility. But just as the consumer is "seduced" into deviating from the optimal path via interest rate changes, the consumer will also deviate from smooth labour supply in response to fluctuations in wage changes. In other words, this is just like an Euler equation for labour. And just as the θ parameter mediated the response of consumption to interest rate changes, the σ does the job here. What it means is the consumer will spread labour over time in response to changes in wages. For example, if the wage increased today relative to tomorrow, the consumer would increase labour supply today relative to tomorrow. But if the wage increased proportionally in *both* periods, there would be no change in relative labour supplies between both periods. In the RBC model, this condition is important. Namely, when A increases temporarily, the wage will also increase. And because the increase is temporary, labour supply will increase this period relative to the next one (or more generally, future ones). Observe too that a high σ will attenuate the degree of *intertemporal substitution of labour.*

2.1.1 Intertemporal Substitution and Interest Rates

So far, I have set $\beta(1 + r_{t+1}) = 1$. But more generally, when $\beta(1 + r_{t+1}) \neq 1$, we get

$$\frac{l_{t+1}}{l_t} = \left(\frac{w_{t+1}}{w_t} \frac{1}{\beta(1 + r_{t+1})} \right)^{\frac{1}{\sigma}}$$

In this case, the rise in the interest rate in period $t + 1$ will raise labour supply today. Think of it this way. A rise in the rental rate means there are more profits to be made from renting out capital next period. In response to this, the consumer should increase investment *this* period. And one means of doing this is to earn more income *today* (by working more) and using that income for investment *today.*

Another way of saying this is the higher rental rate next period raises the return to working this period; in other words, it acts like an increase in the wage.

2.1.2 Labour Supply Levels

Let's talk about the *level* of labour supply for a moment. For now, ignore interest rates. When $u(C_t) = \log C_t$, the first order condition for labour reduces to:

$$\frac{w_t}{C_t} = l_t^\sigma \qquad \Rightarrow l_t = \left(\frac{w_t}{C_t}\right)^{\frac{1}{\sigma}}.$$

This implicitly defines the household's labour supply curve. As we saw a moment ago, if the wage rises today relative tomorrow, the household will supply more labour today *relative* to tomorrow. But what about the actual *levels* of labour supply? With a transitory change in the wage in period t *only*, there are two effects. First of all, the wage, w_t rises. Second, C_t will only rise a little, and certainly less than proportionally to the rise in w_t: because of the permanent income hypothesis, that once-off increment to the wage will be smoothed over the consumer's lifetime time. As a result of both forces, the condition above implies that l_t will rise. For this reason, we can treat the relationship as an upwardly sloping relationship between l_t and w_t; i.e., the household's labour supply curve. To see what will happen in period $t+1$, consider

$$l_{t+1} = \left(\frac{w_{t+1}}{C_{t+1}}\right)^{\frac{1}{\sigma}}$$

Well, w_{t+1} didn't change. But due to the increase in w_t (the substitution effect) and consumption smoothing (the income effect), C_{t+1} will surely rise by a tiny, tiny bit. As a result, l_{t+1} will fall by a tiny bit. Overall, therefore, l_t will rise a lot and l_{t+1} will fall a little, and so $\frac{l_{t+1}}{l_t}$ will certainly fall, as we predicted. (In fact, given the consumer is infinitely lived—and so a transitory wage increase in period t will only have a negligible effect on consumption each period—we often simply assume that l_t rises and l_{t+1} *stays the same* in response to a transitory increase in the wage in period t.) Yet looking at levels—$l_t = \left(\frac{w_t}{C_t}\right)^{\frac{1}{\sigma}}$—a permanent change in the wage will also cause C to rise permanently (both C and w will rise proportionately) and so will have no effect on levels of labour supply.

2.1.3 Timing

Next, I turn to timing. According to RBC theory, the real wage rises in period t due to a technology shock, but stays higher than normal for a few periods. Because the technology shocks are persistent, A—and hence the wage—stays above trend for a few periods. In addition, the increase in A induces an increase in savings and capital accumulation. As we will see, this also causes the wage to rise in subsequent periods. For both reasons, once a technology shock strikes, the wage will remain above trend for a few periods. For example, the time series for the wage could be $\ldots, 10, 10, 100, 70, 50, 10, 10, 10, 10, \ldots$. In this case, the labour supply will jump up in period 3 and will remain above trend until period 6. Naturally, the level of labour supply in period 3 will be the greatest. Labour supply will revert to its long-run trend in period 6.

