Transaction Asset Shortages

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Abstract

Over the course of U.S. history there have been a number of occasions in which aggregate nominal spending has declined, the most recent of which occurred during the recession that began in December 2007. Coincident with these observed declines in nominal spending is a corresponding decline in the quantity of transaction assets and real output, where the former are defined as financial assets that also serve as a medium of exchange. This paper argues that the co-movement evident in the data is the result of transaction asset shortages. In particular, the paper employs a theoretical model in which transaction asset shortages result from shocks to the resalability, or liquidity of privately produced assets. A structural VAR model is then used to examine the effects of these shocks to determine whether they are consistent with the hypothesized effects in the model. Finally, the VAR is used to construct a historical decomposition of the recession that began in 2007 in the United States in order to examine the relative importance of resalability shocks. The results lend support to the hypothesis of a transaction asset shortage.

Keywords
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1 Introduction

Over the course of U.S. history there have been a number of occasions in which aggregate nominal spending has declined, the most recent of which occurred during the recession that began in December 2007. Coincident with these observed declines in nominal spending is a corresponding decline in the quantity of transaction assets and real output, where the former are defined as financial assets that also serve as a medium of exchange.[1] This begs the question as to what generates this co-movement in nominal spending, real output, and the quantity of financial assets. This paper is an attempt at explanation. In particular, it is argued that there are unique characteristics that distinguish transaction assets from other financial assets and that it is ultimately these characteristics that underlie the relationship between transaction assets, nominal spending, and real economic activity.

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[1]For the most comprehensive evidence of this phenomenon, see Friedman and Schwartz (1963a, 1963b).

All financial intermediaries essentially serve the same function in turning illiquid assets into liabilities. Some liabilities are state-contingent, as in the case of insurance contracts, or time-contingent, as in the case of pension funds. Other liabilities, such as demand deposits, are immediately redeemable for currency. A distinguishing characteristic of a subclass of financial liabilities is a dual role as medium of exchange. Demand deposits, for example, are routinely accepted in the course of trade whereas claims to pensions and life insurance policies are not. What distinguishes financial liabilities that are used in transactions from other financial liabilities is what Menger (1892: 242) referred to as their "degrees of saleableness" or what Kiyotaki and Moore (2002: 62) have recently called "resalability." For example, certain financial liabilities represent bilateral commitments in which the liability is redeemable only by the initial purchaser, as in the case of pensions and life insurance. Other financial liabilities represent multilateral commitments, in which the liability is transferable, as in the case of demand deposits. What separates the "resalability" of financial liabilities is the degree of commitment. Even among assets with multilateral commitment, however, there are differing degrees of resalability. Nonetheless, financial liabilities with a multilateral commitment are capable of circulating as medium of exchange.

From the perspective of a representative household, the liabilities described above are financial assets. The objective of a utility-maximizing agent is to choose the quantity and allocation of financial assets in order to make planned purchases. Assets differ in resalability and in rate of return. Resalability is important because it reflects the degree of liquidity of a particular asset for use in transactions. Given that in an equilibrium where all assets are held, utility-maximizers must be indifferent between all assets, this implies a trade-off between liquidity and rate of return. In addition, if the degree of resalability is time-varying, it is possible that unexpected variations can generate a decline in the liquidity of an agent's portfolio thereby implying a shortage of transaction assets. To the extent that these assets were to be used in purchases, this results in a decline in nominal spending and, potentially, real output.

The purpose of this paper is to develop a model consistent with the description above, to map the model into a tractable empirical analysis and test the hypothesis that shocks to resalability, or liquidity shocks, generate the co-movement in the data described above. In discussing the role of transaction assets it is important to develop a framework in which a medium of exchange is essential. As such, the model developed below modifies the framework of Lagos and Wright (2005) to include real assets and government bonds. From the perspective of agents in the model, there are three assets that can potentially serve as medium of exchange. The first asset is fiat money, which is intrinsically useless, but is perfectly resalable. The second asset is a riskless government bond, which is imperfectly resalable because of its physical characteristics.[2] The final asset represents a claim to a real asset that yields a positive rate of return. The degree of resalability of the claims to real assets are assumed to be stochastic and are realized only when a buyer interacts with a seller.[3] As a result, a reduction in the degree of resalability causes in a decline in the liquidity of a buyer's portfolio thereby reducing nominal spending and real output. Subsequently, the framework is mapped into the familiar quantity equation in which money is defined sufficiently broadly to capture the supply of transaction assets.[4] Shocks to resalability are evident in the money multiplier. A structural VAR model is then used to test the hypothesis that shocks to resalability are positively correlated with nominal income and real output. Finally, the VAR is used to construct a historical decomposition of the recession that began in 2007 in the United States in order to examine the relative importance of resalability shocks.

2 Framework

The model consists of a continuum buyers and sellers, both infinitely-lived and with unit mass. Time is discrete, continues forever, and is divided into two subperiods. The subperiods differ in terms of the nature of trade. In the first subperiod, buyers and sellers are matched pairwise in a decentralized market (DM). In the second subperiod, buyers and sellers meet in a centralized market (CM) and exchange goods for money, asset claims and bonds. Buyers and sellers differ in their preferences. In particular, buyers want to consume in the DM, but produce in the CM. Sellers produce in the DM but want to consume in the CM. This generates a basic-absence-of-

[2]It is assumed here that government bonds have physical characteristics that prevent them from being used in all transactions. This could be the case if government bonds are issued in large denominations or as book entry items and are therefore not tradable in certain types of transactions. This is one aspect of the legal restrictions theory articulated by Wallace (1983) and Bryant and Wallace (1980). For more, see Andolfatto (2006).

[3]In the present framework, the resalability of these asset claims are taken as exogenous. This assumption is made merely for simplicity. For example, Li, Rocheteau, and Weill (2012) and Hendrickson (2012) contain models in which resalability, or liquidity, is endogenous because of the threat of fraud. It is possible to use those frameworks to generate implications similar to those presented below.

[4]This paper is concerned with the supply of transaction assets. As such, there is no reason to exclude certain asset classes from a monetary aggregate. In other words, a monetary aggregate should encompass all assets that serve as medium of exchange. More will be said on this point below.

double-coincidence-of-wants problem. In addition, it is assumed that when trading in the DM is completed, the trading relationship is dissolved and that agents do not have access to other agents trading histories. Credit is therefore infeasible. Goods are non-storable. Buyers therefore trade money, asset claims, or bonds with sellers in exchange for goods. As is typical in models with fiat money, money is assumed to be intrinsically worthless. Money and the asset claims differ in their degree of "resalability." Specifically, it is assumed that only a fraction of bonds and asset claims can be used in transactions whereas money is perfectly "resalable."[5] The significance of the assumption of differing degrees of resalability in the model is that it generates differences in liquidity across assets. The degree of resalability of the claims to real assets is stochastic and determined only after the buyers and sellers have been matched. As a result, the model is capable of capturing shortages in transaction assets. In addition, this assumption also reconciles the rate-of-return dominance puzzle in that money is able to co-exist with other assets that have a higher rate of return.

Formally, buyers preferences are given as:

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(q_t) + x_t - h_t]$$

where β is the discount rate, q_t is the quantity of the afternoon good consumed, x_t is the quantity of the night good consumed, h_t is the number of hours worked by the buyer to produce the night good one-for-one, and u is the utility function such that $u(0) = 0$, $u'(0) = \infty$, $u'(\infty) = 0$, $u' > 0$, and $u'' < 0$.

Sellers preferences are given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t [-c(q_t) + x_t]$$

where $c(q_t)$ is the cost, measured in disutility of producing a quantity of the afternoon good, q_t such that $c' > 0$, $c'' \geq 0$, and $c(0) = 0$.

