**Connecting the Supply and Demand Sides of the Economy:
Productivity, Asset Valuation, and Tobin's 'q'**

by

Carol A. Corrado and Charles R. Hulten*

November 3, 2010

<u>Preliminary draft</u>
(not for quotation without authors' permission)

* The Conference Board and University of Maryland/NBER, respectively. Paper prepared the NBER/CRIW conference, "Financial Intermediation, Wealth, and the Real Economy," to be held at the Federal Reserve Board of Governors, Washington, D.C., November 12-13, 2010. Support under NSF's SciSIP grant #0830260 is gratefully acknowledged.

Connecting the Supply and Demand Sides of the Economy:
Productivity, Asset Valuation, and Tobin's 'q'

by

Carol A. Corrado and Charles R. Hulten

1. Introduction

The collapse of the housing-price bubble starting in mid 2006 has had far reaching consequences. One was the reduction in housing wealth of $5.5 trillion between 2006 and the present. Another was the collapse of the sub-prime and Alt-A mortgage market, which, though only a small segment of the overall market for debt, propagated throughout the financial sector, propelled by the financial instruments connected to mortgages. The opaqueness of these instruments created a crisis of confidence—counter-party risk—which, when combined with an unprecedented degree of leverage and a propensity for short-term finance, led to the collapse of many of the most prominent financial institutions in the country.

The crisis of confidence spread to rest of the economy as credit markets dried up, threatening firms and consumer with insolvency. In the language of the time, the crisis spread from "Wall Street to Main Street." While this phrase was coined as part of the effort to generate support of a financial bailout for Wall Street, it captured a key aspect of the crisis: the overall bill paid by households as a result of the crisis was, and continues to be, enormous. From the fourth quarter of 2007 to the first quarter of 2009, household net worth fell from $64 trillion to $48 trillion. Over the same period, eight million jobs were lost and the unemployment rate rose from 4.8 to 8.2 percent. Consumer net worth has recovered somewhat, to $53.5 trillion, but unemployment remains stubbornly high at 9.6 percent (2010Q3).

These numbers are so large by historical standards that they invite the question: why wasn't the approaching crisis more apparent in the formal macroeconomic models and data that inform economic policy? This question is the starting point for the analysis in this paper. We focus on the way sectoral linkages are treated in standard economic theory and national income accounting practice. This leads us to focus on Knight's circular flow model (CFM), which links consumers in the household sector to producers in the business sector via the flow of products through product and factor markets. In this paradigm, the financial sector is treated as one on many industries that draw on scarce resources and deliver goods and services.

We propose an alternative treatment of the CFM that recognizes the special role that financial intermediation plays in a market economy. The financial sector enables product and consumption by the proverbial "lubricating the wheels of commerce." This is an overhead function that links saving to investment, manages risk, and coordinates the flow of payments, but it is not a direct production activity on a par with auto and steel production. We argue that it is precisely this enabling function that allowed the crisis to propagate so rapidly and extensively.

The centrality of financial intermediation in this expanded circular flow model allows for different valuations of the same underlying capital asset, depending on where the agent is located in the intermediation process. Asymmetrical information may result in the producers who use the income-generating capital assets placing a different value on the future income stream than the owners that hold the financial claim to the stream (the "mark-to-market" problem that gained notoriety during the crisis). The relationship between business/producer and owner/financier valuations—Tobin's 'q'—is one-to-one in a theoretically perfect-information world, and the deviation of the ‘q’-ratio from one a signal of disequilibrium and adjustment.[1] One objective of this paper is to measure changes in the value of average ‘q’ over the period of the financial crisis.[2]

We also examine technology shocks over the same period. The IT revolution brought many new processes into the financial sector, from computerized trading to quantitative modeling, and product Innovations like CDSs, CDOs, and ARMs. These innovations increased the efficiency and reduced the cost of market transaction, and offered new ways to manage risk. At the same time, they introduced a greater complexity and opaqueness that made monitoring more difficult and increased the potential for asymmetrical information problems. What, on balance, was the effect on measured sectoral productivity? To address this question, we use standard growth accounting techniques to estimate multifactor productivity in financial and non-financial sectors, with a special break-out of the housing sector (the point of origin of the financial shock). We then compare these results with relative trends in the average rate of return to capital in each sector.

Finally, as a thought experiment, we introduce a variant of multifactor productivity that incorporates the Tobin ‘q’. This alternative measures the effective quantity of capital from the standpoint point of the financial market’s assessment of its value. The alternative measure of multifactor productivity equals the conventional measure less a contribution from the rate of change in ‘q’, and yields a higher rate of productivity growth during period of declining ‘q’ (and vice versa).

---

[1] Strictly speaking, it is marginal ‘q’ that should equal one in the theoretically perfect-information world. Hayashi (1982) derived the theoretical relationship between average and marginal ‘q’ in a setting with adjustment costs.

[2] Tobin’s ‘q’ and its relationship to productivity and asset valuation has been the subject of many past studies. See, for example, Baily (1981) and Hall (2001).

2. The Linkages Between Main Street and Wall Street

Knight's circular flow model of an economy distinguishes two essential economic functions: consumption and production. Consumption takes place in the household sector, and, in a closed economy, households are the recipients of the flow of goods and services; they are also the source of the labor and capital used in the production sector. The production takes place in the business sector, which is divided into industries that deliver intermediate goods to each other, and final demand outside the sector. This sector uses the labor and capital provided by the household sector.

A simplified version of the CFM is shown in Figure 1. Resources flow into the factor markets from household sector, where they are priced, and sent on to producers. There, the resources are transformed into outputs via each industry's production function. The outputs are priced in the product markets and sent on to consumers, whose demand is determined by their utility function and incomes that in turn reflect intertemporal utility-maximizing supply decisions. The flow outputs though product markets creates a dollar value equal to gross domestic product (GDP), and the value of the flow of inputs through factor markets equals gross domestic income (GDI). These flows are linked via the standard national income accounting identity, where output is the value of deliveries to final demand denoted as consumption and investment for simplicity, and income is split between labor and capital:

$$GDP_t = P_t^C C_t + P_t^I I_t = P_t^L L_t + P_t^K K_t = GDI_t. \quad (1)$$

In the U.S. economy in 2009, the value of GDP was \$14.1 trillion.

The counter-clockwise flows shown in Figure 1 and equation (1) are denominated in current prices. The clockwise flows refer to the quantity flows of inputs and outputs between consumers and producers. These flows, when aggregated as chained quantity indexes and expressed in the dollars of a given year do not balance as in the GDP/GDI identity above, except in the base year of the indexes. The reason is that productivity change between years zero and one will result in more output per unit input. The real quantity of inputs must be adjusted by a productivity shifter, A_t, to complete the circular flow. The shifter is a ratio of an output index to an input index and is a form of multifactor productivity measured by the Solow residual. In other words, multifactor productivity is implicit in the circular flow diagram.

In this framework, the financial and nonfinancial sectors are included in the circular flows. Both produce for the final demand of consumers and the intermediate demand within the sector (the markets of intermediate goods are not shown in Figure 1, nor are the government and foreign flows, for simplicity). The standard accounting identity for each industry in the economy relates the value of its output, which is equal to industry deliveries to final demand $(P_{i,t}^{D} D_{i,t})$ and deliveries to intermediate demand in other industries $(\sum_{j \neq i} P_{i,t}^{M} M_{i,j,t})$, to the value added by labor and capital and intermediate inputs purchased from other industries $(\sum_{j \neq i} P_{j,t}^{M} M_{j,i,t})$:

(2) $$P_t^Q Q_t = P_{i,t}^{D} D_{i,t} + (\sum_{j \neq i} P_{i,t}^{M} M_{i,j,t}) = P_{i,t}^{L} L_{i,t} + P_{i,t}^{K} K_{i,t} + (\sum_{j \neq i} P_{j,t}^{M} M_{j,i,t}).$$

When the industry identities are summed across sectors of a closed economy, the value of intermediate inputs and outputs cancel out, leaving the GDP/GDI identity, equation (1). The larger point is that the financial service sectors are treated as but one of many industries that draw from a common pool of available resources.

2.1. Financial Intermediation in the Circular Flow Model

The treatment of capital stocks and flows in Figure 1 is a simple and convenient way of organizing the sources and uses of resources, but this simplicity comes at a cost because the unique role of financial intermediation is suppressed. It is a common-place observation that the evolution of the financial sector was a critical step in the development of today's complex market economies. Banks and other financial entities serve as intermediaries liberating savings from the investments opportunities available directly to those who were able to save, and channelling funds to more productive uses. Financial institutions also help manage risk, and provide liquidity and advice to both savers and investors. In this view, the financial sector is not primarily a producer of goods and services, but an overhead activity that lubricates the engine of production.

The expanded circular flow model of Figure 2 attempts to capture some of this complexity. A wealth account (balance sheet) is attached to each of the sectors in the diagram (the two circular areas adjacent to each box). The balance sheet associated with the production sector contains the net stock of productive capital as an asset, and, because of the role played by changing asset valuation during the financial crisis, it is useful to take a deeper look at the asset measurement and valuation process.

The stock of productive capital at any point in time is the sum of current and past investment goods, weighted by the productive efficiency of those investments:

(3) $$K_t = \Phi_0 I_{t-0} + \Phi_1 I_{t-1} + ... + \Phi_T I_{t-T} .$$

This is the perpetual inventory definition of capital. The weighting index, Φ_s , is the efficiency of an *s*-year old asset relative to a new asset, defined as the ratio of the marginal product of an *s*-year old asset to the marginal product of a new asset. Under geometric depreciation, $\Phi_s = (1-\delta)^s$, and the term $\Phi_s I_{t-s} = (1-\delta)^s I_{t-s}$ is the amount of investment put in place *s* years previously measured in units of productive efficiency. In this formulation, K_t is the total amount of effective capital denominated in units of new capital, that is, the equivalent amount of new capital needed to replace the capacity of the actual stock with its various layers of vintage capital.

