The Wicksellian modification to the Taylor rule and the 3-Equation New Keynesian model introduces the world of finance into the system. In that sense it returns a bit of what was lost when we dropped the LM curve. The model mechanics provide results that indicate that financial markets move in directions that promote equilibrium conditions.

Hyman Minsky, as we learned throughout this class, believed that there were times when financial markets could generate powerful destabilizing forces. We will now augment our model to include a term designed to capture the flavor of Minsky's insight.

The Minsky/Wicksell Modified Model

IS $y_t = a - \alpha(r_t - W*)$

PC $\pi_t = \pi_t^e + \lambda y_t$

TS $R = \omega(f) + (1-\omega)(W) + \omega(\tau) + \sigma$

The IS equation relates the output gap to the difference between the actual real risky long term rate "r" and the risky Wicksellian natural rate "W*". We define "a" as the normal autonomous spending. We define "W" as the value for the rate that puts the output gap over the long term at zero. (The risky Wicksellian natural rate, W*, equals the risk free wicksellian rate, W, plus the average spread between risky and risk free rates, σ.

The PC curve relates the inflation rate in period t to inflationary expectations entering period t, " π_t^e " and to the economy's output gap position, y_t. If we assume backward looking adaptive expectations then $\pi_t^e = \pi_{t-1}$.

The TS curve provides us with a more robust level of central bank/financial market/ real economy interaction. The TS curve, once again, is an attempt to look at how the financial markets and the central bank combine to set the relevant real long term interest rate.

The TS curve now relies upon two notions of how short-term risk free real rates relate to risky-real long-term rates. We posit that the risky real long term rate, r, is a weighted average of the "Wicksellian neutral risk free long rate, the real fed funds rate, a term premium, and a credit spread.

Building Blocks for the Minsky/Wicksell TS Curve

We recall, from lecture 8, the TS schedule for the Wicksell model:

$R = \omega (f+ \tau) + (1-\omega)W$

R = risk free real long term rate	(10-year treasury yield minus TIPS implied inflation expectations)
f = real fed funds rate	(fed funds rate minus TIPS implied inflation expectations)
τ = constant term premium	(0.8% or 80 basis points)
W = risk-free Wicksellian natural rate	(5-year/5-year forward TIPS yield)
ω = weighting factor for Fed policy	(Market expectations for likely duration of Fed policy)

How do we define the neutral real fed funds rate? We replace "2", Taylor's guess, with a market determined estimate:

f* = W- τ (the neutral real funds rate equals the Wicksellian natural rate minus the average term premium)
f* = (5-year/5-year forward TIPS yield minus 0.8)

Employing a bit of algebra we can see that when the neutral fed funds rate is in place, f = f*, the risk free real long term rate equals the Wicksellian natural rate, R = W:

R = ω (f+ τ)+ (1-ω)W posit that f = f* recall that f* = W – τ

R = ω (W – τ + τ) + (1-ω)W, simplify, Type equation here.

R = ω (W) + (1-ω)W, simplify, R = W

Now we introduce credit spreads, in order to solve for, W*, the risky Wicksellian natural rate of interest.

r = the real risky long term interest rate. It equals the risk free rate plus a risk premium, S.

$$r = R + S$$

S, in turn, can be separated into the mean value of risk spreads, σ, and a credit shock term, η:

$$S = \sigma + \eta$$

Now we can build from our TS schedule in Wicksellian risk free space, to a TS schedule in Minsky/Wicksell modified world. The real risky Wicksellian rate of interest equals the risk free Wicksellian natural rate plus the average risk premium:

$$W^* = W + \sigma$$

Recall that r = R + S, thus,

$$r = R + S = \omega(f+ \tau) + (1-\omega)W + \sigma + \eta$$

And since W* = W + σ, we get,

$$r = \omega(f+ \tau + \sigma) + (1-\omega)W^* + \eta$$

Real Time Representations of Minsky/Wicksell Variables

We use the Moody's Baa bond index as a measure of the risky long rate. To estimate r, we subtract inflation expectations from the Moody's Baa index, We posit that the average spread between the Moody's index and the 10-year U.S. treasury index, σ, is 1.8%.

We now have market determined values for r, f, and W. We also have calculated values for t and &. We can use these input to infer a value for ω, at any moment in time. In so doing, we are getting a look at market expectations for how long a given Fed policy position is expected to be kept in place.

