The Chemistry of the Macroeconomy

Robert Gmeiner1,2✉

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Abstract
Asset booms and busts have accompanied or caused recent macroeconomic fluctuations. However, asset prices are not a part of GDP nor are they included in inflation calculations. Links between the financial sector and real economy are increasingly important. This paper borrows an approach from the natural sciences to explain the optimal amount of transactions for unbacked assets. Excessive transactions for such assets impede long run growth. This theory does not involve asset prices, only transactions, offering a distinction from literature on asset bubbles, and leads to concise policy recommendations to improve macroeconomic stability.

Keywords Unbacked assets · Money velocity · Monetary policy · Financial stability

JEL Classification E44 · E52 · E58

1 Introduction

For centuries money has been used to facilitate transactions. In the modern era, debt, stocks, bonds, and other assets have become prevalent alongside money to enhance economic systems. These assets serve some of the same functions as money, such as a store of value, but their prices can fluctuate independently of prices in the real economy. Recently, asset booms and busts have occurred alongside stable, low inflation. These assets also augment the role of money as a medium of exchange by offering liquidity from once-illiquid assets. The prevalence of non-money assets divides the role of money as a medium of exchange into two related, but distinct functions, (1) to facilitate the production and exchange of goods and services and (2) to facilitate “nonproductive transactions.” The residual calculation of money velocity misses asset transactions, thus understating the frequency with which a dollar changes hands, which is this paper’s starting point. Throughout the paper the terms

✉ Robert Gmeiner
rgmeiner@methodist.edu

1 Methodist University, 5400 Ramsey St, Fayetteville, NC 28311, USA
2 The Sunwater Institute, 12358 Parklawn Dr, North Bethesda, MD 20852, USA
“nonproductive transactions” and “nonproductive payments” refer to interest payments and transactions for nonproductive assets. Nonproductive assets include both backed and unbacked financial assets. More specifically, they are any form of debt, stock, or other asset that is not a factor of production or direct contributor to GDP. Specifics of what nonproductive transactions include are given in Sect. 3.1.

This paper answers the question of whether a high prevalence of nonproductive transactions is detrimental to long run economic growth. I define nonproductive transactions into a new variable that augments Fisher’s equation of exchange to produce more accurate measures of money velocity. In order to achieve sustained long run growth, central banks must pay attention to transactions for nonproductive assets when formulating stabilization and growth policies.

The premise underlying the hypothesis that nonproductive transactions adversely affect long run economic growth relies on the link between the financial sector and the real economy. A large financial sector houses a secondary market for nonproductive assets that results in price fluctuations and changes in financial wealth that are at least somewhat independent of the real economy. In 2019, value added by the financial sector amounted to 7.9% of GDP in the United States, and this figure jumped to 8.6% in 2020 during the COVID-19 recession, which shows the size and economic significance of the financial sector. From the peak of 8.6%, it has only diminished to 8.5% in 2021, and its low point since it was first reported in 2006 came in 2005 at 6.0%.1 This nonnegligible sum is only the value added by these services, and does not include the concurrent changes in asset prices. Asset price changes underpin changes in financial wealth, and they can affect consumption and investment. Without a corresponding change in investment and domestic production, consumption changes may also affect the current account.

To answer the research question, I develop an economic model with roots in chemistry equations. In relating economic ideas to chemistry, I continue the long tradition of adapting models from other disciplines, such as physics, for use in economics, for example, Bouchaud (2001). My goal in developing a model from chemistry equations is not simple creativity, but to explain macroeconomic events and trends and offer new decision rules and policy targets beyond what existing macroeconomic models have done. I establish the link between chemistry and economics by beginning with known economics equations, from which I derive equations similar to chemistry relationships.

Section 2 discusses relevant literature, after which I develop the theory in Sect. 3. Section 4 empirically validates this theory, and I present a policy discussion in Sect. 6. This analysis provides insights regarding modern macroeconomic events, including trends that set the stage for the global financial crisis and Great Recession decades. The course of these events coincided with increasing amounts of nonproductive transactions. Section 5.1 documents major changes in macroeconomic trends that occurred beginning in the 1980s, when the subject matter of this paper became persistently important.

1 Source: U.S. Bureau of Economic Analysis, accessed from FRED Series VAPGDPFI, value added by the finance and insurance sector as a percent of GDP.
2 Discussion of Relevant Literature

Recognizing the effect of nonproductive assets on money velocity, Gould and Nelson (1974) model velocity of money as a function of several variables including price level, ratio of current to permanent income, and interest rates. They point out that both income and money are represented by a random walk with upward drift, but are minimally correlated with each other. The authors note that divergence between money and income are causes of velocity changes. This paper augments this understanding by showing that nonproductive assets can cause changes in velocity. The ideas of Gould and Nelson are challenged somewhat because money and income are correlated. This was shown by Bernanke (1986), who cited Friedman and Schwartz’s (1963) *A Monetary History of the United States*.

Bordo et al. (1997) highlighted the view that money velocity is an analogue of the demand for real money balances and showed an increase in velocity that comes with nonproductive (e.g., financial) assets. Similarly Leão (2005) shows that asset purchases induce higher velocity of money in booms and lower velocity in busts. Ireland (1994) shows that financial innovations allow individuals to hold lower cash balances, increasing the velocity of money.

Interest payments on debt can potentially limit GDP. Interest payments may be necessary side-effect of growth, but they are nonproductive transactions. The money that companies use to pay interest could find a productive use if there were no debt obligations. If business investment is productive, its value to the business must be measured net of interest. Under existing conditions of high debt, valuable investment may not be possible due to interest payments. Compounding this issue is the potential need to replace depreciated capital. Lack of investment because of high debt burdens can cause labor productivity to diminish (Woo & Kumar, 2015).

The potential for nonproductive assets to divert money away from productive activity was noted by Asriyan et al. (2020), who believe that asset bubbles foster investment. This may indeed be the case, but it may result in a disconnect between the income source (asset appreciation) from productive activity, which this paper views as problematic. Asset bubbles have a lengthy literature (Samuelson, 1958; Tirole, 1985), but this paper draws a sharp distinction between asset transactions and asset bubbles. Asset bubbles certainly attract money away from productive activity, but the problem is not excessive appreciation; it is excessive transactions and the use of asset wealth for other transactions in the economy. Asset appreciation is good insofar as it reflects fundamental or backed value. Miao and Wang (2018) have noted increases in asset prices and their close links to other macroeconomic variables since the 1990s, and the theory developed in this paper views these links as problematic.

