Finance and Economics Discussion Series

Federal Reserve Board, Washington, D.C.
ISSN 1936-2854 (Print)
ISSN 2767-3898 (Online)

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2025-019

Please cite this paper as:
Corrado, Carol, Arthur Kennickell, and Tomaz Cajner (2025). "Beyond the Streetlight: Economic Measurement in the Division of Research and Statistics at the Federal Reserve," Finance and Economics Discussion Series 2025-019. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2025.019.

Beyond the Streetlight: Economic Measurement in the Division of Research and Statistics at the Federal Reserve*

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This version: December 27, 2024

Abstract

This paper was written for the academic conference held in celebration of the 100th anniversary of the Division of Research and Statistics (R&S) of the Federal Reserve Board. The work of the Federal Reserve turns strongly on empirical efforts to understand the structure and state of the economy, and R&S can be thought of as operating a large factory for discovering and developing data and analytical methods to provide evidence relevant to the mission of the Board. This paper, as signaled by its title, illustrates how the measurement research component of the R&S factory often looks far beyond current conventions to meet the needs of the Board—and has done so since its earliest days. It would take a far longer paper to provide a complete history and evolution of measurement activities in R&S; here, we provide an indicative review focusing on selected areas from which, we believe, it is easy to conclude that R&S has been—and likely will continue to be—an important innovator in economic measurement.

Keywords: Data collection methods and estimation strategies; Business cycles, productivity, and price measurement; Financial accounts and financial data; the Survey of Consumer Finances; Blended data.

*This paper was prepared for the R&S Centennial Conference, November 8, 2023. The authors thank Dave Byrne, whose contributions are close to that of co-author, and Ari Gelbard, who provided research assistance. The authors are grateful for helpful comments from the Conference discussants for this paper, Christopher Carroll and Daniel Sichel.
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Introduction

In commemoration of the 100th anniversary of the merger of the Division of Analysis and Research with the Office of the Statistician in 1923 to create the Division of Research and Statistics (R&S) of the Federal Reserve Board, the paper provides an overview and some insights into the subsequent history and role of economic measurement in the division.

In large part, R&S operates as a large factory for producing information relevant to its mission of supporting the Board through analysis of the economy and the effects of policy decisions. A small, but important, part of that information production involves the creation of primary data via survey data collection as in the case of the Survey of Consumer Finances. A much larger part involves uses of a wide variety of secondary data sources, sometimes blended with other sources. Some such secondary uses feed into the creation of higher-level published statistical series, such as the Financial Accounts of the United States or the Industrial Production (IP) and Capacity Utilization system, or to the creation of routinely used indicators such as household debt burdens. In many other cases, the informational output is the result of an exercise in modeling or estimation for internal use, such as potential output; others are shared with the public via FEDS Notes, such as a recently developed index of common inflation expectations.[1] These estimates serve to clarify the current state of some aspects of the economy or to test the appropriateness of a particular view of economic structure. In a complex data ecosystem such as this, it is difficult at best to define neatly what constitutes "measurement," the subject of this paper. It would not be possible in the scope of this paper to address every relevant angle. Instead, below we sketch a framework of information use and discuss some of the key related elements of measurement.

From the perspective of the present, three mutually supporting factors are most striking about the overall history of measurement in R&S. First, the varieties and sources of data have expanded enormously over time. At one time, simply having reliable national income aggregates and money supply data represented progress. Now, the growing range of relevant data—commercial data, sensor data, administrative data, and data of other sorts from multiple

[1] See Ahn and Fulton (2020).

government agencies—can seem almost boundless. Second, computing and related technologies to cope with such data have grown roughly in parallel. When two of the authors of this paper began working at the Board, anyone using more than one megabyte of computer memory on the mainframe, then the only source of computing other than a calculator or pencil and paper, was required to present a blue card signed by a division officer to a window in the computer center. Even with what was then considered an advanced computer, congestion, delays, and system crashes were often an issue. Such technology seems almost medieval, compared with current resources. Third, these factors supported the growing complexity of the contemporary economy that required an expanded, and more detailed and sophisticated, analysis by Board staff. We will variously return to each of these factors in the discussion of specific analytical areas.

An important facet of measurement in R&S has been, and continues to be, the investigation of tensions within and across data sources for interpreting developments in the economy, or alternatively, tensions between a theoretical prior and incoming data or empirical test results. A remark in a paper by former R&S Division Director David Wilcox expresses this perspective.

> When researchers test and reject an implication of a theoretical model, they usually assume that the model is in error and that subsequent investigation should be directed toward the development of alternative models that might better account for the observed characteristics of the data. They usually spend little effort investigating the characteristics of the data themselves or the suitability of the data for use in the application at hand. This paper reverses these priorities and investigates the source data and estimation methods used to construct the retail-sales and aggregate consumption data in the United States, searching especially for imperfections that might have implications for the outcome of empirical work. (Wilcox 1992, page 922)

This mindset (echoed in our paper's title) plays an important role in the work that has supported and developed the division's statistical programs reviewed in the paper.

Some important measurement systems present alternative constructs that conceptually do not differ but rather make tensions in underlying source data and surveys transparent, e.g., the discrepancy between gross domestic product (GDP) versus gross domestic income (GDI) is almost a “feature” of national accounts. Employment from the Bureau of Labor Statistics (BLS) household survey is adjusted to its establishment employment survey’s concept to illustrate alignment of its alternative sources for collecting data on employment (BLS does not feature this analysis, though a recent website design has made it easier for users to find).

Internally, IP is lined up with goods GDP; the IP flow-of-goods system with NIPA inventories; and, at one time at least, saving in the national accounts with its conceptually consistent counterpart in the financial accounts. Sorting through specific discrepancies is routine in the conduct of division work, but many of the puzzles or tensions that arise in incoming data are not handed to us as part of a statistical release or routine construct. They must be detected and sorted through before they can be identified as a problem in measurement rather than a problem in our economic priors.

The influence of this “beyond the streetlight” mindset goes beyond the work environment of the Board. Distinguished alums of R&S have taken lessons from studying tensions and puzzles in data to other government agencies, academia, and the broad world of policy—exports that could be said to rival the influence of the body of research undertaken by R&S per se. Furthermore, more than a dozen R&S alums serve or recently have served on advisory committees for U.S. statistical agencies, international agencies, and central banks in their capacity as experts in economic measurement. The division nurtures its influence on economic measurement research and practice by being a sponsor of the NBER’s Conference on Research on Income and Wealth (CRIW). The CRIW holds annual research conferences and a workshop at the NBER Summer Institute on economic measurement that bring together practitioners and leading researchers on topics of mutual interest.

This paper does not attempt to capture every aspect of economic measurement in R&S over the past 100 years. To do so would necessitate a far longer paper, which would be tedious reading for all but the most devoted data geeks. Instead, we review five areas of work that seem to us to be ones that are likely to have greatest salience. The first section briefly reviews the IP and capacity system, and the second section covers the history of the measurement research that worked to develop a clearer picture of productivity growth. The third reviews the

Financial Accounts of the United States (formerly Flow of Funds Accounts) from the pioneering research that led to their founding, their uses, and the development of the associated distributional accounts. The fourth section addresses the development of primary data sources, largely financial microdata, in the division, including an in-depth review of the emergence of the modern Survey of Consumer Finances. A fifth section discusses the recent efforts in R&S to combine nontraditional data sources to gain better insight into near-term behavior of the economy. That section makes note of a recent initiative to utilize a broad spectrum of sometimes non-traditional data sources to construct indicators of business conditions, the motivation for the IP index more than 100 years ago, which is where we begin.

1. The IP and Capacity System

The collection of financial market and banking statistics by a central bank seems an obvious duty. Less obvious is that many central banks issue nonfinancial economic statistics generated to support the implementation of monetary policy, e.g., the Bank of Japan issues the country's price indexes for producers ("corporate goods prices"), exports, and imports to this day in support of the Bank's aim of maintaining price stability.

The Federal Reserve's earliest nonfinancial statistics grew out of a need to monitor fluctuations in industrial activity and commodity prices. In the first edition in 1913 of what would become a lifetime of work on measuring and analyzing business cycles, Wesley Clair Mitchell pointed out the need for an index of the physical volume of production and trade as a requisite for understanding the growth and fluctuations in economic activity (Mitchell 1913).

The March 1918 Federal Reserve *Bulletin* announced that indexes of business conditions were under development (Federal Reserve Board 1918). Following plans outlined in subsequent issues, the statistical tables in the January 1919 issue of the *Bulletin* began to report more than 100 different data series on the physical volume of production and trade. The series covered refined agricultural products (e.g., sugar and flour), mining activity (e.g., coal and crude oil), and production by manufactures of iron and steel, nonferrous metals, lumber, textiles, refined gasoline, and wood pulp and paper. In 1922 the Federal Reserve issued "Indexes of Trade and Production" with data beginning in 1919 (Federal Reserve Board 1922). The indexes aggregated available physical production volume series into major components and presented a timely summary of monthly industrial activity that came to be known as monthly IP.

The *Bulletin* announcements of the early 1920s give no hint of the relationship between the Federal Reserve's efforts to compile indexes of production and related work on measuring business cycles by Wesley Mitchell and others. Mitchell had been engaged in a multiyear project with the NBER of the time to collect and organize monthly data on economic activity. In a study of price controls and commodity shortages during the first world war for the government's War Industries Board, Mitchell used the NBER data to construct the first index of the physical volume of production and trade for the United States (Mitchell 1919, pages 44-46).

Mitchell's NBER data gathering project and work for the federal government undoubtedly influenced the parallel project at the Federal Reserve, as well as efforts elsewhere. One such effort took place at Amherst College, conducted by Walter Stewart (Stewart 1921). Stewart's "index of production" appears to have directly influenced the index the Fed published in 1922. Walter Stewart left Amherst that year for the Federal Reserve and in November 1923 became the first director of the Federal Reserve Board's newly created Division of Research and Statistics.

By the 1940s the production index included all industries in manufacturing, having introduced more detailed coverage of new and growing industries like machinery. For many of these industries no monthly physical volume data were available, and annual comprehensive production indexes jointly produced by staff of the Federal Reserve and Census Bureau were used to benchmark monthly series based on production worker hours.[2] The benchmark indexes built into monthly IP were for the five year change to most recent quinquennial Census year,

[2] For example, the 1947 indexes were issued as a supplement to the 1947 Census of Manufactures (e.g., U.S. Bureau of the Census and Board of Governors of the Federal Reserve System, 1952)

with detailed industries aggregated using value added information from the prior Census year as weights.

The joint Federal Reserve-Census Bureau effort considered the impact of alternative base periods for the (implicit) price weights used in aggregation. While the five-year benchmark Indexes used in IP were based on weights for the prior Census year, comprehensive production indexes using current Census year weights, and, interestingly, "cross" weights using information from both years also were reported. Though the cross-weighted indexes did not exactly follow the Fisher formulation now in widespread use in US economic statistics, the work was an early effort to evaluate and avoid substitution bias in official statistics. Compared with a volume measure that used prices in a single year to aggregate its components in all years, the five-year linked benchmark indexes used to construct monthly IP yielded a more accurate indicator of trends in industrial activity.

