SYDNEY LUDVIGSON

The Channel of Monetary Transmission to Demand: Evidence from the Market for Automobile Credit

In response to tight money, both consumer loans and consumption fall. I ask whether there is any causality running from loans to consumption by focussing on how the composition of automobile finance between bank and nonbank sources of credit changes in response to unanticipated innovations in monetary policy. The results indicate that contractionary monetary policy produces a statistically significant reduction in the relative supply of bank consumer loans, which in turn produces a decline in real consumption. The evidence therefore supports the existence of a *credit channel* of monetary transmission to aggregate consumption. Moreover, the nature of automobile finance is uniquely suited to identifying which of two possible subchannels of the broader credit channel is relatively more important, and suggests the results are more likely consistent with a *bank lending channel* than with a pure *balance sheet channel.* However, the findings also indicate that the quantitative effects of the lending channel on the aggregate economy, though precisely estimated, may be quite small.

IS THERE ANY CAUSAL LINK between the availability of consumer credit and consumer demand? In bad times, does consumer credit decline simply because demand is lower, or is the downturn exacerbated by a reduction in the supply of consumer loans to credit-dependent households who would otherwise maintain consumption at higher levels?

The relation of credit market conditions to the production and investment decisions of firms has recently been a topic of extensive research (Bernanke and Blinder 1988 and 1992; Bernanke, Gertler, and Gilchrist 1995; Gertler and Gilchrist 1993). In particular, the *credit channel* theory of monetary transmission postulates that recessions are worsened by the inability of credit-dependent firms to borrow at the levels they could in good times, either because banks decrease the supply of loans after a monetary tightening, or because firms' credit-worthiness declines when net worth falls. If firms depend on bank loans to maintain production and investment activities and to finance inventories, a monetary contraction will have a greater impact on real activity

The author is grateful to Ben Bernanke for his advice and many valuable discussions, to John Y. Campbell, Mark Gertler, Kenneth Kuttner, Margaret McConnell, Ilian Mihov, Don Morgan, Gabriel Perez-Quiros, Mike Woodford, and to two anonymous referees for helpful comments and suggestions, to Beethika Khan for excellent research assistance, and to the Alfred P. Sloan Foundation for financial support. The views expressed in the paper are those of the author and are not necessarily reflective of views at the Federal Research Bank of New York or the Federal Reserve System.

SYDNEY LUDVIGSON *is an economist in the research department of the Federal Reserve Bank of New York.*

Journal of Money, Credit, and Banking, Vol. 30, No. 3 (August 1998, Part 1)

than that predicted by the pure "money" view, according to which loan supply responds passively to changes in the demand for credit induced by variation in the cost of capital.

One can distinguish analogously between two possible views of monetary transmission to consumption with the following question: Does consumer credit simply passively respond to consumption demand (itself responding to variation in income or the user cost of capital), or does a reduction in the supply of consumer credit by banks further retard consumption? This question is in fact twofold: (1) does a monetary contraction reduce the supply of consumer loans from banks, and (2) if so, does this lead to lower consumption?

Although a considerable body of literature has developed to investigate the mechanism by which monetary policy shocks affect the production and investment decisions of firms, much less work has been devoted to establishing whether credit channels of monetary transmission have a significant influence on the consumer sector. One reason it is important to determine whether a credit channel is operative to the consumer sector is that doing so may help resolve the on-going disagreement over how to interpret apparent empirical failures of the permanent income hypothesis. For example, some have argued that the predictability of aggregate consumption growth may be explained by the presence of credit market imperfections in the form of borrowing restrictions on individual consumers (Zeldes 1989; Deaton 1991; Ludvigson 1996; Jappelli, Pischke, and Souleles 1996). Others contend that precautionary motives (for example, Carroll 1997), time nonseparable preferences (for example, Deaton 1992), myopia (for example, Campbell and Mankiw 1989), aggregation bias (for example, Attanasio and Weber 1993; Pischke 1995), or nonlinearities in the consumer's intertemporal first-order condition (Ludvigson and Paxson 1997) may explain the findings. Since the policy implications of credit constraints are very different from those of the other explanations, it is important to determine whether credit market frictions play a role in propagating policy shocks to aggregate consumption.

The main problem with discriminating between the money and credit channels from a reading of the aggregate data is that the two theories are observationally equivalent in the usual econometric applications. For example, in either theory, loans contract after a monetary tightening, rendering it difficult to distinguish between supply-versus-demand–induced movements in credit. Simple correlations between loans and various measures of real activity tell us something about the timing of events, but little about the direction of causality.

One approach to this problem is suggested by Kashyap, Stein, and Wilcox (1993), who study how the ratio of business bank loans to commercial paper (a close substitute for bank credit) is influenced by a shift in monetary policy. Their insight was, if a monetary contraction leads to a decline in the ratio of bank loans to the sum of commercial paper and bank loans, the *supply* of bank credit must be shrinking, since presumably the demand for both types of finance would fall in rough proportion. They found that a monetary contraction was associated with a decline in this ratio and concluded that tight money leads to a reduction in the supply of business loans from banks, consistent with predictions of the lending channel. Whereas the money view

makes no explicit prediction about the behavior of the composition of finance, an implication of the credit channel is that a monetary contraction should shift this composition away from bank loans and toward nonintermediated credit.

This paper follows a research strategy very much in the spirit of Kashyap, Stein, and Wilcox (KSW) by investigating how the composition of consumer loans between bank and nonbank sources of finance changes after an unanticipated disturbance to monetary policy. Consumer installment credit is issued by banks and by businesses and is available as aggregate time series data. Variation in the composition of consumer finance after a contractionary monetary shock provides the needed econometric identification for sorting out supply and demand movements in household credit: a fall in the ratio of bank loans to the sum of bank and nonbank loans indicates a constriction in the supply of bank credit. Before these empirical tests can be performed, however, two implementation issues need to be addressed.

The first implementation issue concerns the choice of household credit series. To ensure that bank and nonbank consumer installment credit is issued for the same pool of products, I focus my study on loans for a particular product—automobiles. Automobile credit is extended by commercial banks and finance companies which are largely subsidiaries of major automobile manufacturers.

A second implementation issue concerns the measurement of monetary policy. In order to track how the composition of consumer credit responds to an unanticipated shift in monetary policy, a metric for measuring the stance of monetary policy is needed. Romer and Romer (1990) follow a descriptive strategy by interpreting minutes of Federal Open Market Committee meetings to identify particular episodes of tighter policy. Alternatively, Bernanke and Blinder (1992) argue that innovations in the federal funds rate are a good indicator of central bank policy because the Federal Reserve has direct leverage over this rate in the short term.