Asset speculation is not the only thing that diverts money away from productive activity. Debt burdens, including but not limited to government debt, can do the same. Low interest rates may encourage debt and also asset speculation, a nonproductive transaction. Reinhart and Rogoff (2010) attracted attention for
highlighting decreased economic growth that results from high external debt. Their conclusion was disputed by Herndon et al. (2014), who correctly identified coding errors in the research. Before this challenge was published, Reinhart et al. (2012) had written a follow-up to their original paper which did not suffer from these coding errors, yet reached a similar conclusion with results of a lower magnitude than the 2010 paper.

Both sovereign debt and private sector debt pose risks for GDP growth. Although it is theoretically possible to roll over debt and only bear the burden of interest, this possibility is limited. For governments and the private sector, as debt principal increases, interest costs rise. Borrowing costs also rise as debt is perceived as less safe. As borrowing costs rise and the ability to roll over debt diminishes, principal payments become a burden along with interest. Section 4 discusses the changes in these burdens over time and includes a graph in Fig. 6.

Much of the literature on the perils of debt comes from disciplines other than economics, such as accounting and finance, where the reality of corporate finance is divorced from the theoretical ease of rolling over debt. Zeller and Stanko (1994) and Jooste (2007) highlighted the role of cash flow analysis in predicting financial distress. Principal payments are certainly a cash flow burden. Ibarra (2009) wrote that financial health cannot be sufficiently understood from income statements and balance sheets alone, and said cash flow analysis provided indispensable insights into financial health. Alti (2003) used a model based on Lucas (1967), wrote that investment is sensitive to cash flows even when financing is frictionless. For all firms, investment is sensitive to cash flow conditional on Tobin’s q, but Alti’s contribution is unique because it shows that financial frictions are not the source of debt-related problems for investment.

Firms are not always committed to repaying debt and, although rolling over debt is not always trivial, efforts to do so can be linked to asset bubbles that make borrowing easier. These asset bubbles are followed by recessions when they burst (Miao & Wang, 2018). Asset booms and busts and their effects on the real economy have given rise to macroeconomic stabilization policies of leaning against the wind (LAW) which entail keeping interest rates higher than is needed to prevent inflation for the purpose of preventing asset bubbles. Although this paper focuses on transactions (flows), not levels (stocks) of asset wealth and debt burdens, LAW policies are still relevant. Chauvet et al. (2016) responded to the view of Bernanke et al. (2000) and Bernanke and Gertler (2001) that central banks should respond to asset prices only if they signal a change in expected inflation. They point out a distinction between macroeconomic stability and financial stability, but financial instability can upend macroeconomic stability. This is a reason for LAW policies, for which they propose a central bank reaction function. Similarly, Gambacorta and Signoretti (2014) believed that a Taylor rule augmented with asset prices and credit could better ensure macroeconomic stability than a standard Taylor rule with inflation targeting.

These LAW policies have their detractors, such as Svensson (2017) who viewed the higher interest rates as weakening the economy before and during a crisis, with their only benefit in forestalling crises. This paper counters this view by demonstrating that the stronger economy before the crisis is only due to an illusion of prosperity.
that comes from nonproductive transactions. Gourio et al. (2018) also opposed LAW policies, believing that they could exacerbate business cycles. For different reasons Diercks (2015) also opposed LAW policies, favoring an optimal inflation rate of about 3.5%, believing that the rate not be too low so as to match the equity premium. My conjecture is that the equity premium exists because equities pay out when times are good, or when the payouts are needed least, which is the mirror image of the desirability of insurance contracts with negative expected value. Diercks’s arguments have some merit, but the policies proposed in this paper are distinct from LAW and they may reduce the equity premium.

The argument of this paper is that policies similar to LAW can be useful in preventing crises and stimulating long run productivity growth. As outlined in Sect. 6, this paper’s recommended policies are more finely targeted than a LAW policy of raising interest rates during expansions, which is too blunt. This complements the skeptical view of LAW policies in Gerdrup et al. (2017), who believed that they are only useful in preventing endogenous, not exogenous, crises. (Ajello et al., 2019) were skeptical of LAW policies believing that they resulted from uncertainty about the probability of a crash. Uncertainty cannot be completely eliminated, but the decision rules in Sect. 6 aid in predicting, preventing, and responding to crises.

This paper fills a gap in the literature starting with the established view that financial asset transactions do affect money velocity. From there I build a model to explain how nonproductive assets are detrimental to long run induce economic activity that is not linearly linked to the productive capacity of the economy and divert money away from productive activity and lead to financial instability. In so doing, this paper complements literature on the importance of cash flows, the real burdens of excessive debt, and the danger of asset bubbles by focusing on transactions, not prices, for nonproductive assets.

3 Theory

To begin, consider Fisher’s (1911) equation of exchange:

\[ MV = PY. \] (1)

In (1), \( M \) is the money supply, \( P \) is the price level, \( Y \) is level of output, and \( V \) is the velocity of money measured by the number of times a dollar changes hands for real economy transactions. This measure of velocity \( V \) is reported by central banks as nominal GDP divided by a measure of the money supply, but this excludes nonproductive transactions. Jacobson (2010) noted this omission and also pointed out that credit and financial assets are the basis for a large proportion of transactions. If these transactions, which are not part of GDP, were included in the velocity calculation, the true velocity, or rate at which a dollar changes hands for all transactions, would be considerably higher. Throughout this paper, \( V \) denotes velocity from (1).
3.1 The Role of Nonproductive Assets

V is an incomplete measure of velocity. To calculate a measure of velocity that includes all transactions including those for nonproductive assets, I introduce W as an analogy to V specifically for transactions for nonproductive assets. Because these transactions are not part of PY, let A denote the total nominal value of these transactions. I update (1) to be

\[ M(V + W) = PY + A \]  

I first calculate A by summing interest payments made by households, nonprofit organizations, corporations, and federal and state governments; residential investment; personal expenditure on financial services; and acquisitions of financial assets by households, nonprofit organizations, corporations and federal and state governments. Figure 1 shows A as a percent of GDP.

Outstanding debt increases A both directly through interest payments and indirectly when nonproductive assets are sold to obtain liquidity to pay debts.