Finally, there is a government that has a consolidated budget constraint given by:

$$\phi_t(M_t + B_t) + \tau_t = \phi_t(M_{t-1} + B_{t-1})$$

[5] This assumption is consistent with the discussion in Kiyotaki and Moore (2002). In particular, it is equivalent to that of Kiyotaki and Moore (2005) in which land is assumed to be perfectly resalable and capital imperfectly so. Here, money takes the place of land and bonds and asset claims take the place of claims to capital.

where M_t is the supply of money, B_t is the supply of bonds, τ_t is real tax revenue, and ϕ_t is the price of money in terms of goods. It is assumed that bonds are issued at the close of trade in the CM. Bonds represent a claim to future dollars and sell at a discount. As such the value of the bond when it is issued is $\phi_t/(1+r_t^b)$ and its value at maturity in the subsequent CM is ϕ_t.

The analysis proceeds by discussing the CM and working backwards to the DM.

2.1 The Centralized Market

Real assets are of the Lucas tree variety as they are fixed in supply and yield a dividend. Buyers enter the period with real money balances, $\phi_t m$, asset claims, $(p_t+\omega_t)a$, and government bonds, $\phi_t b$. The buyer uses labor, h_t, to produce the night good one-for-one and consumes some amount of this production, x_t. The government can issue lump sum transfers or collect lump sum taxes. The net transfer from the government is given by t_t. The evolution of the buyer's portfolio is thus given by:

$$\phi_t m' + p_t a' + \frac{\phi_t}{(1+r_t^b)} b' = \phi_t m + \theta_t (p_t+\omega_t)a + g\phi_t b + h_t - x_t + t_t \tag{1}$$

where m', a', and b' are money balances, claims to the real asset, and bond holdings, respectively, at the end of the period. Here, g denotes the fraction of bond holdings that is resalable and is constant because it is assumed to be determined by government policy. Also, $\theta \in (0,1)$ represents the "resaleability" of the real asset claim and is assumed to be stochastic with a constant mean and finite variance.

The value function for a buyer at night satisfies

$$W_t(m,a,b) = \max_{x_t,h_t,m',a',b'} x_t - h_t + \beta V_{t+1}(m',a',b')$$

where V_{t+1} is the value function of agents entering the afternoon market next period.

Substituting equation (1) into the value function yields:

$$W_t(m,a,b) = \phi_t m + \theta_t(p_t+\omega_t)a + g\phi_t b + \max_{m',a',b'} \left[-\phi_t m' - p_t a' - \frac{\phi_t}{(1+r_t^b)} b' + \beta V_{t+1}(m',a',b') \right]$$

The first-order conditions to the buyer's problem are:

$$-\phi_t + \beta V_{m,t+1}(m', a', b') \leq 0 \tag{2}$$

$$-p_t + \beta V_{a,t+1}(m', a', b') \leq 0 \tag{3}$$

$$-\frac{\phi_t}{(1+r_t^b)} + \beta V_{b,t+1}(m', a', b') \leq 0 \tag{4}$$

where equations (2), (3), and (4), holding with equality if $m > 0$, $a > 0$, and $b > 0$, respectively. Also, note that $W_m = \phi_t$, $W_a = \theta_t(p_t + \omega_t)$, and $W_b = g\phi_t$.

2.2 The Decentralized Market

In the DM, buyers and sellers are matched with probability σ. Once the buyers and sellers meet, they negotiate the terms of trade and exchange money and/or asset claims for goods.

The value function for the buyer entering the afternoon market is:

$$V_t(m, a, b) = \sigma\{u[q(m, a, b)] - \phi_t m - \theta_t(p_t + \omega_t)a - g\phi_t b] + W_t(m, a, b)\} \tag{5}$$

When buyers and sellers are matched, they negotiate the terms of trade according to the following Nash bargaining problem:

$$[u(q_t) - \phi_t m - \theta_t(p_t + \omega_t)a - g\phi_t b]^\delta[-c(q_t) + \phi_t m + \theta_t(p_t + \omega_t)a + g\phi_t b]^{1-\delta}$$

where δ denotes the degree of market power of the buyer.

The first-order condition of the Nash bargaining problem with respect to q yields:

$$\phi_t m + \theta_t(p_t + \omega_t)a + g\phi_t b = \frac{\delta u'(q_t)c(q_t) + (1-\delta)u(q_t)c'(q_t)}{\delta u'(q_t) + 1 - \delta} \equiv z(q_t) \tag{6}$$

This equation captures the demand for real balances necessary to purchase a quantity of the afternoon good, q. Note that from the implicit function theorem, $\partial q/\partial m = \phi_t/z'(q_t)$, $\partial q/\partial a = \theta_t(p_t + \omega_t)/z'(q_t)$, and $\partial q/\partial b = g\phi_t/z'(q_t)$.

Differentiating (13) with respect to m, a, and b, iterating forward and substituting the results into (2), (3), and (4), respectively, yields:

$$\sigma\left[\frac{u'(q_{t+1})}{z'(q_{t+1})}-1\right]+1-\frac{\phi_t}{\beta\phi_{t+1}}\leq 0 \tag{7}$$

$$\sigma\left[\frac{u'(q_{t+1})}{z'(q_{t+1})}-1\right]+1-\frac{p_t}{\beta\theta_{t+1}(p_{t+1}+\omega_{t+1})}\leq 0 \tag{8}$$

$$\sigma\left[\frac{u'(q_{t+1})}{z'(q_{t+1})}-1\right]+1-\frac{\phi_t}{\beta g(1+r_t^b)\phi_{t+1}}\leq 0 \tag{9}$$

where equations (16), (17), and (18) hold with equality when $m > 0$, $a > 0$, and $b > 0$, respectively. These three equations determine the demand for each transaction asset. Note that when all equations hold with equality, buyers are indifferent between holding each asset. This implies that:

$$\frac{\beta\phi_{t+1}}{\phi_t}=\theta_{t+1}\frac{\beta(p_{t+1}+\omega_{t+1})}{p_t}=\frac{\beta g(1+r_t^b)\phi_{t+1}}{\phi_t} \tag{10}$$

where the first term is the rate of return on money and the second and third term represent the rates of return of claims to assets and bonds, respectively, adjusted for resalability. It therefore remains possible for fiat money to circulate despite being dominated in rate of return by other assets used in transactions. Throughout it is assumed that equation (10) holds with equality.

2.3 Resalability Shocks and Nominal Spending

The hypothesis presented above is that the time-varying property of the resalability of assets can generate the co-movement between nominal spending, the supply of transaction assets, and real output. The model presented above produces the following result:

Result 1 *A reduction in resalability reduces the supply of transaction assets, nominal spending, and real output.*

To illustrate this result, define the aggregate nominal spending at time t as Y_t. Aggregate nominal spending is the sum of spending in the afternoon and night markets. Given that ϕ_t is defined as the price of money in terms of the night good, it follows that the price of the night good is simply the reciprocal. Normalizing output in the night market to unity, nominal spending in the night market is given by $1/\phi_t$. In addition, nominal spending in the afternoon is equal to the aggregate nominal supply of transaction assets multiplied by the match probability. As result, aggregate nominal spending can be written:

$$Y_t = \sigma\{M_t + (1/\phi_t)[\theta_t(p_t + \omega_t)A] + gB_t\} + 1/\phi_t \tag{11}$$

where the term in brackets represents the nominal supply of transaction assets. If we define transaction assets as a sufficiently broad version of a monetary aggregate, we can define the monetary aggregate as:

$$M_t^A = M_t + (1/\phi_t)[\theta_t(p_t + \omega_t)A] + gB_t \tag{12}$$

It is straightforward from (11) and (12) to show that $\partial Y_t/\partial\theta > 0$ and $\partial M_t^A/\partial\theta > 0$.