3 The Firm

Firms hire labour and rent capital from the household. To determine equilibrium wages and rental (interest) rates, we must look at the firm's optimization problem. In contrast to the New Keynesian model, the firm here is perfectly competitive and does not choose prices. As in perfect competition, the firm is a price taker. I normalize the constant price level to 1. All the firm does is choose the optimal combination of labour, L, and capital, K, in the production process.

The production function is Cobb-Douglas:

$$Y = AK^{\alpha}L^{1-\alpha}.$$

Ignoring time subscripts, the firms profit is

$$\pi = AK^{\alpha}L^{1-\alpha} - wL - rK.$$

The firm has revenues of $AK^{\alpha}L^{1-\alpha}$ and costs of $-wL - rK$. As already noted, I have normalized the price to one, so w and r refer to the real wage and real rental rate, respectively. The firm's revenues are then simply price times quantity produced, which is obviously just equal to quantity produced, $AK^{\alpha}L^{1-\alpha}$. Note that the levels of capital K and labour L the firm will hire do not necessarily equal the level of capital and labour supplied by the household (k and l respectively.)[6]

3.0.4 Labour Demand

$$\frac{\partial \pi}{\partial L} = (1-\alpha)AK^{\alpha}L^{-\alpha} - w = MPL - w = 0$$

$$\Rightarrow w = (1-\alpha)AK^{\alpha}L^{-\alpha} = MPL \tag{8}$$

As always, the first order condition gives the optimal rule for the firm—in this case the optimal hiring rule. This means that the firm will hire labour up until the wage equals the worker's marginal product of labour. If the marginal product exceeded the wage, the firm would hire more workers (and vice versa). Manipulating the condition above gives an explicit equation for the firm's optimal level of labour demand, L^d:

[6] Yet this will be true in equilibrium.

$$L^d = \left(\frac{(1-\alpha)AK^\alpha}{w}\right)^{\frac{1}{\alpha}}.$$

As we'd expect, labour demand is decreasing in the real wage—so for a given K and A, this defines a downwardly sloping labour demand curve. Importantly, labour demand is increasing in the level of A and the level of K; these variables will shift the labour demand curve.[7] Increases in these variables make workers more productive, and hence raise the attractiveness of hiring more people. Especially important for RBC theory is that a technology shock—a sudden jump in A—will *raise* labour demand.

3.0.5 Capital Demand

To obtain the optimal level of capital hired, we get:

$$\frac{\partial \pi}{\partial K} = \alpha A K^{\alpha-1} L^{1-\alpha} - r = MPK - r = 0$$

$$\Rightarrow r = \alpha A K^{\alpha-1} L^{1-\alpha} = MPK \tag{9}$$

This optimal rule dictates that the firm should hire capital until the marginal product of capital equals the rental rate the firm faces. Manipulating the conditions above gives capital demand, K^d:

$$K^d = \left(\frac{\alpha A L^{1-\alpha}}{r}\right)^{\frac{1}{1-\alpha}}$$

A rise in A will raise the level of capital demanded. Namely, A makes capital more productive (computers, say, are more powerful now), making firms want more

[7] In this perfectly competitive environment, we assume the firm can always sell more of its product; consequently, and in contrast to the NK model, demand for its product has no direct effect on labour demand.

capital. An increase in labour, L, will also increase capital demanded. With more workers, each machine now becomes more useful—making firms want more of them.

3.1 General Equilibrium

As shown, labour and capital demand come from *firm.* Labour and capital supply comes from the household. To obtain market clearing (or general equilibrium) prices, we combine both sides of the market. Keep in mind that, in their decisions, the household and the firm takes the wage and price as *given.* So the household never says: when I supply more labour, I'll push down the wage. If you think about it, this is realistic; everyone is such a small component of the market, they take prices as given.