To calculate total velocity V + W, I add A to nominal GDP and divide this sum by M1 money supply. After calculating V + W, I subtract V, which I obtain by

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2 Tables 1.10, 2.1, 3.2, and 3.3 from the Bureau of Economic Analysis.
3 Table 5.3.5 from the Bureau of Economic Analysis.
4 Table 2.3.5 from the Bureau of Economic Analysis.
5 Table Z.1 from the Federal Reserve Board of Governors.
6 FRED Series GDP.
7 FRED Series MANMM101USM189S.
dividing nominal GDP by M1 money supply. This produces \( W \), which is shown in Fig. 2 along with \( V \).

At this point it is important to justify the use of M1 as the chosen measure of money supply. MZM is historically a good predictor of inflation and includes all money immediately available for transactions. M1 excludes savings deposits and money market funds that are included in MZM. M2 includes M1 plus time deposits, but not money market funds. After the Second World War, MZM velocity rose until around 1980 as growth in output exceeded growth in money supply. Since then, there have been some fluctuations, but the clear trend has been a decrease. M1 velocity historically moved with MZM, but surged in the late 1990s, and then surged again in the early 2000s,

Fig. 2 Two measures of money velocity from eq. (2), \( V \) (money velocity for real economy transactions) and \( W \) (money velocity for nonproductive transactions)

Fig. 3 Difference between total nonproductive transactions \( A \) and the product of M1 and \( W \) (velocity for nonproductive transactions), expressed as a percent of \( PY + A \). This graph validates the assertion that \( A \approx MW \) from (2)
coinciding with asset bubbles. Insofar as asset bubbles reflect the use of alternatives to money and increases in wealth-driven consumption, this is expected. Money held in accounts other than savings or money market funds was used for asset transactions. M2 velocity has been the most stable of the three measures, but it too increased in the late 1990s and has since fallen below pre-1980 levels.

When expanding (1) to produce (2), the addition of MW to the left side and A to the right implies that \( A = MW \). Figure 3 shows the difference between A, calculated as described above, and MW, expressed as a percent of \( PY + A \). This series fluctuates around zero with no clear cyclical deviations, showing that \( A \approx MW \).

After updating Fisher’s basic equation \( MV = PY \) to \( M(V + W) = PY + A \), solving for \( V \) produces

\[
V = \frac{(PY + A)}{M} - W. \tag{3}
\]

The relationship between \( A \) and MW shown in Fig. 3 shows that \( MV = PY \) and \( MW = A \) are two distinct equations. Adding two equations together does not introduce any causality between the two addends, and there is no defined partial derivative of (3) with respect to \( W \). Empirically, \( V \) and \( W \) do exhibit similar trends, and both are affected by \( M \), but the link is not causal, and it is only a result of \( M \) affecting \( W \) in the same way it affects \( V \).

My first assumption is that exchanges of money due to nonproductive assets will, at least sometimes though certainly not always, be followed by an exchange of money for a product that is included in \( Y \). This happens when appreciated assets are sold and the proceeds are used for non-asset purchases, such as a cash-out refinance of a house or sale of stocks for consumption. In some cases, they may be used for purchases of productive assets.

**Assumption 1** Some of the exchanges of money due to nonproductive assets are followed by the individual receiving money then using the money for a transaction that is part of GDP.

The basis for this assumption is stems from the left side of (2), \( M(V + W) \), and the right side of (1), \( PY \). The expression \( M(V + W) \) reflects all transactions that are made, but \( PY \) reflects the tangible wealth of an economy at current year prices. This tangible wealth exists as goods and services that are produced and consumed, an idea popularized by Adam Smith in *The Wealth of Nations* ([1776] 1984).

When transactions for nonproductive assets take place, we have \( M(V + W) \neq PY \). Instead of adding nonproductive transactions \( A \) to the right side as in (2), it is possible to use a multiplicative constant \( R \). The result is an expression for \( R \) as transactions divided by real wealth.

\[
M(V + W) = PYR
\]

\[
M(V + W) \frac{1}{PY} = R, \tag{4}
\]
Because $M(V + W) = PY + A$, $R$ is equivalent to total transactions divided by nominal GDP transactions ($PY$). $R$ is thus a multiplicative factor that converts $PY$ into total transactions. Equation (4) is analogous to the ideal gas law from chemistry

$$\text{pressure} \times \text{volume} = \# \text{of molecules} \times R \times \text{temperature} \quad (5)$$

Although represented in chemistry textbooks as $PV = nRT$, I use words when writing this equation to prevent ambiguity with economic variables represented by letters, except for the letter $R$, for which its meaning in each equation is equivalent. In the ideal gas law, pressure is analogous to $V + W$ in (4), volume is analogous to $M$, the number of molecules is analogous to $Y$, $R$ is analogous to $R$, and temperature is analogous to $P$.

The analogy between the quantity of goods and services, $Y$ and the number of molecules in (5), is the most intuitive. Pressure, the analogue of real velocity $V$, is the force exerted by molecules. As a dollar changes hands more rapidly through transactions, it exerts more “force” by facilitating the production and exchange of more goods. Volume is the space taken up by the gas in (5); analogously, the money supply is the “space” of all potential transactions. A combination of output, prices, and velocity require a specific money supply in the same way that a number of molecules at a certain temperature and pressure occupy a certain volume of space. In (5), $R$ is the ideal gas constant, a proportionality factor that links kinetic energy to temperature. Kinetic energy, or energy due to motion, is intuitively analogous to transactions in the economy. In (4), $R$ is directly linked to $W$ links transactions to output (analogue of number of molecules) at its current price level (temperature analogue).

In (4), $R$ links the total amount of transactions, productive and nonproductive, to GDP to preserve the equality. Although it is a constant in (5), it is not a constant by this economic definition. As $R$ rises, money requires more “energy” to accomplish the economy’s productive transactions as more total transactions take place with a lesser increase in real output. Changes in $R$ result from changes in any of the other variables. Some of these changes may be directly related to the production of goods and services. This happens when $W$ is higher because of initial public offerings or a bond issue, but not when nonproductive assets are exchanged on the secondary market. Should these assets appreciate, secondary market transactions convert them into “ephemeral wealth” that is used for consumption or investment that is not linked to production of goods or services. There are far more asset transactions on the secondary market than on the primary market, and these are of greatest concern when I discuss the dangers of excessive nonproductive transactions Sects. 4 and 6. The size of the secondary market casts doubt on the usefulness of asset bubbles articulated by Martin and Ventura (2012), Asriyan et al. (2020), and Miao and Wang (2012). Although asset bubbles often accompany larger quantities of nonproductive transactions, there is no reason why this must be so. This paper’s focus is on the dangers of nonproductive transactions, and it shows that they may be problematic even without an asset bubble.
3.1.1 Nonproductive Assets and Investment