The relationship between resalability and real output can be illustrated using (6). From the implicit function theorem it follows that:

$$\frac{\partial q}{\partial \theta} = \frac{(p+\omega)A}{z'(q)} > 0$$

Thus, it follows that the reduction in the resalability of an asset leads to a reduction in transaction assets, nominal spending, and real output.

Intuitively, this result can be understood as follows. At the beginning of the period, all agents choose to allocate their portfolio. In an equilibrium in which all assets are held, individuals are indifferent between assets. Thus, although the assets provide different rates of return, they also differ in their degree of resalability. Put differently, assets with higher degrees of resalability provide a liquidity premium that offsets the difference between rates of return. Given that the degree of resalability varies over time and the fact that buyers only find out the degree of resalability in the market when they meet with sellers, it is possible for changes in resalability to generate either excess liquidity or a liquidity constraint. In the former case, the change in resalability represents a windfall to the asset holder who is able to increase spending. In the latter case, the asset holder finds it harder to use particular assets in trade and therefore reduces spending. The fact that the change in spending corresponds with a reduction in real output is the result of the characteristics of the decentralized market. In a centralized (Walrasian) market, the relative rate of return on assets with lower realized resalability would rise to compensate for lower liquidity premium. However, since trade is decentralized, there is no mechanism to coordinate this result.

This situation bears a great deal of similarity to how asset markets actually function. To illustrate this point, consider the example of repurchase agreements. In a repurchase agreement, one party borrows money from another using collateral in the form of U.S. Treasury bonds or asset-backed securities. Put differently the borrower sells assets to the lender and agrees to repurchase them in the future. The lender, however, is able to use this collateral to enter into a repurchase agreement of their own, a process known as rehypothecation. In other words, the borrower provides the lender with claims to certain assets, which are resalable. Nonetheless if, for example, there is an increase in uncertainty about the value of the assets that underlie the asset-backed security, lenders will demand a "haircut" from the borrower.[6] This "haircut" essentially requires the borrower to put up a larger amount of collateral for a given loan value and results in a reduction in the degree of resalability of the asset. In addition, the reduction in resalability is not evident until the agent tries to use collateral in the market. Thus, for a given supply of asset claims, a reduction in resalability reduces the implied purchasing power of the claim holder.

3 Empirical Analysis

3.1 From Theory to Empirics

The model presented above presents a clear hypothesis: a reduction in the resalability of assets causes a reduction in the supply of a transaction assets, nominal spending, and real output. Nonetheless, this presents a problem for empirical analysis because the degree of resalability of a particular asset is not directly observable. As a result, this paper proposes mapping the model into the familiar equation of exchange. In doing so, the model provides a structural foundation for the equation of exchange as well as generating empirical tractability.

Aggregate nominal spending and the broad monetary aggregate are defined in equations (11) and (12). Given these definitions, it is straightforward to solve for velocity, V_t:

$$V_t = \frac{Y_t}{M_t^A} = \left[\frac{\sigma z(q_t) + 1}{z(q_t)}\right] \tag{13}$$

[6] For an extensive discussion of haircuts see Gorton and Merick (2010).

In addition, one can generate the money multiplier as follows. First, define the share of transaction assets that represent claims to asset 1 and asset 2 as Λ_1 and Λ_2, respectively, and the share of assets held in the form of currency as $(1 - \Lambda_1 - \Lambda_2)$ such that:

$$\phi_t M_t = (1 - \Lambda_{1,t} - \Lambda_{2,t}) z(q_t)$$

$$\theta_t (p_t + \omega_t) A = \Lambda_{1,t} z(q_t)$$

$$g \phi_t B_t = \Lambda_{2,t} z(q_t)$$

Given these definitions, it is therefore possible to write:

$$M_t^A = M_t \left[1 + \frac{\Lambda_{1,t} + \Lambda_{2,t}}{1 - \Lambda_{1,t} - \Lambda_{2,t}} \right] \tag{14}$$

where the bracketed term is the money multiplier.

Accordingly, the equation of exchange can be written:

$$M_t^A \left[\frac{\sigma z(q_t) + 1}{z(q_t)} \right] = Y_t \tag{15}$$

Finally, note that $\partial \Lambda_1 / \partial \theta > 0$. The equation of exchange therefore generates empirical tractability for the model presented above because shocks to resalability are evident in the money multiplier. From (14), a reduction in the resalability of a particular asset results in a reduction in the money multiplier and therefore the broad measure of money. It follows from (15) that the reduction in the broad measure of money causes a corresponding reduction in nominal spending.

3.2 On Measuring Transaction Assets

Despite the use of the quantity equation above, the use of the term "transaction assets" throughout the paper rather than "money" is carefully chosen. Money, as it is often defined in M1, M2, and MZM (money zero maturity), is a narrow concept that includes only a subset of assets that are used in transactions. Broader monetary aggregates such as M3 and L are no longer publicly available. Yet, insofar as this paper is concerned there is no obvious reason to confine the definition of money to a subclass of assets. As implied above, any asset that is used in the course of transactions as a medium of exchange should, for all intents and purposes, be considered money. As such any mapping from the initial framework above into the equation of exchange should include a definition of money that includes all transaction assets.

A number of studies over the past few years have attempted to measure the total stock of transaction assets in the United States (Wilmot et al. 2009, 2012; Singh and Stella, 2012; Gorton et al, 2012). These studies, like this one, view transaction assets more broadly than standard measures of money that tend to focus on assets that facilitate exchange at the retail level. The M2 money supply, for example, is limited to checking and saving accounts, small-denomination time deposits, and retail money market funds. Looking beyond retail money assets, these studies also acknowledge the importance of institutional money assets like repos, treasury bills, commercial paper, and GSEs that facilitate exchange for institutional investors like pension funds, mutual funds, and large money managers. Such broad measures of transaction assets that account for both retail and institutional money assets provide a more accurate portrayal of the growth of transaction assets.

In this paper we use the Gorton et al. (2012) measure to empirically examine the economic effect of shocks to transaction assets. This measure is used because among the studies cited it provides the most comprehensive measurement of transaction assets. Using the Flow of Funds data, Gorton et al. (2012) gathers data on the liabilities of financial intermediaries and the government that are information-insensitive, that is, the securities whose value is immune to adverse selection in exchange. With such safe assets there is little incentive for traders of these securities to verify their creditworthiness. Gorton et al. (2012: 1) note that while the most obvious example of safe assets are demand deposits, other information-insensitive assets like treasuries also meet this criteria and thus can also function as form of money:

> To the extent that [highly-rated government] debt is information-insensitive, it can be used efficiently as collateral in financial transactions, a role in finance that is analogous to the role of money in commerce.

Gorton et al. follow through on this reasoning and count both retail and institutional money assets in their measure of the total stock of safe assets. This measure of safe assets provides a good approximation to our definition of transaction assets in this paper. Consequently, hereafter we refer to it as the stock of transaction assets.

[Insert Figures 1 - 4 around here]

Figure 1 shows how the supply of transaction assets as well as its two subcomponents, the information-insensitive liabilities of the private (financial) sector and the public sector, evolve over time.[7] The total stock of transaction assets reaches about $49.6 trillion by the end of 2011. Figure 1 shows that since the 1970s most of the transaction asset growth has come from the private sector. This figure also reveals that the private sectors creation of transaction assets fell during the Great Recession and has yet to return its previous peak. Some of this decline has been offset by the growth in public sector transaction assets during this time, but not enough to push the total stock of transaction assets to its previous trend during the Great Moderation period of 1983-2007, as seen in Figure 2.