The value of the whole capital stock is the value of each of the individual investments in equation (3). Each investment good in (3) has a price reflecting the expected present value of the annual gross returns over its remaining life $P^I_{t,s}$:

$$P^I_{i,s} = \sum_{\tau=0}^{\infty} \frac{(1-\delta)^{s+\tau} E(P^K_{t,s+\tau})}{(1+r_t)^{\tau+1}} \quad . \tag{4}$$

This formulation assumes geometric depreciation at the constant rate δ over an infinite life, T. The variable r_t is the rate of discount and $E(P^K_{t,s})$ is the annual gross expected return to capital (the user cost, or rental price), which, in equilibrium, is equal to the value of the marginal product of the corresponding capital. The total value of the capital stock is then

$$V^K_t = P^I_{t,0} I_{t-0} + P^I_{t,1} I_{t-1} + \ldots + P^I_{t,T} I_{t-T} + \ldots \quad . \tag{5}$$

Little is known about the actual vintage age structure of the stock, and vintage investment prices $P^I_{t,s}$ are not available for a full range of assets in time series form. Fortunately, the assumption of geometric depreciation comes to the rescue here. In this case, the capital stock in (3) can be expressed as a simple perpetual inventory equation, $K_t = I_t + (1-\delta)K_{t-1}$, and the vintage user costs can be expressed as a fraction of the user cost of a new asset, $P^I_{t,s} = (1-\delta)P^I_{t,0}$. Intuitively, the price of a vintage asset is equal to the price of the new asset applied to the shrunken amount the vintage asset (by implication, the value of the marginal of the vintage asset shrinks at a constant rate relative to a new piece of capital).

One important implication of this simplification is that the value of capital can be expressed in an empirically more useful form:

(6) $$V_t^K = P_{t,0}^I I_{t-0} + (1-\delta) P_{t,0}^I I_{t-0} + \ldots + (1-\delta)^T P_{t,T}^I I_{t-T} + \ldots = P_{t,0}^I K_t \quad .$$

In this case, the value of the stock at each point in time equals the price of a new investment good in year *t* times the total capital stock in efficiency units. This approach achieves considerable computational simplicity, but it comes at a cost. The value of the stock, $P_{t,0}^I K_t$, does not show a lot of variation over the business cycle because only data on new investment price and quantity are needed to update the value of the stock in each year (given a fixed δ). The quantity of investment typically falls during economic downturns—BEA real nonresidential fixed investment fell from \$1.6 trillion in 2007Q4 to \$1.3 trillion in 2009Q1, rebounding to \$1.4 trillion in 2010Q3—but the stock, $K_t = I_t + (1-\delta) K_{t-1}$, only changes at the margin.

The price deflator for new investment also shows little cyclical variation—the BEA non-residential investment deflator actually rose from 105.3 in 2007Q4 to 107.1 in 2009Q1, before falling to 103.7 in 2010Q3. The financial crisis is not evident in value of the capital stock, but this does not necessarily mean that the value did not fall. The price of older assets, $P^I_{t,s}$, those with a shorter remaining useful life, may have taken a larger hit than the new investment price.[3] Moreover, the assumption of a fixed rate of depreciation δ may not be appropriate for the period of the crisis, because of accelerated retirements and bankruptcies.

We note, finally, that, the user cost can be estimated by solving (4) for $P_{t,0}^K$ (Jorgenson 1963). Assuming perfect foresight and geometric depreciation, (4) can be inverted to give

[3] The present value formulation in (4) is based on remaining expected present value, which may fall during an unexpected sharp downturn. In the case of a new investment good, the left-hand side price represents a fully arbitraged equilibrium between the production cost of the asset and the expected present value of its future income flow. The latter does not change much with an elastic supply function, and the adjustment to a change in expectation is made on the quantity side. The supply of vintage assets is inelastic and price of vintage assets varies directly with revised expectations. Valuing the latter as a fraction of the former can therefore lead to an over-estimate of the value of the stock. This size of this bias will be apparent later in our discussion of residential housing.

(7) $$P_{t,0}^{K} \cong (r_t - \pi_t + \delta) P_{t,0}^{I} \ .$$

In this formulation, the term π_t is the rate of expected asset price change, paralleling the vintage investment good price, $P_{t,s}^{K} = (1-\delta)^{s} P_{t,0}^{K}$. We will revisit the user cost in the section on productivity measurement, where we discuss the Berndt-Fuss (1986) result.

The value of the capital stock, $P_t^I K_t$, is the core asset of the production sector, but this sector also holds financial assets and working capital on its balance sheets. This balance sheet is shown on the left-hand side of Figure 2. While businesses are the legal owner of these assets, the household sector owns the claims to the current and future income generated by those assets. These claims form the basis for the net worth of the household sector, shown on the balance sheet at the right-hand side of Figure 2. The income accruing to these claims flows from its origin in the business sector (mostly) through financial intermediaries to households, along the pathways determined by the structure of assets and liabilities.

Financial intermediaries also manage the flows of funds needed to finance the purchase of capital goods, connect saving and investment, and provide operating liquidity to business and consumers. They design and manage many of the financial instruments that constitute household net worth. The degree of complexity of this process has grown, and one implication has been that the market for the financial instruments is increasingly disconnected from the underlying income generating assets. This disconnect is an important issue for the analysis of the valuation and productivity of asset stocks, or Tobin's average 'q' ratio.

2.2 Extensions of the Circular Flow Model

The primary focus of Figure 2 is on the distinction between financial and non-financial business. This focus is helpful in laying out the logical structure of the economy, but it is incomplete, since the financial sector also draws on the resource base of the economy and generates value added. The capital income originating in the sector is part of the income flows accruing to households, and the financial instruments issued by the sectors are part of household new worth.

Household production also poses a classification problem. Landefeld and McCulla (2000) estimate that non-market production of consumption goods by households was a significant contributor to economic product, amounting to 43 percent of measured GDP in 1946, but falling to 24 percent in 1997. The circular flows models of Figures 1 and 2 show inputs and output flowing through markets, with prices determined by supply and demand, but the framework can also handle flows of non-market production in theory, by appealing to virtual markets and shadow prices. This point is well known (see Abraham and Mackie 2006), but one implication is that the production part of non-market household activity should be located on the left-hand side of the CFM, in the production sector, while the consumption part is assigned to the right-hand side.

This assignment applies both to owner-occupied housing and consumer durables, which constituted one-third of household assets at the end of 2009. Owner-occupiers are both tenants and landlords and there is an implicit flow of rents between the two sides of the circular flow framework. Owner-occupied houses are, strictly speaking, an asset of the producer of housing services and belong on the balances sheets and income statements of the producer, with corresponding entries on the balance sheets of households. A similar treatment applies to consumer durables.

The government sector presents a deeper theoretical problem. First, much of flow of financed by compulsory taxation, not market determined, and goods are also collective in nature (defense). Still, the resulting flows of products and resources can be fitted in to the CFM (e.g., using the Samuelson's public goods model). The deeper problem is how to treat the assets and liabilities of governments. Are public sector assets like roads, schools, and warships ultimately part of the net worth of individual consumers? Or, should these assets be treated as being held in common by the household sector, with the government a separate consumer within the household sector with its own utility function (as nonprofit institutions that serve households are now)?

The also foreign sector presents difficulties in linking the two sides of the economy. Since GDP is the value of goods produced within the geographic confines of a country, in an open economy the flow of inputs and output between countries introduces a disconnect between production activity and the living standard of domestic consumers. The wealth of domestic consumers need not equal the value of the capital stock even in a zero-rent world with perfect information and markets.

Finally, own-account production in the business sector generates assets that do not appear on company balance sheets or income statements, and are only now starting to appear in a limited way in the national accounts. Own-account production by business includes the investments in R&D, organizational development, worker training, and brand equity that have collectively come to be called intangibles. Extending the original methodology of Corrado, Hulten and Sichel (2005, 2009), Corrado and Hulten (2010) place business investment in intangibles well above investment in fixed capital in the U.S. nonfarm business sector in recent years and estimate that GDP would be $1.3 trillion larger in 2007 if the full range of intangibles in the study were counted as investment. One the balance sheet side, the stock of intangibles is estimated to be $5.7 trillion in 2007, $4.1 trillion higher than published estimates.

Education is the largest own-account production in the household sector. As with owner-occupied housing, the educational production function is located on the left-hand production side of the CFM.

3. Disequilibrium Effects in the Circular Flow Model

The model of Figure 2 is a useful framework for thinking about the general equilibrium, or disequilibrium, effects of the credit crisis. The price shock from the bursting of the housing bubble in 2006 was amplified by the interconnected nature of financial transactions. The force of the shock was further intensified by the higher degree of leverage allowed by regulators during the run-up to the crisis, which, in some cases, was financed by short-term borrowing. The disruptive effect of new technology was also an important factor. The proliferation of new derivative instruments meant that the claims against a given income-generating asset became more tenuously linked to the asset itself. This result was a loss of transparency that, with the other factors, let to a crisis of confidence and the freezing-up of the financial system.

One visible sign of this crisis was a disconnect between market value and underlying valuation based on long-run present value criteria. The mortgage market at the center of the financial crisis is an extreme example. Individual mortgages were pooled to form mortgage-backed securities, which were then packaged into tranches of CDOs, and CDOs of CDOs. The link back to the individual mortgages became ever more tenuous, to the point that it became hard to value the complex derivatives -- the genesis of the mark-to-market valuation crisis that threatened the solvency of a number of financial institutions. It has even proven hard to establish the legal ownership of some properties in foreclosure proceedings.

Corporate equities are a more transparent form of ownership, but even here there are layers of complexity, with mutual funds, exchange traded funds, hedge funds and a variety of pension instruments. In any case, the stock market is far more volatile than the underlying time series on measured $P_t^I K_t$ for the reasons noted above. The S&P 500 stock index was around 1500 at the end of 2007, and plunged to half that value by March 2009, before recovering to its current level of around 1200. Residential real estate prices began to soften earlier, peaking in 2006 and falling 30 percent by 2009 year-end based on data from the flow of funds.

The extent of the overall volatility can be measured by Tobin's average 'q' ratio. In the notation of Figure 2, this ratio is $q_t = W_t / P_t^I K_t$.[4] In the textbook case of perfect information, competition, zero intra-marginal rents, and no distortions, this ratio will have a value equal to one. This need not be the case in a world of imperfect information and principal-agent issues. The owners of the capital stock in the production sector may place a different value on the capital stock than agents who trade financial instruments based on claims against the income generated the stock. This is an empirical issue.

The measurement problems noted in section 2.2 affect the empirical value of average 'q'. A larger point is that the literature that has computed average 'q' has not approached the problem with a view of the circular flow of the total economy. Households as producers of services using productive assets are generally not part of the analysis, nor for that matter is financial business. That said, the basic logic of the standard approach is applicable to our task, and we proceed to measure average 'q' as the ratio of the value of ownership claims on private businesses to the reproduction cost of their productive assets.