The broader context of the Federal Reserve-Census Bureau effort to develop comprehensive measures of the change in manufacturing output was, as in the case of Mitchell's initial physical volume index and the Board's introduction of monthly IP in 1922, a recognition of the need to monitor production stripped of the effects of wartime inflation.[3] Similarly, the Board's capacity utilization measures grew out of a need to monitor short-run pressures on aggregate supply that might aggravate inflation during the booming 1960s (de Leeuw 1962; 1966).

de Leeuw's approach to the measurement of capacity exploited survey data on utilization rates in manufacturing to develop timely, model-based capacity indexes consistent with monthly IP. The utilization data came from a then widely reported survey conducted by McGraw Hill. A major expansion and improvement to the capacity system came with the incorporation of the Census Bureau's annual Survey of Plant Capacity in 1989, which had collected information on industry-level factory utilization in the fourth quarter of each year since the 1970s. Richard Raddock (1990) provides a description and analysis of the new data; he and Charlie Gilbert

[3] It should be noted that the Bureau of Economic Analysis (BEA) only began to publish annual constant-dollar GNP in January 1951, which evolved into a quarterly constant-dollar GNP series that was initially issued in December 1958, about 36 years after the Board's issuance of the initial monthly IP index.

designed and implemented the expanded system. The more rigorously constructed measures were further examined by Corrado and Mattey (1997) who highlighted their economic interpretation and utility in both macro and micro analysis.

Many refinements to monthly IP have taken place since the early days, most of which are described in resources available on the Board's website. The introduction of annual (vs quinquennial) chaining in the production benchmarks was an especially notable step, described in Corrado, Gilbert, and Raddock (1997). The article also sets out how ratios (e.g., capacity utilization) may be preserved in volume indexes. In another key improvement, the estimation of monthly IP now makes use of comprehensive, quarterly survey data on plant utilization collected by the Census Bureau (QPC) and funded by the Board.[4] John Stevens and Norman Morin shepherded the Census Bureau's introduction of the new survey into the capacity measures, and Charlie Gilbert implemented its use in the estimation of monthly IP. The idea here is that quarterly changes in utilization mainly reflect changes in output, and including this information in the estimation of monthly IP diminishes the system's reliance on input data as indicators of production at a high frequency.

All told, a quantum improvement in the monthly and annual processing of the Board's IP index took place since the late 1980s. Charlie Gilbert was responsible for most of these achievements, as spelled out to attendees at his recent retirement party after 40 years at the Board. (Too bad we do not have a recording of those tributes!) Of course, many R&S staff members also contributed to the remarkable automation of the present IP and capacity utilization system, including one of the division's statisticians, Bill Cleveland, and economists Eric Bartelsman, Norman Morin, and Kim Bayard, to name but a few.

A review of the emergence of the modern IP and capacity utilization system would not be complete without considering the division's work to keep pace with the rapid evolution of information technology (IT), the subject to which we now turn.

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[4] The new survey, the Quarterly Survey of Plant Capacity Utilization (QPC) replaced the annual survey as a pilot survey in the fourth quarter of 2007 and has continued as a quarterly survey since then. This new quarterly survey, like its predecessor annual survey, also collects information on plant operating hours.

2. IT Output, Investment and Productivity

Research contributions by R&S staff to the measurement of IT industries and investment and their impacts on productivity are reviewed in this section. We begin this review in the 1990s, when interest in the economic implications of the "tech" sector soared. BEA had introduced quality-adjusted prices for computers in the national accounts in 1986 (Cole et al. 1986), after which IT equipment—commonly understood to include communication equipment as well as computers—emerged as one of the fastest growing segments of aggregate demand.

Interest in understanding the role of quality-change in inflation measures in the division also intensified in the 1990s. The subject of quality change had been in the spotlight in the division when Charles Partee as R&S Division Director established a "Committee on Prices and Price Measurement" composed of academic consultants in 1965. A now classic collection of research papers edited by Zvi Griliches was a product of this committee (Griliches 1971). We know of little else in the division on price indexes and quality change prior to this effort.[5]

We begin with the well-known policy dilemma faced by Chairman Greenspan in the late 1990s and discuss how IT and measurement of prices surfaced in the ordinary business news of the time.

Productivity in the 1990s and "The Man Who Knew"

The 1990s productivity revival in the United States began in the first half of the decade but discernment of the change took hold slowly among professional economists. Productivity analysts did not reach broad consensus that aggregate productivity growth picked up in the mid-1990s until the turn of the decade, when an acceleration in information technology (IT) capital deepening and faster trends in newly available productivity data became apparent (e.g., (Oliner and Sichel 2000). By contrast, the Fed's call that labor productivity growth was

[5] Save for this goodie: As noted by Griliches in his classic paper on quality change in automobiles, which was reprinted in the Fed volume cited above, the earliest construction of a hedonic price index was by Andrew Court while employed as an economist by the Automobile Manufacturers Association in Detroit in the 1930s (Court 1939). Files discovered while cleaning out an office in the Industrial Output section circa 1990 revealed that Court corresponded with staff in the old Business Condition section for comments on his hedonic approach to measuring and analyzing price changes for automobiles.

accelerating—made by Chairman Greenspan in arguments to the Federal Open Market Committee (FOMC, or committee) at its September 1996 meeting—was remarkably early.

This event in monetary policy history and its beneficial aftermath for the economy has been chronicled in the popular press and in books, including Bob Woodward's *The Maestro* (Woodward 2000) and Sebastian Mallaby's biography of Alan Greenspan, *The Man Who Knew* (Mallaby 2016). A lesser-known aftermath is that inside the Board, the event prompted R&S to expend resources on better measuring and analyzing the IT sector of the U.S. economy.

Consider first the puzzle that surfaced in U.S. macro data in the summer of 1996: Wage rates were rising but the increase in labor costs was not boosting inflation. This conundrum could be explained by an acceleration in labor productivity (e.g., due to efficiency gains from IT-induced innovations that were much discussed at the time)—but a boost in productivity was not apparent in the available official data. This suggested to monetary policy commentators (and some committee members) that interest rates needed to move higher to staunch a looming pickup in inflation, a view that was also built into the staff forecast.

To Chairman Greenspan this line of analysis did not accord with the fact that corporate profits remained strong. In an environment of rising wages and stable prices, profits usually weaken, so he commissioned R&S staff to explore this observation. The objective was to take a "deep dive" and develop, to the extent possible, disaggregate estimates of labor productivity and unit costs for manufacturing and non-manufacturing industries and for corporations versus other legal forms of business. To sort through this request, it was necessary to approximate a three-way (industry, legal form of organization, time) decomposition of the available data on productivity and unit costs in the economy—a tough challenge requiring detail not then featured in the industry data published by the Bureau of Economic Analysis (BEA).

The ensuing work, portions of which were issued as a staff study and later published (Corrado and Slifman 1999), generated two primary conclusions. One conclusion was that official GDP growth was likely understated—the statistical discrepancy had swung sharply starting in 1993—and productivity calculated using income-side data (GDI) was increasing faster than the headline product-side (GDP) figure suggested; the 1997 *Economic Report of the President* later estimated that this gap implied that labor productivity from 1994 to 1996 grew 1.3 percentage points per year *faster* than officially reported. The other conclusion was that, using income-side data, the inferred profits of businesses in services industries (corporate and noncorporate) were well maintained while their labor productivity was estimated to be falling. How could these businesses remain profitable while their efficiency measured as real output per hour was outright dropping? One answer to this question was that the price measures used to obtain real output for these businesses were severely biased.

Using these observations, Chairman Greenspan convinced the committee that productivity was growing faster than reported in official data and that hiking the federal funds target rate was not warranted. The possibility that productivity may be mis-measured due to understated services prices or structural change not captured in national accounts was familiar ground for committee members in view of the public discourse on monetary policy and technology at the time. This discourse covered issues ranging from technical issues of price measurement and discrepancies in national accounts to the "irrational exuberance" of the stock market and the possibility emerging from research using company-level data that an "IT revolution" was under way.

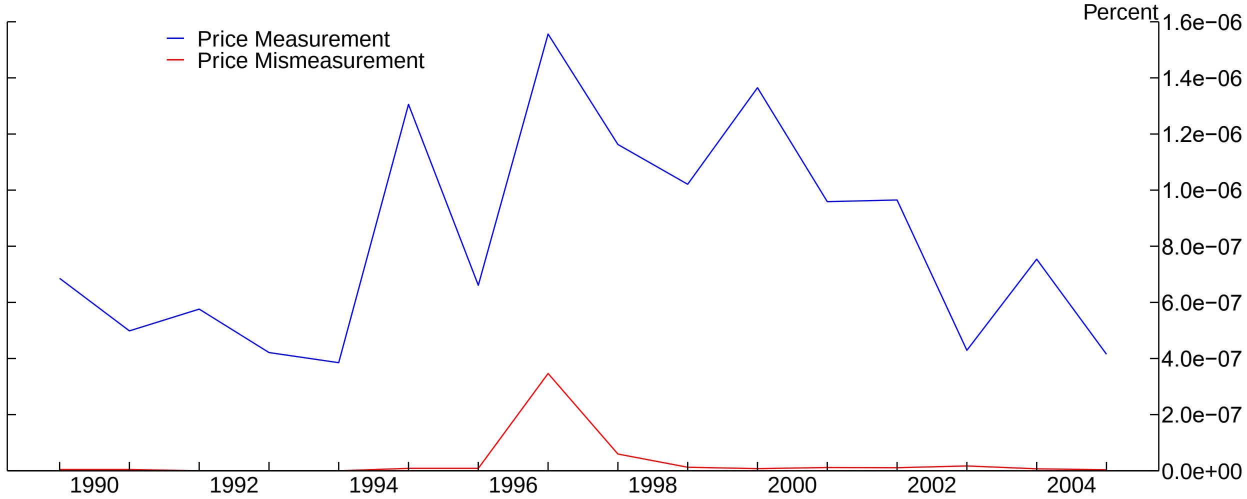
Measurement in the News

Chairman Greenspan famously included a critique of the CPI as a biased measure of price change in congressional testimony in January 1995—a critique drawn from an influential staff analysis (Lebow, Roberts, and Stockton 1994).[6] On December 4, 1996, a group of economists appointed by the Senate Finance Committee reported on their study of the CPI, which estimated that the index overstated inflation by 1.1 percentage points annually (Boskin et al. 1996). This was less than a month after the release of the minutes of the September 1996 FOMC meeting, in which productivity figures based on income-side data and biases in services output prices were mentioned as factors in the committee's decision. Economists' debates over statistical constructs and methods usually do not make the headlines, but in this case the Boskin

[6] See also Shapiro and Wilcox 1996; Lebow and Rudd 2003.

report led to an unprecedented interest in price measurement, e.g., occurrences of “price mismeasurement” and “price measurement” in the Google Books Ngram text corpus jumped dramatically in 1997, with the latter having first shot up after the Chairman Greenspan’s January 1995 congressional testimony (figure 1).

Figure 1. Frequency of Appearance of “Price Measurement” and “Price Mismeasurement”



Source: *Google Books Ngram Viewer; case insensitive results from the American corpus.*

To be clear, the arguments presented to the FOMC in September 1996 did not claim that the biases in official measures of inflation had increased. They were rather points of evidence suggesting that the aggregate data on profits and price and wage inflation were not a puzzle, rather, that the underlying rate of labor productivity growth was faster than reported in the official data. While efforts to identify shocks to productivity and technology is a common topic in empirical macroeconomic research, doing so in real time, i.e., in macroeconomic policy forecasting, remains a formidable analytical and data-intensive challenge.[7]

[7] That said, the utility of “income-side” data has been formalized in official data, based in part on staff research that found that GDI better represents the business cycle than does GDP (Nalewaik 2010; see also Beaulieu and Bartelsman 2006). Accordingly, BEA began to publish an average of GDP and GDI as gross domestic output (GDO) in 2015; GDO is now used for estimating potential output by the Council of Economic Advisors, among others.