Figure 3 breaks down the total supply of transaction assets into an institutional transaction asset category and a retail transaction asset category. These two series are created by defining the retail transaction assets as M2 and subtracting this quantity from the total transaction assets to create the institutional category. This figure indicates that though the retail transaction assets have continued to grow during the crisis, the growth of institutional ones have stagnated since mid-2008. During the Great Moderation period, institutional transaction assets grew on average 2.5 percent each quarter. Since mid-2008 they have grown only 0.4 percent. Together, Figures 1 and 3 suggest that a breakdown of private financial intermediation for institutional investors has led to a drop in the supply of transaction assets available to them.

The extent of the disruption to financial intermediation can be seen in Figure 4. It shows the transaction assets multiplier, the total stock of transaction assets divided by the monetary base. The figure reveals that prior to the crisis financial intermediation resulted in about $52 of transaction assets for every $1 of monetary base. By the end of 2011 only $18 was being financially intermediated for every $1 dollar of monetary base. Even though the monetary base expanded rapidly during this time, it has not increased enough to offset the sharp drop in the transaction asset multiplier and keep the growth of transaction assets on the trend path from the Great Moderation period.

[7] The exact items from the Flow of Funds used to construct these measures of transaction assets can be found in the two appendix tables of Gorton et. al (2012).

Consistent with the previous theoretical findings, these figures suggest that a shock to resalability, which would be manifested in a drop in the transaction assets multiplier, should lead to a decline in transaction assets overall. In turn, that should lead to a drop in nominal income for a given level of transaction asset demand. To further examine this implication and to see more generally the impact of such a shock to the real economy we estimate a structural vector autoregression in the following section.

4 Empirical Approach

In this section we estimate a vector autoregression (VAR) that identifies exogenous shocks to supply of transaction assets. We also estimate a VAR that identifies shocks to the transaction asset multiplier and the monetary base since the product of these two series is the stock of transaction assets. Our goal in both cases is to identify these shocks while imposing minimal restrictions on the data. We do this by running a structural VAR that imposes long-run restrictions on the innovations to the transaction assets series, transaction asset multiplier, and monetary base. These restrictions do not force any structure on the short-run dynamics of the data, but do require the long-run cumulative effect of such a shock to be zero on all the real economic variables in the VAR. In short, we impose long-run money neutrality on the three shocks. This is a reasonable assumption since all three shocks amount to different forms of liquidity shocks.

Our use of long-run identifying restrictions is not novel. It was first introduced by Blanchard and Quah (1989) and has been subsequently used in numerous other studies that examine the effect of money supply shocks on economic activity such as Gali (1992), Lastrapes (1998, 2006), Fackler and McMillin (1998), and Rapach (2001). Our use of this technique can be viewed as extension of these earlier studies with the key difference being that we use the total stock of transaction assets as the measure of the money supply.[8] While this approach does leave the model overall under identified, it does identify the structural liquidity shocks.

Formally, this approach starts with an autoregressive structural model of the form

$$A_0 x_t = A_1 x_{t-1} + \cdots + A_p x_{t-p} + u_t \tag{16}$$

[8] These previous studies used M1 or M2 as the measure of the money supply.

where x_t is the vector of endogenous variables, $A_0, \ldots, A_p$ are n x n structural parameter matrices and u_t is an n x 1 vector of uncorrelated structural shocks that are assumed to be multivariate normal with mean zero and unit variance. The vector of endogenous variables for the initial VAR is defined as follows:

$$x_t = (y_t, r_t, i_t, t_t/p_t, t_t)' \tag{17}$$

where y_t is real output, r_t is a risk premium measure, i_t is the nominal interest rate, t_t/p_t is real transaction asset balances, t_t is the stock of transaction assets. The risk premium measure is included to control for exogenous changes to risk premium that may influence the level of financial intermediation. The last two terms can be viewed as broad measures of real money balances and the money supply. Note that the price level, p_t, can be extracted from the system since both real transaction balances and transaction balances are in it. One can also extract an approximate nominal income series from this system since real output, y_t, and the price level, p_t, are present. We use this fact later to extract price level responses and nominal income responses to the structural shocks without having to explicitly estimate them.

Our second VAR uses the same endogenous variables except now it substitutes the transaction asset multiplier and the monetary base for the total stock of transaction assets:

$$x_t = (y_t, r_t, i_t, t_t/p_t, m_t, b_t)' \tag{18}$$

where m_t is the transaction asset multiplier, b_t is the monetary base, and $m_t b_t = t_t$.

As mentioned above, we identify all three liquidity shocks using long-run restrictions. Consequently, structural shocks to the transaction assets, the transaction asset multiplier, and the monetary base can have no permanent effect on variables preceding them in the vector of endogenous variables. While it is apparent that the long-run monetary neutrality restrictions make sense for the real variables of y_t, r_t, and t_t/p_t, it is also reasonable to apply it to the nominal interest rate, it since it mimics the behavior of the real interest rate in the long run. This is because a one-time permanent liquidity shock only affects the price level permanently not the rate of inflation.

Given this framework, the structural autoregressive models above can be transformed into a structural moving average form so that the relationship between the endogenous variables and the structural shocks can be defined. The structural moving average model can be shown to be

$$y_t = (D_0 + D_1 L + D_2 L^2 + \dots)u_t = D(L)u_t \tag{19}$$

where $D_0 = A_0^{-1}$, $D_i = (A_0^{-1}A_i)^i A_0^{-1}$ and L denotes the lag operator. The coefficient matrices in D(L) represent the dynamic multipliers of the structural shocks. As it stands, (19) is still a structural model and cannot be estimated directly. Rather, a reduced form version must be estimated and then identifying restrictions imposed to recover the structural model. The reduced form moving average can be expressed as follows

$$y_t(I + C_1 L + C_2 L^2 + \dots)\varepsilon_t = C(L)\varepsilon_t \tag{20}$$

There is a mapping between the reduced-form parameters in (20) and the structural parameters in (19) since $\varepsilon_t = D_0 u_t$, $C(L) = D(L)D_0^{-1}$ and $E\varepsilon_t\varepsilon_t' = \Sigma = D_0 D_0'$. However, this mapping is not unique. Consequently, even though the reduced form parameters $C(L)$ and Σ are directly estimable, identifying restrictions need to be imposed to recover the structural shocks. As noted above, the identification scheme adopted here is to impose long-run monetary neutrality restriction on shocks to the money multiplier, real money balances, and the monetary base. Given the ordering of the variables in x_t, this requires taking the infinite horizon sum of $D(L)$, $D(1)$, and imposing the following restrictions for the first VAR in equation (18)

$$D(1) = \begin{pmatrix} d_{11} & d_{12} & d_{13} & d_{14} & 0 \\ d_{21} & d_{22} & d_{23} & d_{24} & 0 \\ d_{31} & d_{32} & d_{33} & d_{34} & 0 \\ d_{41} & d_{42} & d_{43} & d_{44} & 0 \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} \end{pmatrix} \tag{21}$$

Similarly, in the second VAR the long-run restrictions require imposing the following conditions

$$D(1) = \begin{pmatrix} d_{11} & d_{12} & d_{13} & d_{14} & 0 & 0 \\ d_{21} & d_{22} & d_{23} & d_{24} & 0 & 0 \\ d_{31} & d_{32} & d_{33} & d_{34} & 0 & 0 \\ d_{41} & d_{42} & d_{43} & d_{44} & 0 & 0 \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} & 0 \\ d_{61} & d_{62} & d_{63} & d_{64} & d_{65} & d_{66} \end{pmatrix} \tag{22}$$

The zero restrictions in (21) mean that the transaction assets shock have a cumulative effect of zero on the variables ordered above it in the VAR. The same is true for (22) except that in that case it is also assumed that the shock to the monetary base has not permanent effect on the transaction assets multiplier.[9] As noted earlier, this approach does leave the model under-identified, but it does fully identify the liquidity shocks to transaction assets, the transaction asset multiplier, and the monetary base. The results from the next section lend support to this interpretation of the shocks.