Consider the interest rate and inflation rate expectations backdrop in place in April of the years 2013, 2006, 2004, and 2000:

	Moody's Baa Bond Index	federal funds rate	5-year forward real 5-year risk free rate	5-year forward FRB Breakeven inflation rate	10-year treasury
Apr-16	4.6%	0.9%	0.7%	2.0%	2.2%
Apr-13	4.5%	0.1%	0.1%	2.8%	1.7%
Apr-06	6.7%	4.8%	2.6%	2.6%	5.1%
Apr-04	6.5%	1.0%	3.1%	2.6%	4.5%
Apr-00	8.4%	6.0%	4.1%	1.7%	6.2%

Recall that the average fed funds/10-year term premium, 1980-2005 was 0.8%. And the average risky/risk free spread was 1.8%. We can use the market observations noted above and our premium and spread parameters to calculate the risky real bond rate, the real fed funds rate, and risky Wicksellian neutral real rate:

The risky real bond rate is the Baa rate minus expected inflation. We can use the Fed five year forward breakeven inflation rate as a measure of inflation expectations (ignoring TAIL RISKS).

Similarly, the real fed funds rate is approximated by the fed funds rate minus the Fed five year forward breakeven inflation rate.

The risky Wicksellian neutral real rate is approximated by the forward real risk free 5-yr rate plus the average risky/risk free spread.

	risky real bond rate	real fed funds rate	Wicksellian risky real rate	risky-risk free spread
Apr-16	2.6%	-1.1%	2.5%	2.4%
Apr-13	1.7%	-2.7%	1.9%	2.8%
Apr-06	4.1%	2.2%	4.4%	1.6%
Apr-04	3.9%	-1.6%	4.9%	2.0%
Apr-00	6.7%	4.3%	5.9%	2.2%

Recall our formula for the risky real bond rate:

$r = \omega(f + \tau + \sigma) + (1-\omega)W^* + \eta$

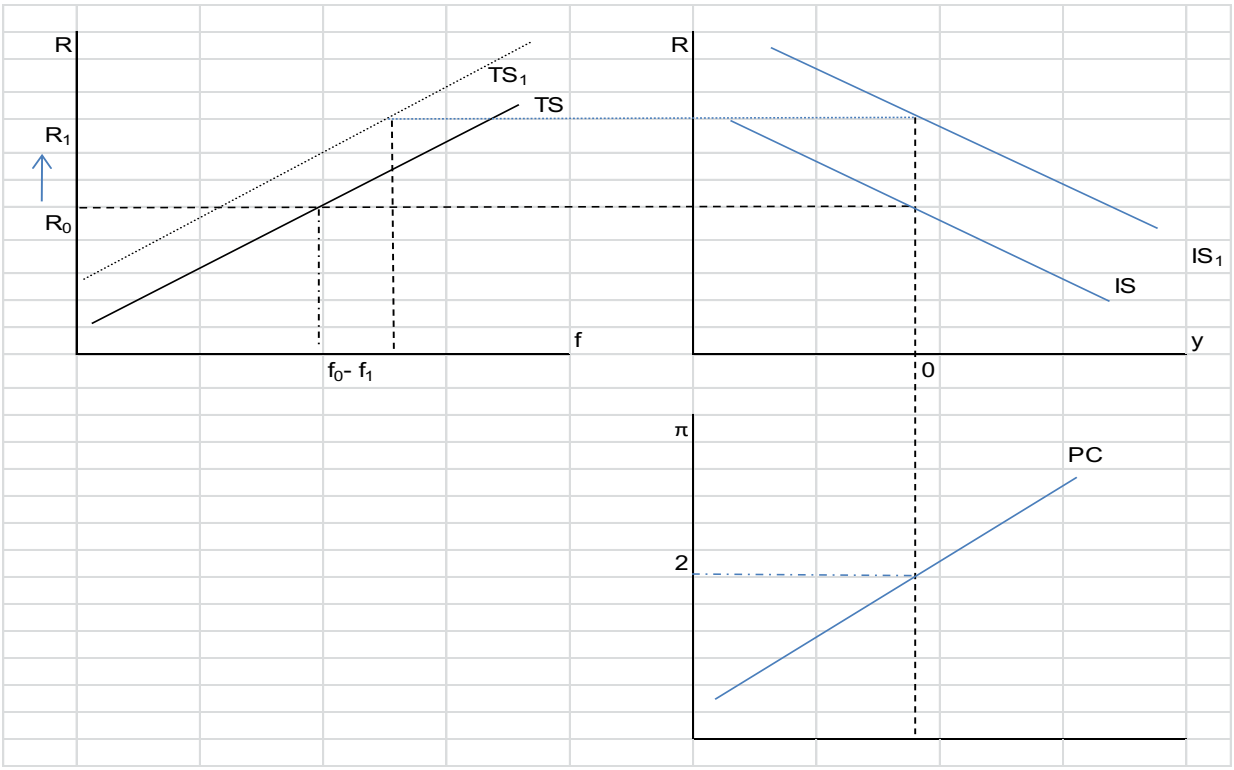
For April, in each of the four years noted above, we have values for r, f, and W*. We know that S, the spread, equals $\sigma + \eta$. We subtract σ from S, and we know η.

