1 Introduction

Among mainstream academic economists and policymakers, the leading alternative to the real business cycle theory is the New Keynesian model. Whereas the real business cycle model features monetary neutrality and emphasizes that there should be no active stabilization policy by governments, the New Keynesian model builds in a friction that generates monetary non-neutrality and gives rise to a welfare justification for activist economic policies.

New Keynesian economics is sometimes caricatured as being radically different than real business cycle theory. This caricature is unfair. The New Keynesian model is built from exactly the same core that our benchmark model is—there are optimizing households and firms, who interact in markets and whose interactions give rise to equilibrium prices and allocations. There is really only one fundamental difference in the New Keynesian model relative to the real business cycle model—nominal prices are assumed to be “sticky.” By “sticky” I simply mean that there exists some friction that prevents $P_t$, the money price of goods, from adjusting quickly to changing conditions. This friction gives rise to monetary non-neutrality and means that the competitive equilibrium outcome of the economy will, in general, be inefficient.

New Keynesian economics is to be differentiated from “old” Keynesian economics. Old Keynesian economics arose out of the Great Depression, adopting its name from John Maynard Keynes. Old Keynesian models were typically much more ad hoc than the optimizing models with which we work and did not feature very serious dynamics. They also tended to emphasize nominal wage as opposed to price stickiness. Wage and price stickiness both accomplish some of the same things in the model— they mean that the equilibrium is inefficient and that money is non-neutral. But nominal wage stickiness implies that real wages may be countercyclical, which is inconsistent with the data. For this and other reasons, New Keynesian models tend to emphasize price stickiness (though many of these models also feature wage stickiness too).

Before delving into the details, I’ll give a brief description the main difference relative to our earlier model. Whereas in our benchmark model output was determined by both supply and demand, in the New Keynesian sticky price model output is demand determined. We assume that
the money price of goods, $P_t$, is exogenously fixed within period (this is an extreme yet simple form of price stickiness). The market structure is such that firms are required to produce whatever is demanded at that fixed price. Changes in the money supply affect the total quantity of nominal demand for goods; if prices were flexible this would have no effect on the actual amount produced. But because we assume that firms have to meet demand and because prices are fixed, changes in the money supply affect real demand.

2 The LM Curve

In this section we introduce a new curve which will be central to our graphical analysis of the New Keynesian model. It is called the “LM Curve,” where the “L” stands for “liquidity” and the “M” stands for “money.” Loosely, the “L” part refers to money demand, while the “M” part refers to money supply. The LM curve shows all $(r_t, Y_t)$ pairs where the money market is in equilibrium, taking the price level, $P_t$, and the money supply, $M_t$, as given. Traditional Keynesian analysis is often called the “IS-LM” model. The “IS” stands for “Investment = Saving,” and is identical to what we have been calling the $Y^d$ curve. As we will see below, we can map what we previously did into the LM curve framework, but the LM curve here is particularly appealing, since it holds the price level fixed, and we assume that prices are fixed in the New Keynesian framework.

Household optimization generates a demand curve for money which takes the following form:

$$M^d_t = P_t M^d(i_t, C_t)$$

Since we take expected inflation, $\pi_{t+1}$, as given, replace the nominal interest rate using the (approximate) Fisher relationship:

$$M^d_t = P_t M^d(r_t + \pi_{t+1}, C_t)$$

As before, the money supply is exogenously set by the central bank, $M^s_t = M_t$.

The only functional difference relative to our earlier model is that the money price of goods is assumed to be exogenously fixed within period. You can think about this as follows. Suppose that firms have to post prices before observing any conditions. Then they are committed to producing whatever is demand at that price for at least one period. Why wouldn’t firms be able to adjust their price after observing different conditions? The simplest justification is something like a “menu cost” – suppose that, to change its price, the firm would have to change its menu, which may mean shutting down production for a period (or at the very least incurring some kind of cost). Implicitly we are assuming that this cost is sufficiently large that firms will never choose to adjust price within a period.\footnote{An astute student may realize that there is a slight tension here. If there are many identical firms, then these firms have no market power and cannot technically set prices. Hence, a discussion of firms setting prices and then observing conditions does not quite seem to work. This is correct. There is a simple way around this that would yield identical results if we had more time and more math at our disposal. Just ignore this detail.} We will call the fixed aggregate price level $P_t = \bar{P}$. 