To get the equilibrium wage we combine an upwardly sloping household labour supply curve and the downwardly sloping labour demand curve. (Note that the households labour supply curve will be upward sloping: with temporary changes in wages—in this RBC model—higher wages will increase labour supply.) Formally, we will have

$$l_t = L_t^d,$$

or

$$l_t = \left(\frac{w_t}{C_t}\right)^{\frac{1}{\sigma}} = L^d = \left(\frac{(1-\alpha)AK^{\alpha}}{w}\right)^{\frac{1}{\alpha}}$$

The interaction of both relationships will give the equilibrium wage. To derive the equilibrium rental rate, we must note that in any given period, the household's supply of capital is *fixed.* Thus to get the equilibrium rental rate, I combine the household's inelastically supplied capital supply (a vertical line) with the firms downwardly sloping demand curve. In equilibrium

$$k_t = K_t^d.$$

These relationships will give us the equilibrium levels of capital, k and labour, l, together with the market clearing wage rate, w^*, and rental rate, r^*. In particular, equilibrium production will be

$$Y = Ak^{\alpha}l^{1-\alpha}. \tag{10}$$

From (9), we have the equilibrium rental rate

$$r^* = \alpha Ak^{\alpha-1}l^{1-\alpha} = MPK \tag{11}$$

The rental rates is often simply referred to as the interest rate. And from (8), we have the equilibrium wage

$$w^* = (1-\alpha)Ak^{\alpha}l^{-\alpha} = MPL. \tag{12}$$

Finally, it is easily shown that

$$\Rightarrow w^*l + r^*k = Y = Ak^{\alpha}l^{1-\alpha} \tag{13}$$

that is, the payments to the factors of production exhaust output.

4 Long-Run Equilibrium

Assuming no steady state growth, in the long run, the labour supply of each person is constant at

$$l_t = \left(\frac{w_t}{C_t}\right)^{\frac{1}{\sigma}}.$$

If there was sustained growth in A, then this would lead to equal growth of C and w, in which case, l would still be constant. Because labour hours are approximately constant in the data, the model is therefore consistent with long-run trends.

To find the equilibrium capital ratio, look back at the Euler equation:

$$\frac{1}{C_t} = \beta(1 + r_{t+1})\frac{1}{C_{t+1}}.$$

Assuming no growth, in a steady state $C_t = C_{t+1}$, which implies that $\beta(1 + r_{t+1}) = 1$. The rental rate is also constant in steady state and from (11) equals $r^* = \alpha A k^{\alpha-1} l^{1-\alpha}$. Thus we have

$$\beta(1 + r_{t+1}) = 1 \Rightarrow \beta(1 + \alpha A k^{\alpha-1} l^{1-\alpha}) = 1 \Rightarrow \frac{k}{l} = \left(\frac{\alpha A}{\frac{1}{\beta} - 1}\right)^{\frac{1}{1-\alpha}}.$$

5 RBC: Review of Dynamics

What happens when there is a technology shock? The following outlines the central mechanisms behind RBC theory:

- Take, for example, a temporary reduction in the level of regulation. Because firms now spend less time filling out forms etc, for any given K and L, there is now more produced. As a result, total factor productivity, A, jumps up. Having rational expectations, the household and firm know this change is temporary and somewhat persistent.

- Because this raises workers' marginal product, labour demand rises, which pushes up the real wage. In response, households increase labour supply. (Remember, the emphasis in this model is *supply*, not demand.) Namely, they know this wage increase is temporary, so the substitution effect dominates. This increase in labour supply and the increase in A raises the marginal product of capital, which again raises the demand for capital, pushing up the rental rate. Additionally, the expected interest rate next period rises—the changes are persistent—next period, which also raises labour supply *this* period.

- Household income rises. Because the change is temporary, most of the increase in income is saved. Yet, since the change is persistent, consumption rises a little. Consider the usual national accounts equation, $Y = C + I$. Because Y has increased a lot—due to A and L rising—while C has only risen a little, I therefore increases a lot. Households smooth consumption intertemporally by building up their capital stock.

- The rise in I leads to more capital in the second period period. A now falls a little, but is still above trend. Meanwhile, the capital stock is now higher due to last period's investment boom. For both reasons, the wage is still above trend. As a result, labour supply remains above trend.

- Over time, A reverts to trend, and the shock "dies out." The additions to the capital stock will also depreciate, and capital will revert back to its "normal" level.[8] All the mechanisms above also die out, and the economy reverts to trend.

[8] For the higher level of capital to be maintained, the savings rate would have to rise permanently; however, because of the temporary nature of the shock, nothing happens to induce a permanent increase in savings.