Christiano, Eichenbaum, and Evans (1994) compare these two ways of measuring monetary policy. As they point out, an advantage of the Romer approach is that it requires no formal specification of the Federal Reserve's policy rule. Its primary disadvantage, however, lies with the ad hoc identification of exogenous policy episodes [of which Romer and Romer (1990) locate six and Romer and Romer (1994) locate one more] as deliberate and large movements in policy-controlled variables. Furthermore, the federal funds rate provides more information about the stance of monetary policy because there is a policy episode for each data point in the sample. Finally, the federal funds rate, unlike the Romer dates, furnishes a quantitative gauge of the intensity of the policy action. For these reasons, I commit up front to a particular feedback rule (or reaction function) for monetary policy, and restrict my empirical tests to those that measure unanticipated policy as an innovation in the federal funds rate.

The general strategy I employ is to use vector autoregressions to evaluate whether shocks to monetary policy influence the composition of automobile credit, and whether variation in this composition in turn affects consumer expenditure on automobiles. In particular, I test (i) whether the composition of automobile finance changes in response to an unanticipated innovation in federal funds rate (helping to sort out supply and demand movements in credit), and (ii) whether variation in this

composition affects sales of new automobiles (providing information on how substitutable these two forms of finance are).

In short, the results suggest that contractionary monetary policy leads to a statistically significant reduction in the relative supply of bank consumer loans, and that this change in the composition of automobile finance produces a statistically significant decline in real expenditure. Thus the results support the hypothesis that there exists cyclical variation in the supply of loans to consumers, and that this variation influences spending. In principle, it is possible that changes in the financing composition represent shifts in the quality mix of borrowers rather than changes in the supply of loans from banks. This alternate explanation is discussed below.

The rest of this paper is organized as follows. Section 1A discusses the empirical procedure for evaluating the hypothesis that a credit channel to consumer demand exists. Section 1B is devoted to documenting how the composition of consumer finance changes in response to an innovation in the federal funds rate, while section 1C asks whether fluctuations in that composition influence real automobile expenditure. Section 1D discusses alternative explanations for the findings presented here; in particular it addresses the issue of whether "hidden" price cutting by automobile manufacturers in the form of more generous financing terms is likely to explain cyclical fluctuation in the composition of automobile credit documented here. Section 1E discusses which of two subchannels of the broad credit channel, the *bank lending channel* or the *balance sheet channel,* better matches the findings in sections B and C. Finally, section 1F asks whether the findings in sections B and C are quantitatively significant. Section 2 concludes.[1]

1. EMPIRICAL TESTS

A. Empirical Procedure

Following the terminology used in KSW, I construct a variable called the "Mix" of automobile finance, equal to the ratio of bank automobile credit to bank automobile credit plus finance company automobile credit, both measured as the stock of credit outstanding. The Mix is included in a set of vector autoregressive (VAR) models using monthly data from 1965:1 to 1994:12[2] and twelve lags of each variable.[3]

As proposed by Bernanke and Blinder (1992), orthogonalized innovations in the federal funds rate represent shocks to monetary policy. As Bernanke and Blinder point out, in order to identify the dynamic effects of unanticipated policy shocks on variables in the system, without having to identify the entire model structure, it is suf-

1. A previous version of this paper included a section describing some institutional aspects of finance companies, including their primary sources of finance. The interested reader is referred to the Federal Reserve Bank of New York *Research Paper* version for more details.

2. Prior to 1965, the federal funds market is generally thought to have been very thin (Strongin 1995) and therefore not an useful indicator of money market conditions. Consequently, innovations in the funds rate are not typically used as an indicator of the stance of monetary policy in pre-1995 data.

3. The data for the Mix variable are obtained from the Federal Reserve Board of Governors in their G.19 and G.20 statistical releases. The other data are obtained from Citibase data bank.

ficient to assume that policy shocks do not influence the other variables within the period. I make this identifying assumption by placing the funds rate last in the VAR. The last equation in the VAR then represents a reaction function of the central bank, so that the innovation is the unanticipated policy shock. The justification for this placement of the federal funds rate in the VAR is the idea that it can affect other variables only with a one-period lag, while the rate itself can respond contemporaneously given the Federal Reserve's reaction function.

Two five-variable VAR models are estimated, with quantity variables in logs. The first model investigates how the composition of finance is affected by monetary policy shocks, and includes the following variables: the log of industrial production, the log of the consumer price index (CPI), the log of the commodity price index, the Mix, and the federal funds rate, in that order.[4,5] The second model investigates how real retail passenger car sales react to an innovation in either the federal funds rate or in the Mix, and includes the log of industrial production, the log of the CPI, the log of the commodity price index, the log of real car sales, and either the Mix, or the federal funds rate, in that order.[6] The impulse responses using these VARs are analyzed. Finally, as an alternative test of the incremental explanatory power of the Mix for real expenditure, I also add the finance composition to some standard automobile demand and reduced-form equations for automobile expenditure.

B. The Effect of Monetary Policy on the Composition of Automobile Credit

I begin by analyzing how the composition of automobile finance changes following periods of tight money. A contraction in the relative quantity of bank loans subsequent to tight money indicates a decrease in the supply of bank loans. Figure 1 plots the financing Mix (the ratio of bank automobile credit to credit issued by automobile finance companies plus bank credit) over time, where vertical lines indicate a date documented by Romer and Romer (1990 and 1994) as representing a period of tight

4. Adding the log of automobile sales and the log of inventories to this VAR does not significantly alter the response of Mix to a Fed funds rate shock. Even though several of these variables may be nonstationary, I do not difference them since the hypothesis tests based on the VAR in levels will have standard asymptotic distributions; see Sims, Stock, and Watson (1990).

5. Christiano, Eichenbaum, and Evans (1994) [see also Sims (1992)] emphasize the importance of including a commodity price index in policy VARs to eliminate the "price puzzle" that contractionary shocks to monetary policy lead to a sustained increase in the price level. Including the commodity price index controls for episodes such as the oil price shock of 1974, in which the subsequent rise in inflation was preceded by a rise in the federal funds rate.