The value of equity is the primary ownership claim on domestic private business. Many debt instruments cancel when the financial and nonfinancial sectors are aggregated, and what matters for aggregate 'q' is who holds the final financial claims, just as what matters for

[4] Just as a productivity ratio links the flows of real inputs and output in the circular flow model, the 'q' ratio is implicit in the flows associated with financial intermediation in Figure 2.

aggregate GDP is who obtains delivery of final production; recall equation (2). When financial accounts are aggregated for a closed economy with no government debt, and after intra-sectoral holdings are cancelled, the aggregate financial account consists of consumer equity and debt holdings. Apart from the valuation issues we are discussing, the assumption that consumers hold 100 percent of the value of claims on an economy's productive assets is depicted in figure 2 by the correspondence between K and W on the two sides of the capital market.

In the real world of widely-held financial business liabilities, an open economy, and financial activity by governments and nonprofit institutions, consumer net worth will not equal the value of claims against domestic productive assets. In arriving at our average 'q,' we therefore develop an alternative statistic for the numerator of 'q.' This statistic takes two major "real world" factors into account. The first is the business governance shifts and rapid growth in bond and non-equity securities (mainly asset/mortgage-backed securities, or ABS/MBS) issuance by financial business in the 2000s.[5] These developments, along with rapid growth in market capitalization of financial corporate business (see figure 3), suggest that liabilities issued by financial institutions loom larger in financial statistics than they did as recently as 10 years ago.

When we use the flow of funds data to account for bonds and structured financial products held by foreigners and households, they imply holdings of nearly \$6 billion in 2007 – about on par with intangibles. Prior to the late 1990s, holdings of these products by foreigners and households were very small (unlike intangibles) and suggest calculations of 'q' that ignore them may be representative through about 2000 but not thereafter. Before we leave this subject, we must point out that the flow of funds data are not at market value for corporate bonds and

[5] We use ABS/MBS to refer to issues of securities and mortgage pool securities by private ABS issuers as well as by government-sponsored enterprises such as Fannie Mae and Freddie Mac. Note that along with the Federal Reserve System, government-sponsored enterprises are part of the financial business sector in official statistics.

ABS/MBS. Although we make an adjustment for corporate bond valuations in our calculations, the lack of official data on market values for bonds and certain structured finance products is a serious omission.

The second factor we consider in developing our numerator for ‘q’ is the trend in foreign-held claims against U.S. businesses. The available data on equity and debt holdings, foreign direct investment in the United States, and U.S. direct investment abroad suggest U.S. consumers (understood broadly to include nonprofit institutions serving households) currently hold about 90 percent of the claims against the domestic productive assets of the United States (figure 4)—and foreigners the remainder.[6] The penetration of foreign-held claims against U.S. business emerged more than 25 years ago, and figure 4 shows that most of the action in this adjustment occurs well before the onset of the financial crisis of 2008. The adjustment is nonetheless crucial to obtain an appropriate numerator for ‘q.’

Our final numerator for ‘q’ includes an estimate of household net equity in their “business” of producing services from owner-occupied housing and consumer durables in addition to the value of claims on U.S. domestic business productive assets. The calculation parallels the standard procedures used for the estimation of equity for noncorporate business (equity = tangible assets + financial assets less financial liabilities). Accordingly, in addition to the obvious tangible assets and financial liabilities (residential real estate, home mortgages, etc.), a portion of deposits is allocated to this account. The fraction of housing services and durable goods spending in total consumption spending is used for this purpose.

With household business equity calculated as described our numerator of ‘q’ accounts for virtually all items on the household balance sheet. Therefore, our numerator for ‘q’ may be

[6] This figure includes nonprofit institutions, whose accounts are comingled with households in standard data. Estimates in the flow of funds for the 1987 to 2000 period suggest that nonprofit institutions hold about 5 percent of the claims against the capacity of U.S. domestic business capital assets.

thought of household net worth adjusted for net foreign claims and excluding deposits allocated to pure consumption. (The details of this calculation will be provided upon request.) The denominator for ‘q’ is the value of fixed assets and land that correspond to real capital input measures used to calculate multifactor productivity growth. Values of fixed assets are essentially identical to those in the flow of funds, which originate from BEA. Land estimates are developed from data issued by the BLS productivity program. Unlike the flow of funds land estimates, the BLS data cover farm and financial business.[7]

Our results for ‘q’ are shown in table 1 for total, enterprise, and nonfinancial business, and in figures 5a and 5b for enterprise and total, respectively. The ratios are representative of many earlier calculations (e.g., Hall 2001), in that the path of ‘q’ trends upward in the 1980s and rises sharply further in late 1990s. After falling in the tech bust of 2000/2001, the ratios then move back up from 2002 to 2006 before plunging in the housing and credit bust of 2008. The results for enterprise business versus total private business, which includes household business, have a similar profile, but the run up in the 1990s is less steep for the total measure. This broad measure, the measure consistent with the CFM, averages about one (.97 to be exact) for the period it has been calculated (1970 to 2009).

The pattern in these ‘q’ rates over the 2000s stem, at least in part, from a persistent difference between the market value of real estate and the measured price of reproducing the installed stock reflected in the productivity statistics. This occurs because the BLS land values largely reflect a fixed ratio between the value of structures and the value of land.[8] The Federal

[7] The more comprehensive BLS data were also used to adjust noncorporate equity to include noncorporate farm land in the calculation of ‘q.’ The ratio of noncorporate farm structures to total farm structures from BEA Fixed Assets accounts (table 4.1) was used for this purpose.

[8] This statement is based on a communication from Steven Rosenthal of the BLS and refers to nonfarm business land. Farm business land values are based on estimates from the USDA, which we understand to incorporate market valuations. The estimates used for owner-occupied residential land are those

Reserve's estimates for real estate, however, reflect a concerted effort to estimate the market valuations for housing and, to a lesser extent, commercial property.[9] When the flow-of-funds implied land values for residential and nonfarm, nonfinancial commercial real estate are swapped for the BLS values in the denominator of 'q,' the result is a 'q' in which structures and land are, in effect, "marked to market" to the best of our ability.

The 'q' with "marked to market" real estate is shown by the dashed lines in the figures and on lines 4, 5, and 6 of the table. These estimates paint a somewhat different picture of 'q' than the baseline calculations, in that the 'q'-ratio for the broad business aggregate rises more slowly in the 1980s and ratios for all aggregates fall off rather than rise (or show no change) between 2001 and 2007. Not surprisingly, these results align more closely with results for recent values of 'q' calculated using data for nonfinancial corporations only and land values are ignored (e.g., Hodge and Corea 2010).

Line 7 of the table reports a 'q'-ratio adjusted to include intangible assets not already capitalized in the official data on productive assets. Although intangibles are estimated to loom large in aggregate investment flows and in financial statements of R&D-intensive companies (Hulten and Hao 2008), the aggregate intangible asset stocks—as currently measured using techniques developed by Corrado, Hulten and Sichel (2009)—are not large enough to materially change the pattern and growth in the 'q' ratios we calculate.

---

developed for the BLS/BEA cooperative total economy production accounts (Harper *et al*. 2009) and are strictly fixed ratios to structures as well.

[9] This suggests it would be natural to consider harmonization of the more comprehensive BLS estimates with the more market-based estimates in the flow funds. Although identifying the price elements for land versus structures for use in productivity analysis still presents a challenge, a certain degree of progress has been made on that front as well (Nichols, Oliner, and Mulhall 2010).

4. Technical Change in the Circular Flow Model.

The disruptive effect of technical change in the financial sector is widely regarded as one of the fundamental causes of the financial crisis in that novel instruments and transactions led to the leverage and illiquidity that was nearly the undoing of the financial system (Adrian and Shin 2009, and forthcoming; Brunnermeier 2009; Diamond and Rajan 2009).

The IT revolution has had an enormous impact in the financial sector, with credit card and ATM use now widespread, along with the advent of computerized trading, quantitative modeling and profusion of new products (credit default swaps, collateralized debt obligations, adjustable rate mortgages, and structured investments). In theory, these innovations promised positive results through superior risk and wealth management, access to liquidity, and efficient portfolio allocation. In principle, the overall macroeconomic result should have been more output per unit of input and in intertemporal equilibrium, more capital per capita. Recent events suggest that this promise was not fully realized, to put it mildly, but new technologies are often disruptive and the long-run consequences may ultimately prove to be positive as studies quantifying the impact of computerization on financial services suggest (e.g., Bresnahan 1986).

The theoretical link between technical change on Wall Street and Main Street can be illustrated by a variant of the model developed in Domar (1961) in which the “real” and financial industries are given their own production functions. For finance, the function takes the form $Z_t = A_{Z,t} F^Z(L_{Z,t}, K_{Z,t})$ where Z_t is the industry’s output, $A_{Z,t}$ is the Hicksian index of productive efficiency, and $L_{Z,t}$ and $K_{Z,t}$ are the labor and capital inputs used in the production of output; the other industry makes a final demand good or service, D_t, using labor, capital, and the output of the financial sector, $D_t = A_{D,t} F^D(L_{D,t}, K_{D,t}, Z_t)$, or

(8) $$D_t = A_{D,t} F^D(L_{D,t}, K_{D,t}, A_{Z,t} F^Z(L_{Z,t}, K_{Z,t})) \quad .$$

In this formulation, technology affects the level and growth in final demand directly through the efficiency term $A_{D,t}$ and indirectly through the term $A_{Z,t}$. A negative technology shock in Wall Street will be transmitted to Main Street in this model.

The empirical application of this class of models requires a somewhat more elaborated structure, since the financial sector makes also deliveries to final demand and it uses intermediate inputs produced in the nonfinancial sector and abroad. A generalization of the Domar model is developed in Hulten (1978). Each sector is assumed to have its own gross-output Hicks-neutral production function

(9) $$Q_{i,t} = A_{i,t} F^i(L_{i,t}, K_{i,t}, M_{1,i,t}, \ldots, M_{N,i,t}), \quad i = 1, \ldots, N.$$

The $Q_{i,t}$ here included both intermediate and final deliveries to demand. The industry version of the Solow multifactor productivity residual is then

(10) $$R_{i,t} = \frac{\dot{Q}_{i,t}}{Q_{i,t}} - s^K_{i,t} \frac{\dot{K}_{i,t}}{K_{i,t}} - s^L_{i,t} \frac{\dot{L}_{i,t}}{L_{i,t}} - \sum_j s^M_{j,i,t} \frac{\dot{M}_{j,i,t}}{M_{j,i,t}} = \frac{\dot{A}_{i,t}}{A_{i,t}} \quad ,$$

The share-weights used in (10) are ratio of the value of the relevant input to the value of industry gross output (not value added). The second equality in (10) indicates that the residual $R_{i,t}$ equals the growth rate of the Hicksian efficiency term, under the conditions of constant returns to scale and competitive pricing. The $A_{i,t}$ in this formulation assumes *costless* advances in technology that improve productivity (the costly part of innovation is part of properly measured capital stock and output as in Corrado, Hulten, and Sichel (2009). Moreover, because $R_{i,t}$ is a residual, it sweeps in factors like measurement and specification error, and omitted variables.[10]

Each industry can be analyzed separately using (10), but because the focus is on linkages between sectors, the technological possibilities implicit in the production functions in (10) can be aggregated into a production possibility frontier, defined implicitly as

$$\Psi(D_{1,t},\ldots,D_{N,t};K_t,L_t;A_{1,t},\ldots,A_{N,t})=0 \tag{11}$$

The PPF is defined the maximum feasible combinations of final goods attainable from given resources, K_t, L_t, and the technology of each sector. Intermediate product flows are subsumed in the formulation of the frontier, as are the sector allocations of labor and capital. For given prices, the maximum level of GDP is defined by a tangent line to the PPF.

