Dynamic IS Curves With and Without Money:

An International Comparison

By

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ABSTRACT

When money is added to a dynamic IS model, evidence from six countries indicates that money growth usually helps predict the GDP gap and that the predictive power of a short-term real interest is much weaker than previous work suggests. Thus, for dynamic IS models such as that used by Rudebusch and Svennson (1999, 2002), the omission of money appears to come at a high cost.

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I. Introduction

There has been a revival of interest in simple empirical business cycle models. These models generally center around some form of dynamic IS curve in which today's GDP gap depends on lags (e.g., Rudebusch and Svensson (1999, 2002)) or expected leads (e.g., McCallum and Nelson (1999a, 1999b, 2001), Woodford (2003), Rudebusch (2005)) of the GDP gap and on some measure of the real interest rate. What distinguishes this type of IS equation is that the reduced form model of the economy excludes any money measure. These models are widely used both in macroeconomic research and in the central banks of many countries. When combined with an expectations-augmented Phillips curve and a Taylor-type interest rate rule, such an IS curve gives one a complete, three-equation model of a nation's economy in which the role of monetary policy comes through manipulations of the short-term interest rate. Money plays no obvious role.

This paper address whether there is a role for money in the empirical version of such IS equations. In particular, we investigate whether real money growth measures are statistically and economically significant when added to Rudebsuch and Svensson's (2002) oft-cited dynamic, real-interest-rate IS curve model, estimated for six industrial economies. Our main interest is to determine whether the roles for money and interest rates in business cycles have changed over time and across varied policy and economic environments.

In brief, we find that the role of money has not diminished at business-cycle frequencies relative to the role of short-term real interest rates. Our evidence indicates that lagged real M2 growth helps predict the GDP gap in Japan, the U.K., and the U.S. while any significant predictive power of the lagged short-term, real interest has vanished

in all six countries. These results, which reinforce the U.S. results of Hafer, Haslag, and Jones (forthcoming), are of interest both to forecasters who want to make the most accurate possible prediction of GDP, as well as to policymakers in industrialized countries looking for rules of thumb regarding the link between monetary policy instruments and the GDP gap.

II. Model, Data and Methodology

The model estimated here is a version of that used in Rudebusch and Svensson (2002). They estimated a dynamic IS equation for the U.S. in which the output gap is explained by the real federal funds rate and lagged gap. Their important and controversial finding is that, at least for the U.S., movements in the money supply play no role in determining deviations of real output from its long-term path.[1] Following Rudebusch and Svensson, we estimate the equation

$$(1) \qquad y_{gt} = \eta + \alpha_1 y_{gt-1} + \beta_1 (\bar{i}_{t-1} - \bar{\pi}_{t-1}) + \beta_2 \Delta_4 m_{t-1} + \varepsilon_t$$

where y_{gt} is the output gap, $\bar{i}_{t-1} - \bar{\pi}_{t-1}$ is a measure of the ex post real rate of interest, m_{t-1} is a lagged measure of the money supply, and ε_t is an error term.[2] We include a constant term (η) in contrast to Rudebusch and Svennson's practice of demeaning all variables and

[1] For related analyses, see, among others, Fuhrer and Moore (1995), Kerr and King (1996), McCallum and Nelson (1999), Rudebusch and Svensson (1999), Gerlach and Smets (1999), Meltzer (2001), Amato and Gerlach, or Nelson (2002). Brückner and Schabert (2003) provide a theoretical model where broad money can impact output, while Goodhart and Hofmann (2003) replicate some of our multi-country results, but are less comprehensive in their choice of money measures. Leeper and Roush (2003) provide another empirical treatment of the issue, while Nelson (2003, 2004) provides thoughtful analyses of money's role in monetary policy.

[2] In an earlier version, we estimated equation (1) with a measure of the real trade-weighted exchange rate included. In every instance we found that this measure was not statistically significant at any reasonable level. This reinforces the classic conclusions of Darby and Lothian (1983), especially the theoretical and empirical conclusions of Darby (1983) and Laskar (1983) in that volume. Darby and Laskar concluded that even under pegged exchange rates, developed countries had substantial monetary policy independence. For sake of brevity we omit these exchange rate results from our discussion.

excluding a constant. In the estimated version of equation (1) two lags of the GDP gap are included to ensure that the econometric specification is not tilted in favor assigning explanatory power to the monetary policy variables.

A key aspect of this study is to expand the number of countries analyzed. In addition to the U.S., we also examine the usefulness of equation (1) for Canada, France, Germany, Japan, and the United Kingdom. Since becoming part of the EU central banking system, one might argue that the evidence presented for the individual countries is moot. We feel that amassing evidence to determine the comparative roles of interest rates and money measures in setting monetary policy remains an important exercise, the results from which could guide central bank policy across a number of institutional arrangements.