6. I do not include the funds rate in the VAR when analyzing how shocks to the Mix affect automobile aggregates. If the Fed funds rate indicates monetary policy, then in a VAR in which the funds rate is also included, changes in the Mix marginally reflect nonmonetary effects; that is, the funds rate is a sufficient statistic for policy-induced changes in real variables. If the credit channel is operative, and if the funds rate indicates monetary policy, then the funds rate should cause the Mix, the funds rate should cause automobiles, and Mix should cause automobiles, but there is no reason to expect Mix to affect automobiles when the funds rate is also included in the VAR. [For further discussion of this issue, the reader is referred to Bernanke (1993).] Nevertheless, this makes it difficult to identify the channels of transmission to real consumption using the VAR analysis if the Mix is a good proxy for a quantity indicator of conventional policy. Note, however, that the *spread* between the interest rates on the two forms of finance is not subject to such identification problems because conventional channels do not predict a correlation between spreads and rates as they do between credit aggregates and rates. The predictions of the credit channel for movements in the spread are discussed below.

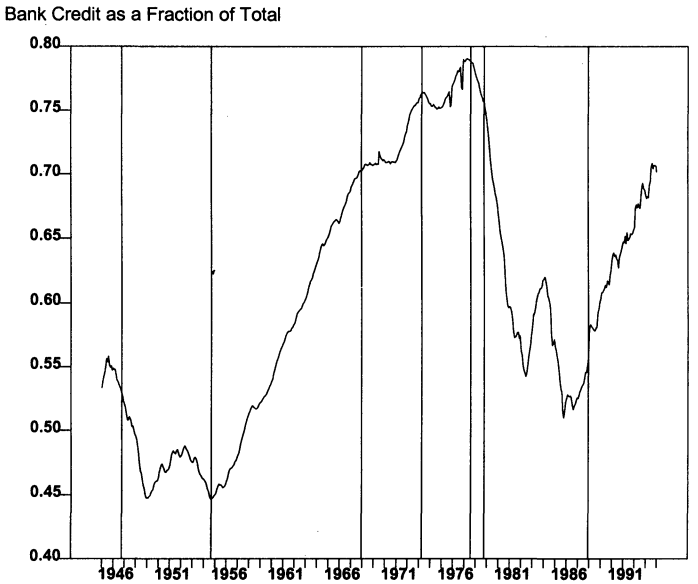

FIG. 1. The Composition of Automobile Finance

monetary policy. As Figure 1 shows, there appears to be relatively little trend in the Mix, though there are some large low-frequency movements. The Mix declines shortly after most Romer dates. If the Romer dates adequately capture periods of tight money, the figure suggests contractionary shifts in monetary policy generally lead to a reduction in the relative supply of bank consumer credit.

Figure 2 displays the response of the composition of automobile finance to a one-standard-deviation increase in the federal funds rate, with two standard error bands.[7] There is a significant decline in the ratio of bank loans to total automobile credit over a period of sixty months after a positive innovation in the federal funds rate. Impulse responses (not shown) of each component of the Mix variable to a positive innovation in the federal funds rate indicate that the financing Mix drops primarily because bank loans contract, while finance company credit remains relatively flat.

C. The Effects of Finance Composition on Real Consumption

The evidence presented in the last section suggests that commercial banks decrease the supply of consumer loans in response to tight money. The constriction in bank loan supply may not affect real consumption if bank and nonbank forms of finance are highly substitutable. If the two forms of finance are not *perfect* substitutes, however,

7. Standard error bands are computed using Monte Carlo simulations and assuming the errors are normally distributed.

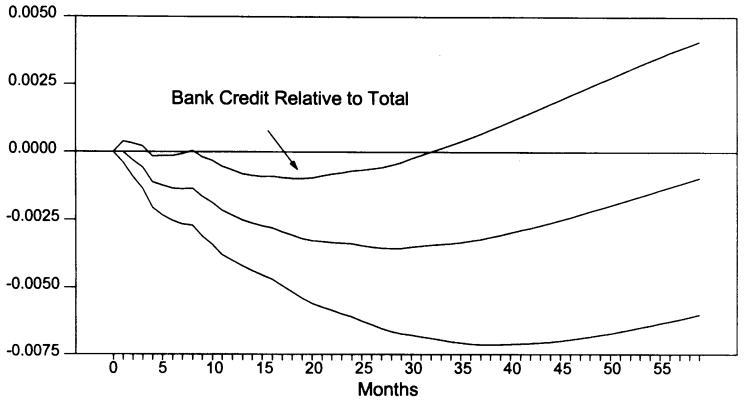

FIG. 2. Response of Mix to Fed Funds Rate Shock and Two S.E. Bands

the overall supply of loans to credit-dependent individuals will decline, leading to a fall in consumption. In this section, I ask whether a decrease in the relative supply of bank loans is associated with a decline in real consumption. I take two approaches. First, I investigate whether the financing composition of consumer credit significantly affects automobile consumption in a VAR controlling for income and the price level. Next, I ask whether the Mix has any explanatory power in "off-the-shelf" automobile demand or reduced-form equations that already include income and interest rate (user cost) variables as controls. Since the effects of conventional channels should operate through the latter variables, any incremental explanatory power of the Mix variable would support the existence of an independent credit channel.

Using monthly data on retail sales of motor vehicles, seasonally adjusted and deflated, Figure 3 shows that real automobile expenditure declines in response to a federal funds rate increase; this correlation is an implication of both the money and credit views. An implication unique to the credit view is that the relative supply of bank loans matters for consumption. Figure 4 plots the cumulative response of the log of automobile sales to a one-standard deviation increase in the Mix. Automobile expenditure rises in response to an increase in bank loans as a fraction of total credit, approximately six months after a positive innovation to the financing Mix.