\footnote{An astute student may realize that there is a slight tension here. If there are many identical firms, then these firms have no market power and cannot technically set prices. Hence, a discussion of firms setting prices and then observing conditions does not quite seem to work. This is correct. There is a simple way around this that would yield identical results if we had more time and more math at our disposal. Just ignore this detail.}
The price level being fixed changes the dynamics of the money market. In our earlier analysis, \( r_t \) and \( Y_t \) were determined independently of nominal variables, and then \( P_t \) moved so as to make the money market be in equilibrium. Since \( P_t \) cannot now move, this is no longer a possibility. Rather, we will have changes in \( r_t \) and \( Y_t \) work to make the money market in equilibrium, given a fixed price, \( \bar{P} \). The LM curve is going to plot out the set of \((r_t, Y_t)\) points where the money market is in equilibrium, given a value of the money supply, \( M_t \), and a price level, \( \bar{P} \). Given the money supply and a price level, suppose that we have a point, \((r^0_t, Y^0_t)\), that generates a position of the money demand curve such that the money market is in equilibrium at the exogenous position of money supply and the fixed price level, \( \bar{P} \). Call this point “A.”

Now suppose that output is higher, say at \( Y^1_t > Y^0_t \). For a given interest rate, this would mean consumption is higher, which would pivot the money demand curve out and to the right to point “B.” For a given price level, \( \bar{P} \), and a given money supply, this is a disequilibrium point. To bring the money market back into equilibrium given that higher level of output, the real interest rate must rise, so that the nominal interest rate also rises. This causes the money demand curve to pivot back in to the left. The rise in the interest rate must be sufficient to pivot the money demand curve back in to its original position, call this point “C” where “C” and “A” are the same point in the money market graph. Connecting points “A” and “C” in \((r_t, Y_t)\) space, we see that the set of \((r_t, Y_t)\) points where the money market is in equilibrium given a quantity of money supply and a price level is upward sloping. This is what we call the LM Curve.

---

2Technically, the position of money demand depends on consumption, not output. This is how it is labeled in the graph. But holding all other factors fixed, consumption can be determined given a value of current income and the real interest rate.
In the graph, I wrote \( LM(M_t, \bar{P}) \) so to explicitly note that the LM curve holds money supply and the price level fixed. If either change, then the LM curve will shift. Suppose that we initially start at point “A”, with \( (r^0_t, Y^0_t) \). Suppose that there is an exogenous increase in the money supply, shifting the \( M^s \) curve to the right. If neither the interest rate nor output changed, this would take us to a point with a higher price level. Since the price level is fixed at \( \bar{P} \), this is not possible. Hence, for the money market to remain in equilibrium the money demand curve must shift in such a way as to restore equilibrium at \( \bar{P} \) under the new money supply curve. To hit this point, we need the money demand curve to pivot right, which requires \( C_t \) rising or \( r_t \) falling, or both. I prefer to think of curves shifting in a horizontal fashion, so I’m going to fix the interest rate and figure out how output/consumption would have to change to restore equilibrium. Since we need the money demand curve to pivot right, for a given interest rate we need higher consumption, which means higher output. So in \( (r_t, Y_t) \) space I show the LM curve shifting horizontally to the right, from point “A” with \( (r^0_t, Y^0_t) \) to point “B” with \( (r^1_t, Y^1_t) \).\(^3\) Hence, an increase in \( M_t \) causes the entire LM curve to shift to the right.

![Graph showing LM curve and money demand curve shifting](image)

Although we think about it being fixed in the New Keynesian model, the LM curve also holds the price level, \( \bar{P} \) fixed. We can think about what would happen to the LM curve if that price level were to change. Suppose that \( \bar{P} \) increases, say from \( \bar{P}_0 \) to \( \bar{P}_1 \). If nothing happened to the interest rate and output, then we would be out of equilibrium for a given position of the money supply curve. To restore equilibrium, the money demand curve must evidently pivot in. For a

\(^3\)Note that I could have done this experiment where the LM curve shifts “down” instead of “right”, by finding a point with a lower interest rate and a fixed level of output.
given interest rate, this would require lower consumption, which means lower output. Hence, we must move from a point like “A” with \((r_t^0, Y_t^0)\) to a point like “B” with \((r_t^0, Y_t^1)\). In other words, an increase in \(\bar{P}\) causes the LM curve to shift in.\(^4\)

3 Equilibrium in the New Keynesian Model

Having derived the LM curve and understanding what causes it to shift, we are now in a position to think about equilibrium in the New Keynesian model. Our basically equilibrium concept – a set of prices and quantities such that markets clear when all agents are behaving optimally – is unchanged, although the set up of the model is now different because the nominal price of goods is assumed to be fixed.