In other words, we now have a value for all terms in the equation except ω. We can solve for ω for each of the four periods:

A Graphical Analysis Using the Wicksell Model

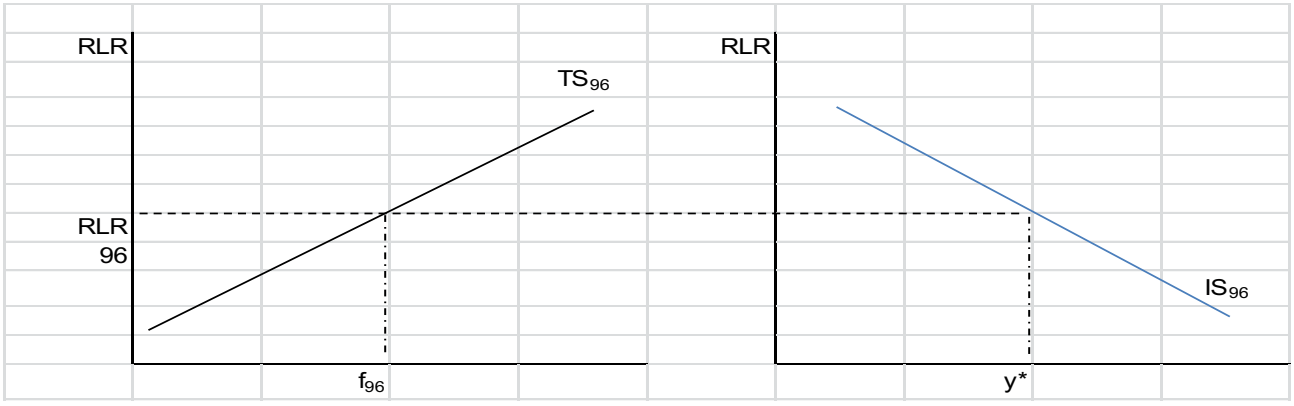
As we noted two weeks ago, "The Market Knows Best", was the dubious virtue of the Wicksellian model. Certainly it was the kind of model in Alan Greenspan's had in mind, late 1990s, when he championed the notion of a "Brave New World" of technology driven investment opportunities. We can follow the logic of a technologically driven shift in investment opportunities, in neutral real rates and in consequent fed funds rate targets using a three quadrant diagram, and employing the TS schedule envisioned in the Wicksellian model. The upper right and lower right quadrants are standard IS and AS curves. The upper left quadrant presents our Wicksellian TS curve. It is here that the world of finance and the central bank interact in establishing the risky real long rate—the relevant rate for investment decisions.

Think back to the experience of the late 1990s. A BRAVE NEW WORLD of technology innovations, for time, drove investment as a share of GDP in the USA sharply higher, and elevated the economics overall growth rate. Simultaneously, the Wicksellian rate, inferred from the 5-year/5-year forward rate, leapt. In other words, the marketplace for credit dutifully recalibrated the equilibrium interest rate at a higher level, in response to this shift. We can capture this dynamic with the charts below.



The key developments? When the IS curve shifts out, the TS curve shifts up, due to the higher value for "W". Thus the tightening needed, to a great extent, appears to be accomplished by the market place.

Consider the world in 1996:

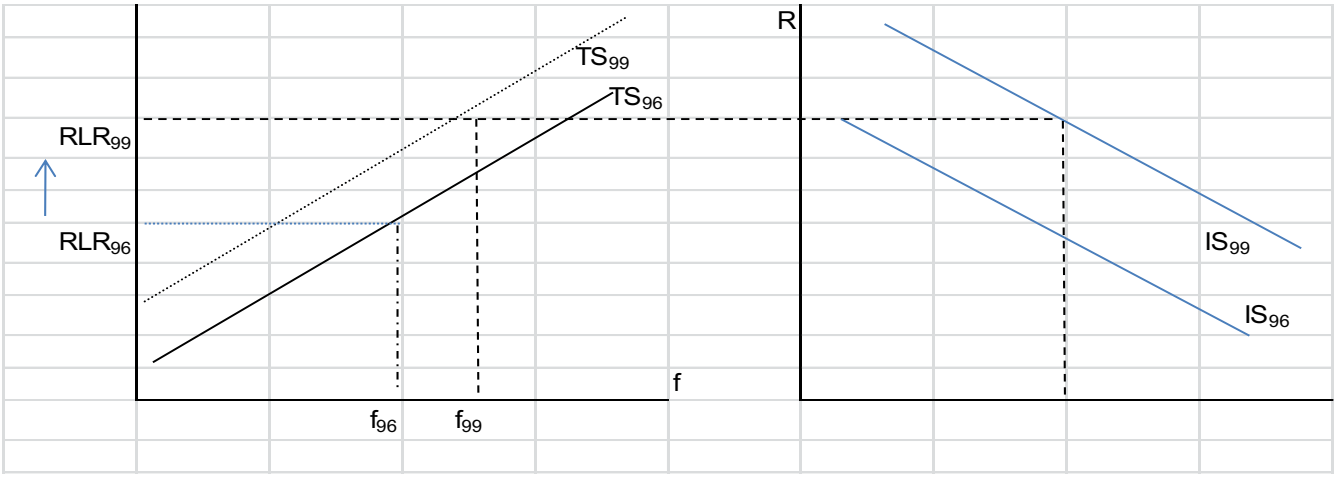


The real funds rate was at 3%, W, the Wicksellian natural risk free rate was 3.6%. Using our TS schedule we that,

$$RLR_{96} = \omega\,(3) + (1 - \omega)\,(3.6) + \omega(0.8) = 3.65\%$$

So the real 10-year yield equaled 3.8%

We then experienced the Brave New World Boom:



The sharp shift outward for the IS curve spoke to the perceived surge in profitable investment opportunities. The surge was noted in the world of finance as W, the Wicksellian risk free natural long rate, we see that it rose to 4.6% by 1999. Graphically we see the effect of that change. Just as the IS curve shifts out, the TS curve shifts up. Our equation captures the change:

$$RLR_{99} = \omega\,(4) + (1 - \omega)\,(4.6) + \omega(0.8) = 4.65\%$$

Notice that the rise for the TS schedule means that the real long term rate is higher for the given fed funds rate. That makes the Fed's job somewhat easier. A modest move up for the fed funds rate, validating the market signal that higher rates are in order, apparently gives us a new healthy higher interest rate equilibrium level.

Of course the reality of the circumstances in the late 1990s turned out to be quite at odds with the notions expectations in place at the millennium came to a close. The "Brave New World" turned out to be mostly a mirage. As the technology bubble burst, so too did belief that ta new higher Wicksellian rate was justified. Rates plunged alongside NASDAQ. And Alan Greenspan found himself easing with gusto to prevent a larger economic decline. At the time it all looked breathtaking. Few knew that the technology wreck of early the 2000s was simply a dress rehearsal for the financial system collapse that was to follow a few short years later.

"The Minsky Modified Model Graphically Takes Us through the Great Recession"

As with the Wicksellian Model, the Minsky model assumes the central bank and the financial markets combine to determine the key interest rates. The distinctive feature of the Minsky model is the performance of credit spreads. This model allows us to incorporate the decidedly

violent moves for risk appetites that attend changing in economic sentiment. A plunge in investment opportunities generally drives risk free real interest rates lower. Our Wicksellian model would therefore look to the marketplace to provide some interest rate relief for the economy . But panic about tail risks, at "Minsky Moments" drives credit spreads sharply higher. The result? Risky real long rates rise amid flagging investment expectations.

The mechanics of the model that produce this result are straightforward. A plunge in investment opportunities and the IS curve shifts inward. The Wicksellian risk free natural long rates falls. But credit spreads soar. As a consequence, the TS curve shifts upward, even as the IS curve has shifted inward. This has the potential to produce a positive feedback loop with decidedly negative implications. Faltering investment opportunities lower the consequent equilibrium output. But elevated risk aversion simultaneously raises the risky rate. This lowers, still further, the equilibrium output level, inviting another downward adjustment for investment opportunities which in turn drives spreads wider which…