I hypothesize that the prevalence of nonproductive assets and debt burdens affect optimal levels of investment. Consider a standard Bellman equation for investment decisions.

\[ V(K_{it}) = \max_{I_{it}} \sum_{t=0}^{\infty} \frac{1}{(1+r)^t} [\pi(K_{it}) - I_{it}] \]  

subject to \( K_{i,t+1} = (1-\delta)K_{it} + I_{it} \). The maximizing value is based on the interest rate, the profits from capital, and the expenses on investment. Profits or losses on nonproductive assets are absent in (6), but they do affect a firm’s bottom line. Nonproductive assets or debt \( A_{i,t} \) add a cost because some of the proceeds must be used for payment (or interest) apart from the cost of investment. To reflect this, I replace \( I_{it} \) with a cost function for investment and nonproductive assets \( C(I_{it}, A_{it}) \). Firms discount future profits at rate \( r \), but profits must be calculated after subtracting all current expenses, including interest. When considering economic costs beyond accounting costs, a lack of liquidity may be a cost. Including nonproductive assets, the Bellman equation becomes

\[ V(K_{it}, A_{it}) = \max_{I_{it}} \sum_{t=0}^{\infty} \frac{1}{(1+r)^t} [\pi(K_{it}, A_{it}) - I_{it} - C(I_{it}, A_{it})] \]  

subject to \( K_{i,t+1} = (1-\delta)K_{it} + I_{it} \). This equation is an abstraction in the sense that it may not refer to an individual firm, but it refers to aggregated decisions about investment and nonproductive assets throughout the economy. It is elementary that if \( C_{it} \) is lower, then the optimizing \( I_{it} \) is higher. Purchasing nonproductive assets or investing both incur costs, so \( C \) is increasing in both. \( A_{it} \) may be positive or negative, depending on whether nonproductive assets yield net returns or liabilities cause net expenses. These assets can yield returns, requiring \( V \) and \( \pi \) to be functions of both \( K_{it} \) and \( A_{it} \). In (7), profits are a function of nonproductive assets as well as investment (productive assets). The harm from nonproductive assets is that they can lead to wealth that is not grounded in productive capacity. The functional form of \( C \) and expectations of future profits can increase or decrease investment apart from returns on \( K_{it} \) and the real interest (discount) rate \( r \). The equity premium demonstrates that the expected rate of return on nonproductive assets, especially equities, can differ substantially from the real interest rate \( r \).

Nonproductive transactions take away money that could be used for investment, thus harming long run growth. They positively affect profits if they appreciate, and these profits may be used to fund productive investment. This is far from certain, however, because investment decisions rely on expected profits which depend on price movements in nonproductive assets. For this reason, a low interest rate that diverts savings from bank accounts to the secondary market in equities may not stimulate productive investment.
3.2 Energy and Entropy

Economic aggregates show a clear link with the ideal gas law shown by (2) and (5). These macroeconomic relationships need a microfoundation to support a broader theory. In this section, I link microeconomic behavior to macroeconomic aggregates in the context of the ideal gas law to provide a microfoundation. This section is theoretical, but it has empirical support in 4. The ideas developed in this section and their explanations show the relevance of these ideas to known macroeconomic conditions from the past four decades.

3.2.1 Entropy

Entropy is a property of a thermodynamic system and it has a useful analogy in economics. It is often thought of as a state of disorder, but more formally it is the number of microstates that are consistent with a macrostate. A macrostate is a macroscopic configuration of a system. A macrostate is collection of simultaneous observations of things such as unemployment, inflation, money supply, GDP, and velocity at a specific time. A microstate is a specific arrangement of economic activity consistent with these macroeconomic aggregates. Many microstates can exist for a single macrostate, even though only one microstate exists at a given moment. For example, if the unemployment rate stays the same when one business closes a factory and another opens one, there are two microstates for one macrostate. This definition is analogous to the definition of entropy in chemistry and thermodynamics. This definition of economic entropy is descriptive, not normative. There is no reason why entropy should be good or bad; indeed, a greater number of microstates for a macrostate may imply a more dynamic, complex, or resilient economy. The second law of thermodynamics holds that the entropy of an isolated system increases with time, but does not decrease.

The formal definition of entropy $S$ is the natural logarithm of the number of microstates multiplied by $R$. In chemistry, it is nigh-impossible to calculate the number of microstates, and the task of counting the number of microstates in an economy is no simpler. To capture the general idea of macrostates and microstates, I take a simpler approach based on transactions and output, defining entropy as

$$ S = \frac{Y}{V + W} = \frac{M}{RP} . $$

The second row of (8) comes directly from (4). As an economy grows, entropy increases, just as entropy in a thermodynamic system must always increase with time absent some external stimuli. Increasing the money supply increases entropy insofar as $Y$ increases. Increases in $R$ (more nonproductive transactions) or $P$ (inflation)
mitigate this effect. Increases in the money supply that just result in excess bank reserves with price stability, which was seen in the years following the Great Recession, may not increase entropy if low interest rates encourage transactions for nonproductive assets. Because entropy $S$ depends on $Y$ (or $M$), the empirical analysis in Sect. 4 uses its percentage change, not its level.

### 3.2.2 Enthalpy and Gibbs Free Energy

This section describes an economy’s capacity, or potential for productive activity. In chemistry, the analogue for this concept is known as enthalpy and is denoted by the letter $H$. It is the sum of internal energy $U$ and the product of pressure and volume, or their analogues of velocity and money supply for real transactions. I define internal energy as $1/RP$, viewing nonproductive transactions and price increases as a diminution of the economy’s capacity. The chemistry definition of internal energy relates it to both entropy and volume, and this expression $1/RP$ is entropy divided by money supply, the analogue of volume in (5). Both of $R$ and $P$ decrease entropy, which decrease is only offset by increases in the money supply. To obtain enthalpy, I add $M(V + W)$ to internal energy. Enthalpy is thus internal energy plus the transactions that occur in the economy. It effectively represents what can be done at a given level of money supply, prices, and nonproductive transactions. Sharp increases in enthalpy that are not matched by corresponding increases in internal energy imply an economy that is too dependent on ephemeral wealth from nonproductive transactions which may be ripe for a downturn that begins in the financial sector. Enthalpy is a state variable that is affected by control variables, so I describe it in terms of changes, not levels, consistent with convention in chemistry, and shown below in (9).