In principle, another way to test for an association between the supply of bank loans and real variables is to investigate whether the *spread* between the bank interest rates and finance company interest rates rises in response to tight money. The credit channel theory predicts that the spread will rise in response to tight money because bank-dependent borrowers can not perfectly substitute between bank and nonbank credit. In practice, analyzing changes in the financing mix to infer the state of bank loan supply may be more reliable than analyzing the response of the spread. The reason is that the spread may not rise even if the credit channel is operative, that is, even if banks do decrease the supply of loans and even when the two forms of finance are imperfect sub-

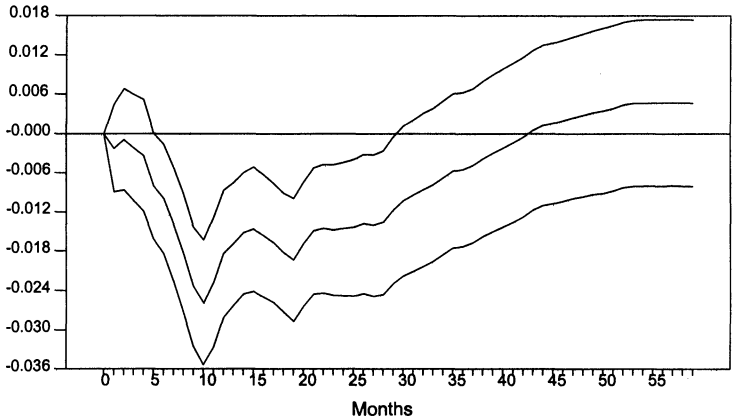

FIG. 3. Response of Auto Sales to Fed Funds Rate Shock and Two S.E. Bands

stitutes. To see this, note that even if banks respond to a decrease in reserves by cutting the overall supply of loans, they may also lend to a less-risky pool on average, and these two factors have offsetting effects on the spread. Note that these considerations generally work to bias tests based on the spread *against* finding evidence in favor of the credit view, so that detecting an increase in the spread in response to tight money is arguably that much *more* supportive of the existence of a credit channel, whereas finding no response is simply uninformative.

Figure 5 displays how the bank–finance company loan rate spread responds to a

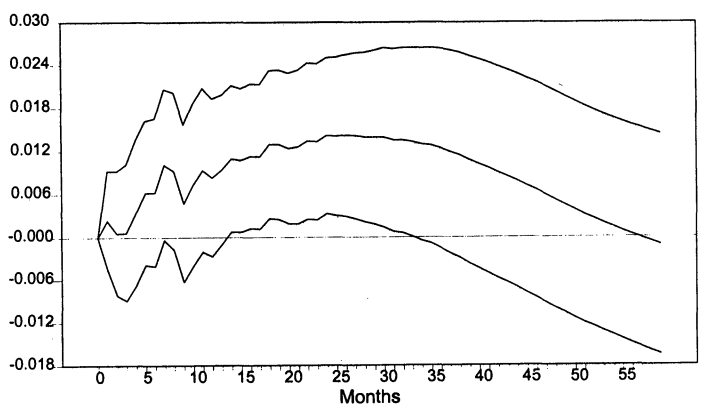

FIG. 4. Response of Auto Sales to Mix Shock and Two S.E. Bands

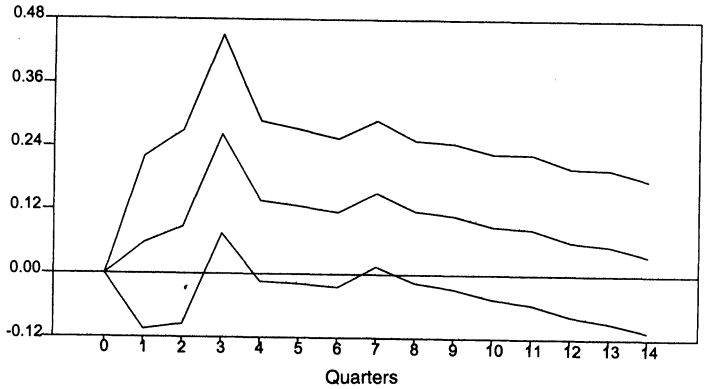

FIG. 5. Response of Bank-FC Rate Spread to Fed Funds Rate Shock and Two S.E. Bands

one-standard deviation shock in the federal funds rate.[8,9] A contractionary shock to monetary policy leads to a significant increase in the spread after about two months.[10] Moreover, Figure 6 shows that a rise in the bank–finance company rate spread leads to a significant decline in automobile sales after about four quarters.[11] Both figures indicate that the two forms of finance are not perfect substitutes.

Next, I consider two aggregate automobile demand equations and ask whether the financing composition adds any explanatory power. The first demand equation comes from Chow (1957). Chow assumes that individuals choose automobile consumption by maximizing utility subject to consumption being proportional to income. The desired stock of automobiles is a linear function of the relative price of new automobiles and real disposable income, suggesting the following equation for automobile demand:

$$S_t = \alpha + \beta_1 RP_t + \beta_2 Y_t + \beta_3 X_{t-1}, \tag{1}$$

where S_t is sales of new automobiles, α is a constant, RP_t is the relative price of new automobiles in terms of consumption, Y_t is real, disposable income, and X_{t-1} is the consumer's lagged stock of automobiles.

Another demand equation comes from a study by Blanchard and Melino (1986).

8. The interest rate data are obtained from the Federal Reserve statistical release G.19 and are annual percentage rates. Interest rates at commercial banks are simple unweighted averages of each bank's most common rate charged for a forty-eight-month new car loan during the first calendar week of the middle month of each quarter. Finance company data are from the subsidiaries of the three major U.S. automobile manufacturers and are volume-weighted averages covering all loans for new cars purchased during the month. Since the data for bank rates are of quarterly frequency, I average the monthly finance company rates over the quarter for Figures 5 and 6.

9. The VAR contains the same variables as those used to compute the responses in Figure 2, except that the credit aggregate is replaced by the bank–finance company spread.

10. The sample mean of the spread using these rates (bank rate minus finance company rate) is −0.84 percent using data from 1972:02 to 1995:01.

11. The VAR used to compute Figure 6 contains the same variables as those used to compute Figure 3, replacing the Mix with the bank–finance company rate spread.