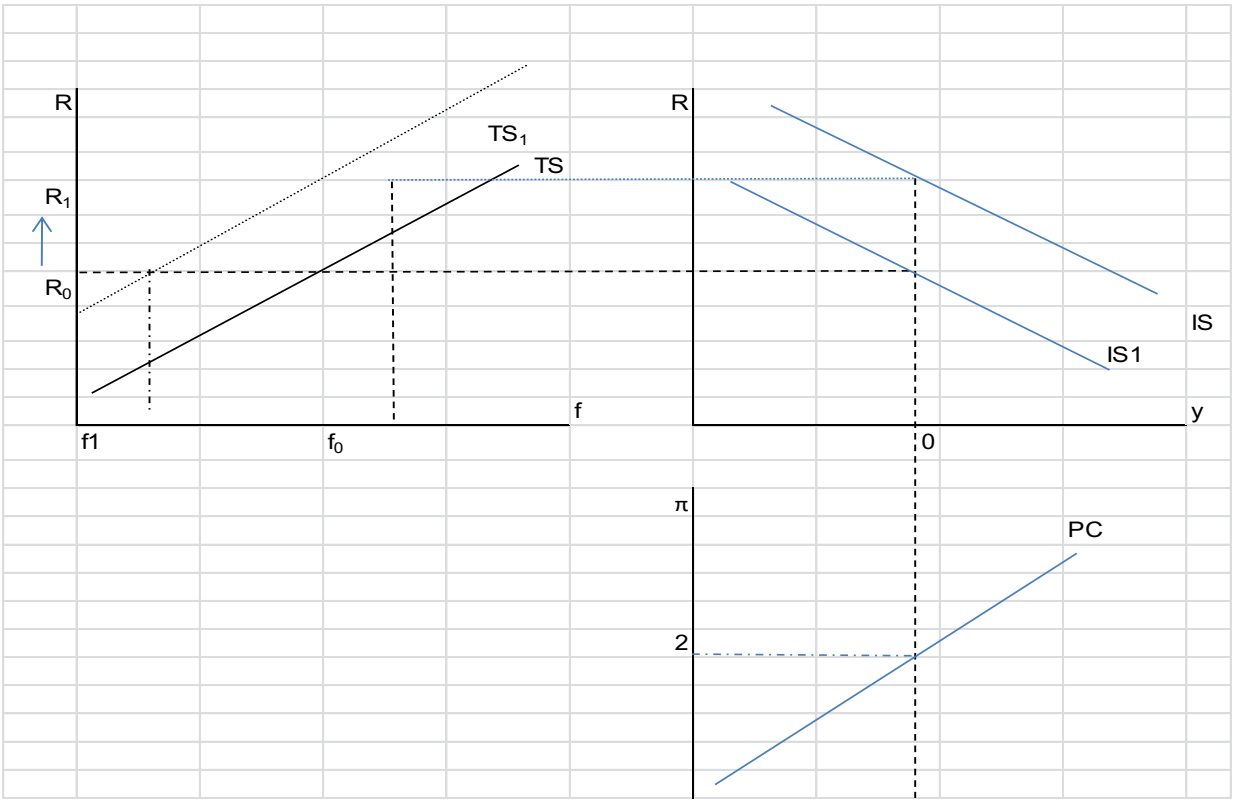
Just such a dynamic gripped the world in 2008-2009.

$R = \omega(f) + (1 - \omega)(W) + \omega(\tau) + \sigma$

2007 RR = .25*(2.5) + .75*(2.5) +.25*(.8) + 1.7 = 4.4%

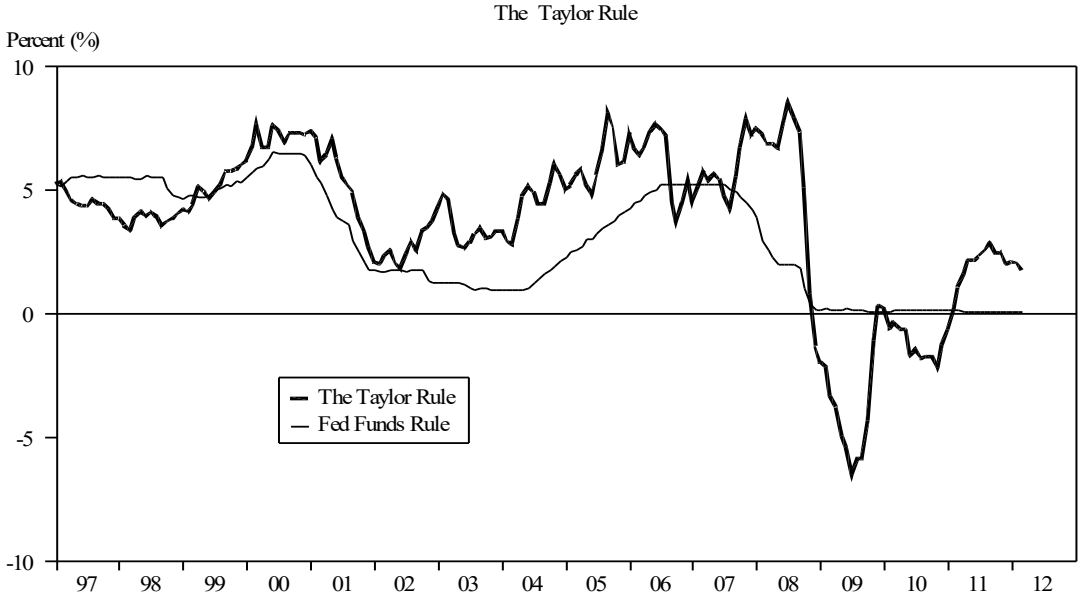
2009 RR = .25*(0.4) + .75*(2) + .25* (.8) + 6.1 = 7.9%

In that experience, risky company borrowing cost NEARLY doubled, in an environment in which economic expectations had plunged. That requires proactive Fed response. Which, of course, is just what we got:



Now let's look at how each of our model's does at predicting actual Fed policy over the past 15 years.