The data used for this study are taken from the IFS dataset. We use quarterly values of real GDP for each country except Germany, where industrial production is used to provide a much longer sample. Inflation is measured using the relevant consumer price index for each country. The interest rate measure is always the short-term rate that is most similar to the federal funds rate for the U.S. Finally, the money measures used include the closest measures to the monetary base, M1, and M2.[3] Logs of real GDP were detrended using a conventional Hodrick-Prescott (1997) filter in order to focus on the business cycle component of the series.[4]

To maintain comparability with the Rudebusch and Svennson approach and findings, the real interest rate is measured as the four-quarter average of the nominal rate minus the four-quarter growth rate of consumer prices. Similarly, the measures of real

[3] No M1 equivalent is available for the U.K.
[4] We also experimented with using a simple detrending of real GDP using deviations from a time trend. The results from this approach are broadly consistent with the Hodrick-Prescott measures.

money growth (nominal money relative to the CPI) are a four-quarter change in the log level of the particular measure. All regressions are estimated using White's heteroskedasticity consistent standard errors.

All regressions initially are estimated over the longest available sample period. The full samples are: Canada (1958-2000); France (1970-1999); Germany (1961-1998); Japan (1960-1999); United Kingdom (1958-2000); and the U.S. (1958-2000). For each country we estimate four different specifications: a baseline version that included only the real rate of interest and lagged gap and then versions that separately include the three money measures.

Before turning to our results, it is useful to consider Rudebusch and Svensson's (2002) reported outcome from estimating their version of equation (1).[5] Based on data for 1961-1996, their results for the U.S. are (t-statistics in parentheses):

(2) $$y_{gt+1} = \underset{(14.70)}{1.161}\, y_{gt} - \underset{(3.36)}{.259}\, y_{gt-1} - \underset{(2.75)}{.088}\, (i - p_t)$$

$R^2 = .90$; SE = .823; DW = 2.08

where the variables are defined as above.[6] In their estimation, the output gap is measured as the percentage difference between actual real GDP and the Congressional Budget Office's (CBO) measure of potential real GDP, i is the federal funds rate, and p_t uses the GDP chain weighted index. As is clear from this regression, the real federal funds rate exerts a negative and statistically significant effect on the gap. Rudebusch-Svensson (2002) note that this estimated relation has two significant characteristics. First, it is

[5] Comparative estimates for the U.S. are provided by Rudebusch and Svensson (2002), Nelson (2002) and Hafer, Haslag and Jones (forthcoming); and for the United Kingdom, Nelson (2002).
[6] The variables are measured as deviations from their mean values before estimation; hence the omission of a constant term. See Rudebusch and Svensson (2002) for more discussion of the construction of the variables.

stable across 1961-96. Second, and most important for our purposes, they report that "lags of money (in levels or growth rates) were invariably insignificant when added" to equation (1).[7]

The outcome from our estimation of equation (1) for the different countries in our sample is reported in Table 1.[8] The results show that money generally plays a statistically important role in explaining movements in the gap for several countries in our sample. For Japan, the U.K. and the U.S., the base, M1 and M2 all are significant. For Canada, only the base measure of money is significant and in Germany, M1 and M2 achieve significance. Only for France do we find that no measure of money helps explain movements in the gap. In every instance the estimated coefficient is of the expected positive sign.

Aside from the statistical significance of the money measures, how does one interpret the estimates? Because the monetary policy variables are measured as four-quarter averages and growth rates while the GDP gap variable is a one-quarter level, the interpretation of these monetary policy coefficients is not intuitive. Consider a case where the GDP gap is an AR(1) process with a coefficient of one. (This is not too far from the truth in these models, since the GDP gap is a persistent process, with the AR(2) coefficients tending to sum to 0.7 or 0.8). If this AR(1) coefficient is equal to one, we can interpret the monetary policy coefficients as a permanent change in GDP. Therefore, if money growth rises once and for all by 1% above its baseline level, then a once and for

[7] Gerlach and Smets (1999) also find that adding M2 or M3 to a three-variable VAR model consisting of output, inflation and a nominal interest rate, does not improve the model's explanatory power when estimated for each of the G-7 countries. The fact that simple VAR models reject the importance of money may stem from the stationarity assumptions imposed on the data.

[8] For sake of convenience we exclude the estimated values for lagged gap. The full results are available on request.

all rise in real M2 would have an impact on the monetary policy indicator *for four quarters*. For example, the coefficient on M2 for the U.S. equals 0.066. That means that a 1% rise in money would lead to a 4%*6.6%= 0.264% impact on GDP after four quarters and a permanent 10 percent rise in M2 would therefore lead to a 2.646% rise in GDP after four quarters.