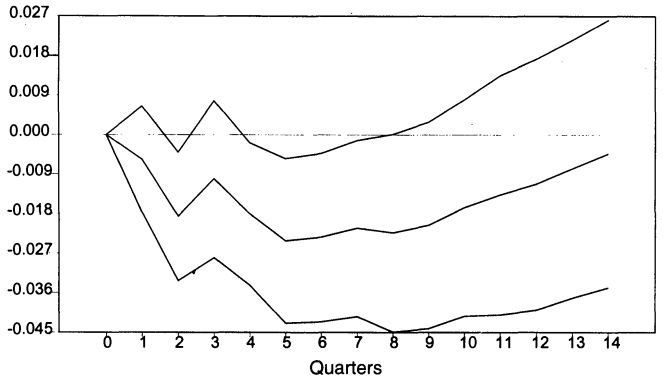

FIG. 6. Response of Auto Sales to Bank-F.C. Rate Spread and Two S.E. Bands

They examine a whole market structure deriving both a demand and supply equation for automobiles. Focusing on their results for the consumer's problem, one can extract a demand equation from their model of consumer behavior. Consumers maximize expected utility over consumption and the stock of automobiles, subject to a wealth accumulation constraint and an accumulation constraint for the stock of cars. After linearizing the first-order conditions and making some assumptions about the information set of the consumer, the following demand equation arises, which is very similar to (1):[12]

$$S_t = \alpha + \beta_1 RP_t + \beta_2 C_t + \beta_3 X_{t-1}, \tag{2}$$

Where C_t is consumption excluding automobile services.[13]

Table 1 summarizes the results of estimating equations (1) and (2).[14] The table shows that the relative price enters with the "wrong" sign (discussed below), but otherwise produces some significant patterns with respect to the composition of automobile finance. The first row estimates (1) itself, and the second row includes the current period financing composition as an additional explanatory variable. The current financing composition is strongly significant, as is disposable income. Adding the current period mix to the regression increases the fraction of variance explained by 12 percent.

12. Once the first-order conditions are linearized, the problem consists of solving a linear, expectational difference equation. I make similar assumptions to those of Blanchard and Melino, that C_t follows a first-order autoregressive process, and use the method of undetermined coefficients to solve for (2).

13. Following Blanchard and Melino, constant dollar personal consumption expenditures are used as a measure of C_t, while the CPI component for new cars divided by the PCE deflator is used to measure RP_t. To obtain a stock for consumer durables, I assume the initial stock is the average on expenditure for, first, fifteen months (67:1–68:3) divided by the depreciation rate, and that subsequent values of the stock evolve using a depreciation rate of 2 percent per quarter.

14. Johansen test statistics, the trace and "L-max" statistics, both rejected the null of no cointegration for the variables in equations (1)–(3) against the alternative of multiple cointegrating relationships. In general, test results also rejected the null of one cointegrating relationship in favor of multiple relationships.

TABLE 1

AUTOMOBILE DEMAND EQUATIONS

Dependent Variable: S_t, 1968:1 to 1994:11

FC	$\Sigma_{i=0}^{3} FC_{-i}$	Y	X_{-1}	RP	$\Sigma_{i=1}^{3} RP_{-i}$	C	$\Sigma_{i=1}^{3} C_{-i}$	r	Adj. R^2	p-value
...	...	0.797	(−0.001)	15.49	...	...	...	...	0.56	...
		(0.11)	(0.001)	(13.38)						
19.67	...	0.797	0.002	17.672	...	...	...	...	0.68	<0.000
(1.72)		(0.096)	(0.001)	(2.854)						
15.77	...	0.796	−0.0002	12.288	...	...	...	−19.46	0.69	<0.000
(2.022)		(0.099)	(0.001)	(3.198)				(5.586)		
16.017	...	0.831	−0.0004	−12.289	25.371	...	...	−19.754	0.70	<0.000
(2.013)		(0.099)	(0.001)	(17.64)	(17.38)			(5.56)		
18.527	...	...	(0.000)	−10.852	25.501	0.019	−0.012	...	0.72	<0.000
(1.635)			(0.001)	(16.89)	(16.78)	(0.005)	(0.005)			
53.619	16.275	...	−0.002	−8.672	21.564	0.017	−0.009	...	0.74	<0.000
(23.803)	(1.706)		(0.001)	(16.60)	(16.52)	(0.005)	(0.005)			
49.328	15.029	...	−0.002	−10.955	22.286	0.015	−0.007	−6.689	0.74	<0.000
(24.092)	(2.029)		(0.001)	(16.72)	(16.52)	(0.005)	(0.006)	(5.895)		

NOTES: See Table 2.

If there are costs to adjusting prices, lagged prices should be state variables in the model and included in the regressions. Subsequent rows therefore include lags of the price variables as well as lags of C_t in (2).[15] The third and other rows include the rate on the six-month Treasury bill as a proxy for the consumer's user cost. The financing composition remains a strong predictor of automobile sales even though the Treasury bill adds explanatory power to the regression. Row 5 shows that it makes little difference whether consumption or disposable income is used, indicating that there is small distinction in practice between the specifications in (1) and (2). Finally, the last two rows include lags of the financing Mix. The sum of the coefficients on the current Mix and its lags has a positive sign and is strongly significant with or without the addition of the T-bill rate, while controlling for consumption, the relative price of new cars and its lags, and the lagged stock of cars.

Note that the relative price enters the regression with a positive coefficient. One obvious reason for this apparent anomolous result is that the relative price is endogenous. Problems associated with price endogeneity might be resolved by using IV estimation if one could find appropriate instruments. However, it is hard to think of what those instruments might be; for example, labor strike dates and wages seem almost as likely as prices to be correlated with the error term. My strategy is instead to commit, up front, to a particular structural model of automobile supply and demand which explicitly recognizes this endogeneity, and then use the reduced-form equation for sales as my empirical specification. The Blanchard and Melino (BM) framework provides a simultaneous model. I add the financing composition into Blanchard and Melino's reduced-form equation for automobile sales:

$$S_t = \alpha + \beta_1 X_{t-1} + \beta_2 I_{t-1} + \beta_3 Z_{t-1} + \sum_{i=0}^{3} \beta_{4+i} C_{t-i} + \sum_{i=0}^{3} \beta_{8+i} W_{t-i}, \qquad (3)$$

where I_t is the producer-dealers inventory of automobiles, Z_t is automobile production, W_t is the real wage, and the other variables are defined as before.[16] Blanchard and Melino obtain the reduced-form equation above by simultaneously solving the demand problem already discussed, and a supply problem for a representative automobile firm that makes both the production and the sales decisions by maximizing the expected present value of cash flows subject to an inventory accumulation constraint. Following Blanchard and Melino, dummy variables for strike dates of the Big Three automobile manufacturers and a (quadratic) time trend are also included in (3).

Table 2 summarizes the results from estimating (3). The first row estimates (3) itself. The results are very similar to those obtained by BM for all variables except the real wage. Here the coefficient on the real wage is significantly positive, whereas they found it to be insignificantly different from zero. The second row adds in the financing composition which again is a statistically significant determinant of automobile sales;

15. Lags of C_t are included in case the first-order autoregressive specification for consumption used to solve (2) is too restrictive.