The Taylor Rule Fails, As Surging And Volatile Energy Prices Implied Volatile, And Very High, Fed Funds.

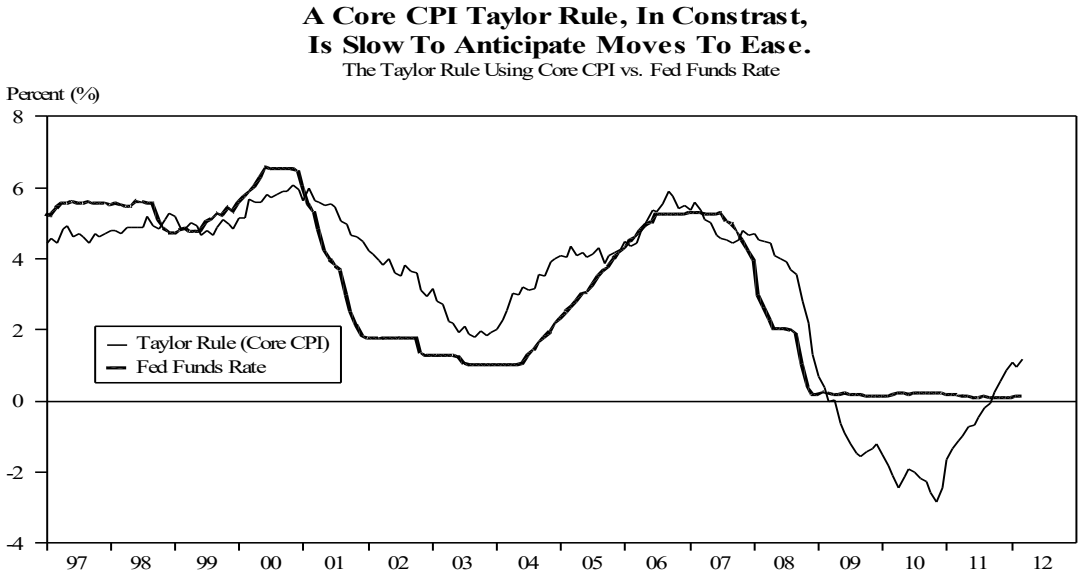


$f = \pi + h * (\pi - \pi^*) + j * (U^* - U) + R$

<u>Monetary Policy Curve</u>

Fed Sets "f". "f" intersects the I.S. curve

The Taylor Rule (Core):