Technical change in any sector shifts the PPF and triggers a shift in the composition of output and a reallocation of inputs. A positive shock to technology increases real GDP, while a negative shock has the opposite effect. This is one way to think about the role technical change in the financial sector played in the recent financial crisis. This approach leads naturally to the empirical question of the magnitude of the technology shocks in each sector and their aggregate effect on GDP. This can be done within the confines of conventional growth accounting by calculating the Solow residuals for Main Street and Wall Street using equation (10). The aggregate effects of the shocks can then be estimated using the generalized Domar model developed by Hulten (1978), in which an aggregate index of multi-factor productivity is derived

[10] This model interprets a technology shock as a shift in the sectoral production function in that more output can be produced with the same inputs. However, much of the financial crisis is about the arrival of new products, like CDOs and CDSs, and for this kind of innovation to show up as a shift in the production function requires that estimates of output be adjusted for changes in "quality." In the case of new financial products, measured output does not contain an explicit adjustment, but may indirectly capture the effects of new products a the portion of the financial sector when output is measured using the FISIM approach (e.g., as in Inklaar and Wang 2010).

from the shift in the PPF. The rate of change of this index, R_t^{PPF}, shows that the shift in the PPF is equal to

$$R_t^{PPF} = \sum_{i=1}^{N} \frac{P_{i,t} Q_{i,t}}{\sum_i P_{i,t} D_{i,t}} \frac{\dot{A}_{i,t}}{A_{i,t}}. \tag{12}$$

The terms involving $A_{i,t}$ are the Solow residuals from equation (10). The weights for each residual are the ratio of sector output, gross of intermediate goods, to total deliveries to final demand (GDP in a closed economy). The weights are those proposed by Domar, and they sum to a quantity greater than one to reflect, among other factors, the transmission of technology in one sector to other parts of the economy via intermediate goods.

One well-known problem is that measured MFP tends to be procyclical. This arises in large part because MFP is measured as a residual and capital is measured in a way that may not capture changes in the quantity over the cycle (discussed in previous sections). As a result, a cyclical change in the utilization of the stock, or accelerated retirements, will be suppressed into the residual. However, this effect is attenuated by the Berndt-Fuss (1986) result that the share-weight for capital embodies an adjustment for variations in capital utilization even if the measured stocks do not. In their framework, capital is viewed as a quasi-fixed input, and the degree of utilization is determined by the amount of variable input applied to the stock. As more or less variable labor and materials are applied to the stock, its marginal product rises or falls. They showed that the if user cost in (7) is calculated using an endogenous *ex post* rather than exogenous *ex ante* rate of return, the *ex post* user cost will correct for the more or less intensive use of capital.[11] The basic problem with this correction is empirical. After the adjustment is

[11] Following Jorgenson and Griliches (1967), the *ex post* rate of return is calculated by finding the r_t that forces the GDP/GDI identity to hold (see review by Hulten 2010 for further details). In the Berndt-Fuss

made, as is done in this paper, a procyclical component is still observed in annual estimates of MFP.

When analyzing productivity between peaks of a business cycle using estimates derived using *ex post* rates of return, the conventional approach generally does not consider whether the peak of one business cycle corresponds to another in terms of capital utilization.

4.1 Wall Street/Main Street Linkage in Input-Output Data

Our sources-of-growth analysis proceeds from viewing the economy as comprised of five domestic activity sectors—household business, nonprofit institutions, governments, financial business, and nonfinancial business—and a special purpose dataset of outputs and inputs is constructed at this level of aggregation. Using equations (10) and (12) for a sources-of-growth analysis requires industry-by-industry input-output (I-O) relationships that must be created, and we look first at the financial/nonfinancial linkages implied by these relationships.

As in the sectoral productivity work of Corrado *et al.* (2007) that fully implemented the Domar-Hulten framework, the estimation of sector output requires *domestic* industry-by-industry I-O relationships at the level of aggregation of the analysis (in this case, the five sectors just mentioned). Special purpose tables that treat imports as a separate industry and generate intermediate uses broken into domestic and imported industry sources of supply can be developed from BEA's benchmark I-O make and use tables, in conjunction with an I-O import matrix.

The industry-by-industry domestic direct requirements table for the five activity sectors based on BEA's tables for 2002 is shown in table 2. It is a depiction of their inter-sectoral

---

framework, an increase (decrease) in capital utilization causes r_t to rise (fall) as more (less) variable inputs are applied to the capital stock, which is fixed in the short run. This is essentially an adjustment cost story. Hayashi (1982) shows how adjustment costs and Tobin's marginal 'q' can, in theory, be introduced into the user cost framework. See also Hall (2001).

production linkages, flows that lie within the producer boxes in figures 1 and 2. The results for the nonfinancial business sector (column 5 and row 5) are about as expected. The row coefficients indicate that other sectors have significant intermediate linkages with nonfinancial business and that own-use also is significant. These are unsurprising results because the sector is large and an aggregate of many interconnected industries (e.g., upstream and downstream goods producers, wholesalers, retailers, and business services providers).

The results for the financial sector (column 4 and row 4 of table 2), upon reflection at least, are also understandable. These coefficients show little interconnectedness with other sectors, and there is a large own-use coefficient (highlighted in the table). This latter suggests the sector's most significant interdependencies are within itself—interdependencies that were of course underscored in the financial crisis via interconnected balance sheets and counterparty risk.

The really interesting result in table 2 is that input-output relationships show *the financial sector to be not very interconnected with nonfinancial business* via provision of intermediate services. In other words, input-output data suggest that Wall Street's primary direct output linkage to Main Street operates through households, through the intermediate services purchased by household business (mortgage services) and the final services purchased by consumers.

To put some figures to these statements, household consumption of finance and insurance services was $576 billion in 2002 (NIPA data), and mortgage interest paid on owner-occupied homes is estimated to have been $321 billion (authors calculation based on data from BEA). Purchased inputs by nonfinancial business according to table 2 was $274 billion—$90 billion of which is estimated to have been mortgage interest paid to household-owned tenant-occupied housing (BEA data again). By this accounting, nearly 90 percent of the sector output of financial business is delivered to households

4.2 Sources-of-Growth Results

We conduct a sources-of-growth exercise using three of the five sectors shown in table 2, the household, financial, and nonfinancial business sectors. The memo items in the table spell out the derivation of sector output and Domar weights of equations (10) and (12), which are key aspects of the productivity calculations.

The data cover the years 1979 to 2009 and contain familiar aggregates in value added terms that are shown in the top two panels of table 3. The third and last panel of table 3 shows our estimates for financial business. The sector has been defined to include, to the best of our ability, the bank holding companies excluded from NAICS-based industry statistics for finance and insurance.[12] We do this for analytical relevance and to be consistent with the flow-of-funds/SNA coverage of financial business that includes bank holding companies, but that said, in terms of the long-period growth rates shown in table 3, our estimates deviate rather little from a literal use of the BEA's real value added data for the finance and insurance industries.[13]

Peak-to-peak sources of growth estimates from the sector output framework are shown in panels B through D of table 4, and annual figures for MFP growth for financial and nonfinancial

---

[12] One of the ways in which NAICS differs from its predecessor SIC system is that company headquarters and holding companies are severed from the regular operations of an industry and included in a separate sector, management of companies (NAICS 55). The move comprises the ability to analyze consolidated operations by broad sectors such as financial versus nonfinancial business.

[13] Following usual conventions, the time periods we use for tabling annual productivity results are business cycle peaks, in terms of years, with 1979, 1990, and 2007 obvious choices with our dataset. Although two business cycle peaks are included for the 1980s (January 1980 and July 1981), we consolidate the period for simplicity and analytical convenience.

With regard to the 2000s, according to the NBER, a business cycle peak *and* trough occurred in 2001, suggesting that either 2000 or 2001 could be chosen as a business cycle peak year. Aggregate labor productivity calculations are essentially invariant to the choice.

For the combined finance and insurance industries, however, BEA estimates real value added rose sharply in 2001 and then edged down in 2002, suggesting 2001 is the appropriate cyclical peak for financial business. Our estimates of changes in annual real value added differ from those of the BEA from 1998 to 2001 (and ours do not rise so sharply in 2001), whereas changes thereafter are virtually identical. Accordingly, we use 2001 as the break point for our analysis of the business cycle expansion that began in the first decade of the 2000s.

business are charted in figures 6 and 7. Looking first at MFP growth (column 2) in financial business and comparing panel C (the 1990s) with panel B (the 1980s), we see the much discussed acceleration in productivity, which the chart confirms occurred in the late 1990s. Since 2001, multifactor productivity in financial business is estimated to have been essentially stagnant. That said, the rate of capital deepening in financial business has remained relatively strong.

Multifactor productivity in nonfinancial business grew at an average annual rate of more than 1 percent per year over the 1980s, 1990s, and 2000s to date. Given the large size of this sector, this performance shows through to the enterprise business and total private business aggregates shown on the table.[14] The consistency of the productivity performance in nonfinancial business is a noteworthy result. Moreover, figure 7 suggests that the rate of growth of MFP for nonfinancial business, in the aggregate, did *not* pick up in the late 1990s.

The *ex post* rate of return calculated for financial business compared with the return calculated for nonfinancial business (figure 8) sheds additional light on the relative performance of the two sectors. The comparison reveals that a gap averaging 4.6 percentage points in favor of financial business emerged between 1995 and 2001, and during that time the capital income of financial business rose as a share of total enterprise capital income. Figure 8 shows that this gap was largely eliminated over the 2000s, however, and that much of the reallocation of capital income toward financial business reversed.