Using these long run restrictions, the estimated VAR can be used to show the effect of the liquidity shocks through innovation accounting. Here, innovation accounting in the form of cumulative impulse response functions (IRFs) are used to show the typical cumulative dynamic response of an endogenous variable to the various liquidity shocks. These IRFs serve to verify whether our identified empirical shocks create responses that are consistent with the implications of the theoretical model. Once this is done, we do a historical decomposition exercise to determine how important these shocks were during the Great Recession.

5 Data

Our data covers the longest period for which a continuous measure of transaction assets can be constructed from the Flow of Funds data: 1952:Q4 2011:Q4. As noted above, we follow the Gorton et al. (2012) list of safe assets in constructing this series. The other variables come from the FRED

[9] We implement these restrictions by taking a Choleski decomposition of the long run covariance matrix. Keating (1996) shows that the ordering of the other variables is inconsequential to identifying the structural liquidity shocks in this manner.

database of the St. Louis Federal Reserve Bank and are as follows. Real GDP is used for real output, the yield on the 10-year treasury is used as the nominal interest rate, and the spread between Moodys Corporate BAA yield and AAA yield is used as a measure of the risk premium.[10] Real transaction assets balances are created by dividing the total stock of transaction assets by the CPI. All variables are in seasonally adjusted form and were transformed into logarithms with the exception of the interest rate and risk premium. Except for the risk premium, standard unit root tests indicate non-stationarity in the levels of all the variables while there was no convincing evidence found for cointegrating relationships among the variables.[11] As a result, we first differenced the data for both periods. Ljung-Box Q test shows 3 lags are sufficient to whiten the residuals and the AIC indicates these many lags are satisfactory.

6 Results

6.1 Impulse Response Functions

Figure 5 report the cumulative IRFs for all the variables – including the price level and nominal income which are constructed from the other series – to a positive, one standard error shock to the stock of transaction assets using the VAR in (17). The solid line shows the cumulative IRF point estimate while the dotted lines show simulated standard error bands. The IRF for the interest rate and risk premium can be interpreted as showing the dynamic change to these variables in terms of basis points. For the other variables, the IRFs can be seen as the percent change to their level.

Figure 5 shows that, for the sample period of 1952:Q4 2011:Q4, a positive standard error shock to the stock of transaction assets creates responses in the other macroeconomic variables that are consistent with the implications of the theoretical section. The shock causes nominal income to rise 0.38 percent upon impact which breaks down into a jump in real GDP of 0.18 percent and in the price level of 0.20 percent. Real GDP continues to rise over the next three quarters, but thereafter

[10] A long-term treasury yield is used because we found that it eliminated a serial correlation problem that was not possible with short-term interest rates. Also, because there are a number of long-term assets in the stock of transaction assets it is reasonable to use a long-term yield.

[11] The two-step Engle-Granger cointegration test gives almost no indication of cointegration (regardless of which variable appears on the left-hand side of the first step of the test) and the Johansen test gives some evidence. Given this lack of convincing evidence and the fact that Lastrapes and McMillan (2004) found that the impulse response functions from monetary shocks with long-run restrictions are very similar in both first-differenced VARs and VECMs, we opt for the first-differenced VAR.

begins to wane owing to long-run monetary neutrality. The price level, though, continues to increase throughout, but at a decreasing rate. Our measure of the risk premium, corporate bond spreads, falls 0.095 immediately and drops for two more quarters. The 10-year treasury yield falls upon impact indicating a strong liquidity effect. Both of these series also begin to see a lessening of the shocks effect over time. Figure 5 suggests, then, that a positive shock to the supply of transaction assets raises nominal income which in turn temporarily increases real economic activity, lowers the risk premium, and cause the price level to rise.

Figures 6 and 7 report the results of estimating the VAR in (18) that breaks apart the stock of transaction assets into the transaction asset multiplier and the monetary base. The first figure shows the cumulative effect of a positive standard error shock to the monetary base. Since the VAR controls for changes in real economic activity, interest rates, the risk premium, real transaction assets balances, and the transaction assets multiplier, the model is effectively controlling for broad money demand as well as demand for the monetary base. Thus, the shock can be viewed as an exogenous monetary policy shock. The second figure shows the cumulative effect of a positive standard error shock to the transaction asset multiplier. It measures the level of financial intermediation for a given dollar of monetary base. A shock to resalability should directly affect financial intermediation and thus be reflected in this series.

Both figures show IRFs that, while unique, are broadly similar to the IRFs in Figure 5. Upon impact, nominal income rises in both cases, which can be decomposed into the temporary rise in real GDP and the permanent rise in the price level. The risk premium falls in both cases, but it drops more sharply with the transaction assets multiplier shock (0.09 percent) than the monetary base shock (0.03 percent). The 10-year treasury yield also temporarily falls too, but shows a stronger and more persistent effect with the monetary base shock. Interestingly, the transaction assets multiplier shock appears to be partially offset by the Federal Reserve shrinking the monetary base. Likewise, exogenous monetary policy shocks appear to be somewhat offset by a reduction in the money multiplier. The former offsetting response is probably the Fed providing countercyclical monetary policy, though it is not clear what is driving the latter offsetting response.

It is interesting to note that IRFs for the shock to the stock of transaction assets is very similar to those effect predicted in standard macroeconomic models for a shock to the money supply. These IRFs, therefore, provide evidence that Gorton et al. (2012) transaction asset measure is measuring money-like assets. The IRFs also imply, then, that a more accurate measure of the money supply is a broad one that includes both retail and institutional money assets. Finally, the IRFs show the importance to the economy of a shock to resalability for transaction assets.

6.2 Historical Decomposition

While the IRFs show us that shocks to the stock of transaction assets matter, they do not show how important these shocks are relative to other economic shocks. In particular, how important were transaction assets shocks during the Great Recession? Figures 1-2 suggest they were important, but cannot shed any light on causality. To further examine this question we use a historical decomposition of the forecast errors that arose from the estimated shocks to the supply of transaction assets. This exercise allows us to attribute the difference between the VARs forecasted value of a particular series and its actual outcome (i.e. the forecast error) to the accumulated effects of transaction asset shocks. Figure 1 indicates the decline in the supply of private transaction assets drove most of the change in the total stock of transaction assets. We therefore reestimate the VAR using the stock of private transaction assets rather than the total stock and then rerun the historical decomposition. This provides a second historical decomposition to facilitate comparison. We run the historical decompositions for the period 2006:Q1 2011:Q4.

Since our VAR was estimated in first differences we examine the difference between the forecasted growth rate of the series and the actual growth rate. Figure 8 provides the historical decompositions for nominal income, corporate bond yield spread, and real GDP. The black line shows the actual growth rates for these series, the gray line shows the VARs baseline forecasted growth rates, and the dashed lines show the baseline forecast plus the accumulated effect of the transaction asset shock on the growth rates. This figure reveals that a significant portion of the forecast error in all three variables during the Great Recession period can be explained by the two transaction assets shocks. The corporate bond yield spread, in particular, appears to be largely explained by the transaction assets supply shocks.