The notion that productivity may be—at long last—accelerating due to efficiency gains from IT-induced innovations was also in the news at the time of the September 1996 FOMC meeting. The notion had appeared in press economic commentaries as early as 1993, when an influential company-level study by Erik Brynjolfsson and Loren Hitt began circulating in academic circles (Brynjolfsson and Hitt 1996). Discussions intensified more broadly when Business Week (Mandel 1994) proclaimed that "the productivity surge of the last two years ... may reflect the efforts of U.S. companies to finally take full advantage of the huge sums they've spent purchasing information technology." The lack of macrodata evidence for this claim added to a sense that the official GDP and productivity data might be missing an important dimension of innovative activity in economies.

Orientation of Price Measurement Research in the Division

As previously indicated, many of the R&S price measurement studies focused on advanced manufacturing products as part of an Industrial Output (IO) section initiative to improve the accuracy of the monthly IP index. The initiative began in 1998 as one piece of a wider effort led by Division Director Mike Prell to improve and update the division's statistics. The division's work on price measurement also engaged productivity researchers Steve Oliner and Dan Sichel, who were already parsing the contribution of IT capital to aggregate productivity (Oliner and Sichel 1994). In the economics profession at large, productivity researchers often undertake research on economic measurement.

The Division's work on IT measurement began with the aim of appropriately incorporating quality change in goods price measures—dubbed the "house-to-house combat" of price measurement by Shapiro and Wilcox (1996). In view of the implications of price mismeasurement for monetary policy inflation targeting, and the fact that missed quality change due to technological change is thought to be the largest source of bias in official measures of price change, this focus was natural—whether the missed quality change was in investment output prices or the consumer price inflation (PCE) target of monetary policy.

Most of the division's price measurement research has been directed at IT investment and intermediate goods that feed only indirectly into the Fed's consumer price inflation target. That said, some works have measured consumer price change directly, including the development of quality-adjusted prices for cataract surgery by Shapiro and Wilcox that underscored the need for better prices for health care services. (Division alums, Ana Aizcorbe and Louise Sheiner have subsequently made substantive contributions in this area.)

And following the body of work on IT goods prices described below, Dave Byrne and Carol Corrado estimated consumer price indexes for paid and "free" digital services (Byrne and Corrado 2020; 2021).[8] Paid-for digital services are squarely within the scope of the Fed's PCE inflation target, and their results implied an increasing bias in the Fed's core PCE inflation target since 2007. The methods they used are included in forthcoming international recommendations for measuring the digital economy in national accounts.

IT Sector Measurement: Data on "Ps" ***and*** *"Qs"*

The work conducted under the IO initiative began with the fast-growing domestic semiconductor industry, which accounted for more than three percent of manufacturing IP by 1996. Along with computers and communications equipment, the pace of technological change in semiconductors reflected the booming "tech" sector of the U.S. economy of the time.

Data availability set the context and scope of much of IO's work on IT prices. Staff constructed price indexes for memory chips (DRAM), computer microprocessors (MPUs), and PCs using very detailed model-level unit price and revenue data purchased from private companies (Aizcorbe, Corrado, and Doms 2003; Aizcorbe, 2006). These product-level price indexes were calculated using a matched-model formulation and, after a period of review, shepherded into monthly IP by Charlie Gilbert, whose routines to calculate chain-weighted indexes were made-to-order for crunching the unbalanced panels typical of model-level datasets.

A matched-model price index will capture quality change as a composition effect, but previous research mainly used hedonic indexes to capture quality change for products undergoing rapid technological change. The adequacy of the quality adjustment in matched-model indexes

[8] Paid-for services include fixed broadband internet services, cellular services, and video services, where the latter contained a component for streaming services from their inception in the over-the-top TV services market.

depends on whether the market for new versions of a product is in competitive equilibrium. If equilibrium prevails, the introduction of a new model with a better price-quality trade off pushes down transaction prices of existing models to equalize quality adjusted prices. At the time of the IO work on DRAM, MPUs and PCs, competition among so-called "IBM clones" in the PC market was fierce, AMD had become a serious competitor to Intel with the K6 processor, and the DRAM was a commodity product characterized by razor slim margins.[9]

The work on communications equipment began by studying a new, leading-edge product of the industry, local area network (LAN) equipment for which data were scarce. Mark Doms and Chris Foreman estimated hedonic indexes based on item list prices compiled from Cisco catalogs discovered in ARC's offices (Doms and Forman 2005; internal memo circa 1999). Doms subsequently developed quality-adjusted price indexes for the many types of equipment that powered fiber optic networks. The work was pathbreaking in the breadth of the products of the industry, new and old, that it covered (M. Doms 2005). But the ink was barely dry on this work when it became apparent that data sources for the growing wireless/cellular equipment segment needed to be developed. New data sources covering both wireless and wireline network products in substantial detail were eventually identified, making possible the development of quality-adjusted matched model price indexes for much of the industry (Byrne and Corrado 2015a; 2015b); an initial working paper was available in the summer of 2007 and results incorporated in the IP index the following year.

The rapid adoption of smartphones after the introduction of the iPhone in late 2007 and the birth of Android—Google's answer to the iPhone—in 2008 led to numerous iterations of smartphone hardware, which by then had become the platform of choice for new apps. A

[9] As a practical matter, the estimation of quality-adjusted prices for high-tech products also is intrinsically related to data availability—and availability of model level transaction prices tends to be scarce at industry inception, e.g., there may only be list prices of items produced by a leading company. Data availability tends to be more plentiful, and sometimes in the ideal form of model-level unit prices and revenues, as multiple products and brands are in competition. And even so, whether available data on a product class are sufficient to capture quality change via matched-model price indexes will depend on the frequency of new product introductions relative to the frequency of available data. For a discussion of these and related issues see (Aizcorbe 2014)

hedonic approach for measuring quality-adjusted cell phone prices was eventually developed (Aizcorbe, Byrne, and Sichel 2020) using quarterly data from IDC (purchased by BEA). The earlier work on MPUs also needed to adapt to industry changes and data availability, and price indexes driven by performance measures were introduced following a shift in Intel's pricing strategy in the mid-2000s (Byrne, Oliner, and Sichel 2018).

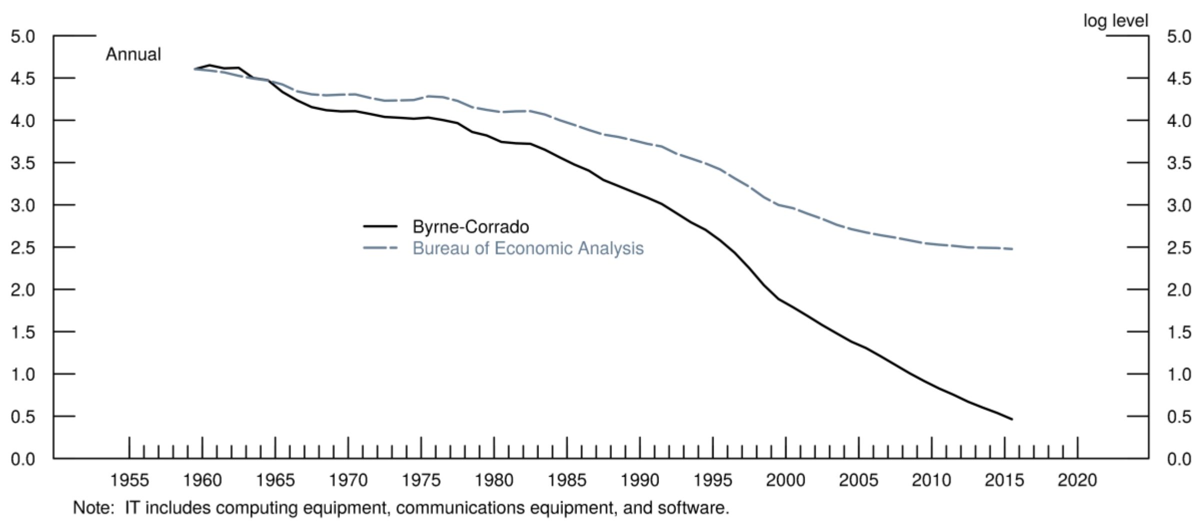
All told, the quality-adjusted IT price indexes developed by R&S staff have material impacts on real investment and consumption via their prices. Research price indexes compiled to reflect this cumulative effort are displayed in figures 2 and 3 below. The IT investment prices are as developed and described in Byrne and Corrado (2017a; 2017b) and those for consumer IT goods and services in Byrne and Corrado (2020; 2021). The details of these constructs shown in figures 2 and 3 are not reviewed here, but it is important to note that they are formulated in the same fashion as in the national accounts and draw upon research price indexes developed by academic researchers, e.g., Gordon (1990) and Berndt and Rappaport (2001), work at BEA (Grimm 1997; 1998), as well as Board staff.

BEA has in fact incorporated research price indexes developed by R&S staff into the IT price indexes for investment and consumption used in the national accounts. The previously mentioned price indexes for wireline network equipment, wireless transmission equipment, and cell phones have been directly included, and the review by Byrne and Corrado (2017a) contributed to an update of BEA's method for calculating a price index for purchased computer software. Also noteworthy, staff-produced estimates of depreciation rates of mainframe computers (Oliner 1993) and PCs (Doms, Dunn, Oliner and Sichel 2004) are incorporated into BEA's measures of national income (via capital consumption). On the other hand, some research price indexes developed by R&S staff were not included in BEA's IT price indexes, and the history for others was truncated—hence a gap between the otherwise common measures shown in the figures.[10]

[10] The exclusions and truncations include the following: the (Byrne 2015) price index for storage equipment; research on price indexes for PCs, including contributions by Berndt and Rappaport (2001) on PC prices that

All told, the matter of "getting IT prices right" offers much to say about a range of economic issues besides their incorporation into national accounts or helping to independently assess current economic conditions (via IP and IT investment demand) and biases in the inflation target of monetary policy. The IT equipment indexes shown in figure 2 were used in Byrne, Fernald, and Reinsdorf (2016) to analyze of the role of mismeasurement in the recent productivity slowdown, and in Byrne and Corrado (2017a; 2017b) to deepen our economic understanding of the evolving trends in technology on productivity growth. The consumer IT prices were used to help understand the significance of "free goods" and digitization of consumer content on consumer welfare in Byrne and Corrado (2021).

Figure 2. IT Investment Prices



Source: Price indexes reported in Byrne and Corrado (2017a, 2017b).