In terms of the crisis period, shown in panel E, the charts suggest that the results for nonfinancial business are not all that different from what appears to have been an end-of-

[14] Enterprise business corresponds to the standard business sector shown on table 3. Accordingly, the MFP results shown for enterprise business on table 4 are very close to the official value added-based statistics published by the BLS. The only notable difference is from 2002 to 2006 when our sector output-based estimates attribute the gains in productive efficiency due to offshoring to purchased inputs whereas value added-based estimates would attribute them to MFP. Figure 7 quantifies this effect.

expansion slowdown in productivity in 2006 and 2007. For financial business, multifactor productivity is estimated to have become more negative during the crisis than it was over the 2000s.

4.3 Housing Sector Productivity and a 'q' Adjusted Version of MFP growth

The procyclicality of the MFP residual during the end-of expansion period and during the financial crisis invites the speculation that problems persist in the measurement of capital's contribution to growth. The way capital stock is imputed using the perpetual inventory method (discussed above) is one potential problem, the disconnect in the valuation at different points in the financial intermediation process is another.   We explore both possibilities in this section.

The formulation of Tobin's average 'q' as the ratio $W_t / P_t^I K_t$ implies that investors, the consumers and foreigners who lay claim to K_t, may see the value of the capital stock differently from the producers. It is the stock K_t that is used in the calculation of the Solow residuals in Table 4, and if 'q' is not one (or at least constant over time), a case can be made for adjusting the capital stock by 'q' to see what the financial markets have to say about the implied quantity of capital. This can be done via the following thought experiment: given $q = W_t / P_t^I K_t$, then $K_t = W_t / (P_t^I q_t)$. If price-adjusted wealth, W_t / P_t^I, is substituted into the Solow residual calculations in place of K_t, the resulting MFP has the form

(13) $$R_t^q = R_t^{PPF} - s_t^K \frac{\dot{q}_{i,t}}{q_{i,t}}.$$

This alternative residual is notionally a "mark-to-market" estimate based on the value of capital perceived by the financial markets and realized by investors/consumers.[15] In times of falling 'q', the conventional residual is biased downward relative to the mark-to-market estimate, because of the restatement of the capital effect.

Using equation (13) to adjust conventionally-calculated productivity estimates assumes that changes in 'q' reveal relative information on changes in the quantity, or productive capacity, of capital input. Two "thought experiments" are conducted to illustrate the applicability and relevancy of this notion. The first experiment looks at enterprise business only and does not fully take on board the notion that real estate valuations reveal changes in the quantity of land and structures. This experiment uses the 'q'-ratio with "marked to market" real estate assets (M2M 'q'), which essentially maintains the usual assumption that land values are proportional to structures values (and that vintages of structures are appropriately priced via the perpetual inventory model—more on this later).

The results of the first thought experiment are shown on line 1 of table 5 and in figure 9. As may be seen, the application of (13) to this sector using M2M 'q' more than wipes out the 1990s' 1.3 percent average gain (annual rate) in productivity—its adjusted productivity falls .6 percent at an average annual rate. The 1990s thereby become a decade of capital accumulation, and along with that, the 2000s a period of productivity growth step up.[16]

The rigidity of the perpetual inventory method of computing capital stocks over the business cycle is another potential source of measurement error. As noted in Section 2, the value

[15] Because 'q' enters (14) as a growth rate, a constant degree of bias that affects the level will not bias the calculation of the residual.

[16] From a different view, that is with no appeal to financial market valuations, such an argument has be made with regard to the impact of the emergence of the Internet, networked computing, and wireless communications on aggregate productivity change in the 1990s versus the 2000s (Corrado 2010). But there, too, the grit behind the argument involved the interpretation and measurement of capital.

of the stock, $P_t^I K_t$, does not necessarily reflect the market value of the individual components of the stock, even if the 'q' problem does not exist. This is apparent in the value of owner-occupied housing where it is possible to revalue the components of K_t to reflect current market prices.

Table 4 showed productivity results for household business, which includes households as renters of shelter to themselves.[17] As may be seen, conventionally-measured household business productivity improves steadily over the business-cycle periods shown in table—a result that stems almost exclusively from stronger growth in real housing services relative to the underlying stock.[18] Productivity growth in household business was especially rapid from 2001 to 2007 and contributed notably to productivity for total private business, as the growth in real output outstripped the growth of measured capital by a wide margin. This relative pattern was more than reversed during the recent crisis.

Our second thought experiment considers the total private business sector, the aggregate of enterprise and household business. For reasons already given, and in light of the financial crisis, the total private business sector is a more appropriate macroeconomic aggregate for gauging the productivity performance of the U.S. economy. Although a core driver of results for this broad aggregate remains nonfinancial business (see the Domar weights in column 5 of table 4), residential assets loom larger on its underlying balance sheet. Accordingly, house prices loom larger in the valuation process that connects producers and investors in the economy as depicted by the asset-pricing equations given in section 2 of this paper.

---

[17] The other component is the private household industry, which reflects the direct hire of employees by households. Combing household's self-provided shelter and hired services into a single sector is standard practice in national accounting. Accordingly, apart from BLS estimates for the quantity of owner-occupied land (who's implied valuations were used to compute the baseline 'q' estimates reported in table 1), real sector output and inputs for household business is derived from published NIPA data.

[18] The household business sector's capital share averages 81 percent. Indeed, the average capital share rises from 30 to 34-1/2 percent when productivity calculations are expanded to include household business.

To adjust the productivity of total private business using (13) for our second thought experiment, the 'q' ratio shown on line 1 of table 1 is used, and the sector's rate of multifactor productivity growth becomes as shown on line 2 of table 5. In very broad terms, the adjusted productivity depicts the U.S. economy as showing little growth in multifactor productivity during the 1980s and 1990s, on average, followed by a step up in the 2000s. Reflecting the real estate bubble and bust, while the correction for the 2001 to 2007 period is essentially nil, the adjustment for the crisis period adds 5 percentage points to the MPF results for total private business shown in panel E of table 4.

5. Conclusion

The basic assumption that underpins the analysis of this paper is that the current financial crisis is essentially a disequilibrium phenomenon driven by the inflation and subsequent bursting of the housing price bubble. If this assumption is essentially correct, and there are those who do not take this point of view, it has some important implications for national income accounting, asset valuation, and productivity measurement.

First, the centrality of financial intermediation for the functioning the economy needs to be recognized in the circular flow model of economic activity, on which most conventional national income accounting is based. We have addressed this problem by placing the financial intermediation process at the center of a modified circular flow model (our Figure 2). In this modified framework, the links between finance intermediaries and nonfinancial businesses are different from the links among nonfinancial firms, and shocks that affect the financial sector can propagate more rapidly and broadly than those that primarily affect nonfinancial business.

We also called attention to the need to treat housing as *both* a part of the household sector and business, linked in part by the financial intermediation of the mortgage market. The replacement value or the housing stock is part of the generalized business sector balance sheet, and the net claims against this stock are part of the household balance sheets.

We argued that the complexity and lack of transparency of the intermediation process can cause a disconnect between the time path of domestic net worth and the replacement cost of capital assets used for production by business. To measure this disconnect, we used a version of Tobin's average 'q' and found that our estimates varied over time with the rise and fall of the two main asset bubbles of the last two decades, and associated swings in the real economy.

We calculated the rate of change of multifactor productivity change in the financial, non-financial, and owner-occupied housing sectors of the economy. Using the conventional sectoral MFP growth accounting model, which is based on the assumption of competitive equilibrium, we examined the hypothesis that the innovation in the financial services market contributed to the financial crisis. The surprise, here, was how little measured MFP growth occurred in the financial sector. However, the way financial sector output is measured may affect this result.

Finally, we allowed for the possibility that the replacement stock of capital used in the conventional calculation of MFP fails to reflect the true quantity of capital. We reexamine the growth of MFP under the controversial assumption that consumer's valuation of capital, as reflected in its net worth, is a more accurate measure (after certain adjustments). The alternative view suggests that the much noted labor-productivity turn-around of the 1990s may have owed much more to capital formation than is usually thought, and that the drop in conventional MFP during the financial crisis of the last two years is overstated. While this alternative view of capital and MFP is little more than a provocative thought experiment, it is not without a degree of resonance about the periods involved.

We end at the point at which we started by stressing the fact that household net worth plunged by 25 percent from the end of 2007 to middle of 2009 and has had a partial recovery. The corresponding capital stock measured at replacement cost showed little decline over the same period. The two valuations are at opposite ends of the financial intermediation process. We have sketched an alternative economic and growth accounting framework that stresses the central role of financial intermediation and allows for disequilibrium in asset valuation. We believe that this framework provides a better start at understanding the processes involved in the financial crisis than existing equilibrium models.

6. References

Abraham, Katharine G. and Christopher Mackie (2006). "A Framework of Nonmarket Accounting." In *A New Architecture for the U.S. National Accounts*, Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus, eds., 161-192. Studies in Income and Wealth Number 66. Chicago: Chicago University Press for the NBER.

Adrian, Tobias and Hyun Song Shin (2009). "Money, Liquidity, and Monetary Policy." *American Economic Review* 99 (2, May): 600-605.

Adrian, Tobias and Hyun Song Shin (forthcoming). "Liquidity and Leverage." *Journal of Financial Intermediation*. (PDF).

Baily, Martin Neil, "Productivity and the Services of Capital and Labor," *Brookings Papers on Economic Activity,* 1, 1–65, 1981.

Berndt, Ernest R. and Melvyn A. Fuss (1986). "Productivity Measurement With Adjustments for Variations in Capacity Utilization, and Other Forms of Temporary Equilibrium." *Journal of Econometrics* 33, 7-29.

Bresnahan, Timothy F. (1986). "Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services." *American Economic Review* 76 (4, September): 742-755.

Brunnermeier, Markus K. (2009). "Deciphering the Liquidity and Credit Crunch of 2007-08." *Journal of Economic Perspectives* 23 (1, Winter): 77-100.

Corrado, Carol, Charles Hulten, and Daniel Sichel (2005). "Measuring Capital and Technology: An Expanded Framework." In *Measuring Capital in the New Economy*, C. Corrado, J. Haltiwanger, and D. Sichel, eds., 11-41. Studies in Income and Wealth, Vol. 65. Chicago: The University of Chicago Press.

Corrado, Carol A., Paul A. Lengermann, Eric J. Bartelsman, and J. Joseph Beaulieu (2007). "Sectoral Productivity in the United States: Recent Developments and the Role of IT." *German Economic Review* 8 (2, May): 188-210. Also FEDS working paper 2007-24 (April) (PDF).