$$\Delta H = \frac{1}{\Delta RP} + \Delta M(V + W)$$  \hspace{1cm} (9)

As long as $P$ and $R$ are increasing, internal energy will diminish. This can be overcome if money supply and transactions rise faster, implying growth in real GDP. Enthalpy represents the total “energy” in the economy, whereas internal energy represents energy independent of economic size, or the energy of the “state” of the economy. The concept of Gibbs free energy reflects the amount of internal energy that is available for use. The change in Gibbs free energy $G$ is the change in enthalpy $H$ less the change in entropy $S$, as shown below in (10).

$$\Delta G = \Delta H - \Delta S.$$  \hspace{1cm} (10)

Eq. (10) is descriptive and does not reflect causation. As good as entropy may be in an economic sense, more entropy means less unexploited economic potential as the economy becomes more dynamic and complex. For sustained growth in potential output or capacity, internal energy is needed along with a clear path to growth. Entropy is a one-way increasing arrow in time in chemistry and in $Y$ in economics. For growth, something must increase along with $Y$, and that is captured by Gibbs
free energy. Gibbs free energy increases when this internal energy increases faster than entropy.

It is essential to keep two things in mind which are specific to this paper. First, economic potential refers to realistic near-term capabilities, which are limited by supplies of capital and labor, financing terms, and expected profits, which depend on current and expected macroeconomic conditions. It does not refer to “optimal” use of all resources. For this reason, this measure of potential diminishes during a recession. Second, efficiency refers to using resources for productive activity as opposed to nonproductive assets; it does not refer to multifactor productivity or any similar measure.

### Table 1 Model Variables

| Variable | Description | Source/Calculation |
|----------|-------------|--------------------|
| A        | Nominal dollar value of nonproductive transactions | Sum of items listed in Sect. 3.1 |
| M        | Nominal M1 Money Supply | Federal Reserve Board of Governors |
| P        | Price Level | Percent change in CPI, from Bureau of Labor Statistics |
| Y        | Real GDP | Bureau of Economic Analysis |
| V        | M1 velocity for real transactions | \( PY \) |
| W        | M1 velocity for nonproductive transactions | \( A \) |
| R        | Multiplicative factor linking \( PY \) to \( A \) | \( M(V + W) = PYR \) – See Eq. (2) and (4) |
| S        | Entropy | \( Y/(V + W) \), or \( M/IRP \) (equivalent) |
| U        | Change in internal energy | \( 1/\Delta P \) |
| \( \Delta H \) | Change enthalpy | \( 1/\Delta RP + \Delta M(V + W) \) |
| \( G \) | Change in Gibbs free energy | \( \Delta H - \Delta S \) |

4 Empirics

This section links the variables defined in the preceding section to known macroeconomic events. For ease in reading, it begins with table 1 which concisely describes all of these variables. Time series plots based on the specified calculations follow.

I begin by calculating \( V \) using Fisher’s original equation \( MV = PY \) using M1 as the measure of the money supply. From there, I augment the right side shown in (2) by calculating nonproductive transactions \( A \) as described in Sect. 3.1 which displays \( A \) as a percent of GDP in Fig. 1. Having obtained both \( PY \) and \( A \), I add them together and divide the sum by \( M \) to produce \( V + W \). \( W \) remains after subtracting \( V \), and both of these measures are shown above in Fig. 2. The face value of these transactions increased relative to GDP throughout the 1960s and 1970s, coinciding with increases in \( V \). They subsequently decreased by a small amount after a peak in the 1980s with a sharp drop during the Great Recession when they returned to 1970s levels.

The recession bars highlight noteworthy changes in both nonproductive payments (Fig. 1) as a percent of GDP and \( W \) (Fig. 2). Until the early 1980s
recession, there were no major changes in $W$ or in nonproductive transactions as a percent of GDP (see Fig. 1) during recessions. Since then, recessions have become increasingly financial in nature. Beginning with the early 1990s recession, both have decreased during recessions, and these changes have increased in magnitude, culminating in the global financial crisis and Great Recession. The trends and fluctuations in $W$ and these other variables are consistent with Carvalho et al. (2012), who noted that asset wealth was stable until the 1990s, when it began to grow dramatically.

Velocity of money for real transactions $V$ has moved with trends visibly similar to $W$. The fluctuations in $V$ are smoother than for $W$, but of larger magnitude. This is reasonable because asset prices are more volatile than prices for finished goods and services. Interestingly, the decrease in $W$ during the Great Recession was larger in percentage terms than the decrease in $V$. This marked the beginning of a long-term policy of near-zero interest rates and massive increases in M1, so it is not surprising that $V$ continued to decline. The corresponding decline in $W$ has been more tempered, reflecting the ongoing prevalence of storing and building wealth through nonproductive assets. Figures 1 and 2 show a paradigm shift in the nature of recessions that has come with increases in nonproductive assets. Until the early 1980s, recessions were real economy events that spilled over into the financial sector, with the exception of the Great Depression, which began in the financial sector. Since that time, they have been financial events that spill over into the real economy.

Much pain during recent recessions has come from wealth losses in the personal and corporate sectors. In the corporate sector, this leads to job losses and declining real GDP. These real economy problems are very real, but the accompanying stress in financial markets exacerbates them more than was once the case. This phenomenon did not originate with the Great Recession; recessions in 2001 and in the early 1990s were similar, but less severe. Monetary and fiscal policy have tamed business cycles, but to the extent that they affect asset markets, policies have replaced...
business cycle fluctuations with asset booms and busts. In other words, they have replaced one type of instability with another.

4.1 Entropy

I next present the changes in entropy in Fig. 4, calculated from (8). Recall that entropy is higher when the economy is larger, more dynamic, and exhibits greater complexity. Changes in entropy were of low magnitude during the 1960s and 1970s, except for some substantial decreases during recessions. During every recession beginning with the early 1980s recession, entropy has increased sharply, and this was especially so starting with the early 1990s recession. Much of this is likely due to the increasing use of monetary stimulus, which causes velocity to diminish. Although it may speed recovery, it may exacerbate the underlying causes of the recession by making them financially more feasible, thus setting the stage for another downturn. Real growth in the late 1980s coincided with decreases in entropy, but this gave way to increases during a period of depressed growth from the late 1980s to the early 1990s.