16. I_t and Z_t are obtained from the Citibase data bank, where the first is given as retail automobile inventories of total new passenger cars, and the second is measured as the Industrial Production Index for automobiles. W_t is obtained from Datastream International and is the average hourly wage for production workers in the automotive industry.

TABLE 2

REDUCED-FORM EQUATIONS

Dependent Variable: S_t, 1968:1 to 1994:11

FC	$\Sigma_{i=0}^{3} FC_{-i}$	X_{-1}	I_{-1}	Z_{-1}	C	$\Sigma_{i=1}^{3} C_{-i}$	W	$\Sigma_{i=1}^{3} W_{-i}$	PFW	Adj. R^2	p-value
...	...	−0.04	0.00	0.11	6.9	1.5	0.22	−0.12	...	0.90	...
		(0.01)	(0.05)	(0.01)	(3.3)	(3.4)	(0.03)	(0.04)			
10.8	...	0.00	−0.10	0.10	10.6	−2.5	0.21	−0.08	...	0.93	<0.000
(0.96)		(0.01)	(0.05)	(0.01)	(2.8)	(2.9)	(0.03)	(0.03)			
14.7	10.4	0.00	−0.09	0.09	9.9	−1.7	0.22	−0.08	...	0.93	<0.000
(12.4)	(0.98)	(0.01)	(0.05)	(0.01)	(2.8)	(2.9)	(0.03)	(0.03)			
8.2	...	−0.01	−0.13	0.09	8.5	−1.3	0.20	−0.06	−2.6	0.94	<0.000
(1.2)		(0.01)	(0.05)	(0.01)	(2.8)	(2.9)	(0.03)	(0.03)	(0.73)		
9.8	7.7	−0.02	−0.12	0.09	7.7	−0.42	0.20	−0.06	−2.7	0.94	<0.000
(12.3)	(1.2)	(0.01)	(0.05)	(0.01)	(2.8)	(2.87)	(0.03)	(0.03)	(0.72)		

NOTES: OLS estimation, standard errors in parentheses. S is auto sales, FC is the financing composition, defined as bank loans divided by total. Y is real, personal disposable income. X is the consumer's stock of automobiles computed assuming a quarterly depreciation rate of 2 percent. RP is the Consumer Price Index for Cars divided by the implicit price deflator for personal consumption expenditures. C is personal consumption expenditures, and r is the six-month T-bill rate. The columns labeled "Adj. R^2" and "p-value" give the adjusted R^2 for the regression, and the p-value on the Mix variable or their sum. I is retail automobile inventories, Z is the index of industrial production for autos, C is personal consumption expenditures, W is the average hourly wage of production workers in the automobile industry, and PFW is the Producer Price index for fuel. Monthly strike dummies, t, t^2 also included.

the marginal significance level is better than 0.0001. The third row includes the financing composition and its lags; the sign of the sum of all coefficients on this variable is positive and strongly significant. Finally, as a robustness check, specifications in the last two rows control for the price of fuel. Though the price of fuel adds explanatory power to the regression, the Mix remains statistically significant at very high marginal levels.

In summary, the evidence presented suggests that the credit channel has a strong statistically significant effect on the consumer sector. Below, I discuss whether these effects are likely to be quantitatively important. Before turning to the issue of quantitative significance, however, it may be useful to briefly discuss whether the findings on the fluctuations in the composition of automobile finance found above can be plausibly explained by cyclical changes in the automobile industry's pricing strategy, and if not, whether the automobile credit data can help sort out which of two subchannels of the broad credit channel is more evident.

D. Credit Channel or Hidden Price Cutting?

One possible interpretation of the behavior of the Mix variable reported above is that consumers willingly switch into finance company credit subsequent to tight money because captive finance companies offer better financing terms when automobile dealers are facing declining demand and growing inventories. The "pricing story" has two parts. (i) First, a contractionary shock to monetary policy reduces automobile sales through some traditional channel of transmission (for example, because income is lower or interest rates are higher). (ii) The Mix declines because, in bad times, finance companies offer more generous financing terms as a form of hidden price cutting in an effort to reduce rising inventories.

To evaluate this alternative explanation for the cyclical behavior of the Mix, several considerations bear noting. First, results in the previous section indicate that the Mix has incremental explanatory power not captured in income and interest rates. This finding is not consistent with (i) which suggests that automobile sales decline in response to tight money due to the operation of conventional transmission channels. Second, if automobile manufacturers offer more generous financing terms in response to contractionary monetary policy, it seems reasonable to expect that the terms of these loans should improve vis-a-vis finance companies' cost of funds. Short-term funds for finance companies are primarily raised in the commercial paper market. Figure 7 plots the response of the spread between rates charged by finance companies on automobile loans and commercial paper rates to a positive shock in the funds rate.[17] The figure demonstrates no significant downward shift in this spread as would be expected if financing terms at finance companies improved following contractionary monetary policy. Third, the pricing story also implies that hidden price cutting in the form of more generous financing terms comes in response to rising costs of carrying higher inventories. It seems reasonable to expect that rising inventories would then

17. This impulse response comes from a VAR with industrial production, consumer prices, commodity prices, the interest rate spread, and the funds rate, in that order.

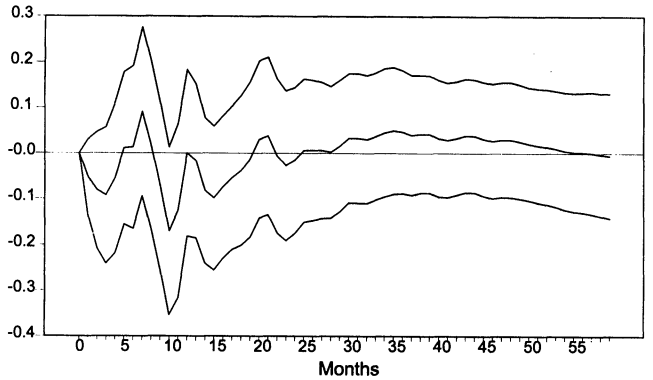

FIG. 7. Response of FC-CP Spread to Fed Funds Rate Shock and Two S.E. Bands

precede a fall in the Mix. To investigate whether the timing of events indicated such a pattern, I performed Granger causality tests: using twelve lags of inventories and Mix, inventories did not Granger cause Mix (the *p-value* for a test that the coefficients on inventories were jointly zero is 0.439), though the sum of coefficients on the lags of inventories had the right sign (negative).