The household side of the model is identical to before. In addition to the money demand function used above, this gives rise to a labor supply function and a consumption demand function:

\[
C_t = C(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)
\]

\[
N^s = N^s(w_t, C_t)
\]

There is also no difference in the firm’s investment decision, since this is forward-looking and there-

\(^4\)As in the previous paragraph, one could also think of the LM curve shifting “up” instead of “in”, moving to a point with a fixed level of output but a higher interest rate.
fore independent of current demand or the current nominal price. This gives rise to an investment
demand function:

\[ I_t = I(r_t, A_{t+1}, K_t) \]

The total demand for goods and services is the same as before:

\[ Y^d_t = C(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t) + I(r_t, A_{t+1}, K_t) + G_t \]

The \( Y^d \) curve will represent the set of \((r_t, Y_t)\) points where \( Y^d_t = Y_t \), and can be derived
d graphically just as we have done before. This is repeated below for convenience. As the real
interest rate increases (decreases), the expenditure line in \((Y^d_t, Y_t)\) space shifts down (up), and the
point where \( Y^d_t = Y_t \) decreases (increases). Connecting the dots, we get a downward sloping \( Y^d \)
curve. The \( Y^d \) curve will shift if \( G_t, G_{t+1}, \) or \( A_{t+1} \) change.

In the parlance of New Keynesian economics what we have been calling the \( Y^d \) curve is often
called the “IS” curve. “I” stands for “investment” and “S” stands for saving. Taking the aggregate
accounting identity from the desired aggregate expenditure relationship, it can be re-written as:
\[ I_t = Y_t - C_t - G_t \]. The right hand side can be re-written as: \( Y_t - T_t - C_t + T_t - G_t \) by adding
and subtracting \( T_t \). The first term, \( Y_t - T_t - C_t \), is total household net income minus consumption,
or private saving. The second term, \( T_t - G_t \), is government saving (a negative value would mean
the government runs a deficit). Private plus public saving is national saving, which must equal
investment. Hence, the aggregate expenditure identity can be interpreted as saying that investment
\( = \) saving, which is why the curve is sometimes called the “IS” curve.

The production side of the New Keynesian model needs to be modified to incorporate price
stickiness. Firms still produce output according to a Cobb-Douglas production function:
\[ Y_t = A_t F(K_t, N_t) \]

The money price of goods is fixed in advance, call this \( \bar{P} \). As noted in the previous section, we will think about a sequencing of events whereby firms choose the money price of goods “before” the period begins, and are committed to sticking with that price through the period. This can be motivated rigorously through some kind of menu cost. The “rules of the game” are that firms must produce however much output is demanded given the price they have posted. This means that they cannot freely choose current employment to maximize profit. Rather, they have to choose \( N_t \) (the only variable factor of production in period \( t \)) to produce however much output is demanded. This means that there is not a normal downward-sloping demand curve for labor as in our earlier setup, and also means that the \( Y^s \) curve that we had previously derived is no longer going to be part of the equilibrium. Put differently, price stickiness essentially obliges the firm to produce however much output is demanded. There is no optimizing choice of labor input, and hence no \( Y^s \) curve.

Rather, equilibrium in the New Keynesian economy is determined by the intersection of the LM and \( Y^d \) curves. In words, equilibrium occurs where the money market is in equilibrium (on the LM curve) and the goods market is in equilibrium (on the \( Y^d \) curve), given positions of money supply and a fixed nominal price, \( P_t \). Conceptually, you can think about this is follows. We need to find a point on the \( Y^d \) curve that also makes the money market be in equilibrium, given \( \bar{P} \) and \( M_t \) (which means you have to be on the LM curve too). Note that the \( Y^s \) curve is not in the picture here. Effectively, you can think of replacing the labor market/\( Y^s \) curve with the money market/LM curve. The equilibrium is shown below:
Having determined output, how can we determine labor market variables? Given their fixed price, firms have to produce enough output to meet demand. Effectively, given the amount of output determined by the intersection of the $Y^d$ and LM curves, the firm solves the production function for the amount of $N_t$ necessary to produce that amount of output. This gives rise a labor demand curve of the sort: $N_t^d = N^d(Y_t, A_t, K_t)$. Labor demand depends on the amount of output, the level of total factor productivity, and the level of the capital stock. If $Y_t$ goes up holding $A_t$ and $K_t$ fixed, then the firm has to hire more labor to produce that amount of output. The amount of labor the firm demands does not depend on the wage, and is hence vertical in a graph with $w_t$ on the vertical axis. The labor supply curve is the same as we have seen. The intersection determines the equilibrium real wage and the equilibrium quantity of employment:

![Graph](image)

### 3.1 Exogenous Increase in $M_t$

Having graphically depicted the equilibrium of our economy, we are in a position to look at how changes in the exogenous variables affect that equilibrium. On the real side, the exogenous variables are the same that we have had: $A_t$, $A_{t+1}$, $G_t$, and $G_{t+1}$. On the nominal side, the exogenous variables include $M_t$ and $\pi_{t+1}$. In doing these exercises, first start in the money market and figure out if the LM curve shifts. Then figure out if $Y^d$ shifts. Then go back to the money market if need be to make things consistent, and finally go to the labor market. In some sense that’s the reverse approach that we have taken in the past, where we started in the labor market. Ending in the labor market as opposed to starting there reflects the fact that output is now demand determined.

Let’s start with an increase in $M_t$. In the benchmark model this had no real effect and only caused the price level to increase. Here something has to give, given that the price level is fixed. An increase in $M_t$ causes the money supply curve to shift to the right. For a given price level, the money demand curve must shift to the right for the money market to be in equilibrium. The movement from the initial equilibrium point A to B represents an increase in $Y_t$ holding $r_t$ fixed, with the LM curve shifting out to the right in $(r_t, Y_t)$ space. Point B cannot be the equilibrium
point because we are not on both the LM and the $Y^d$ curves, so the real interest rate must fall to point C. In the new equilibrium the real interest rate is lower and output is higher (output is higher relative to its initial starting value, but lower relative to its hypothetical value at point B, so that the position of the money demand curve at point C is the same as in point B, but with a lower real interest rate and different level of output).

From the graphs we see that $Y_t$ is higher and $r_t$ is lower. Higher income and a lower real interest rate mean that consumption is higher; a lower real interest rate means that investment is higher. Hence, a monetary expansion causes $r_t$ to fall, $Y_t$ to rise, and both $C_t$ and $I_t$ to rise. It is sometimes said that the “monetary transmission mechanism” works through lowering the real interest rate and thereby stimulating the components of overall demand (consumption and investment).

Finally, go to the labor market. Because output is higher and $A_t$ and $K_t$ are unchanged, the firm must hire more labor. Hence, the vertical labor demand curve shifts out to the right. Because consumption is higher (due to higher income and a lower real interest rate), the labor supply curve shifts in. The net combination is higher employment and a higher real wage.
3.2 A $Y^d$ Shock

Next, consider a shock which shifts the $Y^d$ curve. This could be due to a change in $A_{t+1}$, $G_t$, or $G_{t+1}$. For the purposes of qualitatively figuring out what happens to $Y_t$ and $r_t$ it does not matter what the source of the shift is. For the purposes of figuring out what happens to the real wage and the components of output, however, we do need to know. For the purpose of this exercise let’s suppose that it is an expected increase in $A_{t+1}$ that causes the $Y^d$ curve to shift out.

Starting in the money market, we see that there is no direct effect of a change in $A_{t+1}$. This means that the LM curve does not shift. The $Y^d$ curve shifting out along a stable LM curve means that $Y_t$ must be higher and $r_t$ must be higher as well. Because the money supply curve and the price level are fixed, the net effect of these changes on the position of the money demand curve must be zero – put differently, the money demand curve must be in the same position in the new equilibrium as in the old equilibrium, albeit at a different interest rate, output combination.
Qualitatively it may look like the effect on consumption is ambiguous – current and future output are higher, but the real interest rate is also higher. We actually know that consumption must be higher in the new equilibrium – if consumption were not higher in the new equilibrium, it would not be possible for the money market to be in equilibrium at a higher real interest rate (to keep the money demand curve “in place,” consumption and the real interest rate have to move in the same direction). Hence, consumption must be higher in the new equilibrium. The effect on investment is ambiguous – on the one hand higher $A_{t+1}$ makes firms want to invest more, on the other the higher real interest rate discourages this.

