An Improved IS-LM Model To Explain Quantitative Easing

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26 February 2019

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The paper combines the IS-LM model with a Tobin-style analysis of the banking system. As suggested by Krugman, the resulting model has great predictive power. It can explain quantitative easing and its effect on the economy, helicopter money and money creation by banks. Also, it is free of the normal shortcomings of the IS-LM model.

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I'm grateful to C.A.E. Goodhart and Peter Howells for many helpful comments.

I. Introduction

The IS-LM model has largely disappeared from research and, to some extent, also from teaching. This is understandable given the shortcomings of the model. It is also regrettable given the predictive power of the model.

Krugman (2018) argues that the IS-LM model is in many ways the best model in all of economics. After all, it was the IS-LM model which correctly predicted that there would be no surge in inflation when the Bernanke Fed embarked on quantitative easing and expanded high-powered money by a factor of almost five. And it was the IS-LM model which correctly predicted that the 2009 Obama White House fiscal stimulus would not drive up interest rates. Which other economic model, Krugman asks, provides such strong, counterintuitive and successful predictions?

Krugman suggests that it takes "IS-LM-with-Tobin" to fully leverage the IS-LM model's potential. This paper offers just that. It combines the IS-LM model with a Tobin (1963)-style analysis of the banking system to explain quantitative easing, helicopter money and money creation by banks. In the process, it also frees the IS-LM model of its usual disadvantages.

II. Improved IS-LM Model

The improved IS-LM model is based on three accounting identities and five plausible assumptions. The accounting identities are given by equations (1) to (3) while the assumptions are given by equations (4) to (8).

$$Y \equiv C + I + G \tag{1}$$

$$HPM \equiv CHP + ER + RR \tag{2}$$

$$RR \equiv rrD, \quad \text{with } rr \geq 0 \tag{3}$$

$$I = I(lbi), \quad \text{with } I'(bli) < 0 \tag{4}$$

$$HPM = HPM(ffr), \quad \text{with } HPM'(ffr) < 0 \tag{5}$$

$$CHP = CHP(bli), \quad \text{with } CHP'(bli) < 0 \tag{6}$$

$$ER = ER(bli), \quad \text{with } ER'(bli) < 0 \tag{7}$$

$$D = D(Y), \quad \text{with } D'(Y) > 0 \tag{8}$$

The variables are:

Y:	Output	ER:	Excess reserves
C:	Consumption spending	RR:	Required reserves
I:	Investment spending	rr:	Reserve ratio
G:	Government spending	D:	Demand deposits
HPM:	High-powered money	bli:	Bank loan interest rate
CHP:	Currency held by the public	ffr:	Federal funds rate

Equation (1) is the national income identity for a closed economy. Equation (2) defines the components of high-powered money. Equation (3) defines the reserve ratio.

Equation (4) assumes that investment spending decreases with the bank loan interest rate. This is plausible as a higher bank loan interest rate means that some investment projects are no longer profitable.

Equation (5) assumes that demand for high-powered money decreases with the federal funds rate. This is plausible as the federal funds rate is the

interest rate which banks pay when they borrow high-powered money from the Fed.

Equation (6) assumes that the amount of currency held by the public decreases with the bank loan interest rate. This is plausible as a higher bank loan interest rate generally comes with a higher savings accounts interest rate which makes it more attractive for the public (i.e. households and firms) to reduce currency balances by paying some currency into savings accounts.

Equation (7) assumes that the amount of excess reserves held by banks decrease with the bank loan interest rate. This is plausible as the bank loan interest rate reflects banks' opportunity cost of holding excess reserves instead of making loans.

Equation (8) assumes that demand deposits increase with output. This is plausible as additional output implies additional transactions. Additional transactions imply additional demand deposits, as payment with check, direct debit or bank wire transfer is generally the main method of payment.

The improved IS-LM model consists of an improved IS curve and an improved LM curve.

The improved IS curve is obtained by combining equations (1) and (4).

(I-IS) $$Y = C + I(bli) + G, \quad \text{with } I'(bli) < 0$$

Combining equations (2), (3) and (5) to (8) yields the improved LM curve.