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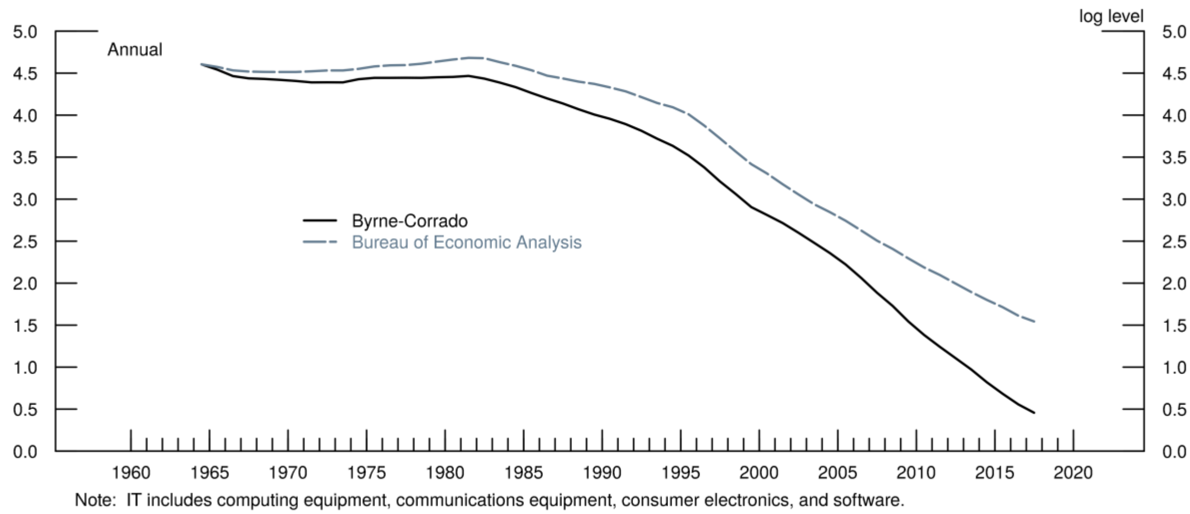
showed very fast drops in the 1990s; the PC prices developed using performance measures to capture quality change after the slowdown in microprocessor speeds in the early 2000s; the mainframe, server, and supercomputer price indexes Byrne and Corrado (2017a) developed for use beginning 1994, roughly the point at which BEA switched from their own computer price indexes to the BLS PPI; the history Byrne and Corrado (2015a) developed for wireline communications equipment that included work by Gordon (1990), as well as their own work on satellite prices from industry inception in 1963 to 1995 and history for wireless equipment from industry inception in 1986 to 2002, the point at which it was adopted by BEA.

Figure 3. IT Consumption Prices



Source: Price indexes reported Byrne and Corrado (2020, 2021).

The Cloud: "Ps", "Qs" ***and*** *"Ks"*

The notion that IT services were becoming increasingly important for the macroeconomy was addressed by R&S staff early in the development of cloud computing services, an area where developments leapt ahead of measurement near the end of the first decade of this century. Using posted prices scraped from the web, Byrne, Corrado, and Sichel (2021) estimated hedonic prices indexes for cloud services from their inception by Amazon in 2009.

The early grasp of the emerging cloud and of cloud technologies became relevant for analyzing and projecting IT investment. Cloud computing technologies enabled higher utilization of the installed computer server base, which helped to explain the weak trajectory of IT equipment investment in the aftermath of the global financial recession. In the event, the weakness also reflected an anomaly in BEA's computer investment series that was highlighted by (Byrne, Corrado, and Sichel 2017) and subsequently addressed in the national accounts.

For some time, IT investment had proxied as macroeconomic indicator of "tech" innovation, and the authors were well positioned to triangulate the apparent weakness in IT investment with the possibility that the national accounts may be missing the production/assembly of computers in the “server farms” of cloud services providers. By the time of their work on the impacts of cloud technologies, owing to prior work on intangible investment that began more than two decades earlier, the authors had a simple, yet uncommon, routine in their back pocket for extracting and viewing time series of intermediate purchases from BEA’s supply-use tables. This permitted them to spot what they reasoned was “missed” computer production by IT services industries in the national accounts.

Intangible Investment

R&S staff emerged as key players in developing the notion of the intangible economy in which a key portion of business investment is “missing” in national accounts. This refers to investments in intangible assets, e.g., the spending that creates a digital platform business model, efficient delivery systems, and global supply chains, that loom especially large in companies that drive global growth. The contribution of Carol Corrado and Dan Sichel, working with Chuck Hulten of the University of Maryland (Corrado, Hulten, and Sichel 2005; 2009); see also (Corrado and Hulten 2010) was to develop a framework for understanding how investment “expanded” to include investments in intangible assets affects productivity and economic growth. Their approach is now widely used, e.g., at the OECD and elsewhere, including the latest edition of the EUKLEMS productivity database, EUKLEMS & INTANProd (LLEE 2023), which includes estimates of intangible investment for 27 EU countries, Japan, the United Kingdom, and the United States. A review and analysis of the implications of intangible capital for productivity and productivity measurement are set out in Corrado et al. (2022) and Corrado (2024).

Before we say a few words on the relevance of the intangible capital framework, consider the popular discourse at the time of its development. The growing IT sector and the gap between equity market and accounting valuations of firms that emerged during the 1990s led many economists and practitioners to believe that there was a “new economy.” But what did that mean from a measurement point of view? Was something important missing in our output and productivity data? To address this question, Corrado and Sichel, along with John Haltiwanger (of the University of Maryland), organized an academic conference “Measuring Capital in the New Economy.” The conference, which was sponsored by the NBER/CRIW, was held at the Board in

April 2002—on the heels of the dot-com crash-induced business cycle that ended November 2001. The timing of the conference thus lent itself to reflection on the longer-lasting measurement challenges that had emerged the digital innovations of the time, mainly new tools for accessing and sharing information via the World Wide Web.

Chairman Greenspan offered welcoming remarks at the new economy conference, in a packed Dining Room E that included many leading economic measurement and productivity scholars along with many Federal Reserve and statistical agency staff. All told five R&S staff were formal participants in the conference as authors or discussants. Besides Corrado and Sichel, Mark Doms presented the work described above, and Jason Cummins and Eric Bartelsman also contributed; for more details, see the conference volume (Corrado, Haltwanger, and Sichel 2005). Also noteworthy, the initial research paper setting out how BEA could implement the capitalization of R&D in the national accounts was presented at the conference by Barbara Fraumeni (and 10 years later, R&D became recognized as a component of investment in GDP).

The original work on intangible capital focused on implications for productivity analysis, with intangible investment considered a broader indicator of the economy's investment in innovation than IT investment alone. Though this continues to be the dominant use of the framework, in recent years, analysis at the IMF, OECD and Bank of England has looked at the implications of the intangibles intensity of investment for the conduct of monetary policy. This body of work, which consists mainly of cross-country studies, is not reviewed here, except to note that findings range from a lowered interest sensitivity of aggregate demand to a flattening of the short-run aggregate supply curve, topics likely to garner additional scrutiny in coming years.

3. Financial Accounts

The precursor to the Federal Reserve's quarterly *Financial Accounts of the United States* (FAs) was its system of flow-of-funds accounts (FFAs). The quarterly FFAs were first published in 1955, reflecting the continuation of a data system the Federal Reserve took over from the NBER in 1947. The system was an accounting scheme for "money flows" pioneered by Morris

Copeland, who designed it to urge a better understanding of the circulation of funds between the financial and nonfinancial economy (Copeland 1947, 1952).[11]

R&S Division Director Ralph Young managed the transition of Copeland's project, soon to be joined by Dan Brill, who worked to develop the Federal Reserve's initial flow of funds system.[12] Steve Taylor, who headed the Flow of Funds and Saving Section from 1961 until he retired in 1985, was responsible for its early computerization and dissemination (e.g., Taylor 1958; 1963) and contributed significantly, along with Senior Economist Susan Hume McIntosh, to the development and expansion of the Fed's system of financial data and use in projections over these years.

As stated in an IMF Handbook, the analytical power of the FOF system of accounts—like that of the income and product accounts—stems fundamentally from the interlocking character of the system—from the across and down totals that balance for every period. Social accounting consistency requires that a flow change in any matrix cell be accompanied by corresponding changes in at least three other cells. (This is because asset demand functions are not independent in a fully specified multi-asset flow of funds model.) For example, if increased government capital formation is to be financed by government debt issues, some sector must absorb the issues. To do so that sector must have larger sources of funds or must reduce other acquisitions. By making use of this feature in various forms, it is often possible to trace the impact of each sector's financial behavior on the others and eventually on the nonfinancial economy, or vice versa.

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[11]Dawson (1996) reports that Morris Copeland was apparently strongly influenced by Walter Stewart as an undergraduate at Amherst College. As noted earlier, Stewart would become first Division Director of R&S. Reportedly, Copeland asked Stewart what he should learn as a graduate student, and Stewart replied, "See if you can learn the difference between a debit and a credit." Copeland worked in Stewart's R&S beginning in 1927, but he did not use his accountancy studies and begin his money flows project until much later, under the tutelage of Wesley Mitchell and Ralph Young, then of the NBER.

[12] Ralph Young came to the Board as assistant director of R&S in 1946 and was appointed director in 1949 (Obituary in the Washington Post, April 8, 1980). Before that he directed the financial research program of the NBER, which included Copeland's money flows project, and was on the faculty of Wharton School and chair of the economics department at the University of Pennsylvania. Dan Brill was Copeland's chief assistant on the money flows project, who subsequently also served as R&S Division Director (Taylor 1996)

Flow-of-funds (FOF) projections conditioned on a GDP projection (and, in turn, the interest rate assumptions that conditioned it) exploit the "vice versa" side of this interlocking feature, i.e., the implications of a GDP path for financial flows. At one time, the implications of the flow of funds analysis of the "corporate financing gap" went strongly the other way, i.e., as a "check" on the staff judgmental forecast. The corporate financing gap is the difference between the corporate capital spending and projected internal cash flow, which reveals the amount of funds that must be raised in capital markets by the corporate sector to meet its capital spending plans (given government saving/borrowing, household saving, rest of world payments, etc.).

This "check" played out in GDP meetings in the 1980s. After presentation of the GDP projection, Division Director Jim Kichline would ask Steve Taylor whether the projected "real side" placed unusual demands on capital markets. More than once the investment analyst and GDP coordinator were asked to rejigger the staff projection because of Taylor's analysis of the implied financing gap. With globalization, increased the proliferation of financial intermediaries and increased participation of nonfinance businesses in financial activities, this check became a less reliable tool for projecting domestic investment and fell out of use.

FAs and Growth in Nonbank Intermediaries

In simple terms, paraphrasing Teplin (2001, page 431), the FAs measure financial flows across sectors of the economy, tracking funds as they move from those sectors that serve as sources of capital, through intermediaries (such as banks, mutual funds, and pension funds), to sectors that use the capital to acquire physical and financial assets. With data extending back to the 1950s, i.e., nearly 75 years, the accounts provide a consistent set of time-series data on financial flows in the economy. They reveal central trends, such as the growth of debt and the development of new financial instruments for providing credit. They document the growth of nonbank financial institutions as intermediaries and show how they became woven into the fabric of the economy.

By the late 1990s, nonbanks held two-thirds of the total credit market assets issued by banks and nonbanks (Fischer 2015). The leverage that had built up in a small but systemically important portion of nonbanks (the so-called “shadow banks”) precipitated the global financial crisis (and the failure of Long-Term Capital Management before that)—the point being that if one wishes to study these major events, the institutional context for them is found in the FAs.