Finally, go to the labor market. Output being higher with no change in $A_t$ or $K_t$ means that the firm must hire more workers. Hence, the labor demand curve must shift right. Because consumption is higher, the labor supply curve must shift in. The net effect is higher employment and a higher real wage.
An astute student may stop and think back to a point we used in our previous analysis. In the equilibrium production model with flexible prices, we argued that, under standard assumptions on preferences, consumption and labor would have to move in opposite directions absent a change in $A_t$ or $K_t$. What we are finding here violates that – here we have both $C_t$ and $N_t$ rising in response to an increase in $A_{t+1}$. What gives? Because the firm is not freely able to choose labor to maximize profits, the real wage is not equal to the marginal product of labor. Without that, our result about co-movement falls apart. In the New Keynesian model consumption and labor can move in the same direction absent a change in $A_t$ or $K_t$.

### 3.3 A Productivity Shock

Next, let’s look at what happens if $A_t$ increases. Starting in the money market, we see that there is no direct effect, and hence no shift in the LM curve. We know from our earlier analysis that there is also no shift in the $Y^d$ curve. In our earlier analysis the $Y^s$ curve would have shifted right, but the $Y^s$ curve isn’t relevant for determining the equilibrium. Since neither the LM nor the $Y^d$ curve shift, a change in $A_t$ has no effect on the equilibrium, with $Y_t$ and $r_t$ both unaffected. This also means that the components of output are unaffected.

There is an effect in the labor market, however. In particular, labor demand is determined by solving the production function for $N_t$ given the equilibrium amount of output. Since output hasn’t changed, but $A_t$ is higher, labor demand must fall. Put differently, if the firm is more productive but is only going to produce the same amount, then it needs fewer workers to do so. Hence, the labor demand curve shifts in. With the labor supply curve not shifting (because $C_t$ is unaffected), this means that the real wage must also fall.\(^5\)

---

\(^5\)You may be wondering how $C_t$ can remain unaffected if both $w_t$ and $N_t$ are lower, so that total labor income is lower. The answer is that profit goes up – firms are producing more with less expense. Hence, household income ends up unaffected.
3.4 What if Prices Were Flexible?

At a fundamental level, we’ve really only changed one thing relative to the benchmark flexible price, real business cycle model. That’s that we have assumed that the nominal price of goods, \( P_t \), is exogenously fixed within period. On the basis of that change we’ve replaced the \( Y^s \) curve with the LM curve.

If prices were flexible as earlier, we could still make use of an LM curve. It would still show the set of \((r_t, Y_t)\) pairs where the money market is in equilibrium, given a value of the money supply and a price level. With flexible prices, however, we’d have to be back on the \( Y^s \) curve. This is because with prices flexible the amount of current output produced would be based off labor market equilibrium, as opposed to firms simply producing however much is demanded at the current nominal price. We could graphically represent the equilibrium of the economy at the intersection of three curves – the \( Y^d \), the \( Y^s \), and the LM curve. Effectively, the real interest rate would be determined by the intersection of the \( Y^d \) and \( Y^s \) curves, while the price level would endogenously adjust to position the LM curve such that it intersects both of those curves at their point of crossing. Recall from above that changes in the price level cause the LM curve to shift. One way to think about things is that if both the price level, \( P_t \), and the real interest rate, \( r_t \) are endogenous, then we can be on all three curves simultaneously. If the price level is no longer exogenous, with \( P_t = \bar{P} \), then in general it’s not possible for for all three curves to cross at the same point, so we drop the \( Y^s \) curve.

Let’s use the graphical apparatus here to think about what would happen following exogenous shocks if prices were flexible. First, consider an exogenous increase in the money supply. First, start in the money market. The increase in \( M_t \) would shift money supply to the right, which would lead to an outward shift of the LM curve if the price level were fixed (this is shown by the \( \rightarrow \) in the graph with the LM curve shifting out). But the price level is not fixed. The intersection of the \( Y^d \) and \( Y^s \) curves would determine \( Y_t \) and \( r_t \), and neither of these curves shift following a monetary
expansion. Hence, $r_t$ and $Y_t$ do not change. Hence, there is no change in money demand. To restore equilibrium in the money market, $P_t$ must rise. Whereas an increase in $M_t$ shifts the LM curve right, an increase in $P_t$ shifts it back to the left. Hence, the rising price level from the monetary expansion effectively shifts the LM curve back in to where it started (although this language is a bit squishy, since this is all happening simultaneously). At the end of the day, the increase in $M_t$ just leads to an increase in $P_t$ such that the LM curve does not shift on net, and money is neutral, with neither $Y_t$ nor $r_t$ affected.