(I-LM) $$HPM(ffr) = CHP(bli) + ER(bli) + rrD(Y),$$
$$\text{with } HPM'(ffr) < 0,\ CHP'(bli) < 0,\ ER'(bli) < 0 \text{ and } D'(Y) > 0$$

III. Improved IS-LM Model Versus IS-LM Model

The improved IS-LM model is similar to the IS-LM model. Developed by Hicks (1937) and Hansen (1953), the IS-LM model consists of an IS curve and an LM curve.

(IS) $$Y = C + I(i) + G, \quad \text{with } I'(i) < 0$$

(LM) $M = L(i, Y)$, with $L'(i) < 0$ and $L'(Y) > 0$

The variables, if not already defined, are:

i: Interest rate L: Liquidity demand

M: Money supply

Figure 1 compares the improved IS-LM model to the IS-LM model. As can be seen, the improved IS-LM operates in output-bank loan interest rate space rather than in output-interest rate space. Also, the improved LM curve has four endogenous variables more than the LM curve. The improved IS curve and the IS curve have the same slope if $I'(i) = I'(bli)$ holds. The improved LM curve and the LM curve have the same slope if $L'(Y) = rrD'(Y)$ and $L'(i) = CHP'(bli) + ER'(bli)$ holds.

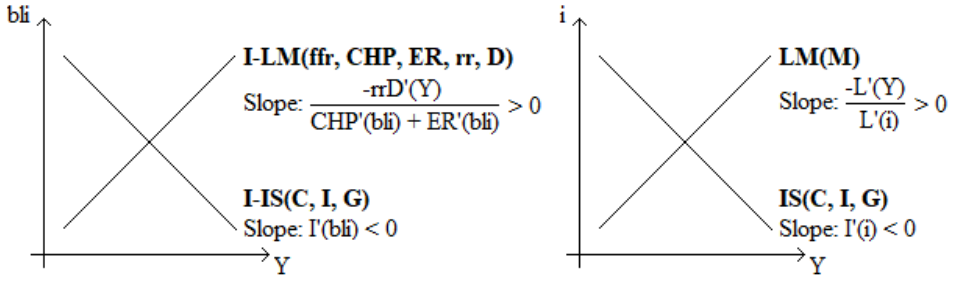

FIGURE 1. IMPROVED IS-LM MODEL VERSUS IS-LM MODEL.

IV. How The Improved IS-LM Model Works

To understand how the improved IS-LM model works, consider a monetary expansion in the model. For $HPM'(ffr)=-4$, $I'(bli)=-20$, $CHP'(bli)=-1$, $ER'(bli)=-1$, $rr=0.1$ and $D'(Y)=1$, a 1 percentage point cut in the federal funds rate leads to a \$20 increase in output, as shown by equation (9).

$$(9) \qquad \frac{dY}{dffr} = \frac{HPM'(ffr)\, I'(bli)}{CHP'(bli) + ER'(bli) + rrD'(Y)\, I'(bli)} = \frac{80}{-4} = -20$$

Figure 2 shows this graphically, assuming arbitrary initial values for the federal funds rate, output and the bank loan interest rate. As can be seen, the 1 percentage point reduction in the federal funds rate from 2% to 1% causes a \$40 rightward shift in the improved LM curve.

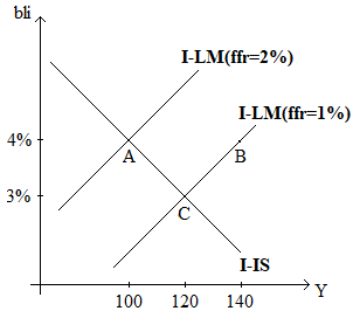

FIGURE 2. REDUCTION IN THE FEDERAL FUNDS RATE IN THE IMPROVED IS-LM MODEL.

Table 1 compares point C – the initial equilibrium – to point A – the new equilibrium – and shows how the variables in equations (I-IS) and (I-LM) change. Several things can be seen.

TABLE 1—CHANGE IN THE INVOLVED VARIABLES: POINT C VERSUS POINT A OF FIGURE 2

(1) Change in the federal funds rate (ffr)	-1 percentage point
(2) Change in high-powered money (HPM)	+$4
(3) Change in the bank loan interest rate (bli)	-1 percentage point
(4) Change in currency held by the public (CHP)	+$1
(5) Change in excess reserves (ER)	+$1
(6) Change in the bank loan supply	+$20
(7) Change in demand deposits (D)	+$20
(8) Change in required reserves (RR)	+$2
(9) Change in bank loan demand	+$20
(10) Change in investment (I)	+$20
(11) Change in output (Y)	+$20

Line 2: The 1 percentage point cut in the federal funds rate comes with a $4 increase in high-powered money as the Fed's New York traders lend an additional $4 of high-powered money to banks to implement the Federal Open Market Committee's decision regarding the federal funds rate.