Uses of the FAs in Macroeconomic Analysis

The FAs include balance sheets for the household and other major nonfinancial sectors and did so from their earliest days. Balance sheets explicitly account for capital gains and losses to maintain stock-flow consistency from period to period. This consistency provides a dimension of analytic capability beyond the many matrices of transactions by instrument and institution that form the core of the accounts. The ability to calculate the market value of household net worth is a prime example of this additional capability; the capability to study home equity extraction and its influence on consumer spending and the demand for credit are related examples. The gap between market valuations of corporate capital in relation to its replacement value enables the study of investment demand using a Tobin’s q model, etc.

From the perspective of domestic macroeconomic analysis, the FAs provide data designed to help understand the behavior of households and corporations. A (highly unscientific) perusal of R&S staff research in this area over the last 50 or so years suggests that the FAs have been used most widely for the analysis of household behavior. Central themes in this body of work include the modeling and forecasting of consumer spending using household net worth and studies of the relationship between household debt and consumer spending.

A body of early work centered on estimating wealth effects on consumption. The channel derives from the aggregate implications of the life-cycle model of consumer spending in which wealth is a determinant of consumption and changes in wealth are induced by monetary policy. The approach was incorporated in the Board’s quarterly econometric model from its earliest days in the 1970s (Brayton and Mauskopf 1985) and remained the paradigm for explaining consumer spending in the inaugural version of expectations-based FRB/US model in the mid-1990s (Brayton, Mauskopt, Reifschneider, Tinsley, and Williams 1997). These models exploit the regularity in aggregate data between saving rates and wealth-to-income ratios predicted by a simple life-cycle model (e.g., see footnote 1 and figure 1 in Dynan and Maki 2001, pages 1 and 40).

The question of whether and how stock market wealth "mattered" for consumption has been the subject of many empirical studies by R&S staff. By the mid-1990s, many studies, inside the division and beyond, were developing new findings on consumption behavior and stock market effects based on disaggregate and microdata, including the Survey of Consumer Finances whose development is discussed in the next section of this paper.

The current paradigm for modeling consumer spending in FRB/US is that there are liquidity-constrained as well as nonliquidity-constrained households and different marginal effects of income according to income group (Brayton, Laubach, and Reifschneider 2014). The fact that limited borrowing opportunities of some households help to explain observed patterns of U.S. household wealth holdings and that consumption tracks household income quite closely over the life cycle (e.g., Carroll and Summers 1991; see also Carroll 1997) were factors in the Division's macroeconomic analysis for some time but not as explicit as in the income-level conditioning built into the FRB/US model.

The utility of an income-level distinction when modeling consumption also helps explains why multiple investigations (in the division and elsewhere) that used aggregate time series failed to reveal a stable, direct link between higher levels of debt relative to income and changes in consumer spending. The Federal Reserve long expressed a sentiment in the Bulletin and FOMC minutes that elevated consumer debt may create financial distress should adverse employment and income conditions unfold, however.

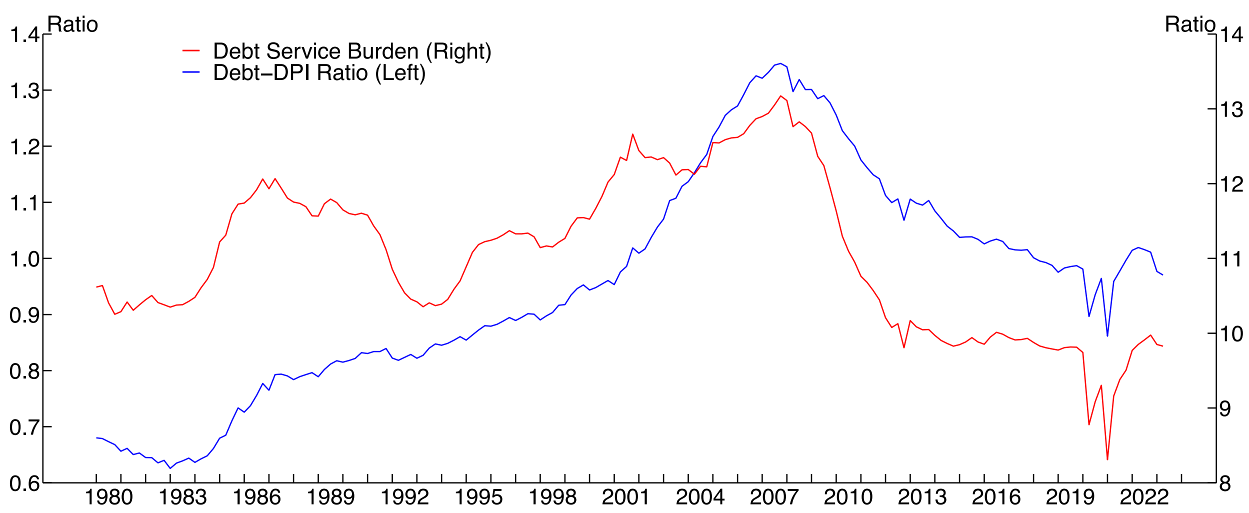
The underlying data on consumer debt in the FAs are provided by the Board's monthly Consumer Credit (G.19) release, a principal economic indicator.[13] The Federal Reserve's monthly press release on consumer credit and quarterly statistics on household debt service

[13] The G.19 release blends information from weekly reporting commercial banks, the Survey of Finance Companies, and multiple other sources, e.g., credit unions and lenders providing student loans. The Survey of Finance Companies is discussed from a measurement perspective in the next section of this paper. For a broad review of historical developments in consumer credit see Durkin, Elliehausen, Staten and Zywicki (2014).

ratios (mortgage and consumer) have probably garnered more ink in the press and Bulletin than any other type of financial data since their publication beginning in the 1950s. Even prior the ballooning of debt in the 2000s and associated household balance sheet stresses, a former Division director once remarked in the presence of one of the authors that the then manager of the consumer credit and debt service burden statistics, Charles Luckett, "was quoted in the press more than any other figure in the Federal Reserve System."

As shown in figure 4, household sector debt outstanding marched steadily upward beginning in the early 1950s, though growth did wax and wane with the business cycle; figure 4 show these data relative to income from 1980 on. The household debt-to-income ratio reached one by 2001, which was then unprecedented. The household debt service burden, measured as scheduled principal and interest payments on debt relative to income, also reached a new high that year. Subsequent years were of course marked by new highs in consumer debt and bank balance sheet turmoil associated with the onset of the Great Recession in 2007.

Figure 4. Debt-to-Disposable Personal Income Ratio and Debt Service Burden



Note. Debt is household sector debt outstanding at end of period from the Federal Reserve's quarterly Financial Accounts. Disposable personal income (DPI) is after-tax income from the national accounts. Debt service burden is the scheduled principal and interest payment on household sector debt as a proportion of DPI as issued quarterly by the Federal Reserve.

Enhanced Financial Accounts Initiative

The financial crisis revealed a need for more detailed information on financial intermediation and indicators of financial stability. The Enhanced Financial Accounts (EFA) initiative was launched in 2014, described on the Federal Reserve's website as "an ambitious and long-term effort to enhance the Financial Accounts of the United States by providing additional detail and disaggregation, higher-frequency data, and additional documentation and analysis of financial data, in order to improve our picture of financial intermediation and activity in the United States." Three initial enhancements were released in 2015, each designed to provide additional detail on assets and liabilities of commercial banks, off-balance sheets items of banks, and newly compiled information on syndicated loans issued by banks and other financial institutions.

From a macroeconomic perspective, one of the most influential contributions of the EFA initiative has been issuance of the Distributional Financial Accounts (DFAs) that provide quarterly estimates of the distribution of household wealth from 1989Q3 to present. The roots of its construction predate the financial crisis, with early work on merging the flow of funds with statistics from the Survey of Consumer Finances (SCF) reported in internal memos from the Division to Chairman Greenspan in 1990s. Carroll (2014) further argued the need for distributional national statistics to understand aggregate household spending behavior at a CRIW conference on expanded national accounts held in Washington DC in 2012. Conference themes touched on other topics related to the EFA and the integration of flow of funds with SCF statistics and existing economic accounts. The conference also included the paper that launched BEA's Integrated Macroeconomic Accounts (Cagetti, Holmquist, Lynn, McIntosh, and Wasshausen 2014). The Integrated Macroeconomic Accounts are structurally compatible with the FAs and reflect a cooperative effort between staff of the Flow of Funds Section and the BEA. Susan Hume McIntosh, who began working with Steve Taylor to develop flow of accounts for the Division nearly 40 years earlier, played a leading role in this effort.

An explosion of interest in the wealth distribution emerged in the wake of influential work by Piketty (2014) and Saez and Zucman (2016). It also highlighted the limitations of the Fed's then publicly available data on U.S. household wealth, i.e., the relatively low frequency of the SCF, lack of microeconomic heterogeneity in the flow of funds, and the fact that household sector wealth in the flow of funds included nonprofit institutions. Saez and Zucman's wealth estimates were based on an indirect method, capitalizing income from assets, which is very sensitive to rates and other assumptions used. Without going in details, R&S staff interacted with these researchers at CRIW summer workshops (as well as elsewhere), eventually contributing to an improvement and revision of the Saez-Zucman estimates that better align with the Federal Reserve's data.

At the same time R&S's own work to further develop and enhance its estimates of the upper wealth tail was publicly discussed and reviewed (e.g., Bricker et al. 2016; 2018). The ensuing release of the DFAs in 2019 was an especially timely response to the public's heightened interest in distribution statistics. This impressive contribution reflected a large team effort within the division—the introductory reviews (Batty, Bricker, et al. 2019; Batty, Briggs, et al. 2019) reviews included 13 major authors, among them, long-serving FOF section senior economist Susan Hume McIntosh.

4. Micro Data

Aside from the construction of the FAs and consumer credit indicators used to analyze the interrelationships between households and businesses and financial flows described above, the context much of the data developed for financial analysis in the division has revolved around the collection of micro data, i.e., observations on individual consumers or companies used to construct sample statistics. In addition, over the past approximately 40 years, there has been growing recognition that macro data alone are often not sufficient for understanding the evolution of the economy or its response to policy interventions. The example of the move to disaggregate income groups in FRB/US to understand the effects of debt and borrowing limitations and the creation of the DFA, as discussed above, are good illustrations.

Monetary Statistics in R&S

The collection or assembly of financial micro data in R&S has a long history. In earlier times, before the separation of R&S and Monetary Affairs in 1987, most of the information collected consisted of money and credit statistics. Such information had particularly great relevance in times when policy focused more directly on management of the money supply and the money demand function played a significant role in macroeconomic analysis. R&S even contributed concepts and data for the analysis of monetary aggregates and their demand. William Barnett (1980) devised Divisia indexes as an alternative to the standard monetary aggregates based on an approach that weights monetary components by their contribution to liquidity. Paul Spindt and colleagues (Avery, Elliehausen, Kennickell, and Spindt 1986) conducted surveys of the use of currency and transaction accounts, with the goal of being able to specify money demand equations at the micro level. Cleveland et al. (1981) developed an approach for characterizing uncertainty in the monetary aggregates.[14]

Early Statistical Surveys in R&S

The oldest surviving micro data project in R&S is, in its current form, the quinquennial Census of Finance Companies, which is used to define the population of finance companies for the Survey of Finances Companies, which collects balance sheet information on firms identified from the Census.[15] These two surveys provide a basis for a monthly panel survey of finance companies. Tabulations, the primary use of these data, began as an official published series in 1955 (G.19), and continue to be used in conjunction with bank-focused data to analyze the financing needs of households and businesses, especially small businesses. The surveys also provide information that is incorporated in the FAs.