What also stands out in Table 1 is the fact that the real interest rate is not a very robust measure across countries. That is, while the real rate is significant for the U.S., as found in earlier studies, it never achieves significance, whether alone or paired with a money measure, in France, Japan and the U.K. Only for Germany is there evidence of a consistent effect from changes in the real rate to the gap. According to the results in Table 1, the real short-term interest rate may not be the only monetary indicator that policy makers should consider. Indeed, excluding money from an analysis of movements in the gap generally is not warranted.

III. Stability Tests and Subsample Results

Parameter instability often is cited as a problem in estimated monetary policy models. We test for parameter instability using a combination of the CUSUM-Square test along with the Chow test. Because there are a number of combinations one could estimate, we take the following approach. The CUSUM test is used to identify a likely break in the equation that includes only the lagged gap. Once this break is identified, we estimate the versions of equation (1) that includes (separately) the lagged real rate and the various measures of money. A Chow test is used to test for the break's statistical significance with the other variables included. In some sense, this allows us to determine which expanded version of equation (1) improves the stability of the relationship.

Although there are other approaches available, this seems reasonable to answer the question at hand.

The outcome of this approach is reported in Table 2. The first column reports the likely break point based on the CUSUM-SQ test when the gap is regressed on itself. The remaining columns report results of the Chow test for parameter instability (at the 95% significance level) for the versions that include the lagged real rate of interest and versions that include the lagged real rate and the various money measures. The CUSUM tests indicate that the most likely break points generally occur in the mid-1970s. Given the impact of global recession at this time, such a finding may not be too surprising. The only deviation from this result is Germany, for which the test suggests a break in the late 1960s.

The results from the Chow breakpoint tests for the CUSUM-selected dates are interesting. When only the lagged real rate of interest is included with lagged gap, the null hypothesis of stability is rejected only for Canada. The significance levels for the other test statistics (reported in parentheses) do not reject stability. When the monetary measures are added, there is greater evidence of instability. Overall, the evidence of stability is spotty: for Germany, using M1 and M2, and for Japan when M1 is used.

Given the break in the estimated relations, what is the recent relative impact of the real rate and money using only the most recent data? To answer this question, Table 3 reports the estimates of equation (1) using only the post-break data. Of note is the fact that, like in Table 1, the real rate of interest usually does not achieve statistical significance when estimated as the only monetary policy measure (the Rudebusch-Svensson outcome). In the cases of Canada, France, and the U.S., the real rate achieves

statistical significance only when conditioned on money. This suggests that when money is omitted from a business-cycle model, it probably is misspecified.[9] And, although significant in Japan, the estimated coefficient on the real rate has the wrong sign.

The results for the money measures indicate that the base significantly affects the gap only for Canada, and M1 is significant at the 10 percent level or better in three countries (Canada, Germany and the U.S.). M2 is significant in four countries; namely, Germany, France, the U.K., and the U.S. Therefore, while there is evidence that the estimated dynamic IS-curve relationship underwent a structural break in recent decades in the countries used, the evidence is consistent with the notion that broad money's statistical affect on the gap, independent of the real rate of interest, persists in the more recent period.

V. Conclusions

The current quest for simple monetary models without money (among others, McCallum (2001), Woodford (2003)) appears premature at best, at misguided at worst. The evidence from the six countries used here suggests that money, independently of the real rate of interest, generally exerts a significant impact on the GDP gap. Indeed, in recent decades, Japan is the *only* country in our sample for which broad money has no statistically significant relationship with the GDP gap. By examining the relative role of the real short-term interest rate and real money in predicting future GDP, we find that real money is the more significant policy measure. Empirical results such as these should encourage future work, theoretical and empirical, to explain money's robust relationship with the GDP gap.

[9] Leeper and Roush (2003) show that the liquidity effect in a VAR model increases substantially when M2 is included.

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Table 1
Full sample regression results[1]