Next, let’s use this set of graphs to think about what happens following an exogenous increase in $A_t$. From our earlier analysis we know that the $Y^s$ curve shifts right, there is no shift in the $Y^d$ curve, and the real interest rate declines and output increases. Higher consumption and a lower real interest rate cause the money demand curve to pivot right, leading to a lower $P_t$. A lower $P_t$ causes the LM curve to shift right, so that it intersects the new $Y^s$ curve and the $Y^d$ curve at the new equilibrium.
Thinking about how this would all play out if prices were flexible is useful in terms of thinking about optimal monetary policy, a subject to which we turn next.

4 Optimal Policy

We’ve been treating $M_t$ as an exogenous variable up until now. This is useful from the perspective of understanding how the model works. But in reality $M_t$ is not an exogenous variable. Rather, the central bank is constantly adjusting the stance of monetary policy in response to changing external conditions. Why do they do that? What is their objective? Should monetary policy respond to other shocks? In which direction? We take up some of these questions in this section.

You will recall from our discussion of the real business cycle model that the competitive equilibrium outcome of that model is efficient. It is efficient in the sense that the quantities that emerge as the equilibrium are the same that would observe if we were to solve the problem of a fictitious social planner whose job it was to maximize household welfare subject to the economy-wide resource constraints.

As a general matter, the equilibrium outcome of the New Keynesian model will not be efficient. Equilibrium in the New Keynesian model occurs where the LM and $Y^d$ curves intersect; equilibrium in a flexible price model would occur where the $Y^d$ and $Y^s$ curves intersect, where the $Y^d$ curve is the same in both circumstances. This suggests that the monetary authority could maximize welfare by figuring out where the $Y^d$ and $Y^s$ curves would intersect, and then adjusting the money supply in such a way as to make the LM curve intersect the $Y^d$ curve at that point. This kind of policy can make the quantities associated with the equilibrium of the sticky price model line up with the
equilibrium of the flexible price model, and is therefore welfare maximizing.

The figure below shows a situation in which the equilibrium of the economy occurs at \((r_t^0, Y_t^0)\) at the intersection of the \(Y^d\) curve and the LM curve, where the LM curve is drawn for a fixed, exogenous price level, \(\bar{P}\), and an exogenous value of the money supply, \(M_t^0\). In a dashed line I show the hypothetical \(Y^s\) curve that would be there if we were back in the flexible price real business cycle world. That \(Y^s\) curve would intersect the \(Y^d\) curve at \((r_t^e, Y_t^e)\). I label this equilibrium with the superscript “e” because it is the efficient, welfare maximizing equilibrium. The actual equilibrium is not efficient, with output too low \(Y_t^0 < Y_t^e\), and the real interest rate too high, \(r_t^0 > r_t^e\).

![Diagram showing equilibrium and hypothetical curves]

The central bank could improve welfare if it could shift the LM curve in such a way as to intersect the \(Y^d\) and \(Y^s\) curves at the same point. It has the tools available to do this. It can increase the money supply to \(M_t^1\), which, for a given price level, will shift the LM curve out to the right. If it picks \(M_t^1\) just right, it can move the equilibrium of the model to \((r_t^1, Y_t^1)\), which corresponds with the efficient equilibrium.
If you compare the above diagram with the diagrams from the “What if prices were flexible” subsection, you can see that, effectively, the central bank can adjust the money supply to play the role that the price level would play in moving to the efficient equilibrium in the flexible price model. There, we saw that if the LM curve intersected the $Y^d$ at too low of a level of output given the position of the $Y^s$ curve, then the price level would fall to shift the LM curve to intersect the $Y^d$ and $Y^s$ curves. Effectively, what determines the position of the LM curve is the quantity of real balances, $\frac{M}{P_t}$. In the flexible price model that quantity automatically adjusts via movements in $P_t$ to get to the efficient equilibrium. In the sticky price model the central bank can implement the efficient equilibrium by adjusting $M_t$ instead.

Now let’s look at how a welfare maximizing central bank would react to exogenous, external shocks. Assume that the economy initially begins in the efficient equilibrium. First, suppose that there is a productivity shock, with $A_t$ increasing. This would shift the hypothetical $Y^s$ curve out to the right, which would raise the efficient equilibrium level of output and lower the efficient real interest rate. If the central bank does nothing, then nothing will happen to the equilibrium. To maximize welfare, the central bank should increase the money supply so as to shift the LM curve to the right, where it intersects the new $Y^s$ curve and the $Y^d$ curve at the efficient equilibrium. In other words, the central bank should “accommodate” the supply shock by expanding the money supply.
Next, consider a shock which shifts the $Y^d$ curve. In particular, let’s suppose that people anticipate an increase in $A_{t+1}$. We know from our earlier analysis that this leads to the $Y^d$ curve shifting right and the $Y^s$ curve shifting left. If prices were flexible, then this would have an ambiguous effect on output but would definitely raise the real interest rate. In the picture below, I have drawn the shifts of the curves such that they exactly offset, with no impact at all on the efficient level of output (though the efficient equilibrium real interest rate would be higher).