The finance company survey provides a good example of how information collection must respond to changes in the environment for measurement. Unlike the case with banks, there is

[14] Augustin Maraval, Bill Cleveland, David Pierce in R&S were among the most important researchers working on seasonal adjustment at the time.

[15] The project began developing to its current form in R&S, starting in 1945, when some previous data collection was transferred from the Census Bureau to the Fed.

no official register of finance companies. Business lists, such as Dunn and Bradstreet, can be helpful in identifying potential candidates, but given the proliferation of finance companies, especially those nested inside larger nonfinancial corporate entities, there can be substantial omissions or questionable classifications. Moreover, the survey began suffering from nonresponse, i.e., companies were becoming less willing to provide the necessary information.

The level of difficulty and approximation required to maintain the finance company data reached a point by 2010 where a fundamental revision of the survey was needed. R&S staff developed novel statistical methods to both estimate the universe of such entities and account for the failure of entities to respond. The new methods also offered the capacity to provide a measure of uncertainty of the estimates, via standard errors for the resulting statistics, a first for any official series at the Board (see Chen, Johnson, and Kennickell 2013).

In its earliest days, micro data outside of tabulated results did not play a significant role in the work of R&S. Following World War II, however, the division supported survey work at the University of Michigan to collect information on consumers' expectations, purchase intentions, use of credit and other financial information. At the time, the economic psychologist George Katona was developing means of assessing economic behavior, including purchase intentions, through measurement of attitudes and other attributes of consumers. Improvements in card sorting (literally, for sorting punched cards according to information encoded on the cards[16]) made it possible to compile more sophisticated cross-tabulations of the surveys' observations. The Michigan Survey of Consumers, which descends from that work, provides valuable statistics used in the division's analysis to this day.

By the early 1960s, computer technology had advanced enough that it was possible to consider collecting and starting to use microdata in some form other than tabulations and simple cross-tabulations. In this regard, the R&S division produced a breakthrough in the study of household finances and survey methodology with its 1962 Survey of Financial Characteristics of Consumers, under the guidance of Dorothy Projector and Gertrude Weiss (1966). The survey

[16] For the younger reader, see https://en.wikipedia.org/wiki/Punched_card_input/output

questionnaire was developed in collaboration with researchers at the University of Michigan, and the data were collected by the Census Bureau. This survey was the first ever to collect detailed and complete household financial balance sheet information from a representative sample of individual households. It accomplished this by using IRS individual income data merged with 1960 Census data in its sample design. The approach allowed the survey to systematically sample the specific income groups and to over-sample the higher income groups to ensure there would be enough observations to support analysis of household investment behavior. Perhaps no other survey of consumer finances, before or after, has had the level of resources to support the accuracy of its results. For example, for corporate stock holdings the survey respondents were asked to report the company names and the number of shares owned. Staff in R&S looked up each stock in a specific issue of the Wall Street Journal and calculated and recorded the total value of the households' stock holdings. Without the benefit of today's model-based imputation methods, staff carefully imputed missing data items by exploiting available information and the technology of the day.

As recounted to one of the authors of this paper by Earling Thorensen, the last of the survey staff remaining at the Fed in the early 1980s, one of Dorothy Projector's greatest aspirations was to be able to compute the Gini coefficient for the U.S. wealth distribution, something that had only become possible to calculate with the completion of the survey data. She was given permission by the Board to have exclusive access to the mainframe computer overnight for this purpose. Reportedly, because machine memory was so limited at the time, all night the machine repeatedly disgorged punched paper tape encoding intermediate stages of the calculation and subsequently re-read the tape. By morning, the ultimate result was only a single number, but a landmark. The estimate was 0.76, compared with 0.82 today, a substantial increase in this measure of wealth inequality.

There was sufficient support to collect a second set of balance sheet data from the same households for the next year in the Survey of Changes in Household Finances (Projector 1968), also a unique accomplishment at that time in collecting wealth panel data. There is even evidence in the small set of remaining project files that there was a subsequent effort to repeat the survey, and even some indication that data for one wave were collected and transferred to machine-readable form via a then advanced type of optical scanning that had been developed. The details of why that work, and the larger survey project, were terminated are not known, but there are some hints. One obvious critical factor was the serious constraint on data processing via computer. The large amount of time needed for dealing with data manually or developing workarounds to cope with computer limitations also meant that there was less time for the use of the data in ways that were relevant to the mission of the Board. One story was that Dorothy Projector was asked to make some seemingly simple calculation that would have had direct value for current policy work. Might she really have said, as claimed, that she had more important things to do to keep the survey on track? Whether true or not, efforts in this area subsequently slept for two decades.

In between, a circa 1976 request from the Senate Banking Committee for information about the use of credit sparked a partial revival of micro data collection on household finances in the division. The 1977 Consumer Credit Survey was produced under the leadership of Thomas Durkin (Durkin and Elliehausen 1978) and transmitted to Congress. As its name implies, the survey was primarily focused on credit-related information, though some limited other wealth and income information was collected.

Emergence of the Modern SCF

Around 1980, a confluence of factors heightened interest in collecting micro data on household finances. These factors included the enactment of the Depository Institutions Deregulation and Monetary Control Act of 1980 and the desire to analyze the rapid emergence of financial innovations in the form of new debt instruments for households. The desire for this type of analysis went beyond the Board and included government agencies such as the Department of Health and Human Services, the Department of Labor, the Federal Deposit Insurance Corporation, the Federal Trade Commission, the Office of the Comptroller of the Currency, and the Treasury. Owing to synergies both in needs and efficiencies, a comprehensive survey, the 1983 Survey of Consumer Finances (SCF) was developed in R&S to serve the needs of interested parties. The survey was under the leadership of Robert Avery with Gregory Elliehausen and in coordination with F. Thomas Juster at the Survey Research Center at the University of Michigan, which collected the data. One of the authors of this paper became involved later, in the technical processing of the collected microdata.

Like the 1962 survey, the 1983 SCF was anchored around the collection of household balance sheet information. But it went further in trying to capture additional details, including broader information on financial services, pension coverage, employment, much more contextual detail, and some information on attitudes and credit use which had a history in earlier work. One critical parallel between the two surveys was in the sample designs, though there were also important differences. Although it may not have seemed like it at the time, in the 1960s it was a less fraught matter to blend IRS and Census information to create a sample design that could oversample the wealthy in a meaningful way. For the 1983 survey, Fritz Scheuren, then director of the Statistics of Income Division (SOI) of the IRS, courageously supported the survey in using statistical records derived from individual income tax returns, under section 6103n of the Internal Revenue Code (a provision for sharing tax-based data for purposes interpreted as being related to tax administration). Even so, the permitted approach to oversampling high-income households had limitations. SOI selected a sample of wealthy households, independent of the selection of the national random sample that constituted the bulk of the respondents. Unlike the case for the general sample, interviewers were not allowed to not approach a person in the SOI sample unless they had explicitly agreed to participate in the survey by returning a postcard stating that fact. The postcard was included in an envelope with a return address for the Office of the Comptroller of the Currency, a government agency not so universally known. Not surprisingly, only about 10 percent of the tax-based sample opened the envelope and agreed to participate, and of those, not all agreed to participate fully enough for their data to be useful. Despite the level of precaution in insulating the SOI sample from any sense of being unwillingly approached, an editorial in the *Washington Post* about the threat to privacy very nearly put an end to the use of IRS data for the SCF.

Although SOI provided a statistical weight for observations based on the tax data, they withheld information about the design of that sample or the nature of the weights, which would be needed for merging it with the separately selected broad random sample. It was only many years later that even partial information could be revealed. Consequently, a large amount of effort was devoted to developing a credible way to merge the special and general samples for analytical purposes. In the end, there was necessarily an unknown level of approximation, which drove efforts to validate the data in other ways, such as through comparisons with data from what is now called the Financial Accounts of the U.S. (Avery, Elliehausen, and Kennickell 1988), a comparison made often and favorably since then.

At first, policy interest at the Board in the survey focused most strongly on credit use by households. That interest supported a plan to undertake more regular collection of such data, preferably on a triennial basis. This led to planning for a 1986 survey, which was envisioned as a re-interview of the 1983 participants, to allow a calculation of saving and to support more sophisticated analysis for which panel data were needed. A critical difference between the situation then and in 1983 is that no outside funding was available, and the Board was unwilling to provide the level of support necessary to conduct the effort on the same scale. Every aspect of the survey was affected by the required reduction in scope, but none as much as the reduction in the survey content. The high-level framework of wealth was retained, but the level of detail was drastically limited. Although there were important benefits from the survey, the limitations for policy and research purposes were obvious. As Ed Ettin, R&S Deputy Director at the time, remarked (paraphrasing), “One of the most important lessons we have learned here is not to try to do this on the cheap.” Fortunately for the future, this reinterview survey proved itself especially notable for being able to provide information to gauge the distribution of effects on household finances of the “black Monday” market crash in 1987.

Yet despite the lesson of the 1986 survey, some of the funding problems persisted with the 1989 survey. To bridge the difference between the cost of a survey comparable to 1983 and what the Board was willing to pay, one of the authors of this paper who was then the project director needed to visit other federal agencies to ask for money to support the data collection, with the nearly universal response being “You are from the Federal Reserve and you are asking ME for money?!” In the end, an important contribution came from a grant from the National

Institute on Aging and a small, but crucially scale-tipping one from the Congressional Joint Committee on Taxation that allowed the project to proceed. Fortunately, the Board recognized the risks of this begging approach to funding and agreed to support subsequent surveys at full cost (which, of course, needed to be fully justified and explained in detail).

The 1989 survey marked an important methodological turn for the survey. For this reason, this survey is usually taken as the baseline when comparing SCF results across years. What would be more immediately obvious to a user would be the changes to the questionnaire. The structure and content were broadly reformed. Among other things, more questions were added to assess households' view of their own preferences and their situation. There were a variety of significant changes on the statistical side, but the most important was the change in the sample design.

Because the desire for panel data remained strong, the 1989 survey incorporated a complicated sample design to allow both representation of the 1983 panel and a 1989 cross-section. The cross-sectional sample was the focus of much innovation. The requirement that the people selected from the tax data explicitly volunteer to participate was dropped and replaced by an option to decline. As expected, this change had a substantial positive effect on contact and participation. In addition, for the first time the survey was able to directly access SOI data, under strict security provisions, to use more sophisticated means to construct the special oversample and to use those data as well for post-survey adjustments. Because since 1983 the SCF data had become an important input to modeling of tax policy in the Treasury and the Joint Committee on Taxation, this use of the information was deemed to be legally allowable. This linkage with tax-based data, and its continuation in more sophistical ways in the later surveys, is essential for the credibility of the SCF in capturing the upper tail of the wealth distribution and for the close correspondence of the survey estimates with those for households in the Financial Accounts of the United States. The survey was truly a pioneer in data linkage, which now plays an increasingly key role in empirical research in many fields, including economics.