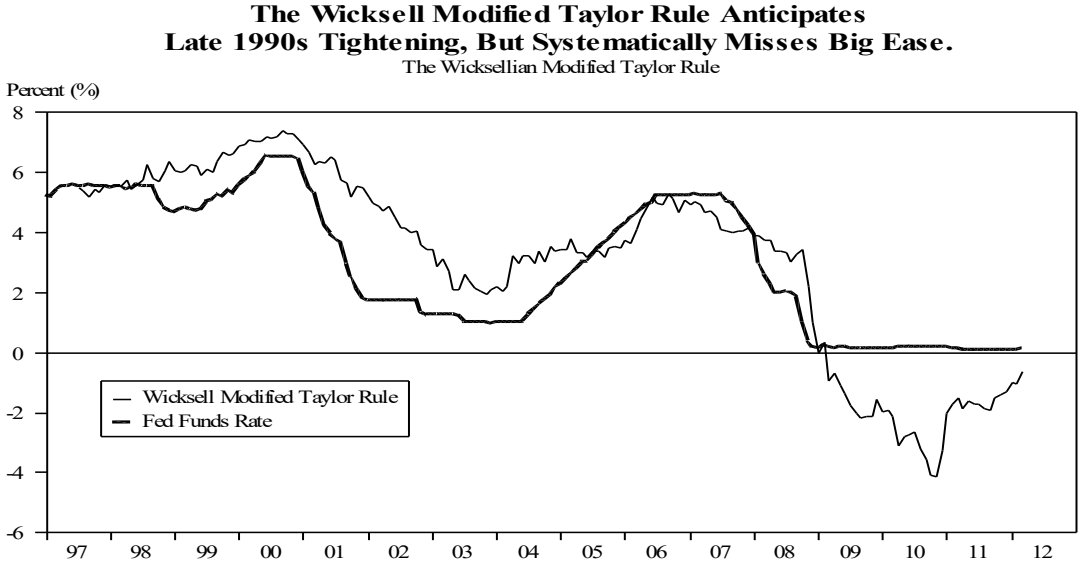


Core CPI Modified Taylor Rule

$f = \pi^{C} + h * (\pi^{C} - \pi^{*}) + j * (U^{*} - U) + R$

<u>Monetary Policy Curve</u>

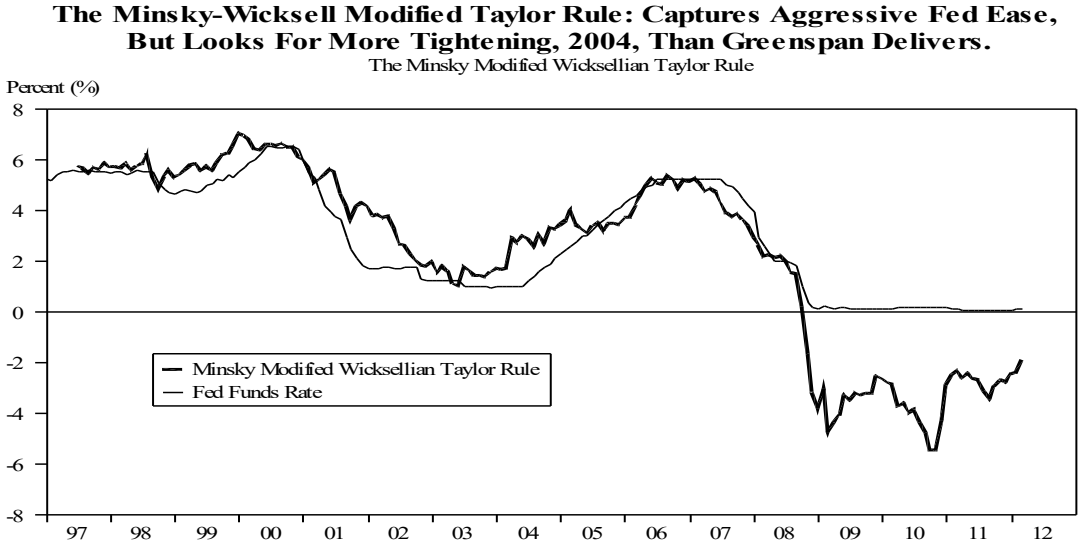
Fed Sets "f". "f" intersects the I.S. curve



π^{*} = Inflation Target = 2% U^{*} = NAIRU = 5% τ = Term Premium = 0.8%

$f = \pi^{c} + h * (\pi - \pi^{*}) + j * (U^{*} - U) + (W - 0.8)$

W = Wicksellian Natural Risk Free Rate = $\big(2 * (10\text{ Year TIPS})\big) - (5\text{ Year TIPS})$



π^* = Inflation Target = 2%

U^* = NAIRU = 5%

τ = Term Premium = 0.8%

W = Wicksellian Natural Risk Free Rate = $\big(2 * (10\text{ Year TIPS})\big) - (5\text{ Year TIPS})$

σ = Average Risk Free Bond Spread = 1.8%

S = Risky Risk Free Bond Spread = (BAA Yield) − (10 Year Yield)

$f = \pi^c + h * (\pi - \pi^*) + j * (U^* - U) + (W - 0.8) + k * (S^* - S)$

We can summarize:

Taylor (Romer) vs. Wicksell (Weiss) vs. Minsky/Wicksell (Barbera/Weise) Models

Taylor (Romer)

Fed funds = I + h*(I-I*) + j*(U*-U) +R

If I=I* and U*=U, then fed funds equals I + R.

Neutral real funds rate is an assertion, exogenously determined (Taylor estimates "2").

Romer model assumes real short rate/IS Curve intersection determines investment and Y.

MP Curve is simply horizontal line, set in this case at "2", the neutral real short rate.

Wicksell (Weise)

Fed funds = I + h*(I-I*) + j*(U*-U) + (W-0.8)

If I=I* and U*=U, then fed funds equals I + (W-0.8)

Wicksell model assumes intersection of real risk free long rate, R, and IS curve determines investment and output.

"W" is the Wicksellian neutral real risk free long rate, inferred from treasury rates.

R, the risk free long rate is a function of f, W and τ*.

TS Equation R= ω(f)+ (1-ω)W + ω(τ)

When Fed wants to establish neutral policy, it wants R, the risk free real long rate to equal W, the equilibrium risk free real long rate.

Neutral Fed policy requires that the fed funds rate drives R to equal W.