Entropy began to increase in the mid-1990s shortly after mortgage rates jumped in 1994 while the Federal Reserve attempted to avoid another bout of inflation. As economic growth slowed, due in part to looming federal budget cuts, the Fed cut interest rates in 1995 to avoid a recession. The entropy increases indicating a downturn were arrested, but the recession was only delayed, not avoided. A potential housing bubble flattened, but a stock bubble began inflating, and the entropy decreases leading up to the 2001 recession coincided with a boom in nonproductive transactions.

Saving rates declined during years that coincided with asset bubbles in the 1990s and 2000s as people focused on wealth in the form of equities and real estate, respectively.9 This reflects the danger of passive income from nonproductive assets when they lead to real economy transactions, which were the source of most of the increases in velocity at this time, as shown by Fig. 2. Just as recent recessions have begun in with nonproductive assets, so too have the preceding booms begun there.

Decreases in entropy as calculated from (8) during times of economic expansion are a warning sign of a crisis, though they may appear a few years before the crisis begins, making them exceptionally useful for macroeconomic policy. The Fed recognized a potential downturn in the early to mid-1990s and responded accordingly. Although this concept of entropy did not inform its decision, the timing was impeccable. Regrettably, the choice of policy instruments was not, and this is elaborated in Sect. 6.

In the years following the Great Recession, entropy has been increasing, but the rate of increase has diminished, despite rapid growth in the money supply. When viewed in light of these persistent and long-term easy money policies, the recovery

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9 See FRED Series PSAVERT (Personal saving rate) and W207RC1Q156SBEA (Net saving as a percent of gross national income).
from the Great Recession looks to be on a shaky foundation, although its natural end was forestalled by shutdowns during the COVID-19 pandemic.

5 Internal Energy and Enthalpy

Figure 5 shows changes in internal energy and enthalpy. The two are closely related, as shown by (9). Internal energy decreased at an increasing rate throughout the inflationary years of the 1970s before stabilizing. When there is stable, low inflation that is nonetheless positive, internal energy will decrease. Beginning with the early 1980s recession, internal energy has increased during recessions. Changes in enthalpy, which are changes in internal energy plus changes $M(V + W)$ have followed a different trajectory, and these represent internal energy alongside economic growth. Booms in the late 1980s, late 1990s, and late 2000s preceded downturns. Enthalpy increases surged ahead of internal energy by the mid-1990s when the Fed cut rates, and this happened again in the early 2000s. Both of these periods of increase may imply that a real economy recession was necessary (i.e., a business cycle fluctuation), but was averted by nonproductive transactions and the illusion of wealth they create. Enthalpy has always fallen during recessions, but its decreases have been especially severe during recessions in the early 1990s, early 2000s, and the Great Recession.

Gibbs free energy is not plotted because it follows a trajectory nearly identical to enthalpy. This is because it is the change in enthalpy less the change in entropy, but
entropy changes are of much lower magnitude. Any insights that could be gained from Gibbs free energy are best observed from comparing changes in entropy from Fig. 4 and changes in enthalpy from Fig. 5.

### 5.1 What Has Happened Since the 1980s?

The story of economic policy since the 1980s has been one of interventionism, but of a different sort than that which led to the Great Inflation of the 1970s. Following the early 1980s recession, inflation was under control for many years in the real economy, but nonproductive transactions increased sharply.

Monetary policy was expansionary from the late 1960s through the 1970s, a legacy of the postwar era’s acceptance of the Phillips curve. By the 1970s, both inflation and unemployment resulted as this curve shifted. Monetary expansion continued as the Federal Reserve attempted to contain unemployment resulting from the Nixon shock and oil crises. Interest rates rose somewhat to compensate for inflation, but funds still flowed out of banks as savers sought returns in excess of what banks were permitted to pay. Repeal of these and other regulations in 1980 gave the Federal Reserve greater control over the money supply by requiring all banks, not just the 40% that were members of the Federal Reserve System, to hold a required amount of reserves.  

Many regulatory changes at this time had the unintended consequence of encouraging risky lending and speculation, contributing to the savings and loan

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10 Inflation was under control until the COVID-19 recession and subsequent inflation, but the time period for this paper is deliberately truncated because there are many contemporaneous events and data that will not be finalized or well understood for several more quarters or years.

11 Depository Institutions Deregulation and Monetary Control Act of 1980, Public Law 96-221.
crisis of the late 1980s and early 1990s. Federal Reserve policy in the late 1970s and early 1980s under Chairman Paul Volcker ended high inflation, but did not stop the quest for higher returns outside of banks. Not taming this need was a tragic misstep as asset prices began to increase. Interest rates diminished in the 1980s and 1990s, with an increase in the early 1990s to avoid inflation. By the late 1990s, they fell to their lowest levels since the 1960s. Although inflation was low, asset bubbles began to emerge, encouraging more nonproductive transactions. The late 1980s, the late 1990s, and early 2000s were times of excessive asset-induced growth that set the stage for subsequent downturns.

Bernanke and Campbell (1988) and Kaufman (1986) noticed substantial increases in debt in the 1980s across many sectors, public and private, shown below in Fig. 6. These burdens sharply increased again in the early 2000s. The increase was tempered in the 1990s, but this is deceptive because there was a federal budget surplus and household asset wealth provided liquidity for consumption that otherwise would have been foregone or financed through debt. The high enthalpy values of the 1990s shown below in Fig. 4 reflect the fact that the underlying problem in the late 1980s and early 2000s was not abated during the 1990s, but that it just took a different form.

Kaufman noted with concern that financial deregulation encourages debt by increasing competition among lenders. Securitization exacerbated this by making debt marketable. Debt-to-asset ratios did not always increase due to equity appreciation, even as debt servicing increased as a percent of cash flow. This encouraged more asset purchases by individuals and firms, which drained money away from productive activity. Moreover, debt servicing is a cash flow burden that cannot be paid with nonmoney assets. Trading of financial derivatives increased dramatically during this time.

After the stock market crashed in 1987, the Federal Reserve propped up the financial system as a lender of last resort. It is easy to attribute the early 1990s recession to contractionary monetary policy, but at least some of its roots were in the financial sector. The Tax Reform Act of 1986 lowered top marginal tax rates, but it also eliminated many tax shelters, thus stopping an asset boom that included real estate. The savings and loan crisis was still in full swing during this time. A recession may have started with the 1987 stock market crash were it not for quick Federal Reserve intervention, which delayed it until the early 1990s. The seeds of these problems were sown years earlier by the failure to restrain nonproductive transactions and asset inflation.