Corrado, Carol, Charles Hulten, and Daniel Sichel (2009). "Intangible Capital and U.S. Economic Growth." *Review of Income and Wealth* 55 (3): 661-685.

Corrado, Carol A. and Charles R. Hulten (2010). "How Do You Measure a 'Technological Revolution'?" *American Economic Review* 100 (2, May): 99-104.

Corrado, Carol A. (2010). "Communication Capital, Metcalfe's Law, and U.S. Productivity Growth." Paper prepared for the CEPR-CRIE conference, *Cornucopia Quantified* (May). Barcelona, Spain: University of Pompeu Fabra (PDF).

Diamond, Douglas W. and Raghuram G. Rajan (2009). "The Credit Crisis: Conjectures about Causes and Remedies." *American Economic Review* 99 (2, May): 606-610.

Domar, Evsey D. (1961). "On the Measurement of Technical Change." *Economic Journal* 71: 710-729.

Hall, Robert E. (2001). "The Stock Market and Capital Accumulation." *American Economic Review* 91 (5): 1185-1202.

Hall, Robert E. and Dale W. Jorgenson (1967). "Tax Policy and Investment Behavior." *American Economic Review* 57: 391-414.

Harper, Michael J., Brent R. Moulton, Steven Rosenthal and David B. Wasshausen (2009). "Integrated GDP-Productivity Accounts." *American Economic Review* 99 (2): 74-79.

Hayashi, Fumio (1982). "Tobin's Marginal q and Average q: A Neoclassical Interpretation." *Econometrica* 50 (1): 213-224.

Hodge, Andrew W. and Robert J. Corea (2010). "Returns for Domestic Nonfinancial Business." *Survey of Current Business* 90 (8, August): 199-203.

Hulten, Charles R. (1978). "Growth Accounting with Intermediate Inputs." *Review of Economic Studies*, 45 (October): 511-518.

Hulten, Charles R. (1990). "The Measurement of Capital." In *Fifty Years of Economic*

Measurement: The Jubilee of the Conference on Research in Income and Wealth, Ernst R. Berndt and Jack E. Triplett, eds., 119-152. Studies in Income and Wealth, Vol. 54. Chicago: The University of Chicago Press for the NBER.

Hulten, Charles R. (2010). "Growth Accounting." In *Handbook of the Economics of Innovation*, Bronwyn H. Hall and Nathan Rosenberg, eds., 987-1031. Elsevier-North Holland.

Hulten, Charles R. and Janet X. Hao (2008). "What is a Company Really Worth? Intangible Capital and the 'Market to Book Value' Puzzle," NBER Working Paper 14548 (December).

Inklaar, Robert and J. Christina Wang (2010). "Real Output of Bank Services: What Counts Is What Banks Do, Not What They Own." Paper prepared for the 20010 IRIW meetings, St. Gallen, Switzerland (August).

Jorgenson, Dale W. (1963). "Capital Theory and Investment Behavior." *American Economic Review* 53 (2, May): 247-259.

Jorgenson, Dale W., and J. Steven Landefeld, "Blueprint for Expanded and Integrated U.S. Accounts," in *A New Architecture for the U.S. National Accounts*, Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus, eds., Studies in Income and Wealth Number 66, Chicago: Chicago University Press for the NBER, 2006, 13-112.

Jorgenson, Dale W. and Zvi Griliches (1967). "The Explanation of Productivity Change." *Review of Economic Studies* 34 (July): 349-83.

Nichols, Joseph B, Stephen D. Oliner and Michael R. Mulhall (2010). "Commercial and Residential Land Prices across the United States." FEDS working paper 2010-16 (April). (PDF)

Patinkin, Don (1973). "In search of the 'Wheel of Wealth': On the Origins of Frank Knight's Circular Flow Diagram," *American Economic Review* 63 (5, December): 1037-1046.

Solow, Robert M. (1957). "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39 (August): 312-320.

Table 1. Annual percent change in domestic business 'q' ratios[1]

Coverage	1979 to 1990	1990 to 2001	2001 to 2007	2007 to 2009
1. Total private business[1]	1.9	3.3	.0	-13.6
2. Enterprise business[2]	1.5	6.3	.7	-15.0
3. Nonfinancial	2.0	4.0	.5	-8.6
'q'-ratios with "marked to market" real estate:				
4. Total private business	1.0	3.6	-.9	-4.5
5. Enterprise business	1.3	6.8	-.9	-5.1
6. Nonfinancial	2.0	4.5	-1.4	-6.0
7. Line 1 enterprise business with new CHS intangibles[3]	1.1	6.0	.8	--

Notes— Changes are log differences. The ratios are calculated using annual data.

1. Includes household business along with enterprise business, with the latter the standard business sector.

2. See note 1.

3. Two important intangible investments, computer software and mineral exploration, are already capitalized in official statistics; "new CHS intangibles" refers to the other computerized information, innovative property (copyright, licenses, etc.) and economic competency assets that are not. The source for these estimates is Corrado and Hulten (2010), which extend Corrado, Hulten, and Sichel (2005, 2009) to 2007.

Table 2. Industry-by-Industry Domestic Direct Requirements Coefficients, 2002

	Household business (1)	Nonprofit Institutions (2)	Governments (3)	Financial Business (4)	Nonfinancial Business (5)
1. Households	.00	.00	.00	.00	.00
2. Nonprofits	.01	.00	.01	.00	.00
3. Governments	.00	.01	.01	.01	.01
4. Financial business	.13	.06	.01	**.25**	.02
5. Nonfin. business	.12	.35	.33	.14	.39
Memos:[1]					
6. Gross output	972	924	2,076	1,507	13,700
7. Sector output[2]	972	920	2,057	1,136	8,314
8. Value added	716	512	1,270	879	7,296
9. Imported intermediate inputs	--	21	59	28	584
10. Domar weight[3]	.086	.081	.181	.100	.732

Notes—Estimates based on BEA input-output tables and import matrix for 2002.

Reading down each column, coefficients are industry-based domestic intermediate inputs expressed as a fraction of own-industry gross output.

Household business is the production of owner-occupied housing services and private employment by households. Governments include government enterprises (e.g., the post office and certain utilities). Nonprofit institutions are industries in which nonprofit activity predominates (education, hospitals, and social, membership, and religious services organizations). Financial business is finance and insurance, and nonfinancial business is all other industries.

1. Billions of dollars unless otherwise noted.
2. Gross output less domestic own use, based on the direct requirement coefficient.
3. Individual sector output relative to total economy sector output (GDP, the sum of row 8 + imported intermediates, the sum of row 9).

Table 3. Real value added and output per hour worked, annual percent change[1]

Sector/Coverage	1979 to 2009 (1)	1979 to 1990 (2)	1990 to 2001 (3)	2001 to 2007 (4)	2007 to 2009 (5)
Total economy:					
Real value added (GDP)	2.6	2.9	3.1	2.6	-1.3
Hours worked	.9	1.5	1.2	.8	-3.4
GDP per hour worked	1.7	1.4	1.9	1.8	2.1
Private business:[2]					
Real value added	2.8	3.0	3.5	2.6	-2.4
Hours worked	.8	1.3	1.3	.3	-4.7
Real value added per hour worked	2.0	1.6	2.3	2.3	2.3
Financial business:[3]					
Real value added	3.2	3.6	4.4	2.2	-2.1
Hours worked	1.3	2.6	1.1	1.0	-3.4
Real value add per hour worked	1.9	.9	3.3	1.3	1.2

1. Based on log differences using annual data.
2. As defined by BLS for multifactor productivity. Corresponds to enterprise business in table 1.
3. As defined in the SNA/FOF. For this purpose, BEA's measures for NAICS 52 with adjustments for bank holding companies included in NAICS 55 are used.

Table 4. Sources of growth for private business sectors (per hour basis)[1]

Time period/Sector	Sector output (1)	MFP (2)	Capital (3)	Purchased inputs (4)	*Memo:* Domar wgt.[2] (5)
A. 1979 to 2009					
Total private business	2.2	1.1	.8	.4	---
Households	2.7	1.3	1.2	.2	.08
Enterprises	2.7	1.0	.7	.4	.93
Financial	2.5	-.5	1.8	1.2	.10
Nonfinancial	2.3	1.1	.6	.5	.87
B. 1979 to 1990					
Total private business	1.8	.7	.8	.3	---
Households	2.5	.5	1.8	.2	.08
Enterprises	1.7	.7	.7	.3	.93
Financial	1.0	-1.7	2.2	.5	.09
Nonfinancial	1.8	.9	.5	.4	.88
C. 1990 to 2001					
Total private business	2.6	1.3	.8	.5	---
Households	3.3	.8	1.9	.6	.09
Enterprises	2.5	1.3	.7	.5	.92
Financial	3.7	.8	1.6	1.4	.10
Nonfinancial	2.5	1.3	.6	.7	.87
D. 2001 to 2007					
Total private business	2.7	1.8	.3	.6	---
Households	2.4	4.8	-1.9	-.5	.09
Enterprises	2.7	1.4	.5	.8	.92
Financial	3.7	-.4	1.2	2.8	.10
Nonfinancial	2.9	1.6	.4	.9	.87
E. 2007 to 2009					
Total private business	2.0	-.4	2.2	-1.6	---
Households	.9	-2.8	4.0	-.3	.09
Enterprises	1.5	-.1	2.0	-.4	.92
Financial	.6	-.8	1.6	-.3	.13
Nonfinancial	1.5	.0	1.9	-.3	.86

Notes—Column 1 equals the sum of columns 2, 3, and 4. “Enterprise” business corresponds to the standard business sector. Entries are independently rounded.

1. Annual percent change based on log differences.

2. Average for period. Weights for individual sectors are relative to sector output for total private business.

Table 5. Rates of growth for multifactor productivity: results of two thought experiments

	1979 to 1990	1990 to 2001	2001 to 2007	2007 to 2009
Experiment number 1:				
Enterprise business				
1. MFP adjusted using "marked to market" 'q'-ratio	.4	-.6	1.7	1.3
1a. Line 1 less unadjusted[1]	-.4	-1.9	.3	1.4
Experiment number 2:				
Total private business				
2. MFP adjusted using baseline 'q'-ratio	.1	.1	1.8	4.7
2a. Line 2 less unadjusted[1]	-.6	-1.2	.0	5.0

Notes— Changes are at average annual rates based on log differences.
1. Percentage points.