Unlike with the standard Taylor rule, the neutral rate changes and we can infer its value from the markets. Suppose we infer from treasury rates that W=2.3%. Furthermore we posit that ω=0.25 and t*=0.8

TS Equation 2.3= 0.25(f +τ) + 0.75(2.3)

2.3 - .75 (2.3) = .25(f + 0.8)

f=1.5

Thus neutral real fed funds rate is 1.5%. That is because when the Fed sets the real fed funds rate to 1.5%, we move along the TS schedule and find that R is 2.3%--the market determined value for W, the neutral risk free long rate.

Minsky/Wicksell (Barbera/Weise)

Fed funds = I + h*(I-I*) + j*(U*-U) + (W-0.8) + k(s*- s)

Minsky/Wicksell model assumes the intersection of real risky long rate, RR, and IS curve determines investment and output.

"W" remains the Wicksellian neutral real risk free long rate, inferred from treasury rates.

"σ" is the spread between risky and risk free long rates.

RR, the risky long rate is a function of f, W, τ* and σ.

σ* is the equilibrium risky/risk free spread(estimated using historical data).

Neutral Fed policy requires that the fed funds rate drives RR to RR*.

RR*=W+ s*

We infer from treasury rates that W=2.3%.

We posit that $\omega=0.25$, $\tau^*=0.8$ and $\sigma^*=1.8$

Thus $RR^*=2.3+1.8 = 4.1$

TM Equation $RR^*= \omega f+(1-\omega)(W)+\omega\tau^* + s^*$

Solve for f:

TS Equation $4.1 = 0.25(f+0.8) + .75(2.3) +1.8$

$4.1 -1.8 = 2.3$

$f = 1.5$

Thus neutral real fed funds rate is 1.5%, with neutral risky real long rate at 4.1%. That is because when the Fed sets the real fed funds rate to 1.5%, We move along the TS schedule to 4.1%--the market determined value for W+s, the neutral risky real long rate. Again, this assumes that all other terms in the equation are at equilibrium levels:

$I=I^*, U^*=U$ and $s^*= s$.

In Tabular Form:

Taylor Rule And The MP Curve (Romer)	**Wicksell Modified Taylor Rule And The TS Curve (Weise)**	**Minsky/Wicksell Modified Taylor Rule And The TS Curve (Barbera, Weise)**
$ff = \pi + b(\pi - \pi^*) + h(u^* - u) + 2$ π, u Real Economy Inputs To FRB	$ff = \pi + b(\pi - \pi^*) + h(u^* - u) + (W - 0.8)$ π, u Real Economy Inputs To FRB	$ff = \pi + b(\pi - \pi^*) + h(u^* - u) + (W-0.8) + j(\sigma^* - \sigma)$ π, u Real Economy Inputs To FRB
IS Curve: ● Downward Sloping ● Investment Schedule Reflects Investor Expectations ● Investment Responds To Changes In Real Fed Funds f	IS Curve: ● Downward Sloping ● Investment Schedule Reflects Investor Expectations ● Investment Responds To Changes In Real Risk Free Long Rate, R	IS Curve: ● Downward Sloping ● Investment Schedule Reflects Investor Expectations ● Investment Repsonds To Changes In Risky Real Long Rates *RR*
MP Curve: Fed Sets "f"	TS Curve: Fed Sets "f", with an eye toward "R" $R= \omega(f) + (1-\omega)(W) + \omega(\tau)$	TS Curve: Fed Sets "f", with an eye toward "R" $r = \omega(f+ \tau+ \sigma) + (1-\omega)W^* + \eta$
<u>Macro Model</u> ● Fed Drives Investment Output Directly, By Shifting The Real Fed Funds Rate	<u>Macro Model</u> ● Fed Manipulates Real Fed Funds , "f" ● When IS Curve Shifts, W Shifts, Reflecting Changes In Investor Expectations ● When IS Curve Shifts, TS Curve Shifts So As To Drive Economy Toward New equilibrium (i.e. IS out, TS up, IS in, TS down) ● Fed Policy Validates "W" Shift Signalled By The Market, Drives Economy Toward New Equilibrium.	<u>Macro Model</u> ● Fed Manipulates Real Fed Funds , "f" ● When IS Curve Shift, W Shifts, Reflecting Changes In Investor Expectations ● When IS Curve Shifts, σ Shifts, Reflecting Changes In Investor Risk Appetites ● At "Minsky Moments" W Falls Sharply But Spreads Surge. The TS, Therefore, Shifts Up As The IS Curve Shifts In. ● At "Minsky Moments", Financial Markets Are Destabilizing And The System Left Unattended, drives itself away from Equilibrium. ● At "Minsky Moments" Fed Policy Must Counter The Market Signals, To Overcome Surge in Spreads, Temper Self Reinforcing Recessions, And Avoid Debt Deflation Depressions.