6 Discussion

6.1 Empirical Evidence

Because $Y = AK^{\alpha}L^{1-\alpha}$, we can calculate A from data on output, labour and capital. We say A is the *Solow residual* from this decomposition. Empirically, growth in A is indeed associated with large fluctuations in Y. This is *a priori* evidence in favour of the RBC model, which claims *exogenous* changes in A lead to fluctuations in Y. Moreover, labour productivity, $\frac{Y}{L}$ is

$$\frac{Y}{L} = \frac{AK^{\alpha}L^{1-\alpha}}{L} = \frac{AK^{\alpha}}{L^{\alpha}}$$

According to RBC theory, therefore, labour productivity—as a result of a rising A—can indeed be procyclical as in the data. By contrast, the New Keynesian model predicts labour productivity is countercyclical: L rises, causing $\frac{Y}{L}$ to fall.

However, New Keynesians counter this by saying that A is endogenous to the cycle. For example, if there were increasing returns, A would rise endogenously in a boom. In such a case, the boom would *cause* the change in A. (This is the usual reverse causation problem that plagues econometric work.) Take, for example, a restaurant. At lunch time, there's surely an increase in effort by the staff. But would we say some "technology shock" is causing the increase in output. Hardly. Rather, we'd say the increase in demand is *causing* the increase in output. Output is rising since the staff are now surely working a lot harder. Specifically, New Keynesians say labour and capital utilization rises in booms. More formally, Keynesians claim the production function should really take the form

$$Y_t = A_t(u_tK_t)^{\alpha}(u_tL_t)^{1-\alpha},$$

where u refers to the level of utilization or "effort." For any given L and K, a rise in u will raise output. Namely, by increasing effort, a higher u would act just like an increase in bodies or hours. Manipulating this gives

$$Y_t = (u_t A_t) K_t^{\alpha} L_t^{\alpha}$$

Thus the Solow residual now is uA. So, with this extension, the Solow residual is not necessarily capturing total factor productivity A—it's capturing u as well. New Keynesians claim u is rising *endogenously* in booms, <u>not</u> A. This way, labour productivity, $\frac{Y}{L}$, can be procyclical, without exogenous changes in A.[9]

6.1.1 Stabilization Policy

Consider: RBC'ers claim that stabilization policy is counterproductive. Why? Recall that stabilization policy aims to reduce the volatility of the business cycle; the objective is to moderate both booms and recessions. By raising interest rates, say, the central bank reduces investment in a boom and raises investment in a recession. Now suppose the RBC theory is correct. That is, productivity is higher in booms and lower in recessions; i.e., potential output is higher in booms and lower in recessions. As an example, say each unit of new capital yields 5 units of output in a boom (since A is higher) but only 2 units of output in a recession. In addition, workers are more productive in booms and less productive in recessions. Yet by trying to reduce investment/employment in booms and trying to raise investment/employment in recessions, stabilization policy is transferring resources/production from productive periods to least productive periods. As a result, stabilization policy is completely *counterproductive* and reduces welfare. As an analogy, imagine you're in great form

[9] Of course, RBC'ers exact the ultimate revenge by saying Y causes the money supply, M, to rise endogenously in a boom—to be sure, a devastating blow to the Keynesian view that M is causing fluctuations in Y.

and full of energy; then you *should* work harder; when you're down and lazy, you *should* stay in bed. It's silly, isn't it, trying to *induce* you to work less when you're full of energy and to make you work harder when you're having a bad day? Analogously, the business cycle simply represents optimal responses by economic agents to changes in their economic environment—so things should be left as they are. In other words, what is, *is* efficient.

Although RBC theory claims money is always neutral, they do, however, agree that fiscal policy *can* raise output. But how it does so is not via the usual Keynesian demand-side channels. On the contrary, government expenditure creates an increase in supply. New Keynesians claim government expenditure increases aggregate demand and hence production (since output is demand-determined). But according to RBC theory, output is always fixed at potential. What happens, they claim, is a rise in government expenditure makes people feel poorer: because of Ricardian Equivalence, people realize that *they'll* have to now pay a higher tax bill in the future. As a result, their lifetime wealth falls. And because households now feel poorer, they reduce consumption and raise labour supply: the negative income effect induces them to consume fewer consumption goods and less leisure. The corresponding increase in labour supply causes an increase in output and hence an increase in economic activity. Thus the mechanism by which output increases is completely different to the channels in the New Keynesian model. Put simply, government expenditure stimulates the economy by making people feel poor and miserable. Yet again, the RBC theory always stresses incentives to supply labour and investment. According to this model, changes in economic activity are almost always due to changing incentives—and not changing demand.