7 Conclusion

Aggregate nominal spending has declined several times throughout U.S. history. The first such decline in the post-World War II era occurred during the recession that began in December 2007. In each case, there has been a coincident decline in real economic activity and the supply of transaction assets. This paper argues that co-movement in the data during these periods can be understood as the result of a shortage of transaction assets. In particular, adverse shocks to the resalability, or liquidity, of transaction assets cause economic agents to be liquidity constrained, which results in lower nominal spending and also real economic activity. In this regard, the paper makes two important contributions. First, the paper provides an explicit link between the microeconomic properties of transaction assets and the implications of these characteristics for macroeconomic fluctuations. Second, the paper uses structural VARs to estimate the effects of the shocks identified in the theoretical framework. The corresponding impulse response functions are consistent with the predictions of the theoretical model. In addition, a historical decomposition centered around the recession that began in 2007 demonstrates that fluctuations in the supply of transaction assets explain a significant fraction of the movement in nominal spending, real economic activity, and interest rate spreads. The results therefore strongly support the hypothesis of a transaction asset shortage.

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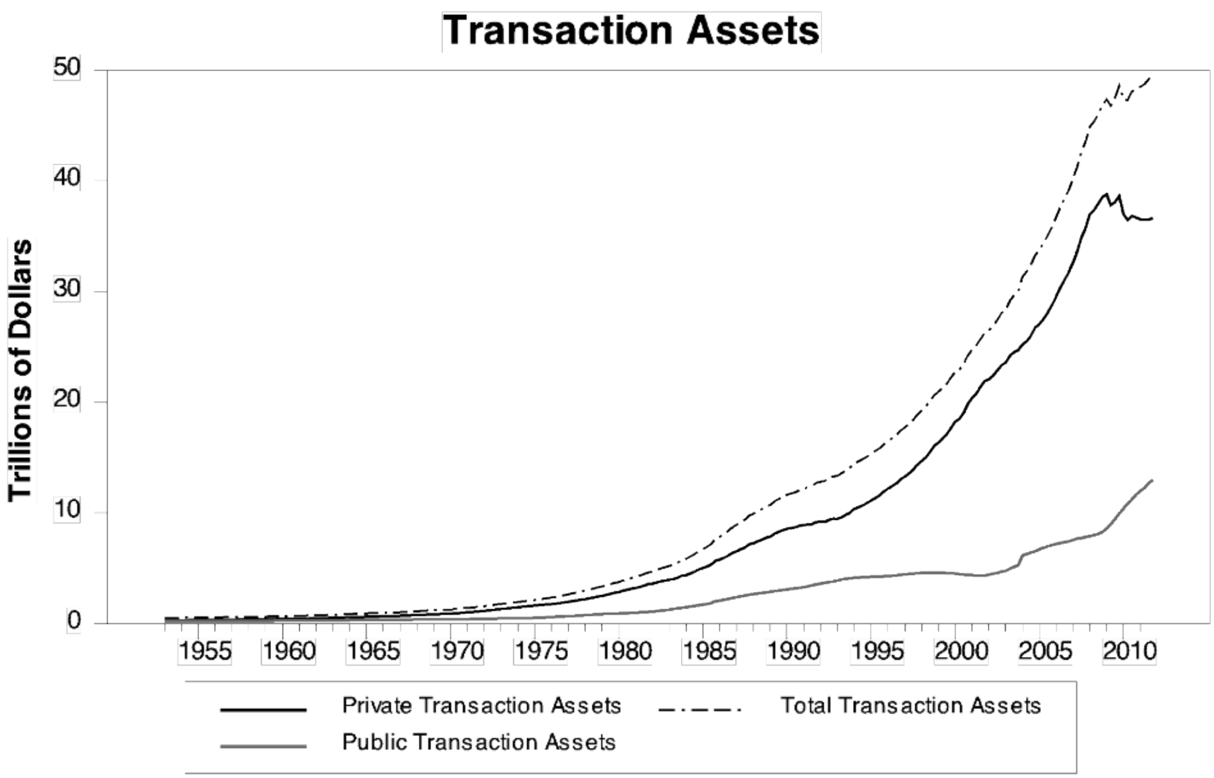