Line 3: The reduction in the federal funds rate comes with a 1 percentage point reduction in the bank loan interest rate.

Lines 4 and 5: The lower bank loan interest rate makes it more attractive for the public to hoard currency by withdrawing currency from savings accounts and makes it more attractive for banks to hoard excess reserves. Of the $4 increase in high-powered money, $1 is absorbed into currency held by the public and $1 into excess reserves. This leaves $2 of high-powered money to hit the real economy.

Lines 6, 7 and 8: Those $2 of high-powered money that hit the real economy are turned into required reserves as banks create demand deposits by

making loans. When banks make loans, they credit the demand deposit accounts of the firms with a demand deposit of the size of the loan so that the firms can use the money. Thus, both bank loan supply and demand deposits are up by $20. Since the reserve ratio is assumed to be 0.1, required reserves are up by $2.

Lines 9, 10 and 11: Like the bank loan supply, bank loan demand is up by $20 as the lower bank loan interest rate makes firms borrow and invest $20 more. When the firms spend the additionally borrowed $20, output increases by $20 as prices are assumed to be fixed in the short run.

A. Monetary Policy Is Partly Self-Defeating

Figure 2 shows that monetary policy is partly self-defeating. The increase in output would be greater if the bank loan interest rate would not decline so that none of the additional high-powered money is absorbed into idle currency held by the public and excess reserves. Such a happy "state of affairs" is the case at point B of Figure 2. However, as Table 2 shows, point B is no equilibrium as bank loan supply (line 6) exceeds bank loan demand (line 9) by $40 there.

TABLE 2—CHANGE IN THE INVOLVED VARIABLES: POINT B VERSUS POINT A OF FIGURE 2

(1) Change in the federal funds rate (ffr)	-1 percentage point
(2) Change in high-powered money (HPM)	+$4
(3) Change in the bank loan interest rate (bli)	Unchanged
(4) Change in currency held by the public (CHP)	Unchanged
(5) Change in excess reserves (ER)	Unchanged
(6) Change in the bank loan supply	+$40
(7) Change in demand deposits (D)	+$40
(8) Change in required reserves (RR)	+$4
(9) Change in bank loan demand	Unchanged

B. Bonds Instead Of Bank Loans

The aforesaid assumes that banks create demand deposits by making loans and crediting the proceeds to the borrower's demand deposits account. However, banks might just as well create demand deposits by purchasing bonds and crediting the proceeds to the bond issuer's demand deposit account.

In this case, the following replacements are necessary in Tables 1 and 2: "bond market interest rate" instead of "bank loan interest rate" in line (3), "bond demand" instead of "bank loan supply" in line (6), and "bond supply" instead of "bank loan demand" in line (9).

It is also conceivable that banks create additional demand deposits partly through loans and partly through bonds. In this case, the appropriate terms are "credit market interest rate", "credit supply" and "credit demand".

V. Improved IS-LM Model And Quantitative Easing

Equation (9) shows that monetary policy becomes ineffective under certain conditions. Those conditions are summarized in Table 3.

TABLE 3—CONDITIONS WHICH RENDER MONETARY POLICY INEFFECTIVE

Condition	Effect on curve	Economic intuition
ER'(bli)→∞	Horizontal improved LM curve	Banks are unwilling to make loans and rather hoard excess reserves
I'(bli)=0	Vertical improved IS curve	Firms are unwilling to borrow
HPM'(ffr)=0	Horizontal improved LM curve	Banks are unwilling to borrow high-powered money from the Fed
CHP'(bli)→∞	Horizontal improved LM curve	The public hoards as much currency as possible
D'(Y)→∞	Horizontal improved LM curve	Firms are unwilling to spend borrowed money
rr→∞	Horizontal improved LM curve	The Fed sets an extremely high reserve ratio

If one of those conditions holds, or nearly holds, the effectiveness of monetary policy is hampered, and the Fed may undershoot its inflation target. In response, the Fed may drive the federal funds rate down to zero. Once there, the Fed may wish to resort to quantitative easing if inflation is still too low.