After the early 1990s recession and a threatened downturn in 1994-95, a period of superficial prosperity followed. During the late 1990s expansion, the real economy experienced productivity gains that resulted in supply-side deflation of a cost-push sort, which can be beneficial unlike the demand-pull sort. Fears of deflation in the late 1990s did not materialize as inflation remained low but positive, despite some deflationary pressures (Delong & Sims, 1999). Deficient demand was not the cause of these pressures; consumer and business demand was high because of illusory asset wealth. Unlike the deflation of the 1930s, which followed asset price declines, asset prices continued increasing. Asset appreciation
did not change net obligations as measured by cash flows. The policy mistake was to persist with easy monetary policy that encouraged nonproductive transactions. Increases in low-cost imports from East Asia contributed to consumer price declines. Federal budget surpluses, made possible by real growth and higher tax rates, served to keep interest rates low without excessive monetary expansion. This unwittingly contributed to demand for assets other than savings deposits and personal and corporate saving declined. Inflation was held under control not by a lack of demand but by cheap imports that masked inflationary pressures. The prosperity of the 1990s, especially the latter part of that decade, was somewhat of an illusion due to nonproductive transactions that were occurring at an unsustainable rate, setting the stage for a deep financial recession. The Gramm-Leach-Bliley Act (Financial Services Modernization Act) repealed the Depression-era Glass-Steagall Act that separated investment and commercial banking, permitting more complex financial services to be marketed. None of this is to say that there wasn’t real growth in the 1990s; there certainly was, but it faded and was seamlessly replaced by an asset bubble that set the stage for the difficulties that would come a decade later.

In 2000, Alan Greenspan observed the potential for these problems. He recognized that wealth-induced demand could outpace growth in supply. The model in this paper agrees, and even traces the beginning of the problem to several years before 2000, but differs from Greenspan in its assessment of effects. Greenspan believed that this asset wealth would spur capital investment and cause supply to increase, something countered by this paper’s exposition of economic entropy. He also recognized the potential for imports to relieve some of this pressure, which does seem likely given the other conclusions in this paper. Greenspan’s critical mistake was in not recognizing the increasing use of money for nonproductive transactions.

The stock market bubble of the 1990s popped and gave way to a real estate bubble and major credit expansion. The global financial crisis came when these asset price increases became unsustainable and were matched with higher energy prices that burdened the real economy and depressed cash flows needed for nonproductive payments. In the long run, consumption can never outpace production, though it can happen temporarily. Excessive transactions for nonproductive assets combined with asset appreciation can lead to this phenomenon, which either must quickly subside or face an inevitable correction in the form of a recession caused by decreased demand, which may be forced by decreased asset wealth. The attempt to remedy this problem was grounded in the same practices that led to the crisis as expansionary interventionist monetary policy reduced interest rates nearly to zero and housing prices recovered in many places. The stock market again began to increase. A major fiscal intervention from the federal government financed by debt accompanied this easy monetary policy.

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12 “Remarks by Chairman Alan Greenspan” January 13, 2000. Economic Club of New York, https://www.federalreserve.gov/boarddocs/speeches/2000/200001132.htm, accessed November 9, 2020.
6 Policy Implications and Decision Rules

The Federal Reserve has the dual mandate of fighting both inflation and unemployment. This mandate ignores asset prices, nonproductive transactions, and real economic output, although all of these are affected by the same policy tools that fight inflation and unemployment. Although asset prices and asset transactions are outside the Federal Reserve’s mandate, they should still inform monetary policy because they do affect inflation and unemployment, something that has become increasingly apparent in every downturn since the 1980s. As part of fighting inflation and unemployment, central banks should target velocity for nonproductive asset transactions $W$, entropy, and Gibbs free energy. All of these need to be evaluated together. In this section, I propose policy tools and approaches to promote a stable, healthy, growing economy.

6.1 Decision Rules

The optimal amount of nonproductive transactions is the amount corresponding to stable decreases in entropy. Entropy decreases with GDP, but if transactions in the real economy and for nonproductive assets remain constant, entropy will be as stable as GDP. Because the numerator in the expression for entropy in (8) is $V + W$, it is affected by the money supply, GDP, and price level. Monetary policy should thus target both inflation and transactions for nonproductive assets. In practice, this will likely mean setting interest rates to affect investment decisions as well as the choice between saving money in banks or the stock market. As helpful as a near-zero rate is for businesses, it encourages the transactions for nonproductive assets that lead to financial instability and a recession that begins in the financial sector.

Gibbs free energy, or near term potential, should also be kept steady, and this means stability of both real velocity $V$, velocity for nonproductive transactions $W$, money supply, and price stability. As enthalpy or Gibbs free energy exceeds internal energy, a financial bubble is likely emerging that will eventually collapse into a recession. The expression for Gibbs free energy in (10) shows increases in the money supply may lead to increases in $W$ instead of $P$, in which case the result is the same. Entropy will rise with $W$, however, so it must be evaluated alongside Gibbs free energy. As is clear from these time series plots and the variables used in their calculations, there is no elegant and simple rule like the Taylor rule. Rather, these concepts derived from chemistry equations show relationships among variables and indicate that policies may be needed to change these variables to change these composite figures like entropy and Gibbs free energy.

Containing does not mean holding asset price increases to a specific level; what matters is to prevent an excessive amount of transactions for nonproductive assets. Reasonable price increases that reflect underlying value are acceptable, but speculation, rapid trading, debt service, and interest payments all drain money away from the productive economy independently of increases in asset prices. Preventing increases in $W$ means discouraging excessive transactions for nonproductive assets,
and this must be done alongside restraining the money supply, which artificially reduces velocity without deterring transactions.

6.2 Policy Tools

Monetary policy in the form of buying government debt, or even quantitative easing and tightening, is too blunt of an instrument for manipulating. W. Galí (2014) showed that rational asset bubbles can exist in an economy using a model that also showed that leaning against the wind can exacerbate bubble fluctuations. I recommend using interest rates to stabilize fluctuations in entropy and Gibbs free energy, but concur that the leaning against the wind is not optimal as a sole tactic. Leaning against the wind should only be used in conjunction with other policy tools, many of which are under the purview of government as opposed to central banks.