Figure 1

The Circular Flow

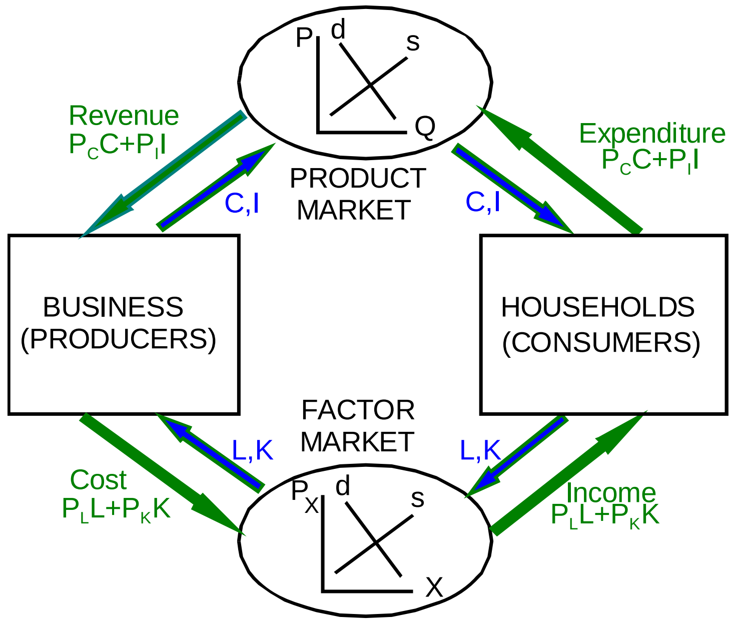


Figure 2

The Circular Flow with Financial Intermediation

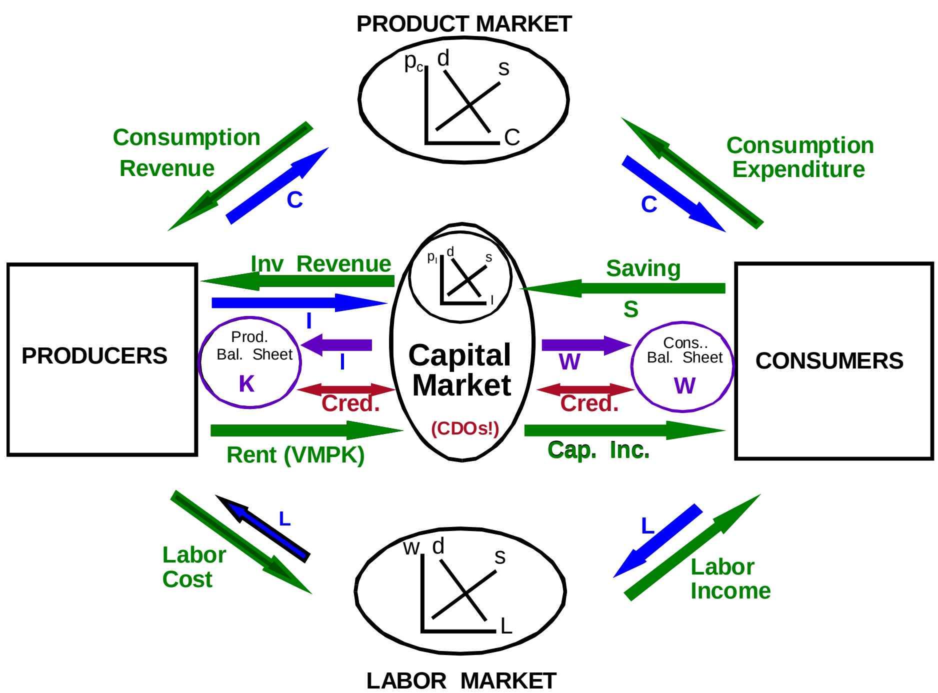
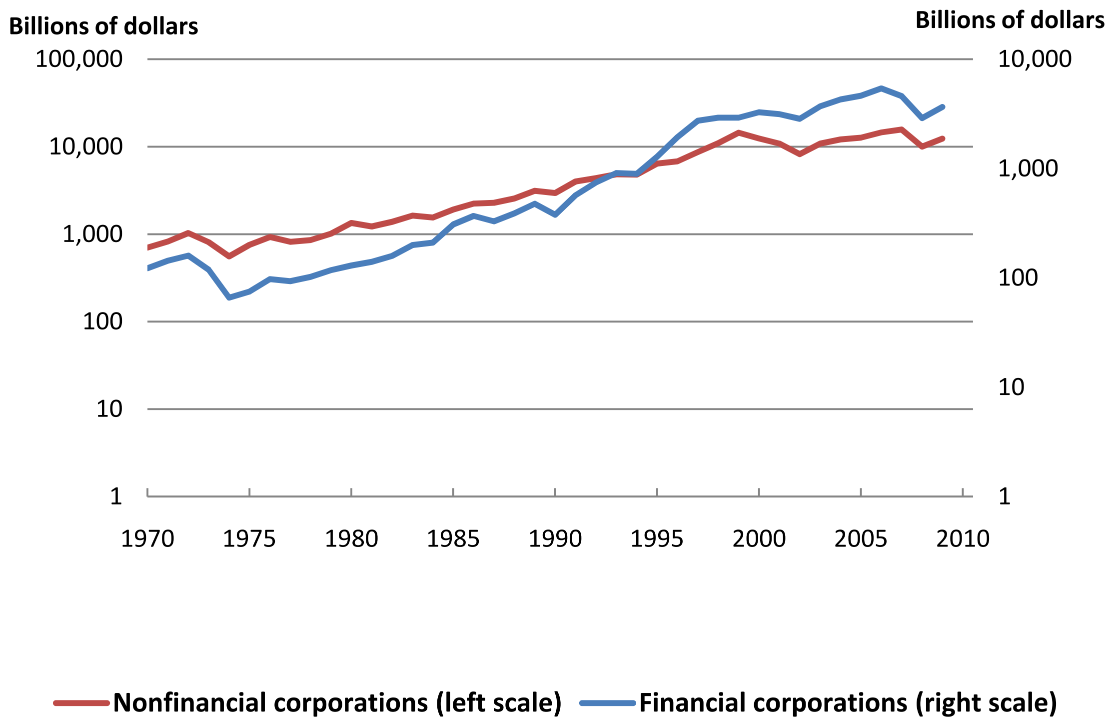


Figure 3

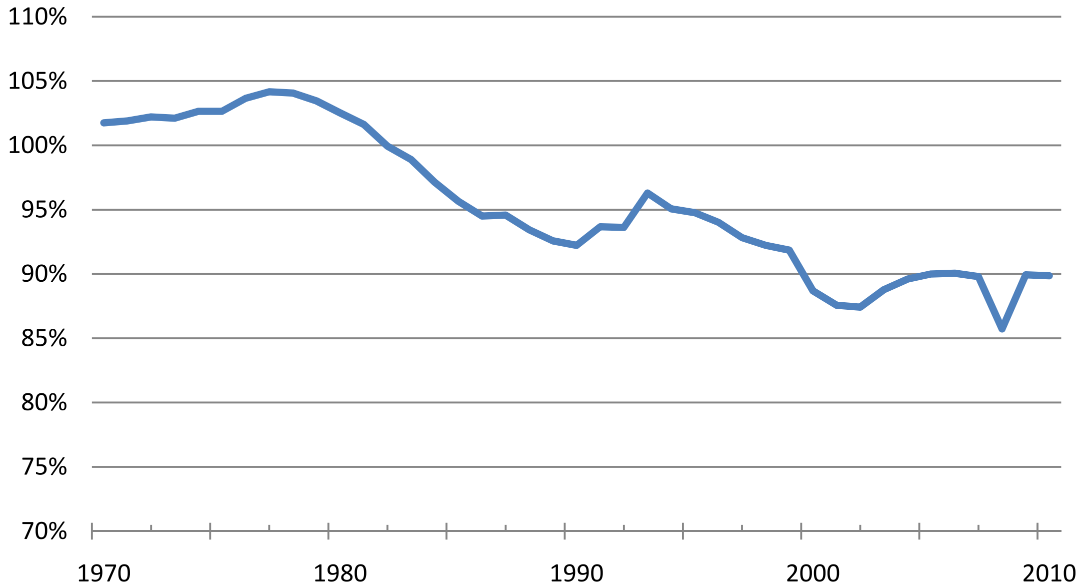
Market capitalization, financial and nonfinancial corporations



Note—Valuations are net of intrasectoral holdings.

Figure 4

Claims against domestic productive assets: percent held by U.S. consumers, 1970 to 2010e



Note—Series plotted is the claims held by U.S. consumers relative to the total claims against U.S. domestic business, after adjusting for foreign direct investment in the United States and U.S. direct investment abroad. Consumer-held claims includes nonprofit institutions serving households, which alone are estimated to hold more than 5 percent of total claims. Series is end-of-period.

