Models of the Liquidity Effect*

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Abstract

An exogenous increase in the money supply is typically followed by a temporary fall in nominal interest rates. Flexible price macroeconomic models argue that this *liquidity effect* arises because asset markets are segmented. That is, only a fraction of agents are present in the bond market when the central bank conducts an open market operation. However, to be quantitatively successful, segmented markets models assume frictions that are too large to be interpreted literally in terms of constraints faced by real-world firms and households. An important open question is: can a complicated array of microeconomic frictions imply one large aggregate friction of this kind?

In macroeconomics, the term *liquidity effect* refers to a fall in nominal interest rates following an exogenous persistent increase in narrow measures of the money supply. According to the classical *Fisher effect*, however, an exogenous persistent increase in money is predicted to increase expected inflation and so increase nominal interest rates. Friedman [1968] argues that, in practice, both forces operate: a persistent increase in the money supply both reduces nominal interest rates and increases expected inflation so that the real rate — nominal minus expected inflation — also falls. Friedman [1968: 5-7] speculates that nominal and real rates may fall below their typical levels for up to a year, but, over time, rates will then tend to increase before tending to the levels consistent with the inflation generated by the original monetary impulse.

Empirical macroeconomists have interpreted Friedman [1968] as follows. At long horizons real interest rates are determined by 'fundamentals' including the rate at which households discount the future and average productivity growth. Consequently we should expect that long-horizon real interest rates are relatively stable and are unaffected by transitory monetary disturbances. Long-horizon nominal interest rates are this stable real rate plus expected inflation. At short horizons, however, Friedman's [1968] argument suggests that real and nominal interest rates are both volatile and positively correlated. His argument also suggests that short-horizon real rates and expected inflation are negatively correlated. (Barr and Campbell [1997] provide evidence consistent with

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this interpretation and Cochrane [1989] provides specific evidence for liquidity effects at short horizons).

Perhaps the easiest way to interpret Friedman [1968] is in terms of the following market equilibrium scenario. Suppose that a monetary authority increases the money supply by conducting an unexpected outright purchase of bonds (an *open market operation*). At short horizons, nominal interest rates fall so that households are willing to hold a smaller quantity of bonds and a larger quantity of money. But this is only a partial equilibrium effect. As households spend their increased money holdings on goods, the price level increases and so real balances do not rise as fast as nominal balances. This general equilibrium effect mitigates the need for the nominal interest rate to fall. In many simple monetary models, households tend to spend money so 'fast' that the general equilibrium price level effect can completely overturn the partial equilibrium effect.

A textbook cash-in-advance (CIA) model with a constant aggregate endowment of goods ('output') and identically and independently distributed (IID) money growth shocks provides a stark example. In this model, households immediately spend an unexpected increase in money on a fixed quantity of real goods. This increases the price level one-for-one with the increase in the money supply so that real balances are unchanged. In addition, because money growth is serially uncorrelated, expected inflation is constant. Taken together, constant real balances and constant expected inflation imply that the money market clears at a constant nominal interest rate. If instead monetary growth shocks are persistent then a positive shock increases expected inflation and nominal interest rates increase. In short: there is a Fisher effect but no liquidity effect. CIA models that are carefully calibrated to empirical processes for money growth and output, such as Hodrick, Kocherlakota and Lucas [1991] and Giovannini and Labadie [1991], lead to similar conclusions. So do studies of conceptually similar production economies, such as Cooley and Hansen [1989].

We now turn to departures from the standard CIA model in which a liquidity effect dominates at short horizons while a Fisher effect dominates at long horizons. Although models with nominal rigidities are in principle capable of generating these liquidity effects, we instead focus on flexible price models in which a liquidity effect is generated by an *asset market friction* of one form or another. Each of the models we discuss — Lucas [1990], Grossman and Weiss [1983], and Alvarez, Atkeson and Kehoe [2002] — captures, albeit in different ways, some of the spirit of Friedman's [1968] intuition.

Lucas [1990] modifies the standard CIA endowment economy with a simple timing assumption: households have to allocate cash between a goods market and an asset market *before* observing the size of an open market operation. Once that allocation has been made, there is a fixed quantity of cash sitting in the bond market. Now consider an unexpected purchase of bonds. Relative to the supply of bonds, there is now an unexpectedly large amount of cash available to purchase assets, so bond prices increase and the nominal interest rate falls.

Fuerst [1992] and Christiano and Eichenbaum [1995] integrate Lucas's [1990] timing assumption into otherwise standard real business cycle (RBC) models. The key innovation of these papers is that, each period, firms have to borrow cash from financial intermediaries in order to pay their workers. After a positive monetary shock, the nominal interest rate decreases so that firms find it optimal to borrow the unexpected increase in money balances. This increases firms' labor demand and increases output. Thus, these models are consistent with the commonly held view that positive monetary shocks have a positive, albeit temporary, effect on output.

A limitation of models that use Lucas's [1990] timing assumption is that the liquidity effect is very transitory even when monetary shocks are persistent. Households can adjust their allocation of cash every period. Therefore, the liquidity effect is entirely driven by serially uncorrelated 'expectational errors' in cash allocation.