If the central bank did nothing, then as we saw above the equilibrium level of output would increase to the point where the new $Y^d$ curve intersects the original LM curve. While it might
seem that more output is better, this outcome is not efficient (recall that people get utility from working too). Output would be too high and the real interest rate too low in that equilibrium. A welfare maximizing central bank would want to optimally respond to this change by reducing the money supply, working to shift the LM curve back in to the left. Here the central bank wants to conduct “countercyclical” policy in the sense of moving the money supply in the opposite direction of how output would move if it did nothing.

In practice most central banks do not operate in terms of monetary aggregates any more. Rather, they think of themselves as adjusting interest rates. As we’ve seen, adjusting monetary aggregates and adjusting interest rates are basically one in the same in this model. One can think of optimal monetary policy along the following lines in the New Keynesian model. The central bank wants to adjust interest rates in such a way as to make the equilibrium real interest rate equal the efficient real interest rate, \( r_t = r^e_t \). The efficient real interest rate varies over time due to exogenous shocks, and so the central bank needs to monitor those shocks, figure out what is happening to \( r^e_t \), and adjust the interest rate accordingly.\(^6\)

In summary, in the New Keynesian model optimal monetary policy calls on the central bank to endogenously adjust the money supply in such a way as to make the equilibrium coincide with the hypothetical efficient equilibrium. On paper this seems like a fairly easy task, but in practice it is not easy. In particular, the central bank must know where the \( Y^s \) and \( Y^d \) curves are at any given point in time to know where to position the LM curve. This requires a pretty sophisticated and accurate model of the economy and real-time understanding of the shocks which buffet it. If the central bank has poor information about where the efficient equilibrium would be, or receives it only after a substantial delay, then activist policies could do more harm than good, moving us further away from the efficient equilibrium rather than towards it. For this reason, many economists and politicians propose that central banks should follow relatively simple policy rules as opposed to using discretion when setting monetary policy. If you go on to take more classes in economics or go on to graduate school, you will likely encounter this literature in some depth.

5 Empirical Evidence

We talked briefly about the ability of the real business cycle model to match facts about the business cycle. What about the ability of the New Keynesian model to match the data? Which model fits better? Though these are seemingly straightforward questions, there are no easy answers. A significant complicating factor concerns what monetary policy is doing. As we saw in the previous section, optimal monetary policy makes the equilibria of the real business cycle and New Keynesian models observationally equivalent. Hence, when looking at the testable predictions of the two models, we are (unless otherwise noted) implicitly assuming that monetary policy is not endogenously reacting to economic conditions.

\(^6\)As I have noted, technically the central bank can only affect the nominal interest rate. However, to the extent to which inflation expectations, \( \pi_{t+1} \), are “well-anchored” (and can thus be interpreted as exogenous and fixed), then moving the nominal and the real interest rates are one in the same thing.
We saw earlier that the defining feature of the business cycle is broad-based co-movement among quantities. In the real business cycle context, the only exogenous variable that could generate this kind of co-movement was $A_t$. In the New Keynesian model, changes in $M_t$ and $A_{t+1}$ can generate co-movement. Another way of putting this is that the real business cycle model emphasizes supply shocks (changes in $A_t$) as the source of business cycles, whereas the New Keynesian model emphasizes “demand” shocks (changes in the money supply and in expectations of the future, $A_{t+1}$, which are sometimes called Keynesian “animal spirits”) as the source of the business cycle. Which explanation holds more water is an empirical question.

A simple test of which theory holds more weight would be to see if changes in $M_t$ have effects on real variables like output. To the extent to which they do, we can reject the real business cycle model. In the data, the de-trended component of the money supply and the de-trended component of output are positively correlated, albeit only mildly so. The positive correlation in itself is suggestive of real effects of changes in the money supply, but recall that causality could go both ways. It could be the case that changes in output driven by changes in $A_t$ lead the central bank to adjust the money supply (perhaps out of a preference to keep the price level stable), so that the money supply expands when $A_t$, and hence $Y_t$, increase. Hence, a simple correlation may be suggestive but is not dispositive because causality could go both ways.