For the panel observations, significant effort was devoted in the survey to understand financial in-flows and out-flows due to routine wealth rearrangement activities such as selling a home or because of changes in household structure since the 1983 baseline, with the goal of being able to connect more closely with NIPA measures of saving. Although this decomposition effort was unsuccessful, the panel overall was successful in terms of usability. Unfortunately, the complexity of managing data with both cross-sectional and panel representation collided with the survey's limited resources, computer and human. One key computer program needed to address problems of missing data required approximately six months of error-free run time. Although computer technology subsequently advanced to the point that such a long program could be run within a day, the human resources constraint has remained. As a result, no further SCF panel data were collected until a special one-time re-interview of the 2009 SCF participants in 2010 to help understand the effects of the financial crisis on individual households.

Through subsequent waves of data collection, the SCF continued to be a source of sometimes path-breaking innovation in a variety of areas, including methodology, implementation, quality control, and privacy issues.[17] This innovation was driven only to a moderate degree by abstract principles, but more strongly by the need to cope with the ever-evolving problems of conducting such a survey and making the resulting data fit for use. As Catherine Haggerty, the project manager of the SCF for many years with the collector of the data, NORC at the University of Chicago, once aptly remarked, “Of all the surveys we do, the SCF is the most challenging.” No such project can operate for long on autopilot. A firm commitment to a model of evaluation and continuous improvement is important for its continued survival as a reliable source of data.

For example, gaining cooperation in surveys has grown more difficult over time in all surveys in the U.S., and the sensitive nature of the SCF subject matter make it susceptible to such problems. As cooperation deteriorates, the greater possibility there is for selectivity biases to become problematic. Although a variety of changes in the patterns or intensity of effort were developed to mitigate this problem, beyond some limits such approaches become more imperfect and may lead to sharply escalating costs, a key practical concern. Consequently, focus on potential selectivity biases and means of mitigating them have been a core research and

[17] See Kennickell (2017) and other papers in the same issue of the *Statistical Journal of the IAOS*.

development issue for the SCF. In the past, a large part of that effort was focused on exploiting the power of the SOI data for understanding the patterns of selectivity among the upper reaches of the wealth distribution and for mitigating them. Going forward, deterioration of cooperation more broadly, as is seen clearly in many surveys, may more strongly raise the need to address selectivity issues for other parts of the distribution as well, perhaps by expanding the use of SOI data or other sources that could help to align the observed population with the key economic and demographic dimensions of the actual population.

The SCF has had a rich and broad use for policy and research within the Board. Most importantly, it allows for seeing how economic changes or policy play out among a wide variety of groups, not just for a "representative consumer." It is, of course, also a natural place to try to understand inequality of wealth, across wealth groups, racial groups, and other groups.[18] With time, the Board overcame its reluctance to highlight inequality issues and began including concentration ratios in articles about the SCF published in the *Bulletin*. Among important recent uses of the SCF within the Board is as an input to the creation the Enhanced Financial Accounts, which provides quarterly data of household finances distributed over wealth groups, as mentioned earlier. Because the survey has comparable data on wealth and income, as well as some information on households' consumption, it has the potential to address the joint distribution of wealth, income and consumption, an area that has garnered increasing attention since at least the time of the Stiglitz-Sen-Fitoussi Report (Noll 2011). It has also supported a large body of academic research and influenced the creation of similar surveys elsewhere. For example, the Household Finance and Consumption Survey of the European Central Bank is in many ways modeled on the SCF.

The SCF faces three informational limitations that historically have constrained its use. First, the survey is only triennial, and as such it serves most directly only as a periodic benchmark of the structure of household finances and related matters. The second limitation is the length of the delay in the data release implied by the complexity of collecting and processing the data. The

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[18] See Avery et al (1988) and Kennickell (2003).

delay makes it a practical impossibility to think it could be used directly for strictly contemporaneous analysis even for the year of the survey. Modeling can be used to address these two issues, potentially by introducing a variety of external data, to project the relationships in the data to other periods, as is done for the distributional accounts. Another, as possibility proposed in the past, would be to design and execute rapid small-scale surveys based on the most recent SCF sample and focused on current topics of interest. Analysis of the newly collected data could be conditioned on the substantial body of data on households in the baseline survey.

Finally, there is typically no linkage of households across waves of the survey. As noted above, in the post-1989 period, the only follow-up panel of SCF data was collected in 2010, based on the 2009 SCF sample. The absence of SCF panel data has long been a serious complaint among academics. It is widely recognized that such information is important in model building, for addressing issues of causality, and in quantifying the degree of fluidity in the household economy that repeated cross-sectional observations obscure. In addition, data collection for panel surveys is typically less expensive than cross-sectional surveys, because people who have already cooperated once are more likely to cooperate again. However, there are also important countervailing costs. First, the unit of observation, the primary economic unit (like a household), may change in economically important ways over time, through marriage or divorce and in other ways. Compensating for such changes is at best challenging. Second, even though panel households tend to be more likely to cooperate, cumulating even a 90 percent response rate across three waves beyond the baseline implies that only 73 percent of the original sample would remain, thus raising additional questions about selectivity bias. Third, owing to the aging of panel members and changes in the overall population structure, panels progressively lose cross-sectional representativity. Addition of a “refreshment sample” designed to compensate for structural changes can minimize those representativity problems. Finally, processing panel data is substantially more difficult, owing to the cross-constraints implied by multiple observations on the same unit. All these problems indicate that their intensity grows the longer a panel runs. Moving in the direction of even a relatively short SCF panel would require more staff and money, for a project that is already quite expensive.

Other Surveys

Another important development of micro data within R&S was the Survey of Small Business Finance (SSBF), a survey conducted four times between 1987 and 2003, with John Wolken as the project director (Mach and Woken, 2006). As is well known, small businesses (officially, those with fewer than 500 employees) are an important part of the dynamics of the job market and a source of innovation. But often lacking the history and financial weight of larger firms, financing for such businesses can face quite different obstacles. This survey was designed to cover both the important aspects of the businesses' balance sheets, their financial relationships, and other characteristics necessary for understanding the context in which the businesses operated and obtained credit and other financial services. This project, which collected a unique set of information, was regrettably canceled after the 2003 wave of the survey. Its influence lingers. A small amount of the information on small businesses can be obtained from the SCF, and since 2014, a Federal Reserve System effort has supported the annual Small Business Credit Survey, which continues some of the efforts of the SSBF.

The number of special-purpose efforts in R&S to collect survey data, including inclusion of questions on omnibus surveys, is so large and varied that it would be impractical to try to cover it all. Many efforts have been aimed at understanding the current economic conditions of households. Some have addressed specific questions in response to a request, sometimes from Congress. One unusual and amusing such request was for an estimate of the number of dollar coins in 2010 of distinct types (Eisenhower, Susan B. Anthony and Sacagawea dollars, and the Presidential and Native American series) that were held either in Federal Reserve vaults or private coin terminals on behalf of the Federal Reserve. Nearly one billion such coins were held across all 103 locations. Because it would have been impossible to enumerate all the coins, a sample survey seemed appropriate, if a suitable framework for efficient random sampling could be devised. Developing a stratified random sample of locations was straightforward. But the only common factors across locations were that the total number of coins in each location was known, all coins were held in bags of an approximately fixed content and an approximately fixed number those bags were held in individual containers. Otherwise, the physical arrangements across locations were different. Because the coins did not circulate very often, there would be a tendency for bags of coins to cluster by date of issue. To ensure an appropriate and comparable dispersion of the sample across all locations, it was necessary to develop an abstract topology of containers and bags that could apply equally across locations, regardless of the positioning of the containers. For the curious reader, in the end it was estimated that 60 percent of the coins were from the Presidential series, with a standard error of 1.3. Though perhaps not the most serious subject matter for Board purposes, the effort exemplifies the creativity of staff in addressing difficult measurement questions.

Blending and Merging Data

R&S contains a substantial number of economists who work on financial institutions and markets, for the purposes of assessing market risks and financial stability, competitiveness of markets, and other aspects of the behavior of financial institutions. Although the Board, through the Monetary Affairs Division and the Division of Supervision and Regulation, collects data relevant to these tasks, such as the information in the National Information Center on the corporate structure of banks, in many cases the information is available at too low a frequency or too low a level of detail to be useful without additional data. A variety of sources of market data and data from vendors such as Bloomberg provide higher-frequency data, and R&S staff are adept at blending and managing these sources.

Using and blending multiple sources of data in a straightforward way in the financial context or more broadly requires clear and compatible definitions of variables across sources. In some cases, industry standards such as ones developed through the International Organization for Standardization (ISO) provide this service. Where such standardization is not present, substantial additional work is often required to develop appropriate approximations. A particularly compelling example in the context of financial analysis is the identity of a legal entity. Identity can be context dependent or multidimensional. For example, an entity might be seen as only an aspect of a larger corporate structure or simply as an object itself. A web of corporate relationships often can be exceedingly difficult to determine. In addition, many data sources use proprietary codes to identify such entities and charge a fee to use those codes. Mapping across data sources can be difficult or imperfect, often involving a degree of “hand” work. A classic example of the effect of these problems was the difficulty in identifying and connecting the legal entities in the corporate structure of Lehman Brothers at the beginning of the 2008 financial crisis (Bottega and Powell, 2011). In the aftermath of that crisis, the 2010 G20 meeting of finance ministers and central bank governors recognized the importance of improved financial data and called for the development of a global system for entity identification. Many national regulatory authorities and central banks came together, with support from the Financial Stability Board, to develop a suitable technical framework and a governance framework.[19] R&S, together with other U.S. agencies, played a key role in the technical development and implementation of this frameworks. The resulting operational body, the Global LEI Foundation, went live in June of 2014 and continues to develop.

5. Recent Advances in Blending Data

Across many parts of the field of statistical measurement, there has been great focus and energy devoted to bringing together multiple sources of data, either through merging data or via modeling, to address questions that could otherwise not be addressed as effectively. Obviously, the explosion of nontraditional data sources and the advances in data processing hardware and software have supported this exciting work.

R&S has always applied its deep set of measurement skills in exploiting novel and informative data when analyzing the economic landscape. The work in financial analysis noted above is perhaps the longest running such effort in R&S where micro data are the core. But over the past decade, measurement with nontraditional data has become more intentional and systematic in R&S, as it has in other parts of government and elsewhere. Indeed, such work may currently be the most rapidly developing area of statistics. In principle, nontraditional data may be part of an administrative program such as the income tax system with its well-defined population, a statistical survey conducted elsewhere for a different or overlapping purpose,

[19] See www.leiroc.org/about/index.htm and www.gleif.org/en/about/history for details.

remote sensor information, and a wide spectrum of other types, including information generated within a nonstatistical framework, such as scanner data.

Use of administrative data has a long history on the real side in R&S, most notably as an input in the construction of the Industrial Production Index and in the support for the SCF, as noted earlier. In past times, a person from R&S who had qualified under Census rules would need to go physically to the Census Bureau to work with the necessary data. Under the leadership of Norman Morin in R&S, a Federal Statistical Research Data Center (FSRDC) was established at the Board in 2019, allowing direct access to the data. The restricted-use data available through an FSRDC span a wide range of government data beyond the information traditionally used for IP. Some movements elsewhere have made it highly likely that this facility will grow in importance.