In quantitative easing, the Fed purchases financial assets from banks with high-powered money. Despite the additional high-powered money, the federal funds rate does not go any lower as it has already reached its zero lower bound.

The improved IS-LM model can show quantitative easing. For HPM'(ffr)=0, high-powered money becomes exogenous and the Fed can increase it directly. Equation (10) shows the effect of such a direct increase in high-powered money on output in the improved IS-LM model.

(10) $$\frac{dY}{dHPM} = \frac{I'(bli)}{CHP'(bli) + ER'(bli) + rrD'(Y)\, I'(bli)}$$

Equation (10) is equal to equation (7) with the only exception that the term HPM'(ffr) no longer appears. Given the similarity of both equations, it follows that if the efficiency of conventional monetary policy is restricted by an unfavorable parameter other than HPM'(ffr), quantitative easing is suffering, too.

If quantitative easing is more effective than conventional monetary policy, then only because of scale. In quantitative easing, the Fed can increase high-powered money quite drastically. For example, following the financial crisis, the Fed increased high-powered money by a factor of almost five.

A. LM Channel of Quantitative Easing

If the improved LM curve is minimally upward sloping rather than flat and if the improved IS curve is not vertical, sheer mass may make quantitative easing somewhat effective. A small portion of the flood of high-powered money may trickle into the real economy, leading to some increase in bank loans, demand deposits, required reserves and output. The remainder of the additional high-powered money ends up idly as currency held by the public and/or excess reserves.

B. IS Channel of Quantitative Easing

There is also the possibility that the flood of high-powered money shifts the improved IS curve to the right. This is not modelled here, yet it is conceivable. In this case, output will increase if the improved LM curve is not vertical which most likely it isn't as otherwise monetary policy would be highly effective and there would be no need to resort to quantitative easing in the first place.

The ratio of the increase in high-powered money to the prompted shift in the improved IS curve will probably be large, so that most of the additional high-powered money ends up idly as currency held by the public and/or

excess reserves. Again, a small portion may however trickle into the real economy as some firms are willing to borrow and spend additional money because of quantitative easing and its effect on credit conditions.

Then Fed chairman Ben Bernanke emphasized the "IS channel" in 2009 when the Fed embarked on quantitative easing. Bernanke went so far as to make a distinction between "pure" quantitative easing as employed by the Bank of Japan from 2001 to 2006 and the Fed's approach (Bernanke 2009).

While he admitted that both approaches involve an expansion of the central bank's balance sheet, he argued that in pure quantitative easing, the focus of policy is the quantity of bank reserves, which are liabilities of the central bank; at the same time, the composition of loans and securities on the asset side of the central bank's balance sheet is only incidental.

In contrast, according to Bernanke, the Fed's credit easing approach focused on the mix of loans and securities that it holds and on how this composition of assets affects credit conditions for households and businesses. Bernanke even tried to call the Fed's new policies "credit easing" to distinguish it from pure quantitative easing. However, as Blinder (2010) notes, the label did not stick.

C. Predictive Power Of The Improved IS-LM Model

Irrespective of whether quantitative easing works through the IS channel or the LM channel, the improved IS-LM model suggests that even very large increases in high-powered money affect output (and/or prices if the latter are flexible) only modestly if quantitative easing is employed in a situation where unfavorable parameters hamper conventional monetary policy. Instead, only currency held by the public and/or excess reserves go through the roof.

This is a good prediction. US quantitative easing increased output and prices by only 26% between January 2008 and December 2015. At the same time, it increased excess reserves by 140,000% (Federal Reserve 2018). As Krugman (2018) notes, this is not only a successful prediction

but apparently also a counterintuitive one as there were many people who predicted that quantitative easing would lead to high inflation.

If it is a flat improved LM curve that gives rise to quantitative easing, the improved IS-LM model suggests furthermore that fiscal stimulus does not drive up interest rates when employed alongside quantitative easing. As Krugman (2018) notes, this is another counterintuitive IS-LM prediction which came true recently.

VI. Improved IS-LM Model And Helicopter Money

From the aforesaid it follows that quantitative easing does not work if (a) the improved LM curve is horizontal and if (b) the improved IS curve does not react to quantitative easing.

In such a case, the Fed may want to attack the IS curve directly. This is called helicopter money.