A relatively large empirical literature tries to identify exogenous variation in the money supply (or in other measures of the stance of monetary policy, like interest rates) to look at how those correlate with changes in output. This literature typically finds that there are real effects of nominal changes, but that these real effects are (i) relatively small and (ii) relatively short-lived. In a strict sense this evidence rejects the basic real business cycle framework, but any model that we write down will be rejected given good enough data, as models are simple abstractions. The fact that the real effects of nominal shocks appear small and short-lived suggests that the real business cycle model may not be a poor benchmark, particularly if the frequency of analysis is not too short. Nevertheless, the fact that there do appear to be real effects of nominal shocks lends evidence to something like the New Keynesian model.

Another key difference in the predictions of the two models concerns how the economy reacts to productivity shocks. In the real business cycle framework, changes in $A_t$ lead to changes in $Y_t$ and almost certainly to movements in $N_t$ of the same direction (though the change in labor is technically ambiguous, for conventional preference specifications labor input usually rises when $A_t$ rises). The New Keynesian model, in contrast, predicts that changes in $A_t$ should not affect output and should lead to lower $N_t$ (presuming that the stance of monetary policy is held fixed). One simple test is to therefore look at the correlations between an empirical measure of $A_t$ and output and employment, as we did earlier. There we saw that the Solow residual, or total factor productivity, is strongly positively correlated with output and employment, which seems to favor the real business cycle model. Nevertheless, as noted, one criticism of this approach is that employment and capital may be systematically mis-measured due to unobserved utilization (e.g. you run machines longer when demand is high, work workers harder when conditions are good, etc.). There are two different empirical approaches to handling this criticism. One tries to “purify” the Solow residual by using a
little bit of economic theory to back out time series for unobserved utilization. This literature has argued that purified Solow residuals are essentially uncorrelated with output and negatively correlated with employment, consistent with the predictions of the New Keynesian model. Another uses identifying restrictions in a vector autoregression, and argues as well that changes in productivity lead to employment contractions. Though strands point to the New Keynesian model in favor of the real business cycle model, the results are not without dispute. There are several papers that challenge the theoretical basis of the approaches used, and argue that technology shocks raise hours worked, consistent with the real business cycle framework. At the end of the day, I think it fair to say that this is an unsettled empirical question.

Another difference in the implications of the real business cycle and New Keynesian models revolves around the effects of changes in $A_{t+1}$. Technically, this is a stand in for expected future productivity, but you could think about it more widely as being a stand-in for optimism or pessimism. The real business cycle framework suggests that changes in $A_{t+1}$ cannot be a main driving force behind the business cycle, because in that model changes in $A_{t+1}$ cannot produce co-movement: if output goes up following an increase in $A_{t+1}$, then consumption must be going down. In the New Keynesian framework, in contrast, changes in $A_{t+1}$ can produce broad-based co-movement. Here I personally have done some research. My empirical findings cast doubt on changes in $A_{t+1}$ as a source of the business cycle – in particular, in my work I find that such changes lead to (i) small effects on output and (ii) negative co-movement between consumption and hours, output, and investment. These findings are more in line with the real business cycle model than with the New Keynesian model.

A final test of the New Keynesian model is to inspect the empirical evidence in support of the main mechanism in the model, price stickiness. The kind of analysis we have done in class is necessarily simple, as we simply assumed that the aggregate price level is fixed within period. This is too large of an abstraction. Some papers, notably Bils and Klenow (2004), look at micro data from individual firms to look at how often prices change in practice. If prices of goods change infrequently, this is supportive of the price stickiness mechanism at the center of the model. In practice, prices of most goods change on average once every 6 or so months. Hence, prices do not appear perfectly rigid, but they are reasonably flexible.

At the end of the day, the empirical evidence does not compellingly point to either the real business cycle or the New Keynesian models as the definitive model of the business cycle. This suggests that more research needs to be done to further refine our theoretical frameworks for

---

thinking about economic fluctuations. This does not mean, however, that these two models are not useful. I think that the insight from real business cycle theory that fluctuations may be the efficient response to changing condition is quite powerful, and I think that the New Keynesian model provides a very useful framework for thinking about monetary policy. Whichever model is better, it makes sense for monetary policy to behave in the way prescribed here. If prices are really flexible and monetary policy is neutral, then there is not much cost for doing so. If prices are rigid, then there are welfare gains to be had from this kind of monetary policy.