		Estimated coefficients			
Country	Real rate	Base	M1	M2	R^2/DW
Canada	-0.042				0.69/2.01
	(1.72)*				
	-0.011	0.041			0.70/2.01
	(0.43)	(2.04)**			
	-0.044		0.014		0.70/2.02
	(1.85)*		(1.60)		
	-0.042			0.002	0.70/2.01
	(1.54)			(0.08)	
France	-0.021				0.73/2.08
	(1.06)				
	-0.022	0.003			0.72/2.08
	(1.18)	(0.71)			
	-0.024		0.020		0.75/2.01
	(0.90)		(1.13)		
	-0.019			0.018	0.75/2.01
	(0.65)			(0.95)	
Germany	-0.174				0.72/2.01
	(2.38)**				
	-0.246	0.011			0.72/1.94
	(3.49)**	(0.31)			
	-0.167		0.040		0.72/2.03
	(2.31)**		(1.90)**		
	-0.274			0.097	0.73/1.99
	(3.25)**			(3.36)**	
Japan	0.025				0.67/1.98
	(0.79)				
	0.026	0.030			0.68/1.96
	(0.80)	(2.51)**			
	0.015		0.035		0.69/1.98
	(0.51)		(3.31)**		
	-0.003			0.045	0.69/1.97
	(0.09)			(3.48)**	
UK	0.007				0.61/1.92
	(0.34)				
	-0.006	0.022			0.62/1.94
	(0.28)	(1.88)*			
	-0.021			0.024	0.63/1.94
	(0.90)			(3.04)**	
US	-0.0004				0.76/2.12
	(1.46)				
	-0.001	0.034			0.77/2.19
	(1.62)*	(2.44)**			
	-0.001		0.041		0.77/2.03
	(1.64)*		(2.85)**		
	-0.001			0.066	0.78/2.00
	(1.91)**			(3.26)**	

1. Sample periods and variables are described in the text. All equations include two lags of the dependent variable and a constant term. (Complete estimation results are available upon request.) Values in parentheses are absolute values of t-statistics. Significance at the 10 percent level is indicated by *; significance at the 5 percent or higher level is indicated by **.

Table 2
Stability test results

Country	CUSUM-SQ date	Chow tests results[1] for model with: Rate	Rate/Base	Rate/M1	Rate/M2
Canada	1973.4	5.10 (0.002)	3.51 (0.004)	3.60 (0.004)	4.96 (0.003)
France	1978.4	0.40 (0.76)	2.18 (0.06)	2.65 (0.03)	2.48 (0.04)
Germany	1967.4	2.18 (0.93)	2.87 (0.02)	1.61 (0.16)	0.49[2] (0.78)
Japan	1973.4	1.90 (0.11)	2.22 (0.06)	1.59 (0.17)	2.10 (0.07)
UK	1973.4	0.57 (0.68)	2.83 (0.02)	NA	3.62 (0.004)
US	1974.4	1.03 (0.39)	0.30 (0.91)	4.12 (0.002)	2.09 (0.07)

1. F-statistics with levels of significance in parentheses.
2. Due to data restrictions on M2, this break is the midpoint of the sample, 1983.4.

Table 3
Post-break regression results[1]

		Estimated coefficients			
Country	Real rate	Base	M1	M2	R^2/DW
Canada	-0.022				0.83/2.05
	(1.01)				
	0.0001	0.040			0.84/2.04
	(0.01)	(2.05)**			
	-0.037		0.018		0.84/2.03
	(1.75)*		(1.70)*		
	-0.032			-0.019	0.83/2.05
	(1.30)			(0.98)	
France[2]	-0.027				0.75/2.06
	(1.00)				
	-0.027	-0003			0.74/2.06
	(1.00)	(0.05)			
	-0.024		0.020		0.74/2.02
	(0.91)		(1.12)		
	-0.150			0.018	0.78/2.04
	(2.10)**			(1.87)*	
Germany[2]	-0.243				0.72/1.87
	(2.91)**				
	-0.320	0.026			0.71/1.86
	(3.96)**	(0.69)			
	-0.246		0.037		0.72/1.89
	(2.94)**		(1.79) *		
	-0.420			0.111	0.59/1.99
	(1.92)**			(2.88)* *	
Japan	0.064				0.64/1.68
	(1.71)*				
	0.065	0.010			0.64/1.69
	(1.72)*	(0.53)			
	0.056		0.022		0.65/1.69
	(1.46)		(1.36)		
	0.043			0.031	0.65/1.69
	(0.96)			(1.47)	
UK	0.014				0.70/1.98
	(0.68)				
	0.006	0.013			0.70/2.01
	(0.26)	(1.06)			
	-0.007			0.015	0.70/2.00
	(0.32)			(2.93)**	
US	-0.0003				0.79/2.08
	(0.95)				
	-0.0004	0.030			0.80/2.09
	(1.221)	(1.34)			
	-0.0004		0.023		0.80/2.06
	(1.25)		(1.67)*		
	-0.0007			0.065	0.81/2.02
	(1.78)*			(2.17)**	

1. Variables are described in the text. All equations include two lags of the dependent variable and a constant term. (Complete estimation results are available upon request.) Values in parentheses are absolute values of t-statistics. Significance at the 10 percent level is indicated by *; significance at the 5 percent or higher level is indicated by **.

2. Due to data restrictions, the sample breaks for broad money specifications for France and Germany use 1984 as the hypothesized breakpoint.