In helicopter money, the Fed uses newly created high-powered money to acquire demand deposits at banks. The Fed then gifts the demand deposits to households or, alternatively, to the government. While it is not clear whether households will spend the money so received, it seems certain that the government would agree to do so if this is necessary to combat deflation. If helicopter money is distributed to the government, the process is also known as government debt monetization.

This mechanism is very powerful as both the improved LM curve and the improved IS curve shift to the right here. In fact, this is the very mechanism through which all past hyperinflations came about.

VII. Improved IS-LM Model And Money Creation By Banks

As McLeay et al. (2014) note: In the modern economy, most money takes the form of demand deposits and is created endogenously by banks. The improved IS-LM model reflects that. This is a major step forward when compared to the IS-LM model which assumes that all money is created by the Fed.

A. Tobin's (1963) Analysis Of The Banking System

The improved IS-LM model also drives home a point made by Tobin (1963), namely that banks do not possess a "widow's cruse". There are limits to the banking systems' capability to create money as "Marshall's scissors of supply and demand" apply also to the output of the banking industry (i.e. to bank loans and demand deposits). If demand deposits are excessive relative to public preferences, Tobin argued, they will tend to decline, and banks cannot do anything about it.

The improved LM and IS curves reflect Marshall's scissors of supply and demand. Banks can create additional demand deposits only subject to public preferences. If there is no demand for loans, that is, if the improved IS curve is vertical, banks cannot create additional demand deposits at all.

For a non-vertical improved IS curve, banks can create additional demand deposits (a) because they themselves choose to do so by exogenously decreasing excess reserves, or (b) because the Fed, households, firms or the government curve induce them to do so.

B. Fed- And Non-Fed-Induced Money Creation By Banks

How the Fed can induce banks to create additional demand deposits was described in chapter IV. There, a 1 percentage point reduction in the federal funds rate made banks create $20 in additional demand deposits. The process is governed by equation (11).

$$\frac{dD}{dffr} = \frac{HPM'(ffr)\, I'(bli)\, D'(Y)}{CHP'(bli) + ER'(bli) + rrD'(Y)\, I'(bli)} = \frac{80}{-4} = \text{-}20 \tag{11}$$

Next to the Fed, households, firms and the government can induce banks to create additional demand deposits. Equation (12) shows how a $1 increase in, here, consumption spending makes banks create $0.5 in additional demand deposits for the parameters from chapter IV.

$$\frac{dD}{dC} = \frac{CHP'(bli)\, D'(Y) + ER'(bli)\, D'(Y)}{CHP'(bli) + ER'(bli) + rrD'(Y)\, I'(bli)} = \frac{-2}{-4} = 0.5 \tag{12}$$

The same expression holds for an increase in investment or government spending. Equation (12) drives home the point of Goodhart (2017) that banking is a service industry which sets the terms and conditions whereby the private and government sector can create additional money for itself.

VIII. Eliminated Shortcomings Of The IS-LM Model

As a welcome side-effect, the improved IS-LM model eliminates all the shortcomings of the standard IS-LM model.

A. Unlike The IS-LM Model, The Improved IS-LM Model Does Not Assume That The Fed Targets Money

The IS-LM model assumes wrongly that the Fed targets money, and more specifically the money supply M. In principle, the Fed might do so by setting a target path for M or by explicitly changing M from time to time, for example after a Federal Open Market Committee (FOMC) meeting.

This is, however, not how the Fed conducts monetary policy today. Rather, the Fed targets the federal funds rate: The FOMC from time to time decides upon a change in the federal funds rate and the Fed's New York traders continuously adjust a measure of the money supply (high-powered money) as necessary to keep the federal funds rate as close as possible to the FOMC's target. The improved IS-LM model fully reflects that.

B. Unlike The IS-LM Model, The Improved IS-LM Model Is Clear About Its Money Measures

The IS-LM model is unclear about the LM curve's money measures M and L. Very few authors are willing to take a stance whether M and L reflect high-powered money, M1 money or some entirely different money measure.

In contrast, the improved LM curve is clear about its money measures which are: High-powered money, currency held by the public, excess reserves, and demand deposits.

High-powered money gives the Fed's leverage over the economy: Banks need it because the public demands currency and/or because the Fed demands required reserves; at the same time, only the Fed can create it.