Insofar as the goal is to discourage excessive transactions, but not prevent asset appreciation that reflects underlying value, policy tools should target these transactions without discouraging demand for long-term demand for securities holdings. The first policy I recommend is to index capital gains tax to the length of time the investment has been held. Capital gains from assets traded rapidly and held for only a short time should be taxed at very high rates which would gradually decrease as the asset is held for a longer time. The tax penalty would only apply if an asset is sold quickly after purchasing it, which removes the incentive to seek liquidity for consumption from asset price fluctuations that may not be linked to an economy’s overall productive capacity. It will discourage rapid trading. For a paper that is largely about promoting stability in the real economy and financial sector, this policy proposal may seem to lack relevance. I propose this policy to deter transactions that are not related to long-term holdings, and thus prevent growth in W. For this reason, this policy is superior to leaning against the wind as it can prevent rapid falls in entropy. These effects assume that the constant the money supply, real economy velocity V, and the rate of inflation are all held constant. This policy may have averted the run up in enthalpy that accompanied the late 1990’s stock bubble and led to a recession.

The second policy tool I propose is to make bank reserve requirements dependent on balance sheet characteristics. The purpose of this is to deter expansion of the money supply for real economy transactions when that money is linked to asset wealth. Reserve requirements should be higher for institutions that are involved in lending for nonproductive assets (residential mortgages, consumer debt). As with the first policy, the goal is similar to that of leaning against the wind, but the targeting is more fine to prevent the specific activities that lead to crises while not deterring productive activity; simply raising interest rates does not make this distinction. Lending for business investment should cause banks to face lower reserve requirements. To discourage securitization and risky lending, reserve requirements should treat loans that were recently sold as still outstanding and exclude sale proceeds.
from reserve totals. This will prevent reasonable loans for business investment from feeding speculation on the secondary market.

The objective of this policy proposal is to convert demand for nonproductive assets into a tool for long term financial planning. By doing so, it reduces the ability of nonproductive assets to facilitate transactions that are not clearly linked production in the real economy. This policy proposal is currently a theoretical construct for the future because the reserve requirement in the United States, historically 10%, has been annulled even as reserves have climbed to historic highs. This requirement will only become relevant when the money supply diminishes and the Federal Reserve’s balance sheet shrinks.

This policy proposal is distinct from lending standards which were tightened after the Great Recession and the reforms mandated by the Dodd-Frank Wall Street Reform and Consumer Protection Act. These reforms were designed to prevent risky loans from being made and to prevent banks themselves from engaging in risky trading on their own accounts using depositors’ money, but did not address nonproductive transactions in general. At issue in this paper is avoiding instability that comes from excessive nonproductive transactions. As more lending happens for these transactions, even with creditworthy borrowers, we see A and W rise. The result is the behavior that eventually causes crises and instability. This instability arises not from credit defaults, but because of a disconnect between spending and production that is facilitated by nonproductive assets.

My third recommendation is that the central bank’s balance sheet be limited to a specific percentage of GDP. This will prevent quantitative easing and easy monetary policy more generally from inflating asset bubbles. I propose allowing the central bank to buy assets from commercial banks to increase the money supply and target A and W more finely. Supporting this proposition, Cúrdia and Woodford (2011) wrote that targeted asset purchases can be more effective than pure quantitative easing, though not for the same reasons articulated in this paper.

The dangers of a large central bank balance sheet are a known issue. Del Negro and Sims (2015) believe that a central bank may need fiscal support to control inflation when its balance sheet is large. This issue may be of even greater importance when considering prices of nonproductive assets, not just real economy prices. Monetary expansion can stimulate this inflation, the mechanism of monetary expansion is most frequently to expand the central bank’s balance sheet. Arce et al. (2020) find that a smaller central bank balance sheet with well-timed interventions is not inferior in terms of welfare effects compared to a persistently large balance sheet. A hard limit on a central bank’s balance sheet may threaten its ability to respond to crises, but this may be offset by a lower likelihood of a financial crisis. Keeping a large central bank balance sheet and paying interest on excess reserves is harmful because it encourages nonproductive transactions as people look for returns in excess of what banks pay. When sovereign debt is monetized, this problem naturally results, showing the dangers of excessive debt even when interest rates are low enough to prevent default.

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13 Public Law 111-203 or 124 Stat. 1376-2223.
7 Conclusion

During the Great Moderation, it was thought that major macroeconomic fluctuations could be avoided or at least controlled. This view was abruptly shown to be incorrect as the global financial crisis precipitated the Great Recession. It is easy to blame the real estate bubble for proximately causing the Great Recession, but it is overly superficial to attribute the Great Recession to one bubble. The seeds of this downturn were sown in the 1980s, sprouted and grew through the 1990s, and finally blossomed during the housing bubble.

The problem was excessive nonproductive transactions involving unbacked financial assets that became a drag on real productive growth. This paper explains a theory for this that links nonproductive transactions to asset bubbles and consumption patterns that are disconnected from productive activity. Nonproductive transactions include debt service payments, acquisition of financial or other nonproductive assets, and expenditures on financial services. When nonproductive transactions become prevalent to the point that income is sought from nonproductive assets themselves, they supplant productive growth in the real economy.

Several chemistry equations have stunning relevance in economics; I link the ideal gas law with Fisher’s equation of exchange, augmented with a term for the portion of money velocity induced by nonproductive transactions which are not a part of GDP in many cases. From this equation, I develop a theory of nonproductive asset transactions which, when excessive, are a drag on productivity and lead to financial crises and recessions.

During the Great Inflation of the 1970s, nonproductive transactions became increasingly prevalent in the economy. After the early 1980s recession, inflation remained low despite fairly expansionary monetary policy, and nonproductive transactions increased. During the 1990s asset bubbles began to form as nonproductive transactions increased. Wealth-driven consumption did not lead to inflation because of inexpensive imports. The current account balance can potentially mask or delay economic malaise from nonproductive transactions. The stock bubble of the 1990s gave way to a real estate bubble which ended in the Great Recession.

This paper offers several strategies for maintaining stability beyond the Federal Reserve’s current dual mandate of fighting inflation and unemployment. In addition to fighting inflation in the real economy, the amount of money velocity induced by nonproductive transactions must be controlled. I outline potential policy tools that can be employed to deter excessive nonproductive transactions and deter asset bubbles. These are designed to depress demand for such transactions and also to reorient the supply of funds from nonproductive assets toward productive assets and thereby link nonproductive transactions (debt servicing) to real productive activity. The current strategy of easy monetary policy will only set the stage for ongoing problems like those experienced during and since the Great Recession. By reorienting stabilization policies to account for nonproductive transactions, central banks can prevent future financial crises and recessions.

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