We now turn to Grossman and Weiss [1983] and Alvarez, Atkeson and Kehoe [2002]. These are general equilibrium models inspired by Baumol [1952] and Tobin's [1956] 'inventory-theoretic' analyses of money demand. In this class of models, two key forces influence short horizon liquidity effects. First, at any point in time, there are always some households who participate in asset markets and some households who do not. Second, because households do not acquire cash every period, they choose to spend their money holding slowly over time. The first force alone is sufficient to generate a liquidity effect, the second force provides an *amplification* mechanism.

In this setting, an open market increase in the money supply must, in equilibrium, be held by the subset of households who are currently participating in asset markets. Therefore, even if the price level responds one-for-one with the increase in money supply, the *share* of aggregate real balances that must be held by these households increases. Hence, the nominal interest rate falls to clear the market. Also, because they hold a larger share of real balances, these households are able to increase their share of aggregate consumption and this drives down real interest rates. So at short horizons, there is a liquidity effect.

Moreover, if households spend their money slowly over several subsequent periods then the price level does not respond one-for-one to an increase in the money supply. Instead, the price level responds slowly. This implies that aggregate real balances rise (equivalently, in a model with constant output, *velocity* falls) and this provides a second force driving down nominal interest rates. The liquidity effect is amplified.

The influential model of Grossman and Weiss [1983] is a deterministic CIA endowment economy that exhibits both effects. Households are imperfectly synchronized and only participate in asset markets every second period. They spend money on consumption goods over two periods. (Rotemberg [1984] studies a production version of essentially the same environment).

Alvarez, Atkeson and Kehoe [2002] endogenize the fraction of households who participate in asset markets. They assume that households can participate if they pay a fixed cost. If a household's individual real balances are neither too high nor too low, they don't pay the cost, don't participate in asset markets, and end up consuming their individual real balances. If their real balances are high, they pay the cost and invest money in the asset market. Similarly, if their real balances are low, they pay the cost in order to purchase goods with money invested in the asset market. The equilibrium amount of participation ends up depending on the curvature of the utility function, the expected growth rate of money and on the size of the fixed cost. For example, in a high inflation economy almost all households pay the cost to participate in asset markets. Hence, increases in the money supply raise expected inflation and nominal interest rates as in a basic CIA model. By contrast, in a low inflation economy, more households choose not to participate and the effects of incomplete participation are larger and may be big enough to cause a liquidity effect (i.e., to dominate the Fisher effect at short horizons).

To simplify their analysis, however, Alvarez, Atkeson and Kehoe [2002] set up the model so that both active and inactive households spend all their money each period. No households save money to spend on consumption over multiple periods. Therefore, velocity is constant and the price level responds one-for-one with increases in the money supply. Alvarez, Atkeson and Kehoe [2002] can therefore generate a liquidity effect but without the amplification that is provided by a (transitory) fall in velocity. Alvarez, Atkeson and Edmond [2003] provide a stochastic counterpart to Grossman and Weiss [1983] where both forces are operative (but at the cost of reverting to an exogenous timing of transactions).

Limited participation models of the liquidity effect provide a number of important qualitative insights into the co-movements of money, interest, and prices (and, to a lesser extent, output).

The *quantitative* insight provided by these models is, however, more debatable. To generate realistic co-movements of money, interest and prices, calibrated models of liquidity effects need 'large' asset market frictions. It is typically difficult to interpret the calibrated friction literally in terms of constraints faced by real-world firms and households (making it difficult, in the words of Manuelli and Sargent [1988: 524], to "find the people"). For example, the most successful parameterizations in Alvarez, Atkeson and Edmond [2003] require the representative household to make withdrawals of money (broadly defined) from an asset market account once every 24-36 months. Alvarez, Atkeson and Edmond [2003] defend this with an appeal to the low frequency of asset market participation observed in the *cross-section* by Vissing-Jorgensen [2002]. Thus, the size of the friction is defended by appealing to the likely size of the friction facing a household representative of the US economy rather than by appealing to direct evidence of the heterogeneous frictions facing individual observations of US households.

Cole and Ohanian [2002] provide another demonstration of the difficulty of interpreting such models literally. They note that the distribution of money holdings between US firms and households has been quite unstable over the postwar period. When this observation is embedded in a model of liquidity effects, it implies a corresponding instability in the effects of money shocks on output – an instability that seems to be counterfactual.

In our opinion, these limitations should not be interpreted as reasons for rejecting models of asset market segmentation. If anything, these limitations are instead reasons for rejecting an implicit aggregation hypothesis. Traditional macro models work with relatively crude frictions that are intended to summarize a complicated array of micro frictions facing individual households and firms. For example, the literature on models of liquidity effects assumes only one level of market segmentation — either between households and asset markets, or between firms and asset markets. However, asset market segmentation seems to occur at numerous levels of financial intermediation. A large body of empirical evidence shows that phenomena consistent with market segmentation arise within the financial system — a system that might best be viewed as a collection of partially integrated and relatively specialized 'local' asset markets (see, among many others, Collin-Dufresne, Goldstein, and Martin [2001]).

This evidence motivates us to ask how a collection of small segmentation frictions cumulates in the aggregate, and whether they add up to a quantitatively significant macro friction. If they do, then the models of liquidity effects that we have discussed here would indeed be natural laboratories for the analysis of the monetary transmission mechanism.

In short, we conjecture that addressing segmentation at a disaggregative level is likely to provide important empirical and theoretical insights into the relationship between patterns of intermediation in financial markets and traditional macro questions — including the size and stability of liquidity effects at short horizons and the monetary policy transmission mechanism more generally.

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