Figure 5a

Q-ratios for total private business

(incl. household business), 1970 to 2009

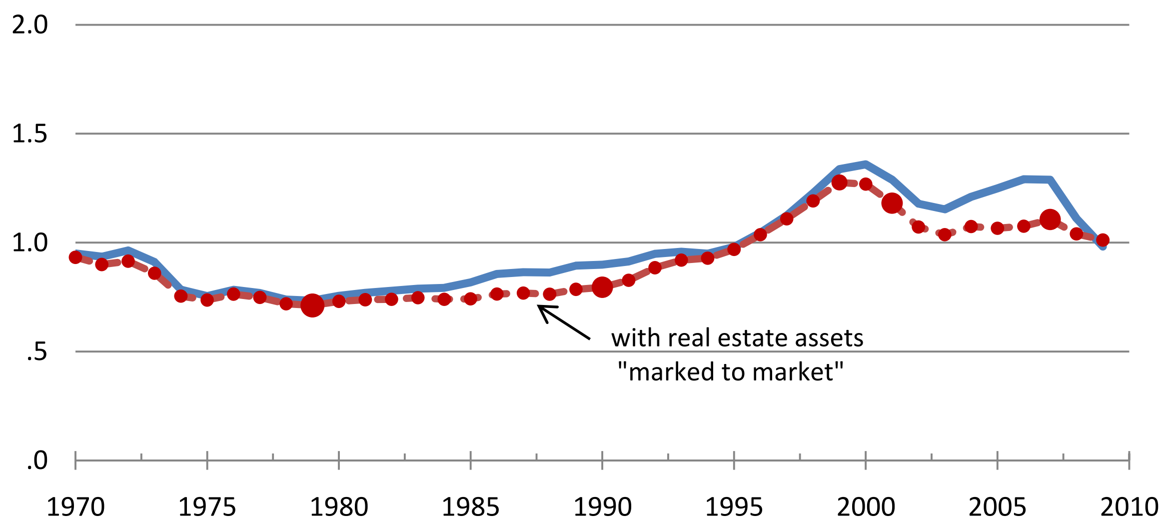


Figure 5b

Q-ratios for enterprise business

(financial and nonfinancial business), 1970 to 2009

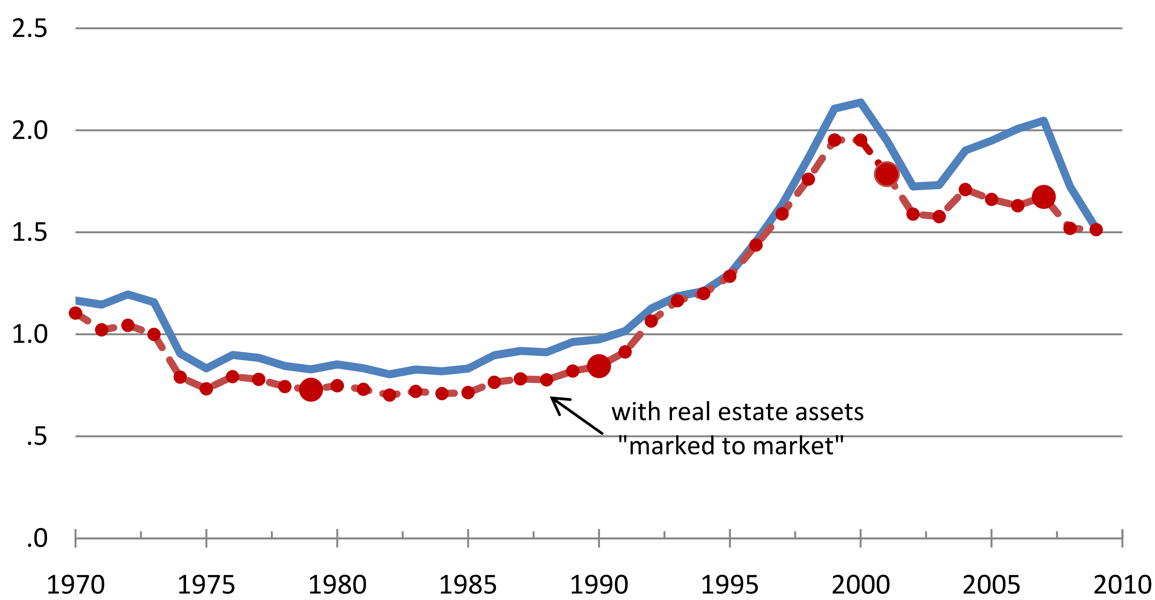


Figure 6

MFP growth in financial business,

1979 to 2007

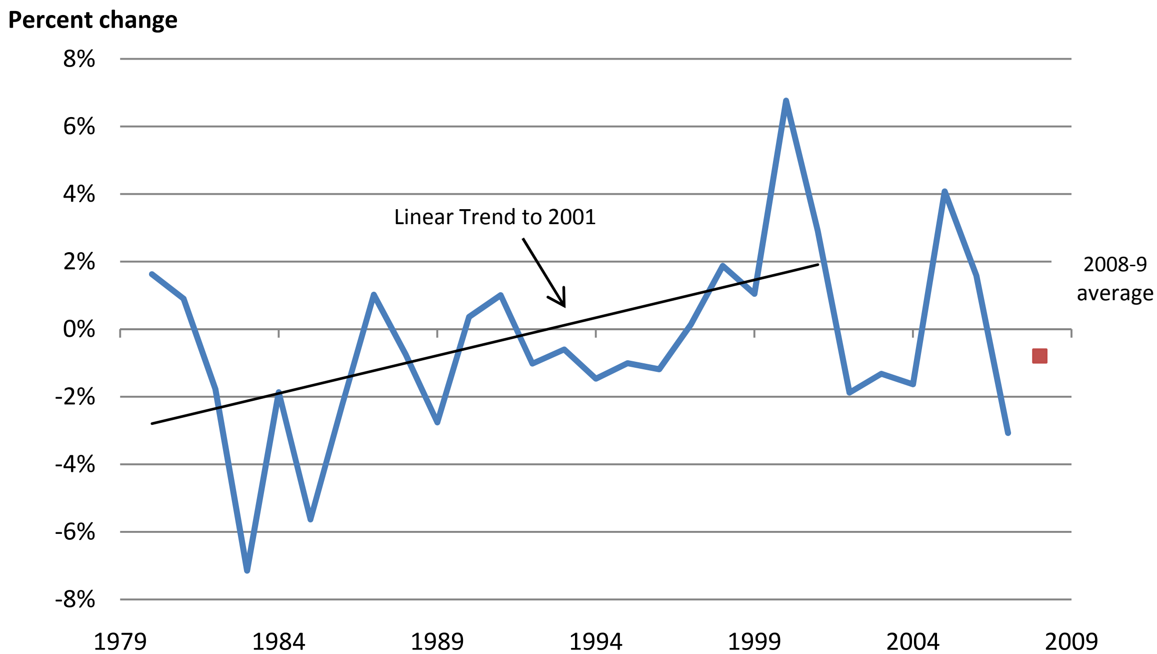


Figure 7

MFP growth in nonfinancial business, 1979 to 2007

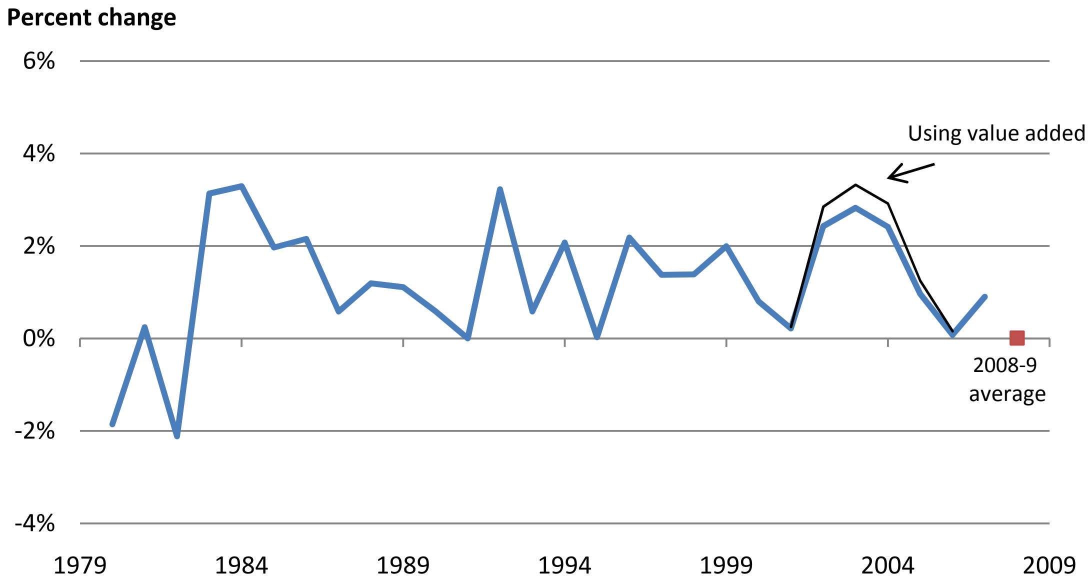


Figure 8

Rate of return on capital and capital income, financial vs. nonfinancial business

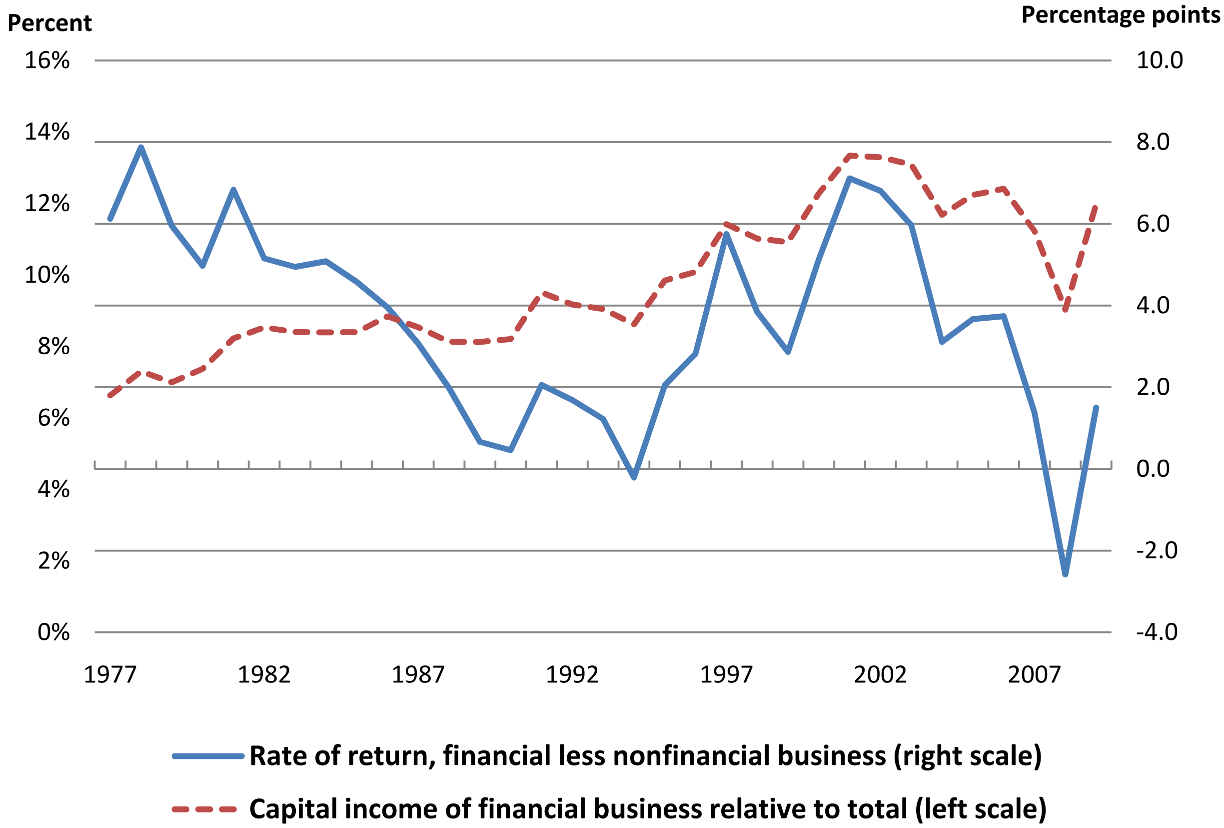


Figure 9

MFP growth in enterprise business 1979 to 2009