Following the report of the 2016 U.S. Commission on Evidence-Based Policymaking created under the Evidence-Based Policymaking Commission Act (Public Law 114-140), in 2018 Congress passed the Foundations for Evidence-Based Policymaking Act (Public Law 115-435, often referred to as the "Evidence Act"). Among the most relevant aspects of the act for the work of R&S is the presumption that all federal government data should be available, subject to statutory limitations and appropriate provisions for maintaining confidentiality, and the application for data access is standardized across all agencies. Linking or otherwise blending such data will be a central issue.

To support the development of a broad expanded measurement agenda (EMA), Christopher Kurz, Norman Morin, and John Stevens, along with Micheline Casey (head of the OCDO at the time) traveled to the Bay Area in October 2014 to visit tech companies and academic institutions. Around this time, they invited multiple tech companies visit the Board to continue exploring data-sharing and other collaboration. Progress on EMA led David Wilcox (then R&S Director) in 2016 to create a group by that name within the Industrial Output section to continue this work, with Christopher Kurz as the first group manager.

The new data sources serve two main purposes. First, they help the R&S staff to forecast macroeconomic indicators with improved accuracy, at a higher frequency, or with greater disaggregation by, for example, geography or product type. Second, the new measures derived from these data themselves assist in the identification of the current cyclical position of the economy. For example, these and other series are used as inputs into a statistical filtering exercise to estimate latent factors associated with the economic cycle in real time; this "nowcasting" effort became part of the mission of the Current Macroeconomic Conditions Section led by Gianni Amisano, created in 2015 also at the initiative of David Wilcox. While the expanded measurement agenda formally resides within the Industrial Output section, the work with novel nontraditional data requires extensive collaboration throughout R&S and the Federal Reserve Board.

Considering the broader technical evolution in using such data and the discovery of new data sources, continuing outreach is an integral component of the EMA group's responsibilities. The group stays actively connected to private, academic, and government institutions through organizing and participating in conferences, hosting visitors, and collaborating closely with the Federal Statistical Agencies and other policymaking institutions, such as foreign central banks. Inside the Board, the group has partnered with the Division of Monetary Affairs and the Division of International Finance. For example, staff participated in organizing conferences in 2018 and 2019 at the Bank of England and in 2019 hosted a broadly attended two-day conference featuring new research on nontraditional data, machine learning, and natural language processing in macroeconomics, highlighting the importance of nontraditional data sources and new empirical methods for macroeconomic analysis. The success of the latter led to an international partnership and the expansion of the conference. Since 2019 the Board has coordinated on three more events, with the Sveriges Riksbank, Bank of Canada, and the Banca d'Italia. The events are also now jointly coordinated with the Central Bank Research Association (CEBRA), and the Economics with Nontraditional Data and Analytical Tools (ECONDAT) program. Notably, the event returned to the Board in 2023, with the 5th conference on "Nontraditional Data, Machine Learning, and Natural Language Processing in Macroeconomics" in November of 2023.

One of the earliest systematic efforts in R&S to leverage nontraditional data involved an attempt in 2016 to gain access to microdata from the payroll processing firm Automatic Data Processing (ADP). At that time ADP in collaboration with Moody's was already using these data in a modeling exercise to predict payroll gains in the BLS Current Employment Statistics (CES). However, many economists at the Board thought that a better utilization of ADP microdata would be to generate an independent measure of payroll employment gains. Following successful, if intense, work to obtain access to ADP weekly microdata in near real time, by 2017 R&S staff were able to generate a new measure of payroll employment for use in presentations to the Board.

Another important early example of R&S working with nontraditional data was in measuring consumption, using near real-time data from First Data (acquired by Fiserv in 2019), a payments management company. These data were successfully used for measuring consumption responses to different events, ranging from hurricanes (Aladangady et al. 2016), sales-tax holidays (Aladangady et al. 2017), and federal tax refunds with an earned income tax credit (Aladangady et al. 2018). Aladangady et al. (2019) gives a broad overview of the construction of a real-time, high-frequency, geographically detailed measure of consumer spending from these transaction data.

In the area of measuring business formation, economists from R&S joined forces with Census and academic economists to construct a new dataset for measuring business formation in near real time (Bayard, et al. 2018a, 2018b). The new dataset was based on applications for Employer Identification Numbers (EINs) submitted in the United States, known as IRS Form SS-4 filings.

The experience with nontraditional data for economic measurement proved especially helpful in dealing with the economic uncertainty accompanying the COVID-19 crisis. At that time, economic activity was deteriorating at an unprecedented pace and many critical monetary and fiscal policy decisions had to be made before the release of the usual official statistics. Cajner et al. (2022) describes the work done in R&S to rapidly measure economic developments during that period, which relied importantly on high frequency indicators.

Three main benefits that nontraditional data sources provided during the pandemic were timely measurement, granularity, and crisis-specific estimates. First, in terms of timely measurement during the pandemic, R&S took advantage of the progress made on EMA in the years before the pandemic started. For example, the enormous employment losses during the pandemic became visible in official statistics only in the beginning of May 2020, when the BLS released its April 2020 employment situation report. However, R&S was able to monitor employment declines during the pandemic essentially in real-time with the weekly ADP-FRB data (Cajner, Crane, Decker, Grigsby, et al. 2020). Similarly, work with information from First Data allowed R&S to measure in near real-time consumption declines, while Business Formation Statistics published by the Census provided crucial information about business starts, which surged surprisingly in the aftermath of the pandemic (Decker and Haltiwanger 2023). Relatedly, a team of authors from R&S worked on measuring in near real time business exit during the pandemic (Crane et al. 2021).

Second, while official government statistics provide reliable information about aggregate statistics, they often lack granular detail, such as detailed measurement across geographic areas (states or counties) or by different breakdowns of other individual statistics (such as income). During the pandemic, the new methods developed within R&S allowed a granular assessment of events. For example, given that the first wave of the pandemic produced relatively more severe COVID-19 outbreaks in northeastern parts of the country, R&S was able to use an array of granular information in nontraditional data—including geographically detailed data on employment, spending, public transportation, and health indicators—to better understand links between health shocks and the responses of economic variables. This knowledge proved very important in predicting the evolution of the U.S. economy as the pandemic became widespread throughout the country. Similarly, essentially real-time analysis of the Paycheck Protection Program performed by a group of R&S and academic economists with the ADP microdata provided crucial understanding of how this program affected the evolution of employment (Autor et al. 2022).

Third, there were important measurement needs during the pandemic for which official government statistics provided little or no information. Policymakers needed to pay attention to the influence of health-related indicators—such as COVID-19 cases, hospitalizations, deaths, and vaccinations—in understanding disruptions to the economy. With its accumulated experience and access to nontraditional data, R&S was quickly able to develop relevant indicators and provide regular weekly updates thereafter. This experience increases confidence that R&S can address other types of disruptions in the future, beyond typical economic recessions.

Use of nontraditional data by R&S has proven worthwhile, but there are frequently costs and risks in doing so. Very many sources with seemingly useful data are commercial organizations that may face incentives that differ importantly from those of the Fed. Typically, data must be purchased, sometimes at substantial cost. Costs may also rise unexpectedly over time, to the point that the data become prohibitively expensive. Variables may not be documented to the extent typical of data collected within a scientific framework. Moreover, such data are most typically collected for a specific business purpose, and variable definitions may change over time as business needs change—or a series may stop altogether. R&S staff usually must invest considerable effort to make the data useable for its purposes, an effort that is lost when the data can no longer be obtained. Frequently, such data are not available for a fully representative population and statistical methods must be developed to make them fit for purpose. Broader measurement expertise within R&S has been helpful in addressing this and other important methodological issues with nontraditional data. A final risk that has been raised by some users of commercial data is that the data provider might work with their own data for the purpose of learning about the decision-making processes of a user.

Despite all the challenges of using nontraditional data, important opportunities remain for future work. Across the domain of official statistics, nontraditional data already have a role, and that role seems likely to increase. The ongoing discussions and collaborations within the government support sharing of methods and ideas that will benefit the Federal Reserve Board and the broader production of official statistics. In its most recent initiatives, the EMA group in

R&S has been working to advance measurement efforts by using text analytics, natural language processing, machine learning, and large language models. While still in their initial stages, these efforts are already producing some promising results. The future for innovation in measurement in R&S looks very good!

6. Concluding Remarks

Several themes emerge from our review of statistical programs in R&S and chief among them is the importance keeping these programs up to date. Surveys such as the SCF must continue to adjust to changes in the financial landscape, availability of relevant new data sources, new demands for data, and statistical issues such as maintaining meaningful response rates. Price measures will remain relevant as indicators of technology only as long as they remain up to date in terms of products covered and appropriate methods are used. Financial accounts must keep up with the proliferation of financial institutions and instruments and emerging analytical needs.

Another key theme is that financial microdata, new nonfinancial constructs, and miscellaneous economic indicators collected or assembled elsewhere increasingly became key resources in R&S. The division's march in this direction looks even to have accelerated in recent years with the Expanded Measurement Agenda launched to explore the utility of nontraditional sources of information on economic activity the wake of the COVID-19 crisis—a move on the heels of the Enhanced Financial Accounts initiative to improve the depiction of nonbank institutions and financial intermediation in the FAs following the global financial crisis. In addition, the recently established Federal Statistical Research Data Center (FSRDC) has eased access to a variety of government data sources that are available only in a secure setting. The passage of the Foundations for Evidence-Based Policymaking Act (Public Law 115-435, often referred to as the "Evidence Act") in 2018 explicitly calls for greater ability for agencies to share and link data for research aimed at policymaking, making it highly likely the division's FSRDC facility will grow in importance. As we have seen, there is a long experience of linking or otherwise blending a broad swath of financial and nonfinancial data in R&S.

The division's capability in sample design and technical processing of data is widely admired and has had significant positive spillover effects on the work of the Board as a whole—as well as far beyond the Board. Support from R&S provides sample designs for ancillary surveys of financial institutions in Monetary Affairs. By the same token, other divisions, e.g., Supervision and Regulation as well as Monetary Affairs, generate a lot of data R&S uses for understanding financial conditions. Of course, understanding the resilience and potential risks financial institutions may pose for the broader economy is priority for many at the Board, but we believe it is fair to say that R&S provides the major tools and datasets that sustain and advance this effort.

The body of R&S research on real IT output, productivity, and investment continues to provide insights for policymakers, researchers, and practitioners seeking to assess and improve economic performance. Working to construct quality-adjusted price indexes for high-tech products and industries builds near geek-level command of technologies and, less obviously, of industry production geography. This knowledge has proved relevant to analysis of the Chips Act and related industrial initiatives of the Biden administration. The intangibles framework helps to provide perspective on how the current wave of AI technology may affect the economy, and while not discussed in this paper, the policy relevance of how the pace and composition of intangible investment influences total factor productivity though spillovers.

Finally, besides the analysis of financial conditions per se, the data from the FAs, consumer credit, and the SCF have provided the basis for many studies of consumer behavior and assessments of data on consumers, areas where R&S staff have been especially prolific. Topics investigated include how the level, dynamics, and distribution of wealth and debt, including the cost of debt and capital gains (and expectations of them), affect consumer behavior—and the adequacy of existing data sources for understanding these matters. Grasping these issues are central to understanding how financial conditions affect consumer spending and to formulating theories and testing them based on disaggregated or microdata.

All told, we believe it is fair to say that the Board would be in a very reduced information state about current economic conditions, financial stability, the performance of the economy (especially the role of technology in driving it), and many fundamental factors affecting consumer spending and business capital formation without the economic measurement programs in R&S.

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