In summary, this evidence taken together is at least suggestive that changes in the financing Mix cannot be interpreted simply as the result of price cutting of automobile manufacturers (via financing costs) designed to stimulate sagging sales and deplete mounting inventories.[18]

E. Bank Loan Supply Channel or Net Worth Channel?

The statistically significant shifts in the financing Mix found here are consistent with the predictions of a broad credit channel. One interpretation of this channel, offered above, is that banks cut the supply of loans to borrowers who cannot perfectly substitute into nonbank forms of credit. I refer to this as a subchannel called the *bank lending channel.* However, another possibility, in principle consistent with the results above, is that shifts in the financing Mix represent a change in the quality mix of borrowers, and not a change in the supply of bank loans. If tight money leads to a "flight to quality," high-grade borrowers may be better able to satisfy their demand for credit than lower-grade borrowers, so that the change in financing composition may simply represent a shift in lending away from low-grade borrowers and toward high-grade borrowers. I refer to this subchannel as the *balance sheet channel.*

In previous research, results have been ambiguous about which subchannel is opera-

18. It's worth noting that the pricing story begs the question of why the automobile manufacturers would cut prices by cutting financing costs, rather than cutting the list price directly. One economic explanation is that this strategy represents a rational response to a decrease in the supply of loans by banks: finance companies would benefit (at the margin) from price discriminating between constrained and unconstrained consumers if credit conditions at banks were tightening.

tive. For example, though KSW argued that their results were supportive of a bank lending channel, it is possible to interpret their findings as equally consistent with a pure balance sheet channel because only high-grade borrowers have access to commercial paper. The shift in finance composition away from bank loans toward commercial paper that they find is therefore in principle consistent with either a decline in bank loan supply, or a shift in lending toward borrowers with higher credit ratings.[19]

Oliner and Rudebusch (1993) have emphasized the importance of investigating how financing patterns differ across various groups of borrowers in interpreting the mechanism of credit channel transmission. In this context, it is informative to know how the average quality grade of bank borrowers compares with that of finance company borrowers. I obtained data on delinquency rates for the automobile credit contracts of commercial banks and finance companies.[20] The delinquency rates on bank loans are consistently below rates on finance company loans: in monthly data from 1980:1 to 1994:12, the delinquency rate at commercial banks averaged 1.81 percent, while that of finance companies averaged 2.07 percent. The difficulty with analyzing shifts in the composition of business credit between bank loans and commercial paper is that a decline in the supply of bank loans cannot be distinguished from the alternative explanation that a greater share of credit is going to better borrowers who have near exclusive access to the nonintermediated credit. In contrast, in the case of automobile credit, it is *riskier* borrowers who are more likely to use the primary source of nonbank finance (finance company loans). The evidence is not consistent with a pure balance sheet channel because the behavior of the Mix (an increase in the relative quantity of finance company loans after tight money) cannot be explained by an increase in credit going to higher quality borrowers. The evidence instead suggests that shifts in the bank–finance company auto loan Mix are more likely consistent with a bank lending channel than a net worth channel.

F. How Quantitatively Important is the Credit Channel?

The evidence presented above suggests the existence of a bank lending channel transmission mechanism to automobile consumption that is statistically significant. A remaining issue is whether these effects are *quantitatively* significant. This section attempts to quantify the impact of funds rate innovations on the Mix, and to determine how economically important changes in the finance composition are in influencing real automobile sales.

Several authors have argued that a good metric for determining the quantitative effect of one variable on another in a VAR system is a variance decomposition, the use of VAR residuals to decompose the forecast variance of one variable into the contributions by the other variables (see, for example, Sims 1980; Friedman and Kuttner 1993). Table 3 reports the percentage of Mix innovation variance that can be attrib-

19. Oliner and Rudebusch (1993) argue that the KSW results are more consistent with the existence of a broader credit channel, but not with a bank lending channel.

20. Source: Staten and Johnson (1995). The rates are measured as the percent of automobile loans thirty or more days past due, seasonally adjusted.

TABLE 3

DECOMPOSITIONS OF THE INNOVATION VARIANCE OF MIX

Percentage of Mix variance	Federal Funds Rate	Mix
Six months ahead	2.19	94.28
Twelve months ahead	5.15	89.89
Twenty-four months ahead	11.79	83.09
Thirty-six months ahead	13.98	77.19

NOTES: This table reports the percentage of the finance composition (Mix) innovation variance that can be attributed to the variable listed in the column head. The orthogonalization order is industrial production, consumer price index, commodity price index, Mix, federal funds rate.

uted to the Funds rate and to the Mix's own lags using the following ordering of five variables in the VAR: industrial production, consumer price index, commodity price index, the Mix, and federal funds rate. Several points are worth noting. First, at forecast horizons of six and twelve months, the contribution of funds rate innovations to Mix fluctuations is negligible; the variance of the funds rate only accounts for about 2 to 5 percent of the respective forecast variance of the Mix. Second, the contribution of the funds rate is never very large even at longer horizons, and reaches its peak thirty-six months out at about 14 percent. Third, the second column in the table shows that at most forecast horizons, the Mix is almost entirely determined by its own innovations, suggesting that the Mix is "Granger-causally exogenous." In short, the numbers in Table 3 suggest that innovations in the funds rate, while having a statistically significant impact on the composition of automobile finance as evidenced from the impulse response function, have a small quantitative impact as measured by the variance decomposition.

To quantify the impact of fluctuations in the Mix on real automobile sales, I add the current period Mix to the Blanchard and Melino reduced-form equation (3), putting the quantity variables in logs. If the Mix adequately proxies for the incremental effects of changes in relative bank loan supply on automobile expenditure, then the estimated coefficient on the Mix in the BM reduced-form equation should give some indication of how quantitatively important the credit channel is for real activity. The resulting point estimate indicates the incremental effect of a 1 percent decline in the current period Mix is a 0.73 percent decline in automobile sales. This coefficient is very precisely estimated, with standard error equal to 0.0007.