Figure 1: Transaction Assets

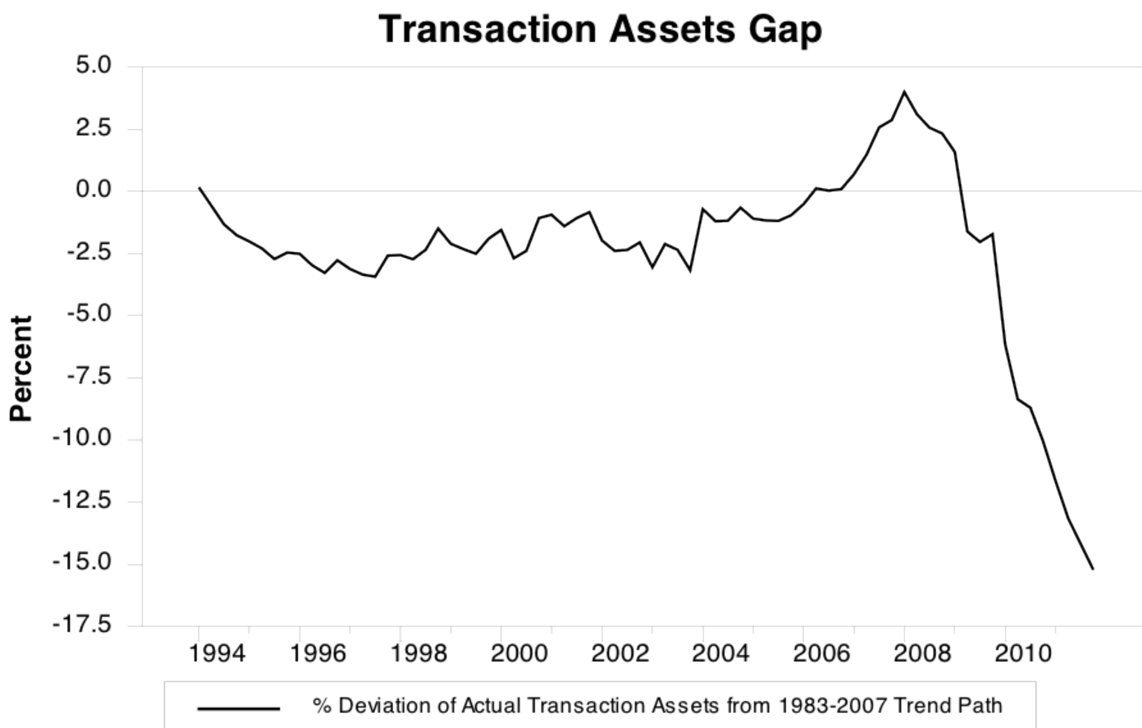

Figure 2: Transaction Assets Gap

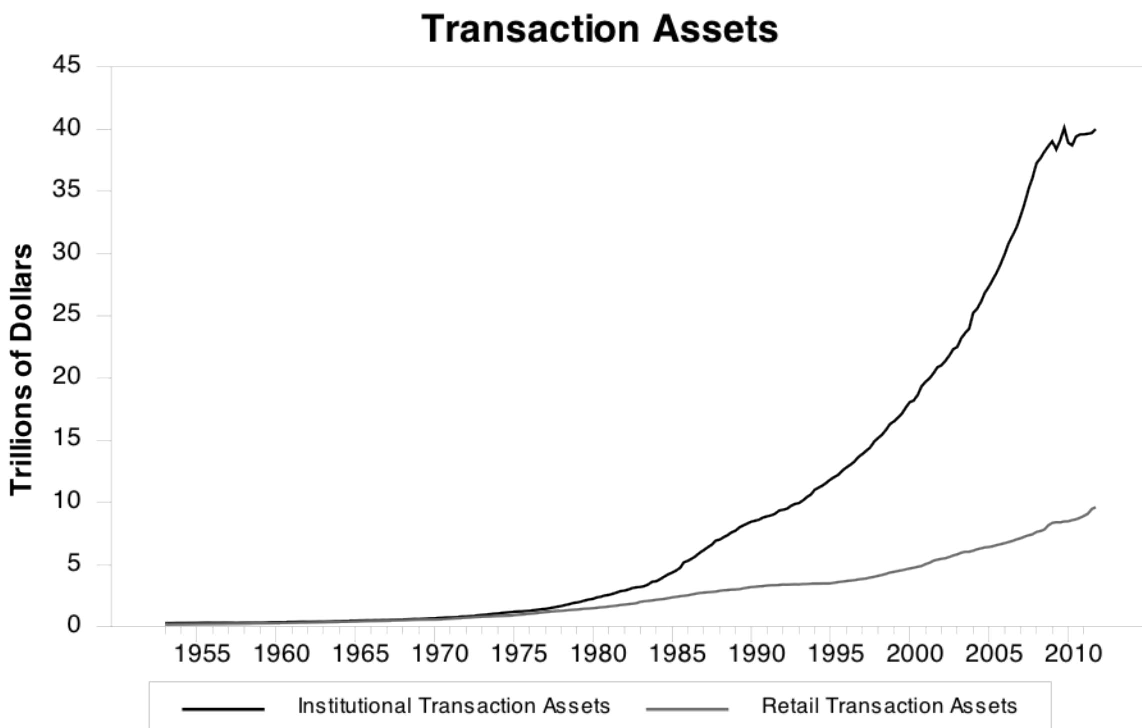

Figure 3: Institutional and Retail Transaction Assets

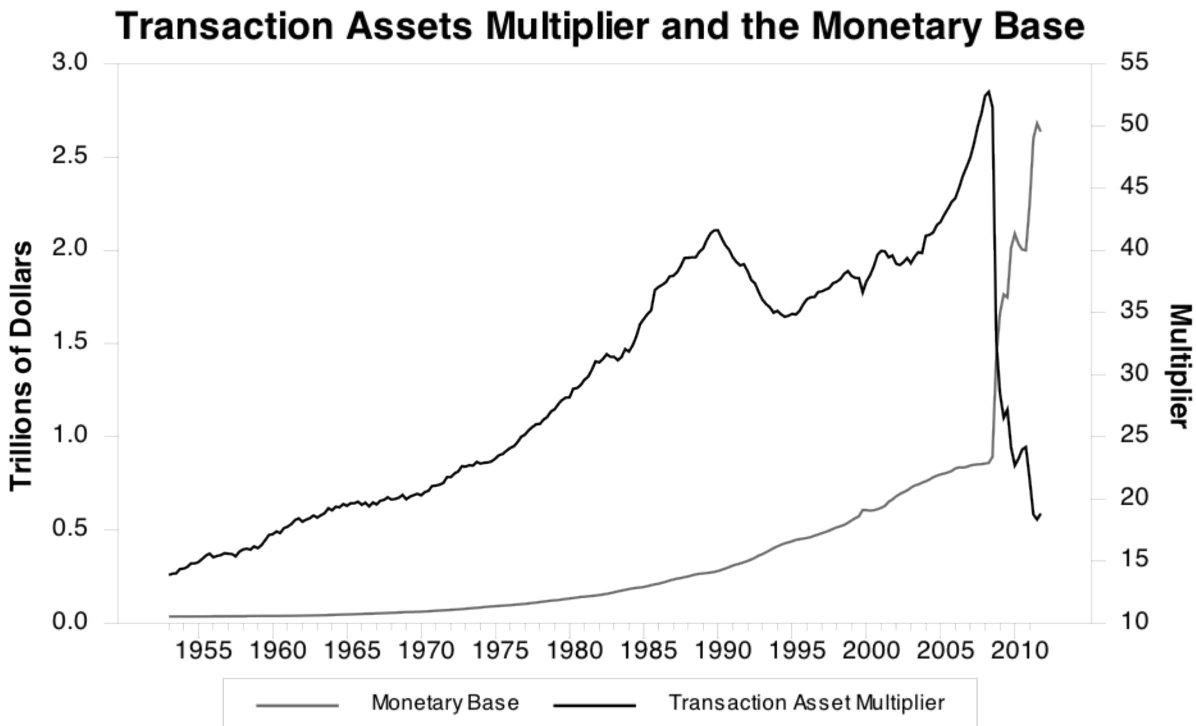

Figure 4: Transaction Asset Multiplier and the Monetary Base

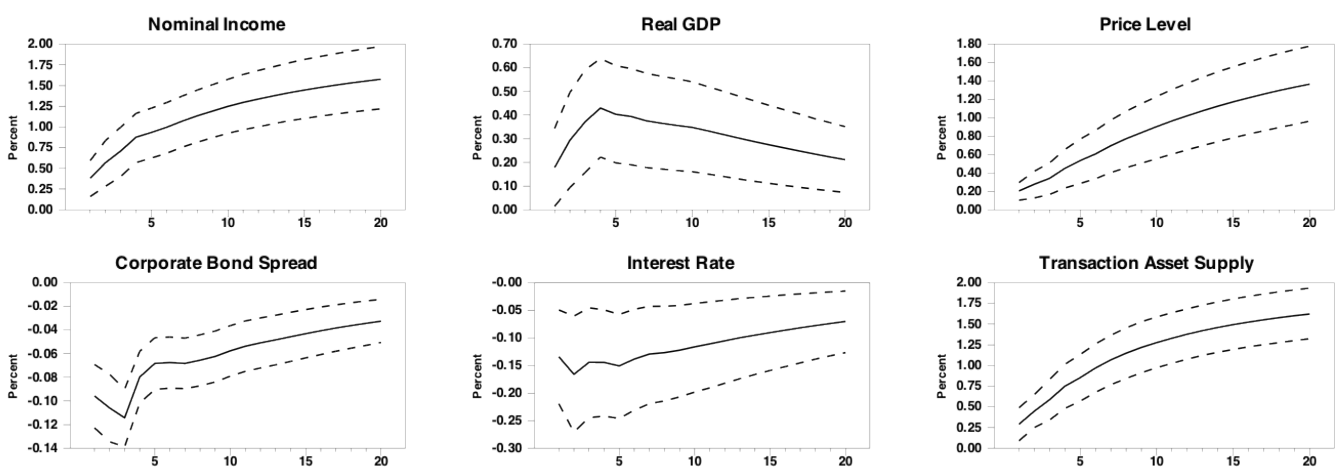