Demand deposits underlie transactions which in turn underlie additional output. Equation (4) assumed that all transactions are settled cashless through demand deposits as output is not related to currency held by the public. For added realism, one could also allow for cash transactions. In this case, in equation (4), the demand for currency held by the public would depend not only negatively on the bank loan interest rate but also positively on output.

C. Unlike The IS-LM Model, The Improved IS-LM Model Is Clear About Its Interest Rate

The IS-LM model is unclear about its interest rate i. Very few authors are willing to take a stance whether i reflects the federal funds rate, the bank loan interest rate or some entirely different interest rate.

In contrast, the improved IS-LM model is clear about its interest rates which are the federal funds rate and the bank loan interest rate.

The federal funds rate is the Fed's policy rate and the Fed manipulates high-powered money as necessary to achieve its target for the federal funds rate. The bank loan interest rate matches demand and supply for bank loans. As discussed in section IV B, the interest rate can be generalized to a bond market interest rate or a credit market interest rate.

IX. Conclusion

The improved IS-LM model puts flesh on the bones of the IS-LM model. While it maintains the IS-LM model's basic structure, it is more precise regarding its money measures and interest rates (Table 4).

TABLE 4—THE IMPROVED IS-LM MODEL PUTS FLESH ON THE BONES OF THE IS-LM MODEL

Variables of the IS-LM Model	Variables of the Improved IS-LM Model
Output (Y)	Output (Y)
Interest rate (i)	Bank loan interest rate (bli)
	Federal funds rate (ffr)
Consumption spending (C)	Consumption spending (C)
Investment spending (I)	Investment spending (I)
Government spending (G)	Government spending (G)
Money (M)	High-powered money (HPM)
Liquidity (L)	Currency held by the public (CHP)
	Excess reserves (ER)
	Demand deposits (D)

This paper is not the first attempt to improve the IS-LM model in general and the LM curve in particular.

Bernanke and Blinder (1988) suggest a modified LM curve which includes bank reserves to analyze the relative merits of bank assets and bank liabilities as indicators and targets of monetary policy. Since Bernanke and Blinder were not interested in quantitative easing or helicopter money, their LM curve does however not include high-powered money as an entity separate from reserves. Nor does it include excess reserves or the federal funds rate to distinguish quantitative easing from conventional monetary policy.

More recently, Mierau and Mink (2018) suggest a modified LM curve which includes bank equity to analyze the role of capital requirements in the transmission of monetary policy. Like Bernanke and Blinder, Mierau and Mink do not attempt to explain quantitative easing and helicopter money and so their model doesn't include high-powered money or excess reserves.

Many other authors have discarded the LM curve all together. Following Clarida et al. (1999), interest rate rules have displaced the LM curve in most research.

In teaching, the LM curve has held its ground better. Mankiw (2006) gives detailed reasons why, for teaching, he continuous to prefer the LM curve to an interest rate rule. Next to Mankiw (2016), other textbook authors who uphold the IS-LM model include Abel, Bernanke and Croushore 2017, Blanchard 2017, Dwivedi 2015, Froyen 2013 or Heijdra 2017. However, even in teaching, the LM curve is under pressure as Romer (2000),

Allsopp and Vines (2000), Taylor (2000), Walsh (2002), Carlin and Soskice (2005) or Bofinger et al. (2006) have suggested simple models that replace the LM curve with an interest rate rule.

The aforesaid sketches the competition and the environment which the improved IS-LM model faces. Naturally, for the improved IS-LM model to succeed, it must be superior to the other models, at least for some applications. Table 5 provides a comparison on which the improved IS-LM model might stake its claim.

TABLE 5—IMPROVED IS-LM MODEL VERSUS OTHER MODELS

	Improved IS-LM Model	Standard IS-LM Model	Interest Rate Rule	Bernanke/ Blinder Mierau/Mink
Assumes that the Fed targets the federal funds rate in conventional monetary policy?	✓	×	✓	×
Shows how the Fed targets the federal funds rate by manipulating high-powered money?	✓	×	×	×
Is clear about its money measure(s) (if any are included in the model) and its interest rate(s)?	✓	×	✓	✓
Recognizes that most of today's broad broad money is created by banks and not by the Fed?	✓	×	×	✓
Can explain quantitative easing and helicopter money (including government debt monetization)?	✓	×	×	×

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