The impulse response results indicate that a one-standard-deviation (0.5 percent) increase in the funds rate leads to a maximal decline in the Mix equal to about 0.32 percent. Defining a "typical" monetary contraction as the average of the positive orthogonalized innovations to the funds rate (about 0.3 percent), I can use the impulse responses along with the point estimates reported above to calculate a "typical" reduction in real automobile sales resulting from a typical policy-induced decline in the Mix. That is, the impulse responses indicate that a 0.3 percent increase in the funds rate leads to, at most, a 0.19 percent reduction in the Mix. A decline in the Mix of this magnitude would lead to a 0.14 percent decline in real automobile sales according to the reduced-form point estimate reported above. In comparison, using the VAR that produced Figure 3, the overall reduction in automobile sales in response to a "typical"

(0.3%) increase in the Fed Funds rate is roughly 1.6 percent, or about eleven times as large. Although the impact of the Mix on automobile sales is statistically significant, the estimated effects on the aggregate economy may be quantitatively quite small.[21]

2. CONCLUSIONS

The evidence presented in this paper supports the existence of a bank lending channel of monetary transmission to aggregate consumption demand. Unanticipated shocks to monetary policy have a statistically significant effect on the *composition* of automobile credit, a finding consistent with the predictions of a credit channel theory, but not with conventional theories of monetary transmission. Furthermore, innovations in the financing Mix have statistically significant effects on automobile consumption not explained by variation in conventional demand indicators.

The evidence is consistent with results in a number of other preexisting studies which have found support for the presence of a credit channel to the investment sector. One issue that remained unresolved in this literature is how quantitatively important the channel is. The results presented in this paper indicate that the incremental impact of the credit channel on real consumption is very precisely measured and extremely small. Thus, while the results support the existence of a bank lending channel, they also suggest that the channel may be a quantitatively insignificant part of the overall monetary transmission mechanism to the aggregate economy.

21. This calculation characterizes the *incremental* effect of the Mix on real automobile sales that can be expected from a typical contractionary policy shock. It is possible that the overall impact of the Mix on sales is somewhat larger if the Mix affects spending through its influence on other variables. However, the impulse response of automobile sales to a shock in either the Mix or the bank–finance company rate spread is also quite small, indicating that the effect on automobile spending of a one-standard-deviation impulse in either of these indicators is at most 2.5 percent.

LITERATURE CITED

Attanasio, Orazio P., and Guglielmo Weber. "Consumption Growth, the Interest Rate, and Aggregation." *Review of Economic Studies* 60 (1993), 631–49.

Bernanke, Ben. "How Important Is the Credit Channel in the Transmission of Monetary Policy? A Comment." *Carnegie-Rochester Conference Series on Public Policy* 39 (1993), 47–52.

Bernanke, Ben, and Alan, S. Blinder. "Is It Money or Credit, or Both, or Neither? Credit, Money, and Aggregate Demand." *American Economic Review Papers and Proceedings* 78 (2:1988), 435–39.

_____. "The Federal Funds Rate and the Channels of Monetary Transmission." *American Economic Review* 82 (4:1992), 901–21.

Bernanke, Ben, and Mark Gertler. "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review* 79 (1989), 14–31.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist. "The Financial Accelerator and the Flight to Quality." *Review of Economic Studies* (1995).

_____. "Credit-Market Frictions and Cyclical Fluctuations." Unpublished, Princeton University, February 1997.

Blanchard, Olivier J., and Angelo Melino. "The Cyclical Behavior of Prices and Quantities: The Case of the Automobile Market." *Journal of Monetary Economics* 17 (1986), 379–407.

Campbell, John Y., and Gregory Mankiw. "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence." National Bureau of Economic Research, *Macroeconomics Annual* (1989), 185–216.

Carroll, Christopher D. "Buffer Stock Saving and the Permanent Income Hypothesis." *Quarterly Journal of Economics* 112 (1:1997), 1–56.

Chow, G. C. *Demand for Automobiles in the United States.* Amsterdam: North Holland, 1957.

Christiano, Lawrence, Martin Eichenbaum, and Charles Evans. "Identification and the Effects of Monetary Policy Shocks." Working paper, Northwestern University, 1994.

Deaton, Angus. *Understanding Consumption.* New York: Oxford University Press, 1992.

Eichenbaum, Martin. Comment on "Interpreting The Macroeconomic Time Series Facts: The Effects of Monetary Policy." *European Economic Review* 36 (June 1992), 1001–1011.

Friedman, Benjamin, M., and Kenneth N. Kuttner. "Another Look at the Evidence on Money-Income Causality." *Journal of Econometrics* 57 (1993), 189–203.

Gertler, Mark, and Simon Gilchrist. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence." *Scandinavian Journal of Economics* 95 (1993) 43–64.

Jappelli, Tullio, Jörn-Steffen Pischke, and Nicholas S. Souleles. "Testing for Liquidity Constraints in Euler Equations with Complementary Data Sources." Unpublished, MIT Department of Economics, October 1996.

Kashyap, Anil, Jeremy C. Stein, and David W. Wilcox. "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance." *American Economic Review* 83 (1:1993), 78–98.

Ludvigson, Sydney C. "Consumption and Credit: A Model of Time-Varying Credit Constraints." Working paper, Federal Reserve Bank of New York, December 1996.

Ludvigson, Sydney C., and Christina H. Paxson. "Approximation Bias in Linearized Euler Equations." Working paper, Federal Reserve Bank of New York, April 1997.

Oliner, Stephen D., and Glenn D. Rudebusch. "Is There a Bank Credit Channel for Monetary Policy?" Working paper, Board of Governors of the Federal Reserve System, October 1993.

Pischke, Jörn-Steffen. "Individual Income, Incomplete Information, and Aggregate Consumption." *Econometrica* 63 (4:1995), 805–40.

Romer, Christina D., and David H. Romer. "New Evidence on the Monetary Transmission Mechanism." *Brookings Papers on Economic Activity* 1 (1990), 149–213.

_____. "Monetary Policy Matters." *Journal of Monetary Economics* 34 (1994), 75–88.

Sims, Christopher A. "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered." *American Economic Review* 70 (1980), 250–57.

_____. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." *European Economic Review* 36 (1992), 975–1000.

Sims, Christopher, James H. Stock, and Mark W. Watson. "Inference in Linear Time Series Models with Some Unit Roots." *Econometrica* 58 (1:1990), 113–44.

Staten, Michael E., and Robert W. Johnson, eds. *Household Credit Data Book,* 4th ed. West Lafayette: Credit Research Center, 1995.

Strongin, Steve. "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle." *Journal of Monetary Economics* 35 (1995), 463–97.

Zeldes, Steve P. "Consumption and Liquidity Constraints: An Empirical Investigation." *Journal of Political Economy* 97 (1989), 305–46.