Figure 5: Cumulative IRF to a Transaction Asset Supply Shock

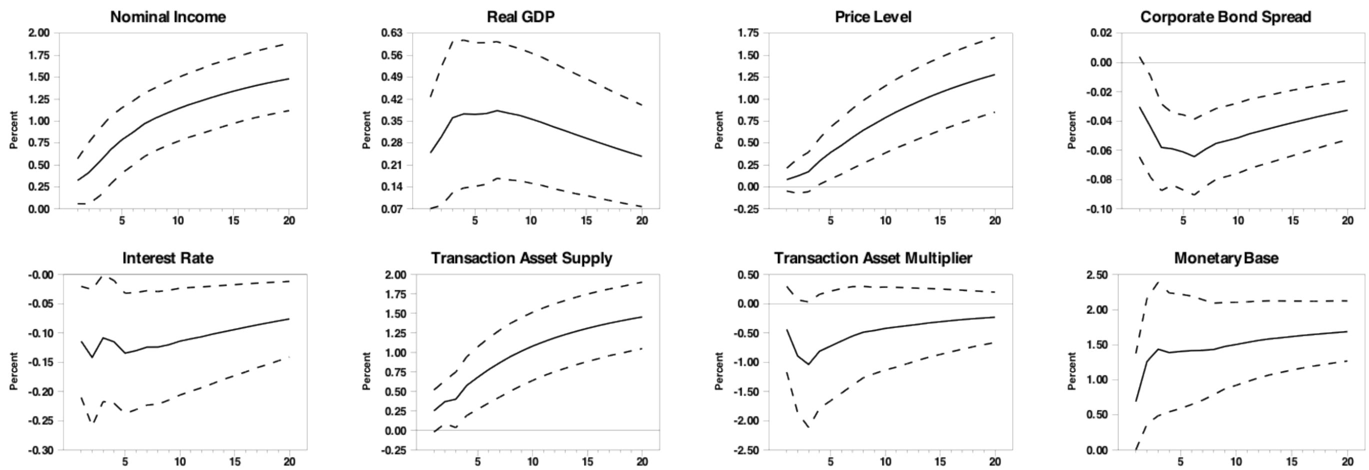

Figure 6: Cumulative IRF to a Monetary Base Supply Shock

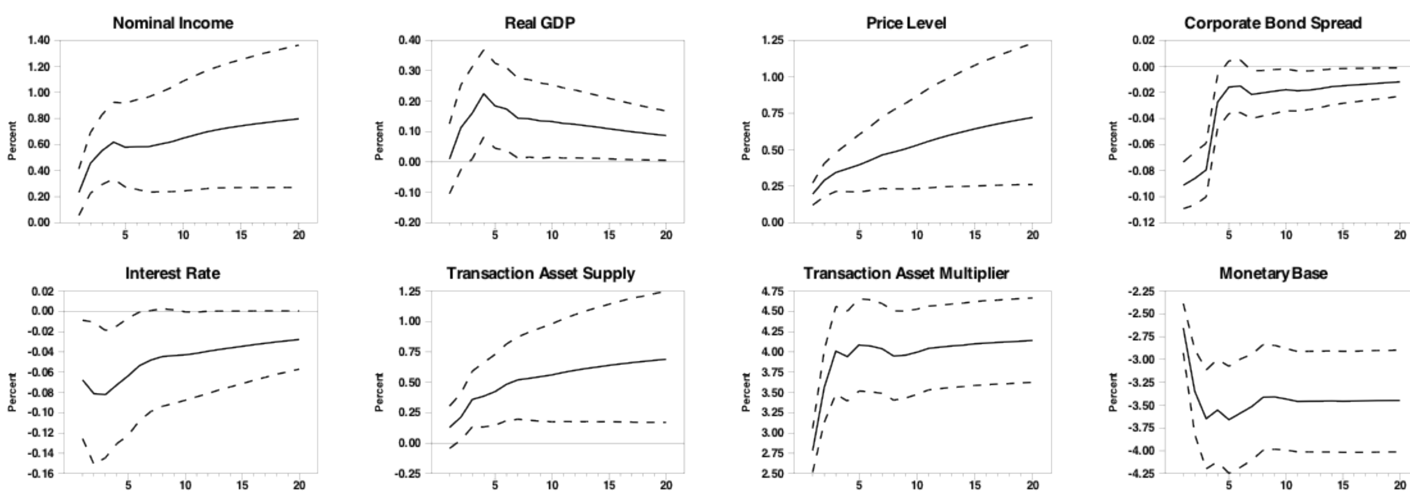

Figure 7: Cumulative IRF to a Transaction Asset Multiplier Shock

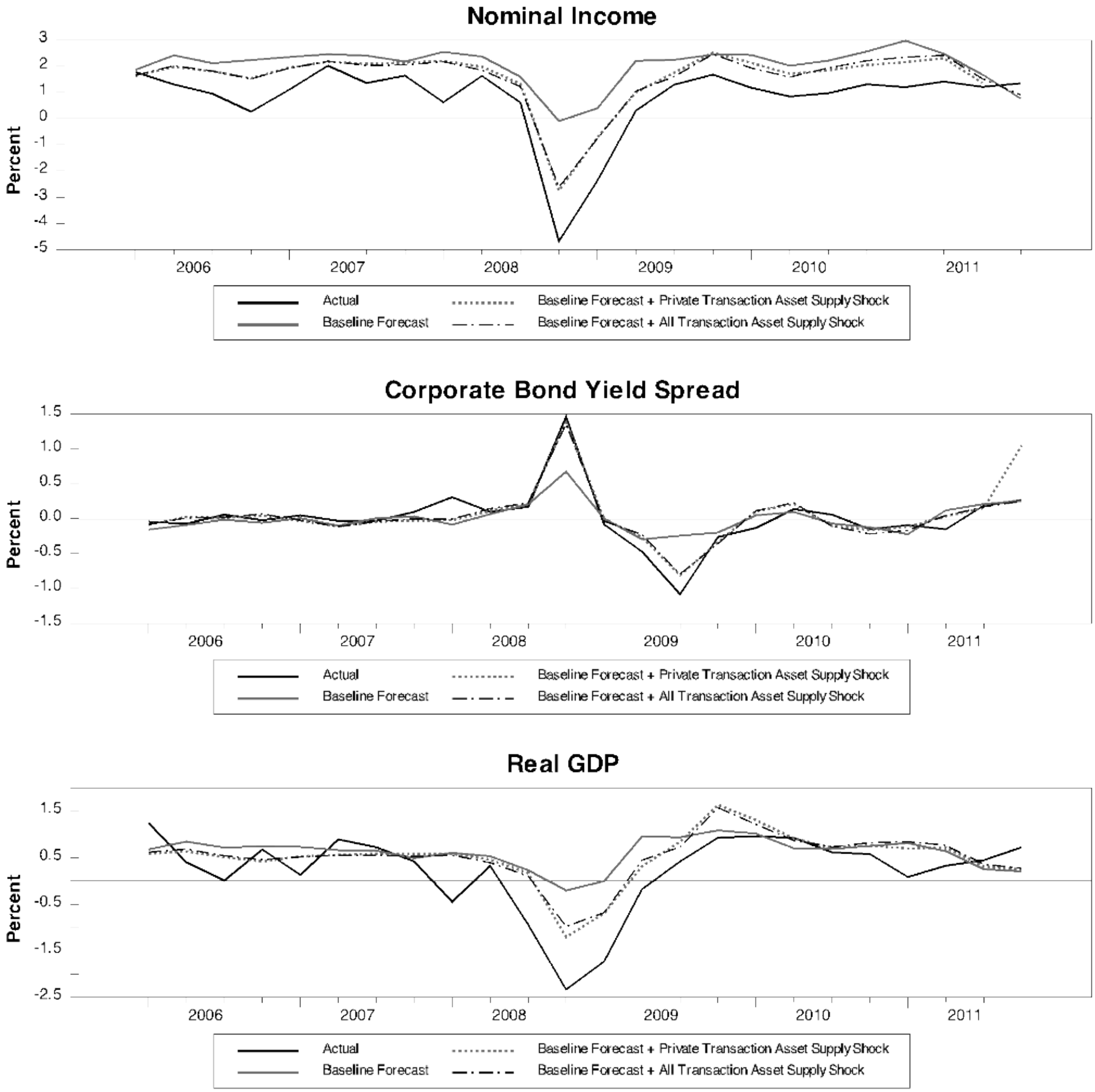

Figure 8: Historical Decompositions